KINGDOM OF BHUTAN

FIRST BIENNIAL TRANSPARENCY REPORT TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

DEPARTMENT OF ENVIRONMENT AND CLIMATE CHANGE
MINISTRY OF ENERGY AND NATURAL RESOURCES
ROYAL GOVERNMENT OF BHUTAN

December 2024

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The First Biennial Transparency Report from the Kingdom of Bhutan to the UNFCCC

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Glossary of Acronym

ADB	Asian Development Bank
ATF	Aviation Turbine Fuel
BC	Biological Corridors
BEA	Bhutan Electricity Authority
BGI	Biodiversity and Glacier Inventory
BHU	Basic Health Unit
BLSS	Bhutan Living Standard Survey
C4	Climate Change Coordination Committee
CAT	Centre for Appropriate Technology
CBD	Convention on Biological Diversity
CITES	Convention for International Trade in Endangered Species
CNR	College of Natural Resources
CR	Critically Endangered
CRDS	Centre for Rural Development Studies
CRSED	Centre for Renewable and Sustainable Energy Development
CRU	Climate Research Unit
CSMA	Centre for Sustainable Mountain Agriculture
DLGDM	Department of Local Governance and Disaster Management
DECC	Department of Environment & Climate Change
DGM	Department of Geology and Mines
DJF	December, January, and February
DoA	Department of Agriculture
DoE	Department of Energy
DoFPS	Department of Forest and Park Services
DoI	Department of Industry
DoIT	Department of Information Technology
DoPH	Department of Public Health
DoW	Department of Water
DRE	Department for Renewable Energy
EAA	Environmental Assessment Act
EDP	Economic Development Policy
EN	Endangered
ERA5	ECMWF Reanalysis
EW	Extinct in the Wild
EX	Extinct
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GNH	Gross National Happiness
GNHC	Gross National Happiness Commission
GVA	Gross Value Added
GWh	GigaWatt Hour
Ha	Hectare
HCEH	Himalayan Centre for Environmental

	Humanities
HDPE	High-Density Polyethylene
IUCN	International Union for Conservation of Nature
IPCC	Intergovernmental Panel on Climate Change
JJAS	June, July, August and September
JNEC	Jigme Namgyel Engineering College
LDC	Least Developed Country
LEDS	Low Emission Development Strategies
LEES	Centre for Lighting and Energy Efficiency Studies
LPG	Liquefied Petroleum Gas
MAM	March, April and May
MDP	Mineral Development Policy
MEA	Multilateral Environmental Agreements
MMMA	Mines and Mineral Management Act
MMMR	Mines and Mineral Management Regulation
MoAL	Ministry of Agriculture and Livestock
MoENR	Ministry of Energy and Natural Resources
MoESD	Ministry of Education and Skills Development
MoF	Ministry of Finance
MoFAET	Ministry of Foreign Affairs and External Trade
MoH	Ministry of Health
MoHA	Ministry of Home Affairs
MoICE	Ministry of Industry, Commerce, and Employment
MoIT	Ministry of Infrastructure and Transport
MT	Metric Ton
MW	Mega Watt
NAMAS	Nationally Appropriate Mitigation Actions
NAP	National Adaptation Plan
NAS	National Accounts Statistics
NBC	National Biodiversity Centre
NCCC	National Climate Change Committee
NCHM	National Centre for Hydrology and Meteorology
NCWC	National Commission for Women and Children
NDC	Nationally Determined Contribution
NEC	National Environment Commission
NECS	National Environment Commission Secretariat
NEPA	National Environment Protection Act
NFI	National Forest Inventory
NLCS	National Land Commission Secretariat
NP	National Parks
NRDCL	Natural Resources Development Corporation Limited
NSB	National Statistics Bureau
NWIS	National Waste Inventory Survey
PA	Protected Areas
PET	Polyethylene Terephthalate
PHCB	Population and Housing Census of Bhutan
RBP	Royal Botanical Parks
RCP	Representative Concentration Pathway
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RTC	Royal Thimphu College
RUB	Royal University of Bhutan
SMCL	State Mining Corporation Limited
SNR	Strict Nature Reserve
SOC	Soil Organic Carbon
Tmax	Maximum Temperature
Tmin	Minimum Temperature
TNC	Third National Communication
toe	Tonnes of oil equivalent
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNGA	United Nations General Assembly
VU	Vulnerable
WS	Wildlife Sanctuaries
WTO	World Trade Organization
WWF	World Wildlife Fund

FOREWARD

Climate change is one of the defining challenges of our time, demanding bold action, global solidarity, and steadfast commitment to safeguarding the planet for future generations. As a nation that values environmental stewardship and sustainable development, Bhutan has been consistently investing its efforts and its leadership in addressing the impacts of climate change and advocating for a carbon-neutral future.

Our responsibility to the global community includes transparency and accountability in reporting our progress and commitments. We are glad to submit our first Biennial Transparency Report (BTR1) to the United Nations Framework Convention on Climate Change (UNFCCC), which reflects Bhutan's dedication to these principles. It outlines the strides progress that we have made in reducing Greenhouse Gas emissions, achieving our commitment to carbon neutrality, adapting to climate impacts, and fostering resilience within our communities.

As a carbon-negative country, Bhutan remains a symbol of what can be achieved when policies, actions, and a deep-rooted cultural connection to nature align. This report also highlights the challenges we face, underscoring the urgent need for sustained international support and collaboration to ensure our ability to maintain this status and further enhance our contributions to the global climate agenda. I would like to express my gratitude to all stakeholders - government agencies, civil society, non-governmental organizations, private sectors, international partners, and local communities whose contributions have been integral to the preparation of the BTR1. This report is a reaffirmation of Bhutan's unwavering commitment to combating climate change and a call for action from nations worldwide to rise to this existential challenge.

(Karma Tshering)
Chairman, National Environment Commission
Secretary, Ministry of Energy and Natural Resources

CHAPTER 1:
NATIONAL CIRCUMSTANCES AND INSTITUTIONAL ARRANGEMENTS

Bhutan, a landlocked nation in the Eastern Himalayas, spans an area of 38,394 km² and shares borders with China to the north and India to the south, east, and west. The country's diverse topography, steep mountains, and deep valleys, significantly influence its climate, biodiversity, and hydrological resources. Bhutan's unique geographical features contribute to its rich natural heritage, including a network of rivers, high-altitude wetlands, and extensive forest cover.

The Kingdom is a democratic constitutional monarchy with a parliamentary democracy. Its governance structure includes an executive branch led by The King and the Prime Minister, a bicameral legislature comprising the National Assembly and National Council, and an independent judiciary. Local Governance is facilitated through Dzongkhags (Districts) and Gewogs (Blocks), ensuring participative decision-making at various administrative levels.

Bhutan's economy heavily relies on climate-sensitive sectors such as agriculture and hydropower. Agriculture employs over 44 % of the rural population and is vital for food security, while hydropower generation is a cornerstone of national revenue and energy supply. However, the country faces significant vulnerabilities due to climate change impacts, including extreme weather events that threaten agricultural productivity and infrastructure.

The hydrological resources of Bhutan are defined by major rivers flowing from north to south, which experience seasonal fluctuations due to monsoon rains and snowmelt. The country has also mapped 3,027 high-altitude wetlands that play a crucial role in maintaining biodiversity and regulating water resources.

Bhutan has established a comprehensive climate change policy framework aligned with international agreements. Key institutions such as the Department of Environment and Climate Change (DECC) and legislation like the National Environment Protection Act, 2007 guides these efforts. Strategic initiatives like the Low Emission Development Strategies and Bhutan's Long-Term Low Greenhouse Gas Emission and Climate Resilient Development Strategy (LTS), 2023 aim to transition from fossil fuel dependency while promoting sustainable development practices across sectors.

This chapter of Bhutan's first Biennial Transparency Report (BTR1) explores the national context in detail, addressing critical aspects across various sections to depict the current circumstances and pertinent considerations facing the country. The report aims to provide insights into Bhutan's efforts to address climate change while enhancing resilience and promoting sustainable development initiatives.

1.1. Administrative Structure

Bhutan's administrative structure is organized into the executive, legislative, and judicial branches. A Local Governance system also plays a crucial role in the country's political and administrative landscape. The following is an overview of each component which is also shown in the figure below:

1.1.1. Executive Branch

Head of State: The King of Bhutan (The Druk Gyalpo) is the constitutional monarch and the Head of the State. The King plays a vital role in the country's governance, providing guidance and direction for national policies and initiatives.

Prime Minister: The Prime Minister is the elected Head of Government. The Prime Minister leads the executive branch, formulates government policies, and oversees the administration.

Cabinet Ministers: The Prime Minister appoints ministers to head nine ministries, responsible for specific areas such as finance, agriculture and livestock, education, health, home affairs, energy, employment, infrastructure, and foreign affairs. These ministers implement government policies and programmes.

Civil Service: The civil service is a professional body that supports the executive branch in implementing policies and delivering public services. Civil servants are recruited based on merit and are expected to uphold integrity and professionalism.

1.1.1 Legislative Branch

Parliament: Bhutan has a bicameral Parliament consisting of two houses:

National Assembly: This is the lower house, with 47 members elected for five years. It is responsible for proposing and debating laws, as well as scrutinizing government actions.

National Council: This is the upper house, consisting of 25 members. It includes 20 members elected by local communities and five eminent members appointed by the King. The National Council reviews legislation passed by the National Assembly and provides recommendations.

Legislative Process: Bills can be introduced in either house of Parliament but require approval from both to become law. Additionally, the Parliament holds responsibility for approving the national budget and ensuring government accountability through oversight mechanisms.

1.1.2 Judicial Branch

Supreme Court: The Supreme Court is the highest judiciary body in Bhutan, overseeing the judiciary and ensuring the rule of law. It has the authority to interpret the Constitution and adjudicate constitutional matters.

High Court: Below the Supreme Court, the High Court hears appeals from lower courts and has jurisdiction over serious criminal and civil cases.

District and Dungkhag Courts: These courts deal with local matters, encompassing civil and criminal cases at the district level. Dungkhag (sub-district) courts specifically address issues pertinent to rural and Dungkhag regions. These courts deal with local matters, encompassing civil and criminal cases at the district level. Dungkhag courts specifically address issues pertinent to rural and Dungkhag regions.

Judicial Independence: The judiciary operates independently of the executive and legislative branches, ensuring fair and impartial administration of justice.

1.1.3 Local Governments

Local Governance Structure: Bhutan is administratively divided into 20 Dzongkhags (districts), which are further subdivided into 205 Gewogs (Blocks) grouped under 47 constituencies and four Thromdes (Municipalities). Each level of Local Government has specific responsibilities and powers. Figure 1 represents the administrative map of Bhutan.

Dzongkhag Administration: The Dzongkhag Tshogdu, or District Council, is crucial in facilitating consultative decision-making at district level. This body brings together representatives from various local governments, senior officials from the Dzongkhag Administration, and Regional Offices to discuss and decide on important issues. The composition of the Dzongkhag Tshogdu includes:

1. Gups (elected Heads of Gewogs)
2. Mangmis (elected Deputy Heads of Gewogs)
3. Thromde Ngotshabs (municipal representatives)

Leadership of the Dzongkhag Tshogdu is determined through a democratic process. Members elect a Chairperson and Deputy Chairperson from among themselves using a secret ballot system. Any member of the council is eligible for these leadership positions. While the Dzongkhag Tshogdu is responsible for making decisions, the implementation of these decisions falls to the Dzongkhag Administration. This administrative body consists of civil servants and is led by the Dzongdag (District administrator)[1].

Gewog Administration: Gewogs are managed by Gewog Tshogdu (gewog council) members. The Gewog Tshogde plays a crucial role in facilitating participative decision-making at the gewog (block) level in Bhutan. This local government body ensures that representatives from rural communities are actively involved in the decision-making process. The Gewog Tshogde comprises several key members:

1. Gup (Chairperson)
2. Mangmi (Deputy Chairperson)
3. Tshogpas (Representatives)

Thromde Administration: A Thromde Tshogde, which translates to Municipal Committee, plays a crucial role in urban governance in Bhutan. This body is responsible for facilitating participative decision-making at the Thromde (municipal) level, ensuring that representatives from urban communities are actively involved in the decision-making process[2]. The composition of a Thromde Tshogde includes:

1. Thrompon (Mayor): Thrompon serves as the Chairperson of the Thromde Tshogde for five years.
2. Thromde Thuemis (Municipal Councilors) for all Dzongkhag towns/mucipalities.

1 Department of Local Governance and Disaster Management (website)
2 Ministry of Home Affairs (MoHA), 2024

Figure 1: Administrative Map of Bhutan[3]

Figure 2: Bhutan Physical Map

3 https://gisgeography.com/bhutan-map/#Physical-Map

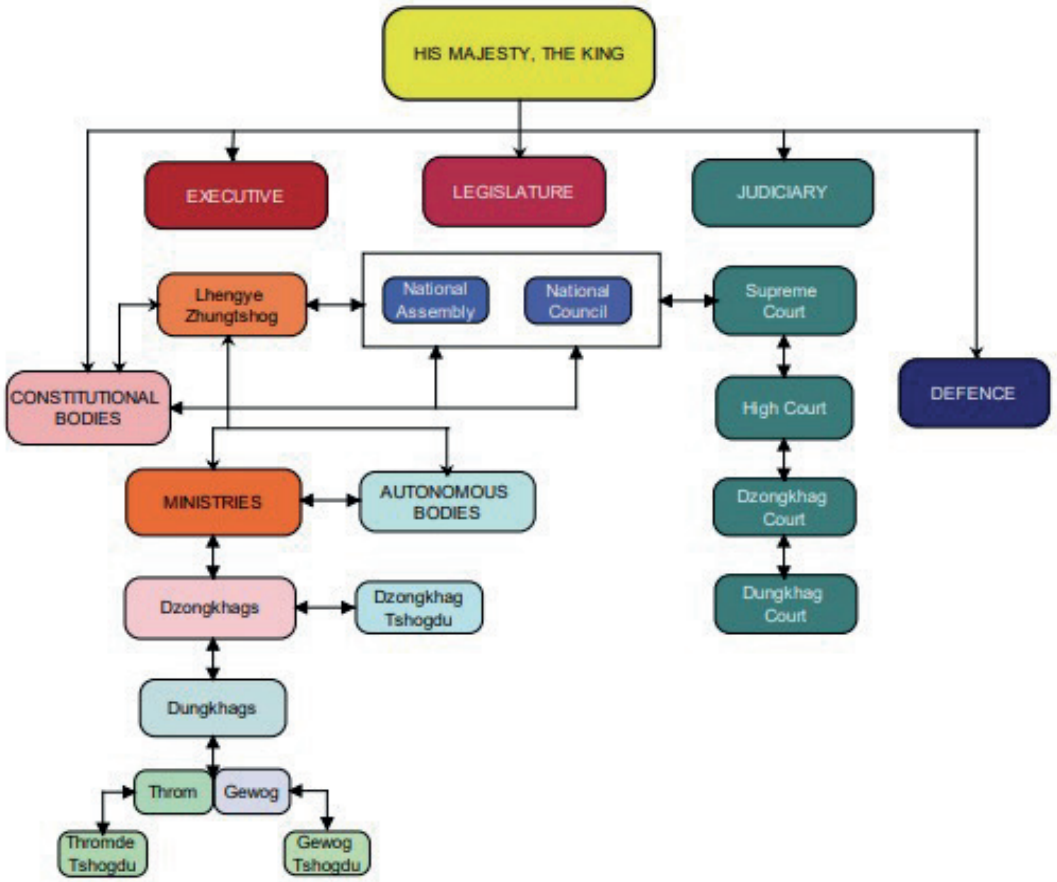

Figure 3: Administrative Structure of Bhutan

1.2 Geography and Topography

Bhutan is a landlocked country covering an area of 38,394 km^2 nestled in the Eastern Himalayas. The country is mountainous with altitudes ranging from about 100 meters above sea level (masl) in the southern foothills to over 7500 masl in the northern part of the country[4]. The high Himalayas in the north, with its snow-capped peaks and alpine pastures, are Bhutan's most notable topographic characteristics. Rough slopes, deep valleys shaped by swift-moving rivers, alluvial plains with wide river valleys, and north-south valleys and ranges that create watersheds all contribute to the terrain. Bhutan is extremely vulnerable to the effects of climate change and extreme weather events because of its delicate alpine habitat. Due to the nation's limited financial, technical, and human resources, as well as its low capacity for adaptation, this scenario is made worse[5].

Additionally, Bhutan's economy is still largely dependent on climate-sensitive sectors such as agriculture and hydropower. The mountainous terrain also complicates communication and transport, making them both fragile and costly[6].

4 https://www.nsb.gov.bt/wp-content/uploads/dlm_uploads/2023/10/SYB-2023.pdf
5 https://www.nsb.gov.bt/wp-content/uploads/dlm_uploads/2023/10/SYB-2023.pdf
6 National Adaptation Plan (NAP) of the Kingdom of Bhutan, 2023.

1.3 Hydrological Resources

The major rivers in Bhutan predominantly flow from north to south, originating in the alpine regions and descending into the tropical areas adjacent to India. These rivers are characterized by steep gradients and narrow, steep-sided valleys, which sometimes expand to create small flatlands suitable for agriculture. During the monsoon season, they transport substantial volumes of water and sediment, while snowmelt at the end of the dry season also plays a crucial role in their flow. Additionally, short tributaries fed by rain cascade steeply from both sides to merge with these primary rivers. The distinct wet and dry seasons lead to significant fluctuations in river flow; during the monsoon, rivers experience high water levels and sediment loads, whereas flow decreases in the dry season due to limited rainfall and a lack of major groundwater reservoirs[7]. Snowmelt from the northern alpine areas further enhances river flow at the close of the dry season. Beyond the main north-south rivers, Bhutan features a dense network of small perennial and rain-fed tributaries that rush down steep slopes and side valleys, often manifesting as waterfalls before joining the major rivers.

1.3.1 River System of Bhutan

The principal rivers in Bhutan include the Amochhu, Wangchhu, Punatsangchhu, and Manas. Notably, the Mangdechhu and Drangmechhu converge to form the Manas river. The Manas river drains approximately half of Bhutan's territory. Most river discharge is primarily derived from rainfall, with an estimated 2-12% originating from glacial melt and around 2% from snowmelt. The total combined outflow of these rivers is estimated at 70,576 million cubic meters per year, which translates to about 2,238 cubic meters per second[8] (Table 1).

1.3.2 Wetlands

Bhutan has mapped 3,027 high-altitude wetlands, including supra-snow, glacial, supraglacial, and marshes above 3,000 meters above sea level. These high-altitude wetlands account for approximately 0.26% of the country's total land area[9] (Table 1).

On September 7, 2012, Bhutan ratified the Ramsar Convention on Wetlands of International Importance, and currently, it has designated three Ramsar wetland sites covering a total area of 1,225 hectares. These sites include Khotokha (113.5 hectares) and Gangtey-Phobji (970 hectares)[10], both located in Wangdue Phodrang district, as well as Bumdeling (141.5 hectares) in Trashiyangtse district, which is part of the Bumdeling Wildlife Sanctuary[11].

With an average flow of 2,238 m^3/s, Bhutan generates 70,572 million cubic meters (m^3)per annum, i.e. 94,500 m^3/person per year, the highest in the region (NIWRMP, 2016) (Table 1). Despite a high per capita water availability in Bhutan, accessibility remains a major issue, causing seasonal localized shortages. Geographically, human settlements and farmlands in the country are mostly

7 https://www.undp.org/sites/g/files/zskgke326/files/2023-11/undp-bhutan-climate-risk-assessment-on-water-resources-for-nap-nov-2023.pdf
8 https://www.adb.org/sites/default/files/project-documents/46463/46463-002-dpta-en.pdf
9 https://www.uwice.gov.bt/admin_uwice/publications/publication_files/Reports/2011/UWICER-IOHAWIB.pdf
10 https://rsis.ramsar.org/RISapp/files/RISrep/BT2264RIS_1604_en.pdf
11 https://www.wwfbhutan.org.bt/?203094/Bhutan-joins-the-Ramsar-Convention

located on hilltops and the upper slopes of mountains. On the other hand, the water resources flow through streams and rivers at the bottom of the valleys, making it physically difficult for residents to access the resources easily.

Table 1: River Basins of Bhutan[12]

River Basins	Catchment (Km²)	Annual Flow (Million m³)	High Altitude Wetlands	Glaciers
Aiechhu	1937	6989	0	0
Amochhu	2310	9357	115	0
Jaldakha	942		0	0
Drangmechhu	8457	13569	431	124
Mangdechhu	7380	11797	1173	287
Punatshangchhu	9645	19130	904	466
Wangchhu	4596	5209	324	58
Nyera-Amari	2348	4507	10	0
Jomori	642		0	0
Merak Saktengchhu	137		70	0
Total	**38,394**	**70,576**	**3,027**	**935**

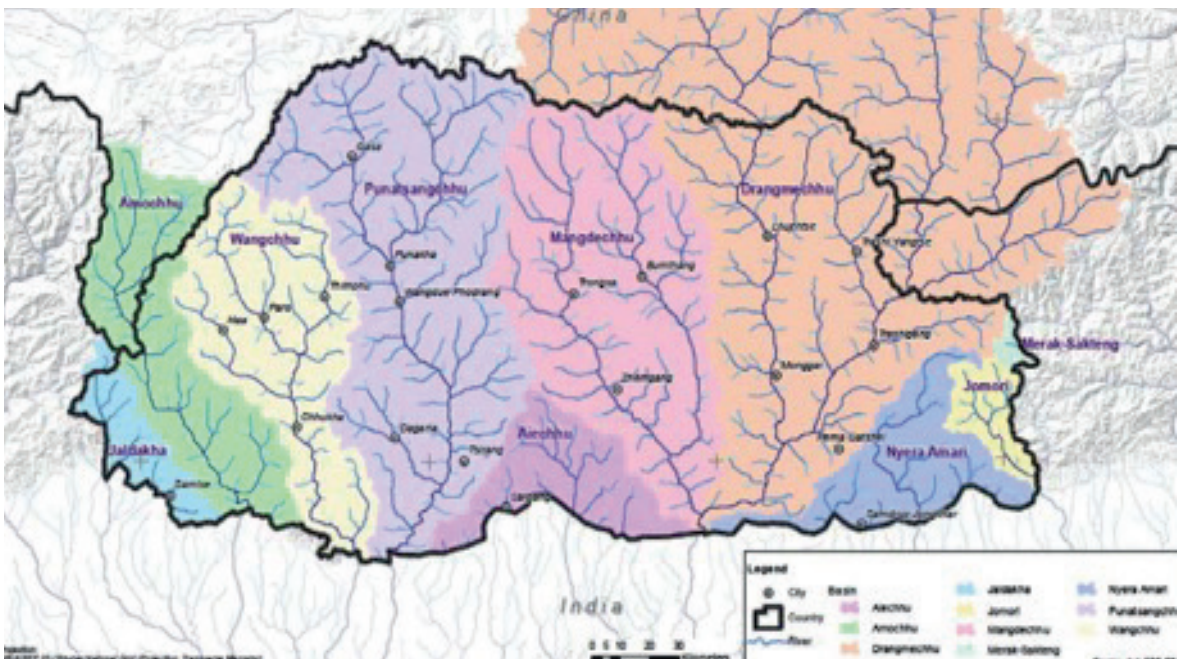

Figure 4: River Basins and Drainage Network[13]

12 https://www.undp.org/sites/g/files/zskgke326/files/2023-11/undp-bhutan-climate-risk-assessment-on-water-resources-for-nap-nov-2023.pdf

13 https://www.undp.org/bhutan/publications/assessment-climate-risks-water-resources-national-adaptation-plan

1.3.3 Glaciers

Bhutan is renowned for its breathtaking glaciers, primarily along its northern borders. These glaciers are vital freshwater sources for the country's perennial rivers, and crucial for agriculture, hydropower generation, and various ecosystems. According to the 2018 Biodiversity and Glacier Inventory (BGI), Bhutan is home to approximately 700 glaciers that cover around 630 km^2, accounting for 1.64% of the nation's total land area[14]. However, in recent decades, these glaciers have been significantly impacted by the climate change. Rising temperatures and changing precipitation patterns have caused glacier retreat, leading to reductions in both the surface area and volume of glacial ice.

Among the 700 glaciers, the Punatsang Chhu basin has the highest concentration, featuring 341 glaciers that span 361.07 km^2, while the Wang Chhu basin has the fewest, with only 47 glaciers covering 33.38 km^2. The largest glacier in Bhutan is MMagr16_482 (G090443E28024), located in the Mangde Chhu sub-basin; it measures 15.56 km in length and covers an area of 45.85 km^2[(15)]. The distribution of these glaciers across various basins and sub-basins is illustrated in accompanying figure and Table 2.

Table 2: Basin to sub-basin wise distribution of glaciers of Bhutan[16]

Major Basin	Sub-basin	Glaciers (Numbers)	Area (in km^2)
Wang Chhu	Ha Chhu	31	0.27
	Pa Chhu	13	28.39
	Thim Chhu	3	4.72
PunatshangChhu	Mo Chhu	135	108.64
	PhoChhu	206	252.42
Manas	Mangde Chhu	111	108.26
	Chamkhar Chhu	90	68.277
	Kuri Chhu	90	55.29
	Drangme Chhu	21	3.28
Total		**700**	**629.55**

14 https://www.nchm.gov.bt/attachment/ckfinder/userfiles/files/BGI%202018.pdf
15 State of Climate, 2023
16 nchm.gov.bt/attachment/ckfinder/userfiles/files/State of Climate%2C 2023.pdf

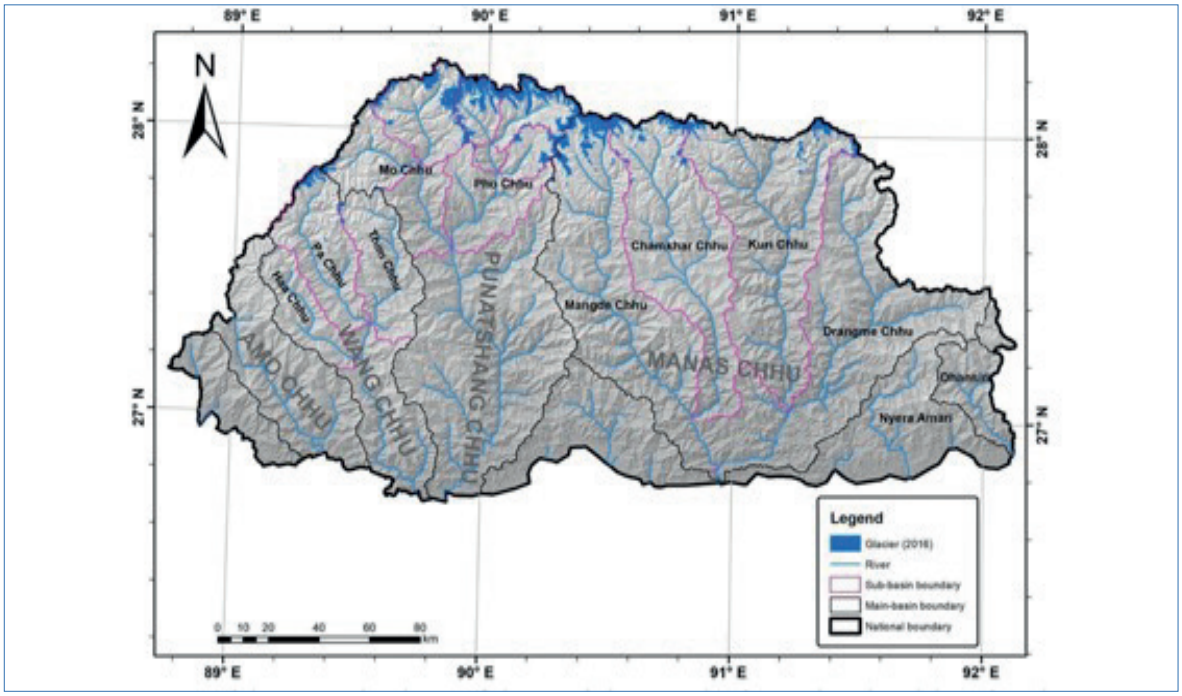

Figure 5: Sub-basin-wise distribution of glaciers of Bhutan.[17]

1.3.4 Potentially Dangerous Glacial Lakes of Bhutan

According to the National Centre for Hydrology and Meteorology (NCHM 2019), Bhutan has 17 potentially dangerous glacial lakes[18]:

- **Pho Chu sub-basin:** The sub-basin has the highest number of potentially dangerous glacial lakes, with nine lakes. Some of the lakes in this sub-basin include Pho_gl 84, Pho_gl 148, Pho_gl 163, Pho_gl 164, Pho_gl 209, Pho_gl 210, Pho_gl 211, and Pho_gl 213.

- **Mangde Chu sub-basin:** The sub-basin has seven potentially dangerous glacial lakes, including Mangd_gl 99, Mangd_gl 106, Mangd_gl 270, Mangd_gl 285, Mangd_gl 307, Mangd_gl 310, and Mangd_gl 385.

- **Mo Chu sub-basin:** The sub-basin has five potentially dangerous glacial lakes, including Mo_gl 200, Mo_gl 201, Mo_gl 202, Mo_gl 234, and Mo_gl 235.

- **Chamkhar Chhu sub-basin:** The sub-basin has three potentially dangerous glacial lakes.

- **Kuri Chhu sub-basin: The sub-basin has** one potentially dangerous glacial lake.

17 nchm.gov.bt/attachment/ckfinder/userfiles/files/State of Climate%2C 2023.pdf . Pink polygons show the sub-basin boundary, dark blue polygons show the glaciers and light blue polygons are rivers of Bhutan.

18 https://www.nchm.gov.bt/attachment/ckfinder/userfiles/files/Reassessment%20of%20Potentailly%20Dangerous%20Glacial%20Lakes.pdf

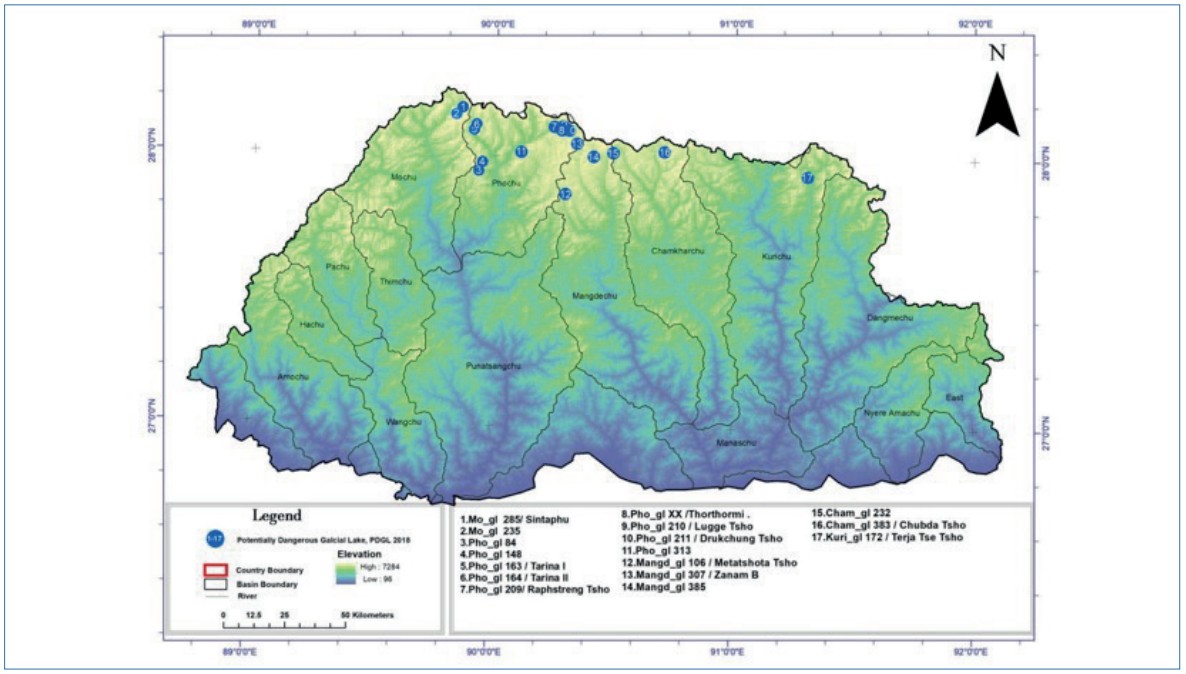

Figure 6: PGDLs in Bhutan (NCHM 2019)

The lakes are located between 4,062 and 5,507 masl. The lakes are identified as potentially dangerous based on their morphology, position relative to the glacier, and other physical conditions. The lakes are a vital source of water for the Bhutanese people, but climate change is causing the glaciers to melt and threaten the valleys downstream. This is based on revision carried out by both field data and improved satellite images which clarified that eight of them were deemed safe based on lake morphology, its surrounding features, bathymetry condition and associated feeding glacier which updated the earlier 24 PGDL.

1.3.5 Watersheds

Bhutan is divided into 186 watersheds, within these watersheds, a total area of 518,882 hectares has been identified as critical watersheds across various basins. Notably, the Kurichhu sub-basin contains the largest area of the critical watershed, encompassing 132,083 hectares[19].

1.3.6 Lakes and Hot Springs

Bhutan is home to 567 high-altitude glacial lakes, which collectively cover an area of 55.04 ± 0.055 km², representing about 0.14% of the country's total land area. Among these lakes, 17 are identified as potentially dangerous[20]. Most of Bhutan's glacial lakes are situated at elevations ranging from

19 https://www.uwice.gov.bt/admin_uwice/publications/publication_files/Reports/2018/Bhutan%20Water%20Facts%20August-2018.pdf

20 https://kuenselonline.com/bhutan-records-567-glacial-lakes-17-potentially-dangerous/

4,062 masl with the largest lakes found between 5,000 masl and 5,200 masl. The Wang Chhu basin has the fewest glacial lakes, totaling 31 and covering an area of 0.6 km², while the Manas basin contains the most, with 331 glacial lakes spanning 29.2 km² [21]. The distribution of these lakes by sub-basin is detailed in Table *3*.

Table 3: Basin to sub-basin wise distribution of glacial Lakes of Bhutan[22]

Major Basin	Sub-basin	Glacial lakes (numbers)	Area (in km²)
Wang Chhu	Ha Chhu	0	0
	Pa Chhu	13	0.60456
	Thim Chhu	0	0
PunatshangChhu	Mo Chhu	66	4.254
	Pho Chhu	157	20.98
Manas	Mangde Chhu	130	11.8558
	Chamkhar Chhu	131	11.5627
	Kuri Chhu	61	5.00721
	Drangme Chhu	9	0.77262
Total		**567**	**55.0369**

Bhutan is home to 10 well-known hot springs, known as Tshachhus, and 26 mineral springs, referred to as Menchhus according to the Ministry of Health (MoH). Both Tshachhus and Menchhus are considered sacred, and they are highly regarded for their significant therapeutic properties. These natural springs attract many visitors seeking their reputed health benefits and spiritual healing[23].

1.3.7 Groundwater Resources

Groundwater knowledge in Bhutan is limited. Due to the country's steep terrain and deeply incised valleys, it is generally believed that significant groundwater aquifers do not exist. However, subsurface flow through fluvial deposits is thought to occur. In the broader and flatter valleys, such as those in Paro, Punakha, Thimphu, and especially Samtse, Phuentsholing, Sarpang, and Samdrup Jongkhar near the Indian plains, there may be groundwater reserves that could potentially be utilized. While groundwater is currently being extracted in these areas on an individual basis, the government remains hesitant to develop it as a resource until its sustainability has been thoroughly assessed[24].

1.4 Natural Resources

Some of the most notable natural resources in Bhutan are minerals, forestry, agriculture, and energy.

21 https://www.undp.org/bhutan/publications/assessment-climate-risks-water-resources-national-adaptation-plan
22 nchm.gov.bt/attachment/ckfinder/userfiles/files/State of Climate%2C 2023.pdf
23 https://www.moh.gov.bt/wp-content/uploads/B5_Report-on-Tshachhu.pdf
24 https://www.adb.org/sites/default/files/project-documents/46463/46463-002-dpta-en.pdf

1.4.1 Minerals

1.4.1.1 Mining in Bhutan

The mining sector in Bhutan is recognized as one of the country's five key economic pillars due to its potential for growth and diversification. Governed by the Mines and Mineral Management Act (MMMA), 1995 and the amended Mines and Mineral Management Regulations (MMMR), 2022, the sector aims for the scientific management of mineral resources to maximize benefits for both the nation and local communities. The collection of minerals primarily occurs from riverbeds and surface areas, with permits issued by the Department of Geology and Mines (DGM) for various minerals, including gypsum, dolomite, quartzite, talc, limestone, marble, coal, iron ore, calc tufa, phyllite, and construction stones[25].

The Economic Development Policy (EDP) of 2016 and the Mineral Development Policy (MDP) of 2017 further guide the sector's development. The allocation of mining permits generally follows a first-come, first-served principle, although strategic mines are allocated to State-Owned Enterprises. Given Bhutan's rugged topography, mining is primarily conducted through open-cast methods, utilizing drilling and blasting techniques for mineral extraction. Excavators and trucks are employed for loading and transporting both minerals and wastes[26].

1.4.1.2 Current Mining Scenario

Currently, out of 84 registered mines and quarries in Bhutan, only 25 mines and 32 stone quarries are operational. The remaining sites are inactive due to market challenges, with some quarries recently leased[27]. The distribution of these mines and quarries varies regionally, as shown in figure below.

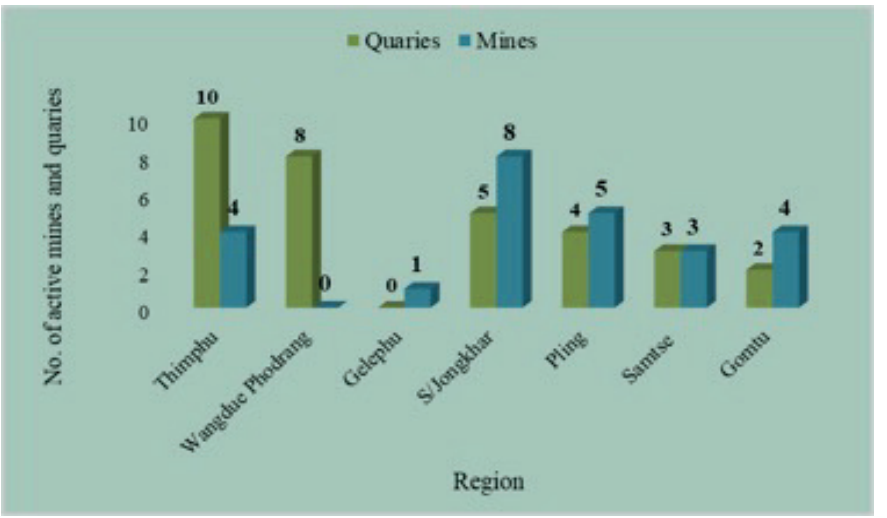

Figure 7: No. of active mines and quarries based on the Regions[28]

25 Geosciences and Mining Journal 2022
26 https://www.moenr.gov.bt/?page_id=943
27 MoENR,2024
28 Geosciences and Mining Journal 2022

Among the significant operations are the dolomite mine in Chunaikhola, Samtse, gypsum mine in Khothakpa, Pemagatsel, and a coal mine in eastern Bhutan. These large-scale mines were auctioned for 15 years. Upon completing their auction periods, they were allocated to the State Mining Corporation Limited (SMCL). Further, there are total of 30 permit holders for the collection of minerals from the riverbeds and surface (mostly land development). Four different types of minerals collected under the DGM permit are shown in figure below.

Figure 8: No. of permit holders[29]

The government recognizes the importance of reforming the mining sector to enhance its contribution to national income, job creation, and export revenue. Efforts include comprehensive geological mapping to identify unexplored mineral resources and developing strategies to improve export capabilities while promoting value addition within Bhutan. The aim is to significantly increase the mining sector's Gross Domestic Product (GDP) output over the coming years while prioritizing sustainable practices. Table 4 shows the distribution of mines and quarries in each Dzongkhag. The allocation of mines generally follows the first-come, first-serve principle while the government allocates those strategic mines to State Owned Enterprises.

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Table 4: Dzongkhag wise distribution of mines and quarries[30]

Dzongkhag	Types of Minerals												
	Calc Tufa	Coal	Construction	Dolomite	Granite	Gyp-sum	Lime-stone	Marble	Iron Ore	Phyllite	Quartzite	Talc	Total No.
Bumthang			4										4
Chhukha			4								5	1	10
Dagana			3						1		1		5
Gasa													0
Haa													0
Lhuentse													0
Monggar			4										4
Paro			5				1						6
Pemagatshel			4			3	2						9
Punakha													0
Samdrup Jongkhar		5	0										5
Samtse	1		9	1			3				4		18
Sarpang													0
Thimphu			4				1	2					7
Trashigang			3										3
Trashi Yangtse			1										1
Trongsa			1										1
Tsirang			1										1
Wangdue Phodrang			9		1								10
Zhemgang			0										0
Total													84

1.4.1.3 Revenue Contribution from Mining

In Bhutan, the revenue generated from mining comes from various sources, including royalties, mineral rents, land lease rents, auction fees (licenses), corporate income tax, business income tax, and other taxes. Over recent years, the mining sector's contribution to the economy has increased. However, in 2021, royalty contributions

from the mining sector decreased to Nu. 312.79 million from Nu. 456.70 million in 2020 due to the impacts of the pandemic[31]. The mineral-wise production for the last five years (2017-2021) is shown table 5. The quantity of mineral sales in the domestic and export markets in 2020 and 2021 is shown in figures below.

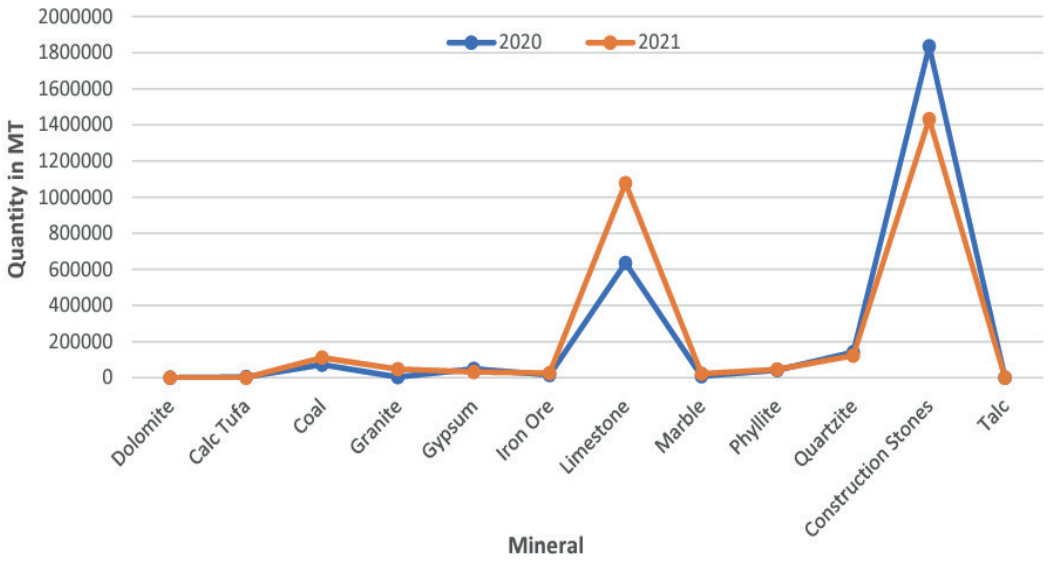


Figure 9: Sale of minerals in the domestic market in 2020 & 2021[32]

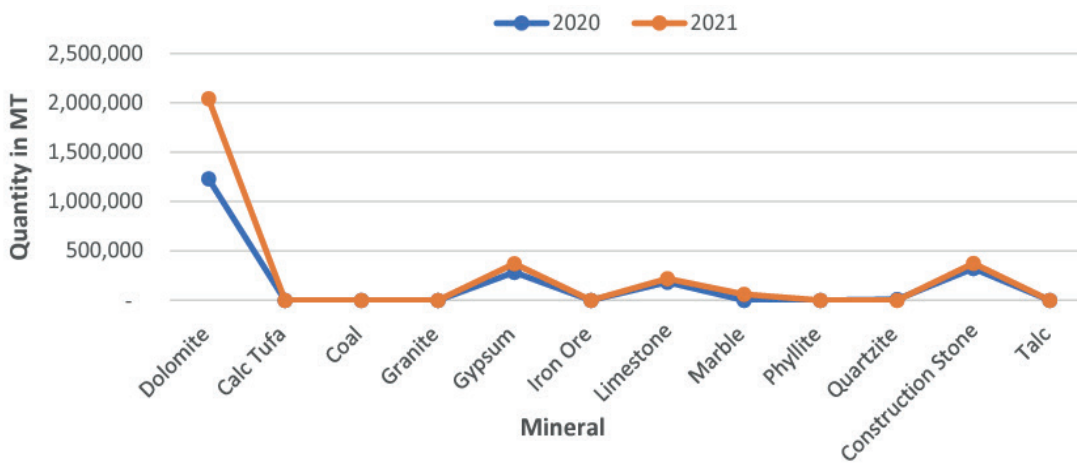


Figure 10: Export of minerals in 2020 & 2021[33]

31 https://www.moenr.gov.bt/wp-content/uploads/2018/12/Geosciences-and-Mining-Journal-2022.pdf
32 Department of Geology and Mines (DGM)
33 Geosciences and Mining Journal 2022

Table 5: Mineral production for the last five years[34]

Sl. No.	Mineral in MT	Year					Total
		2017	2018	2019	2020	2021	
1	Calc Tuffa	0.00	12,323.80	22,079.10	3,753.12	0.00	***38,156.02***
2	Coal	161,526.74	186,823.75	184,784.50	72,838.11	111,544.69	***717,517.79***
3	Construction stones	3,828,254.00	3,730,975.36	3,325,418.60	2,157,386.97	1,806,488.88	***14,848,523.81***
4	Dolomite	2,536,693.31	2,821,116.44	3,027,517.70	1,232,106.76	2,041,154.90	***11,658,589.11***
5	Granite	26,364.04	6,293.33	3,391.30	3,568.01	47,334.35	***86,951.03***
6	Gypsum	328,127.99	461,128.12	490,595.50	331,049.57	403,752.98	***2,014,654.16***
7	Iron ore	32,974.37	37,843.08	36,864.20	14,734.12	25,916.73	***148,332.50***
8	Limestone	1,235,161.67	1,344,037.86	1,546,302.10	817,458.68	1,295,516.90	***6,238,477.21***
9	Marble	96,567.10	188,900.53	94,318.30	8,874.40	84,034.55	***472,694.88***
10	Phyllite	61,910.29	53,188.53	78,246.40	42,178.12	45,083.43	***280,606.77***
11	Quartzite	175,501.08	145,713.93	141,065.90	150,131.31	123,320.32	***735,732.54***
12	Talc	1,293.20	2,042.46	1,374.80	972.09	677.88	***6,360.43***

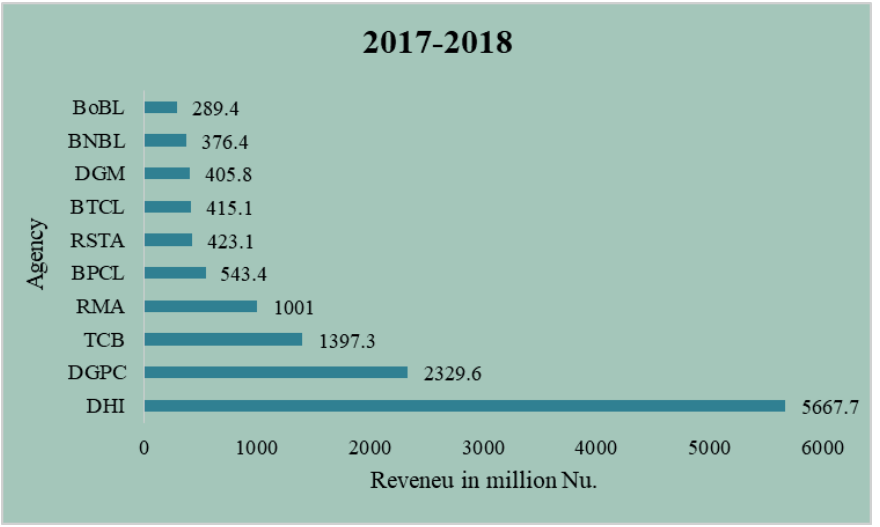


Figure 11: Major revenue contributors in 2017-18[35]

34 https://www.moenr.gov.bt/wp-content/uploads/2018/12/Geosciences-and-Mining-Journal-2021.pdf
35 https://www.moenr.gov.bt/wp-content/uploads/2018/12/Geosciences-and-Mining-Journal-2021.pdf

Despite its potential, the mining industry faced challenges during the pandemic, which affected revenue streams and operations. Nevertheless, it remains a vital component of Bhutan's economic strategy as the government seeks to enhance its contribution to national income and job creation while exploring ways to sustainably manage its rich mineral resources.

1.4.2 Forests

The total forest area is estimated to be 69.71 % (2.68 million ha) of the total land area while 30.29 % (1.16 million ha) of the total land area is estimated for the non-forest area[36] which is reflected in Table 6 below. Wangdue Phodrang Dzongkhag has the largest forest cover area, estimated at 258,969.43 hectares, closely followed by Zhemgang Dzongkhag, which has approximately 223,067.45 hectares. Notably, around 94% of Zhemgang Dzongkhags' total area is under forest cover, making it the Dzongkhag with the highest percentage of forest cover. Gasa Dzongkhag has the least forest cover, with only 21%, amounting to a total of 65,468.32 hectares. Meanwhile, Tsirang has the smallest forest area at 54,380.94 hectares, which represents 82% of its total land area[37].

Broadleaved Forest constitutes 67.99 % of the total forest in Bhutan with a total forest area of 1,819,649.63 ha. Coniferous forests constitute only 32.01 % of the forest area and cover an area of 856,895.79 ha.

The total carbon stock of Bhutan is 609.01 million tonnes which translates to a carbon density of 268.94 tonnes ha^{-1} including carbon stored in non-forest land.his includes carbon in non-forest areas. Bhutan's Forest constitutes 86 % of the total carbon stock of Bhutan with 523.87 million tonnes of carbon with a carbon density of 195.73 tonnes ha^{-1}. The forest biomass constitute 341.54 million tonnes of carbon and a Soil Organic Carbon (SOC) of 182.33 million tonnes carbon , which translates to 127.61 tonnes ha^{-1} of biomass carbon and 68.12 tonnes ha^{-1} of SOC[38].

Table 6: Total land area by Forest and Non-Forest

Land Type	Area (ha)	Forest Cover (%)	MoE (%)	Lower Limit	Upper Limit
Forest	2,676,545.42	69.71	1.87	2,626,585.13	2,726,505.71
Non-Forest	1,162,854.58	30.29	1.87	1,141,148.78	1,184,560.38

Table 7: Forest Coverage by Forest Class

Forest Class	Forest Area (ha)	Percentage of Country Area (%)	Percentage of Forest Area (%)	MoE (%)	Lower Limit	Upper Limit
Broadleaved	1,819,649.63	47.39	67.99	2.21	65.78	70.19
Coniferous	856,895.79	22.32	32.01	2.21	29.81	34.22

36 BHUTAN_STATE_OF_FOREST_REPORT_20230726.pdf
37 https://bfl.org.bt/wp-content/uploads/2023/08/BHUTAN_STATE_OF_FOREST_REPORT_20230726.pdf
38 ://bfl.org.bt/wp-content/uploads/2024/05/National-Forest-Inventory-Volume-II_State-of-Forest-Carbon-Report-2023.pdf

1.4.3 Agriculture

Agriculture in Bhutan relies heavily on monsoon rains and is particularly susceptible to climate change and extreme weather, leading to uncertainties in production. The agricultural sector encompasses farming, livestock, and forestry, playing a significant role in the nation's economy. Despite only 2.93% of the total land area allocated for agricultural use, this sector contributed 14.96% to the GDP in 2023 and employed approximately 44.08% of the population[39] [40] [41]. For many Bhutanese, agriculture serves as a primary source of livelihood, with rice, maize, and wheat being the staple crops. The government actively promotes sustainable agricultural practices to improve food security and enhance rural livelihoods.

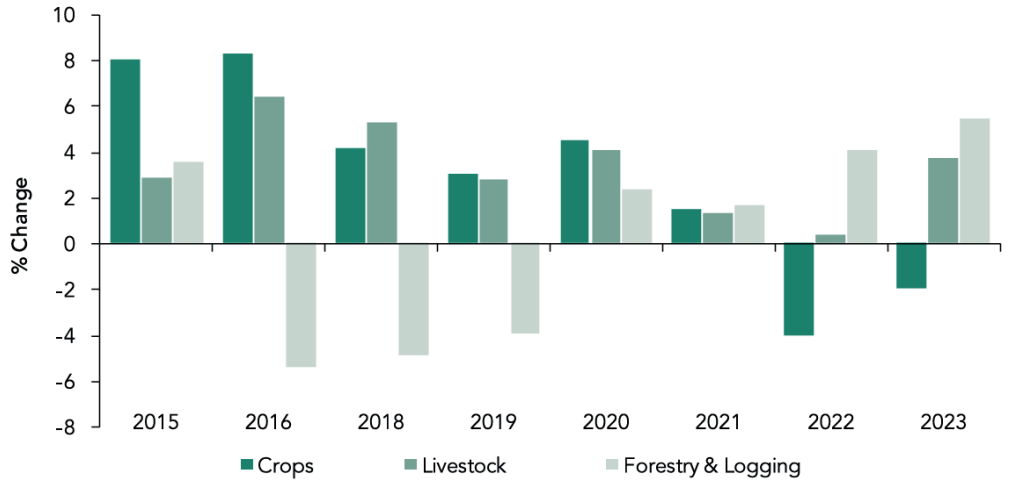


Figure 12: Growth rates of the agriculture sector, 2015 – 2023[42]

1.4.3.1 Crops

In 2023, the agricultural sector experienced a negative growth rate of -1.95%. However, this decline was less severe than the -4.00% drop recorded in 2022, indicating an improvement of 2.05 percentage points from the previous year. Despite this negative growth, the sector contributed a value addition of Nu. 16,382.87 million in 2023, an increase from Nu. 15,521.92 million in 2022, which accounted for approximately 6.57% of the GDP. This underscores the sector's significance within the economy, even amidst challenges in crop cultivation during this period[43].

1.4.3.2 Livestock

In the livestock sector, a growth rate of 3.70 percent was recorded in 2023, representing a significant improvement of 3.39 percentage points

39 https://www.nbc.gov.bt/wp-content/uploads/2010/06/Multiple-Cropping-Paper-Bhutan-for-SAC-1.pdf
40 https://www.nsb.gov.bt/https-www-nsb-gov-bt-wp-content-uploads-dlm_uploads-2024-07-nas-2024-for-web-pdf/
41 https://www.nsb.gov.bt/https-www-nsb-gov-bt-wp-content-uploads-dlm_uploads-2024-07-nas-2024-for-web-pdf/
42 National Accounts Statistics (NAS) 2024
43 NSB, 2024

compared to the modest growth rate of 0.31 percent seen in 2022. This increase indicates enhanced performance and productivity within the sector. The livestock sector contributed 0.18 percentage points to GDP growth in 2023, up from just 0.02 percentage points in the previous year. At current prices, the Gross Value Added (GVA) for the livestock sector in 2023 was estimated at Nu. 14,743.30 million, marking a substantial increase of Nu. 2,717.71 million from the previous year's GVA. This highlights the economic significance of the livestock sector, which accounted for 5.91 percent of the GDP, underscoring its importance within the broader economy[44]. Different livestock types reared in the country are presented in Table 8 below:

Animal breed	2018	2019	2020	2021	2022
Livestock					
Brown Swiss pure breed	17	25	133	346	6,637*
Brown Swiss cross breed	3,929	4,270	4,112	4,638	
Buffalo	531	477	398	385	331
Doeb-Doebum	11,950	9,689	9,290	7,244	5,839
Doethra-Doethram	12,357	11,652	11,248	14,084	8,787
Holsten-Friesian breed	1,046	1,183	1,056	1,007	656
Jaba	2,204	2,212	2,443	4,008	9,627
Jatsha-Jatsam	33,301	32,473	27,009	26,951	23,379
Jersey Pure breed	4,644	4,399	4,674	6,967	90,735**
Jersey Cross breed	103,012	109,684	108,676	109,167	
Mithun	418	453	390	347	300
Nublang-Thrabum	97,274	98,277	86,807	98,840	90,809
Yaks	41,463	41,918	40,897	38,642	30,328
Yangku-Yangkum	29,182	28,725	25,567	22,192	18,428
Zo-zoms	9,581	9,904	10,680	11,161	7,435
Other Livestock					
Equine	16,820	16,792	14,649	12,418	11,665
Pig	21,200	20,070	17,577	22,954	33,082
Poultry	1,099,493	1,299,810	1,383,714	1,384,449	975,152
Sheep	10,786	11,466	10,793	10,694	10,024
Goat	43,839	47,735	44,119	59,577	56,004

44 https://www.nsb.gov.bt/https-www-nsb-gov-bt-wp-content-uploads-dlm_uploads-2024-07-nas-2024-for-web-pdf/
45 Agricultural Statistics Division, NSB

1.4.4 Energy

1.4.4.1 Hydropower

Water resources are critical for domestic use, agriculture, and hydropower generation. Bhutan's commitment to integrated water resource management is essential for balancing these competing demands. "Water has been to us what oil is to Arabs," as stated by His Majesty The Fourth Druk Gyalpo, highlighting the crucial role of hydropower generation in Bhutan's socio-economic development.

According to the Statistical Yearbook of Bhutan 2023, hydropower contributes 13.4% of the country's GDP[46]. Bhutan's hydropower sector is essential for electricity generation, leveraging the nation's abundant hydropower resources. The country has a significant hydropower potential estimated at 30,000 Mega Watt (MW), with 23,760 MW deemed techno-economically viable. Currently, the installed capacity stands at 2,334.1 MW (including 8.1 MW from embedded hydro generation), which is expected to rise to 4,672.1 MW with the completion of major projects such as Punatsangchhu I and II, and three small hydro plants. The Tala Hydropower Plant is Bhutan's largest, accounting for 42.1 % of the country's total electricity production in 2022[47]. The installed capacity of the major hydropower in the year 2022. Bhutan has been increasing its power exports, reaching a peak of 9,186 GWh in 2020. However, exports fell to 7,240 GWh in 2022. While power imports have generally trended downward, it rose to 204 GWh in 2022, up from 80 GWh the previous year[48].

1.4.4.2 Solar Energy

According to the Renewable Energy Resource Assessment, 2015, Bhutan has a theoretical potential of 3,706,328 MW for solar photovoltaic power generation based on solar irradiance. However, this assessment also considered various constraints, such as rugged terrain, national protected areas, and other restrictions, resulting in a restricted theoretical development potential of approximately 12,000 MW for solar PV power generation in Bhutan. In 2022, a total of 745.7 MWh of solar electricity was generated, with the majority originating from institutional and commercial buildings.

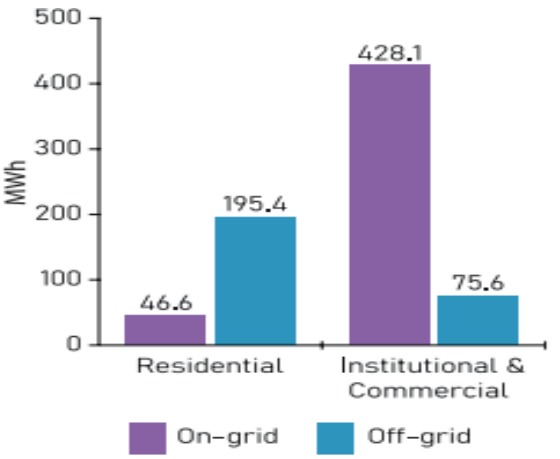


Figure 13: Solar Electricity Generation in 2022 (MWh)[49]

1.3.4.3 Wind Energy

Bhutan has a substantial capacity for leveraging wind power systems. The restricted theoretical development potential for wind power in the

46 https://www.nsb.gov.bt/download/12175/
47 https://www.moenr.gov.bt/wp-content/uploads/2018/11/Final-copy-of-BEED-2022.pdf
48 https://www.moenr.gov.bt/wp-content/uploads/2018/11/Final-copy-of-BEED-2022.pdf
49 Final-copy-of-BEED-2022.pdf

country is estimated to be approximately 761 MW, with Wangdue Phodrang Dzongkhag exhibiting the highest potential at 141.7 MW, followed by Chhukha Dzongkhag at 91.8 MW[50]. In 2022, Bhutan generated a total of 427.7 MWh of electricity from wind power. Although this marked an increase compared to the previous year, it fell short of the levels achieved in 2016 when the country first started harnessing wind energy.

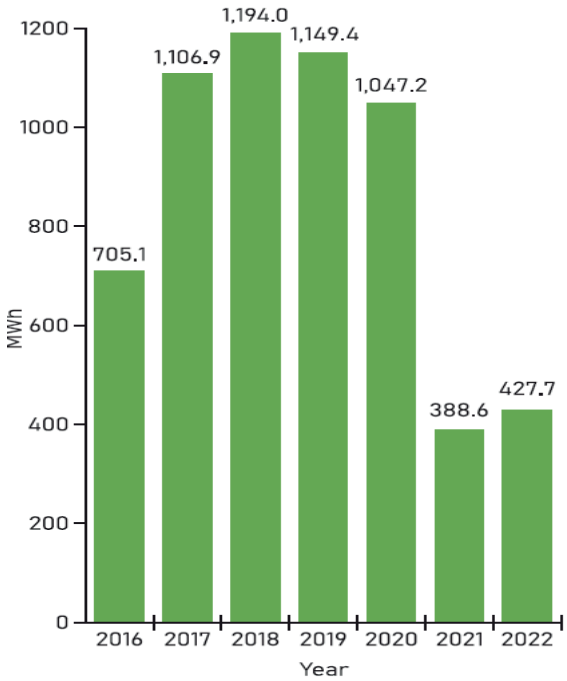


Figure 14: Wind Energy Generation from 2016 to 2022 (MWh)[51]

1.4.5 Energy Production and Consumption

The primary energy consumption in Bhutan is heavily reliant on biomass and hydropower. As of 2022, Bhutan's total energy consumption reached approximately 752,441.03 tonnes of oil equivalent (toe) in 2022 and an energy supply of 793,263.30 toe. The energy mix consists mainly of biomass energy, which accounted for 25.2% of total energy supply, while electricity comprised 37.6%. Within this mix, petroleum products 17.6%. Notably, electricity from alternative renewable sources such as solar comprise of 0.02% and wind remained 0.005% of the total energy supply[52].

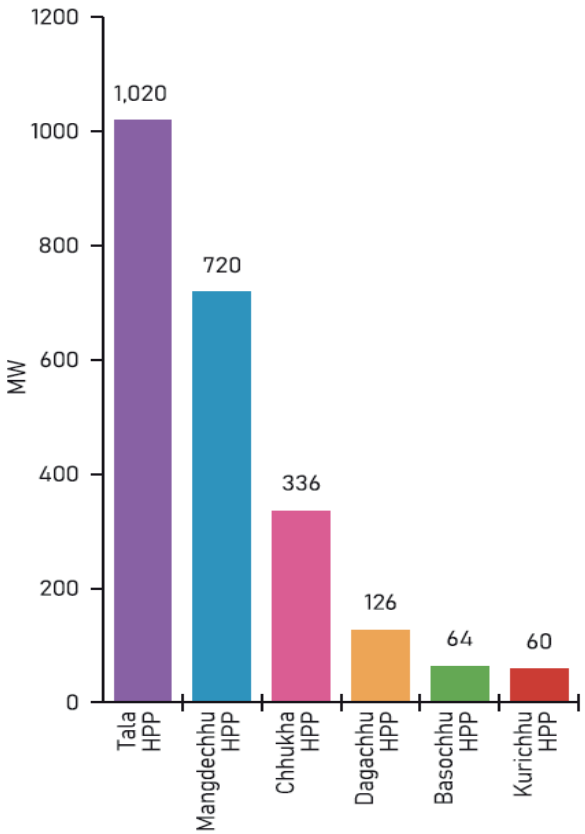


Figure 15: Installed Capacities of Major Hydropower Plants in 2022[53]

50 DRE, 2015
51 Final-copy-of-BEED-2022.pdf
52 Kuensel. (2023). Electricity-rich Bhutan still relies heavily on thermal energy. https://www.drukgreen.bt/en/2023/08/10/electricity-rich-bhutan-still-relies-heavily-on-thermal-energy/
53 Final-copy-of-BEED-2022.pdf

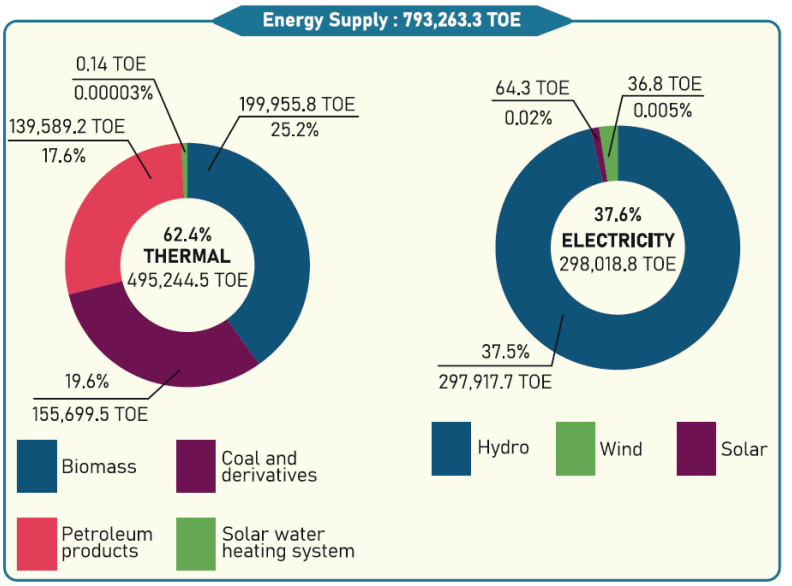


Figure 16: Fuel Mix of Bhutan (EDD 2022)

1.4.5.1 Petroleum Product

Bhutan has a long-term agreement with India to import petroleum products, which are distributed by four main companies: Bhutan Oil Distributor, Damchen Petroleum, Druk Petroleum Corporation Limited, and State Trading Corporation of Bhutan Limited. The Department of Trade is responsible for regulating the petroleum market in Bhutan, ensuring a steady supply of these products. The consumption of Liquefied Petroleum Gas (LPG) initially experienced growth but has shown a slight decline in recent years as shown in Table 9. On the other hand, S.K. Oil consumption has consistently decreased over time. Kerosene (ATF) consumption displayed fluctuations, with a notable decrease in 2021. Petrol consumption, although subject to minor variations, has demonstrated an overall increasing trend. Meanwhile, diesel consumption has remained relatively stable, with slight fluctuations observed.

Table 9: import of Petroleum Products from 2018 to 2022[54]

Fuel	Unit	Year				
		2018	2019	2020	2021	2022
LPG	Kg	5,016,953	10,198,148	9,107,690	8,889,640	8,331,665
S.K Oil	kl	3,585	2,922	1,698	1,730	1,144
Kerosene (ATF)	kl	4,878	4,956	1,720	1,239	2,307
Petrol	kl	46,912	50,959	34,776	33,331	36,697
Diesel	kl	159,723	154,617	108,987	113,424	107,643

54 Final-copy-of-BEED-2022.pdf

1.3.5.2 Coal and Derivatives

Based on the data presented for the year 2022, a clear pattern emerged in coal production and imports. Sub-bituminous coal accounted for the highest production volume, reaching 133,501.10 Metric Tonnes (MT). In terms of imports, coke/ semi-coke coal had the highest volume at 108,998.06 MT, followed by sub-bituminous coal at 39,389 MT and other coals at 14,979.08 MT. Notably, sub-bituminous coal was the only coal category that saw export activity, with a volume of 24.16 MT

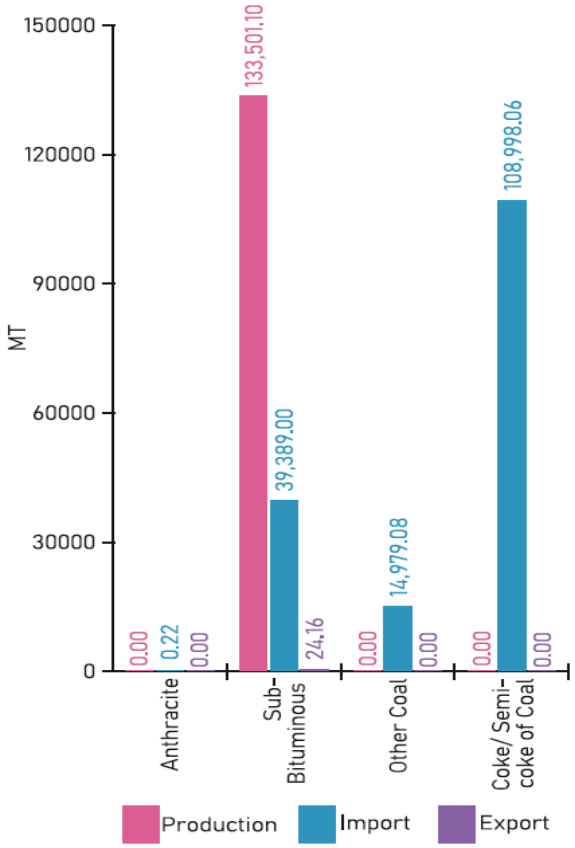


Figure 17: Production, Import, and Export of Different Types of Coal in 2022 (MT)[55]

1.4.5.3 Biomass

Biomass refers to the renewable organic matter derived from plants and animals. In Bhutan, biomass is major in fulfilling the country's energy requirements. Fuelwood stands out as the primary biomass energy resource used in Bhutan. Wood remains a vital fuel source, particularly in rural areas, used mainly for cooking and heating. Notably, Bhutan maintains an impressive forest cover, accounting for approximately 69.71% of its total land area (2.68 million ha).

a. Fuel wood

Fuel wood has historically played a significant role in Bhutan. In urban areas, the fuelwood supply is generally managed well as it is primarily sourced from the Natural Resources Development Corporation Limited (NRDCL) depots and monitored by the Department of Forest and Park Services. However, in rural areas, accurately estimating fuel wood supply is challenging. According to the National Forestry Statistics of 2023, the estimated fuel wood supply in 2023 was 84,616.89 m^3 of firewood.

b. Briquettes

Briquettes are a condensed and compacted form of biomass waste that is produced through the application of heat and pressure. In Bhutan, briquettes are primarily produced from waste wood and sawdust obtained from local sawmills. These briquettes are an alternative to fuelwood in various heating applications in households and industries. The production of briquettes in 2022 amounted to 132.39 MT, representing a 58 percent reduc-

55 Final-copy-of-BEED-2022.pdf

tion as compared to the production of 316.15 MT in 2014.

c. Biogas

In rural households, fuelwood remains the primary choice for cooking and heating. However, this reliance on fuelwood contributes to deforestation, Greenhouse Gas (GHG) emissions, and indoor air pollution. To address these issues, the promotion of biogas can bring about various benefits. It provides increased access to modern cooking and heating methods, leading to reduced GHG emissions and deforestation. Biogas also helps reduce health risks from indoor air pollution. Additionally, it saves time spent collecting firewood and improves crop yields by utilizing organic by-products from biogas plants. Biogas plants in Bhutan are available in various sizes, ranging from 4 m^3 to 70 m^3. As of December 2022, a total of 8,306 biogas plants have been installed, with an estimated cumulative biogas generation of 6,116.9 MT (Table 10).

Table 10: Estimated Annual Generation of Biogas in 2022 (MT)[56]

Size (m^3)	Number	Capacity	Generation (MT)
4	4,148	1.2	2,205.6
6	3,733	2	3,308.3
8	415	2.8	514.9
10	0	3.6	0.0
30	3	9.78	13.0
50	3	16.48	21.9
60	1	30	13.3
70	3	30	39.9
Total	8,306		6,116.9

1.4.6 Biodiversity

According to the 2017 Biodiversity Statistics, Bhutan is home to 11,248 species from various groups, including 5,114 animals, 5,369 plants, and 690 fungi. Additionally, 55 species are classified under the Kingdom Chromista, 18 species of Eubacteria, and two species of protozoa from the Kingdom Protista[57]. Many of these species are categorized as vulnerable, endangered, or critically endangered according to the International Union for Conservation of Nature (IUCN) Red List, as detailed in Table 11 and Table 12.

Table 11: IUCN List of Threatened Species[58]

Kingdom	Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)	Extinct in the Wild (EW)	Extinct (EX)
Animalia	55	23	8	0	0
Plantae	15	20	13	1	1
Total	**70**	**43**	**21**	**1**	**1**

56 Final-copy-of-BEED-2022.pdf
57 https://biodiversity.bt/biodiv/content/documents/document-0f89f358-790f-40a2-bbca-2da3ee6d8efd/630.pdf
58 Source: https://bt.chm-cbd.net/conservation-and-protection-status

Table 12: Number of Red List species by taxonomic classification[59]

Classification	Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)
Fishes	8	3	0
Birds	22	4	4
Mammals	13	11	2
Seed Plants	15	20	13
Amphibians and Reptiles	11	5	2
Butterflies	1	0	0
Total	**70**	**43**	**21**

1.4.7 Protected Areas

The protected area (PA) network of Bhutan consists of five National Parks (NP), four Wildlife Sanctuaries (WS), one Strict Nature Reserve (SNR), nine Biological Corridors (BC), and a Royal Botanical Park (RBP). The total PA covers 52.0% of the country's area. Table 13 shows the detailed information on the coverage of the protected area. The PA system in Bhutan is unique because there are human settlements within the protected areas that play an essential role in conservation. This contrasts with other parts of the world where communities in the PAs are relocated[60].

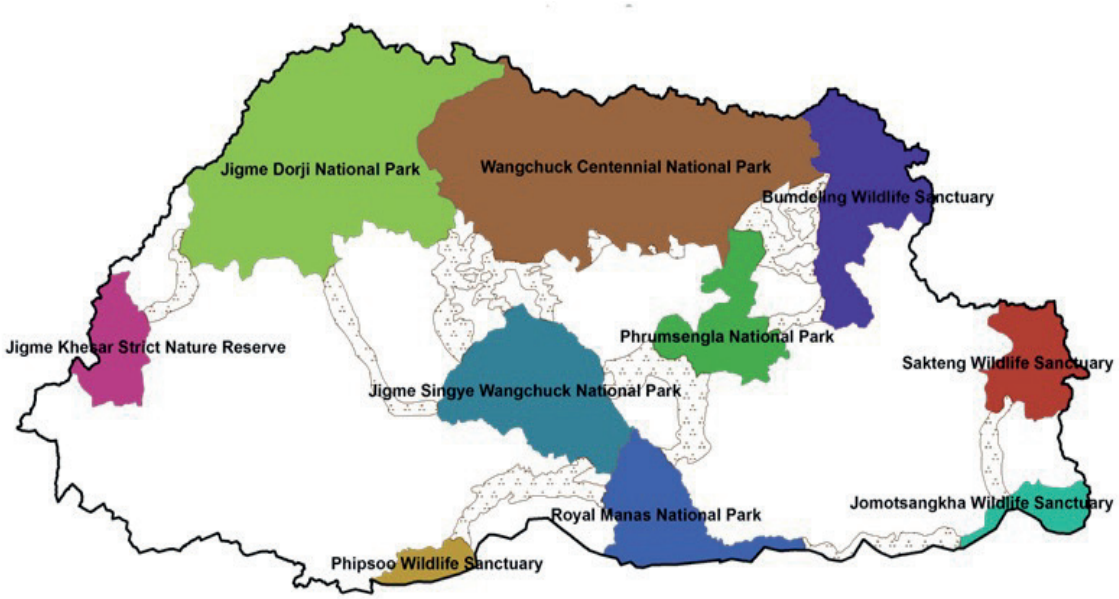


Figure 18: Protected Area of Bhutan[61]

59 Source: https://bt.chm-cbd.net/conservation-and-protection-status

60 https://unfccc.int/sites/default/files/resource/LTS%20Report_final%20print_copy.pdf

61 Source: https://bt.chm-cbd.net/protected-areas/protected-areas-and-biological-corridors-bhutan

Table 13: List of Protected Area and Biological Corridors with Area and Dzongkhag[62]

Protected Areas	Notification Year	Gazettement year	Establishment Year	Dzongkhags	Total Area (sq.km)
Wangchuck Centennial Park	2008	2008	2008	Gasa, Wangduephodrang, Bumthang, Trongsa, Lhuentse	4,914.00
Jigme Dorji National Park	1993	1995	1995	Punakha, Gasa, Thimphu, Paro	4,316.00
Jigme Singye Wangchuck National Park	1993	1995	1995	Trongsa, Wangdue, Sarpang, Tsirang, Zhemgang	1,730.00
Bumdeling Wildlife Sanctuary	1993	1995	1998	Trashiyangtse, Lhuentse, Mongar	1,520.61
Royal Manas National Park	1993	1995	1996	Sarpang, Zhemgang	1,057.00
Thrumshingla National Park	1993	1999	2000	Bumthang, Lhuentse,Mongar, Zhemgang	905.05
Sakten Wildlife Sanctuary	1993		2003	Trashigang, Samdrup Jongkhar	740.60
Toorsa Strict Nature Reserve	1993			Haa	609.51
Khaling Wildlife Sanctuary	1993			Samdrup Jongkhar	334.73
Phibsoo Wildlife Sanctuary	1993			Sarpang, Dagana	268.93
Total Protected Area Network					**16,394.43**
Biological Corridors (BC)- Nine Biological Corridors	Haa, Paro, Thimphu, Punakha, Wangduephodrang, Sarpang, Tsirang, Trongsa, Zhemgang, Bumthang, Mongar, Lhuentse, Trashigang, Samdrup Jongkhar, Trashiyantse.				3,504.44
Others: Royal Botanical Park, Lampelri	2004	2004	2004		47.00
Total Area of Protected Area Systems (PAs) in Bhutan					**19,966.15**
Percentage cover of PAs					**52%**

1.5 Climate Profile

Bhutan's climate is notably diverse, featuring three distinct climatic zones: subtropical, temperate, and alpine. Southern Bhutan has a hot and humid subtropical climate with average temperature variations between 15 to 30˚C that remain fairly static throughout the year. The central parts of the country consist of a temperate climate with warm summers and cool, dry winters while the higher parts (above 3,500 m, the Alpine zone) have very short, cool summers and winters with substantial snowfall. This diversity is further en-

62 Source: Protected areas and Biological corridors of Bhutan | Bhutan Biodiversity

hanced by various micro-climates resulting from significant changes in elevation and topography. Two primary factors influencing the variation in mean temperature and precipitation are the country's vast altitude differences and the impact of the North Indian monsoons. Bhutan's position at the northern edge of the tropical circulation is crucial in shaping its climate.

1.5.1 General Climate Features

Bhutan's general climate features have been most recently described by NCHM (2019) and are reiterated in textbox 1[63].

1.5.2 Historical climate trends

The increase in temperature in Bhutan was seen since 1960, with minimum temperatures increasing at a faster rate than maximum temperatures[64]. The observational data between 1997- 2017 confirms this trend[58]. The observed climatology derived from CRU data shows that the southern part of the country has a higher temperature, but decadal analysis of the temperature as derived from ERA5 reanalysis shows that a greater magnitude of positive change both in maximum and minimum surface air temperature in the north and western part of Bhutan than south in the recent past.

Box 1: Main climate features of Bhutan (Excerpt from NCHM, 2019)

- The rainfall regime of 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.

- The control exerted by the dry winter-time air mass from the northern high latitudes during the winter seasons is primarily modulated by what is popularly known as the "western disturbances" bringing a temperate nature to Bhutan's climate. This also results in temperature variations and the little rainfall/snowfall received during the otherwise dry winters.

- Periodic impact by remnants of cyclonic systems that sometimes cross through India from the Bay of Bengal also result in high rainfall events, particularly in the eastern areas. Southernmost areas of the country are prone to severe thunderstorms during the months of April to June due to strong summertime heating and the development of strong convective systems. Further north, during the transition months of autumn or spring, such systems can cause damaging hailstorms.

- Bhutan has four seasons - the winter season from December to February; the spring season from March to May; the summer season from June to September; and the autumn season of October and November. The Southwest or Summer Monsoon (June-September, JJAS) contributes about 72% to the total annual rainfall of Bhutan with the highest amount received in the month of July followed by August. The spring (March-May, MAM) and autumn (October-November) periods contribute about 22 % to the total annual rainfall.

63 https://unfccc.int/sites/default/files/resource/NAP-Bhutan-2023.pdf
64 https://www.nchm.gov.bt/attachment/ckfinder/userfiles/files/Bhutan%20Climate%20Projection%20Report.pdf

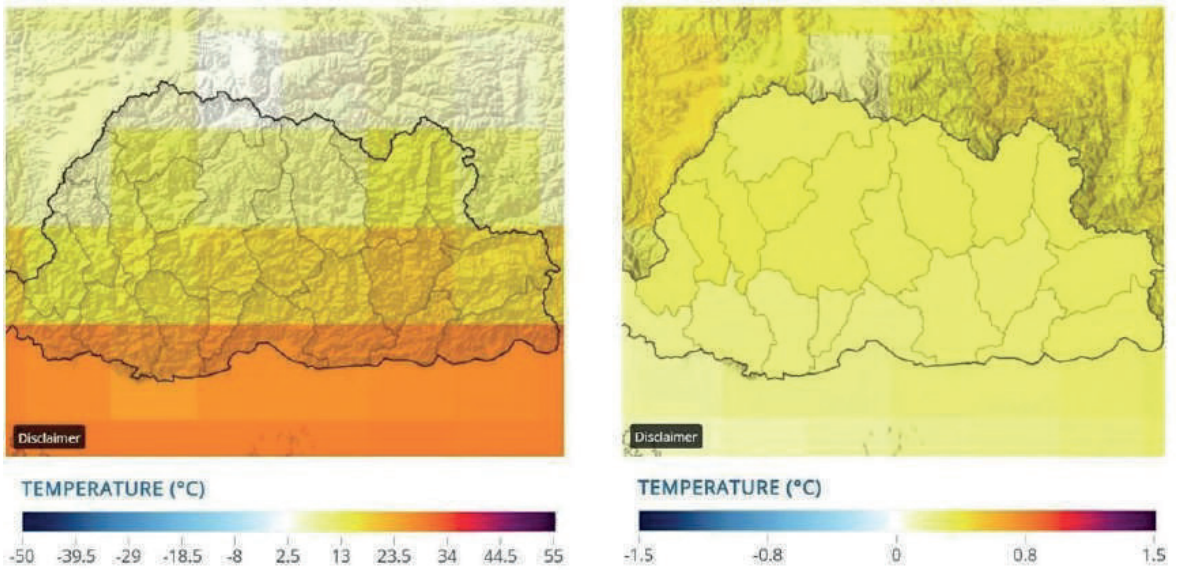


Figure 19: Observed climatology of average maximum surface air temperature 1991-2020 (left) and average annual maximum surface air temperature trend per decade 1971-2020 (right) in Bhutan[58]

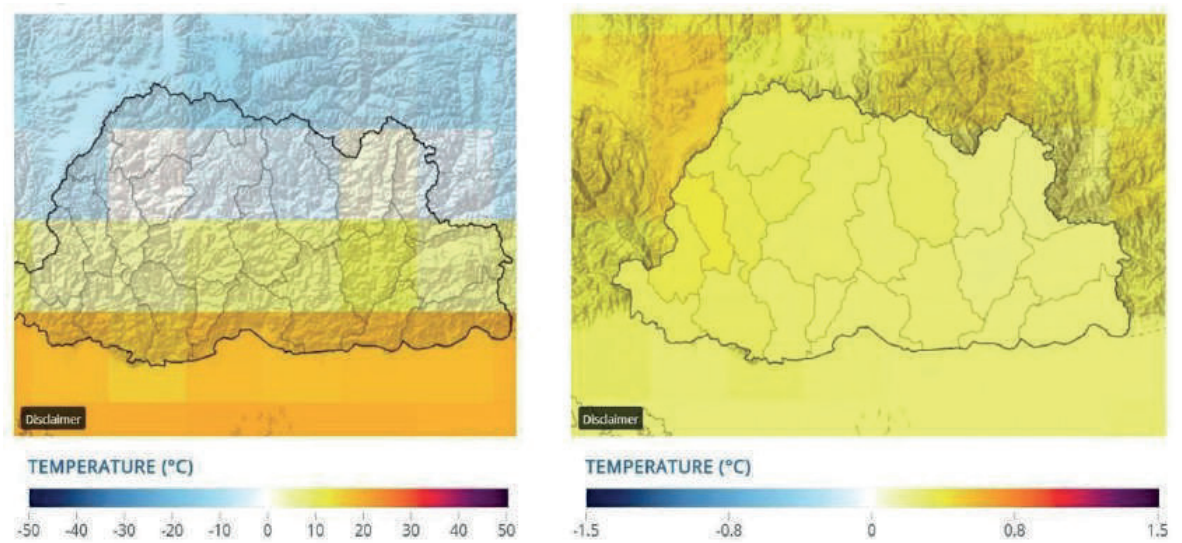


Figure 20: Observed climatology of average minimum surface air temperature 1991-2020 (left) and average annual minimum surface air temperature trend per decade 1971-2020 (right)[58]

The increase in temperature has been sharper in recent decades (1991-2020) mainly contributed by GHG emission and socioeconomic development. The recent decades have also witnessed a greater number of high air temperature-related extreme events (such as heatwaves) with maximum temperature significantly deviating from the mean monthly maximum temperature

over the climatology of 1991-2020. The decadal change in the minimum temperature is sharper than the maximum temperature. A higher number of extreme events related to low temperature (like cold waves) were observed in the past which confirms the increase in minimum temperature in the recent decades.

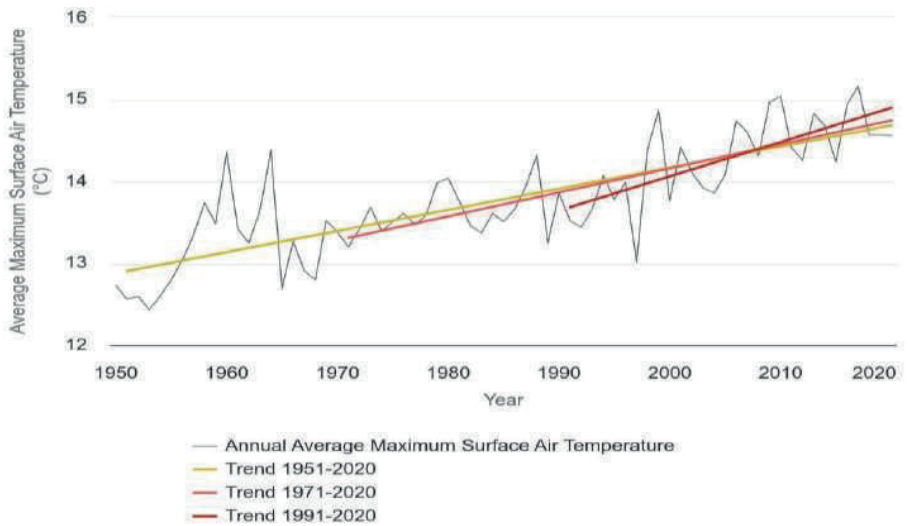


Figure 21: Average maximum surface air temperature trends with significance trend per decade, 1951-2020[58]

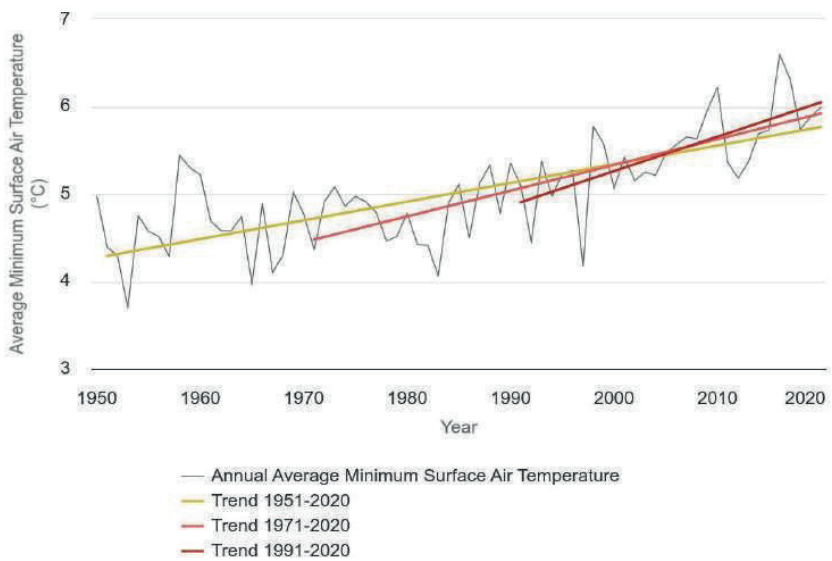


Figure 22: Change in event intensity of maximum daily maximum temperature, 1951-2020[58]

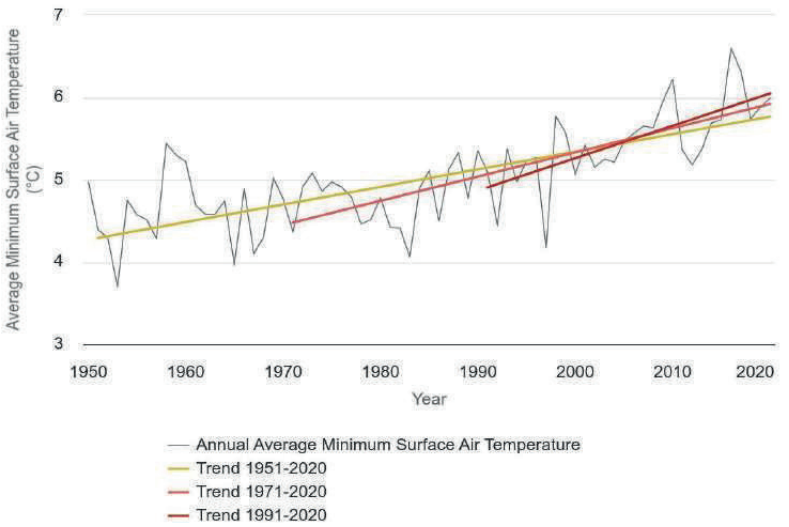


Figure 23: Average minimum surface air temperature trends with significance trend per decade, 1951-2020[58]

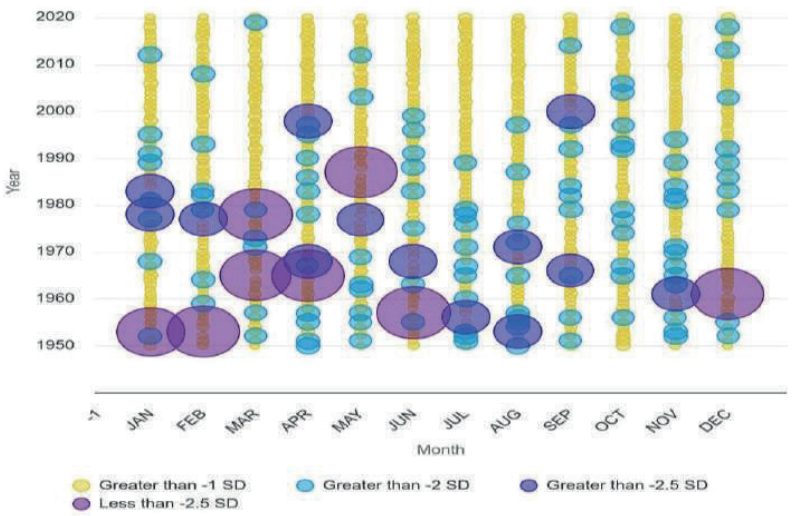


Figure 24: Change in event intensity of minimum of daily minimum temperature, 1951-2020

In general, the annual precipitation is higher in the southern part of the country, which decreases as we move northwards. The annual precipitation trend per decade shows that some of the districts in the central and south-eastern parts of Bhutan receive more rainfall than the other parts of the country. The decadal trend shows that in the long term (1950-2020) annual precipitation has decreased. However, in recent decades (1970 onwards) there has been an increase in precipitation in Bhutan. From 1990 onwards, the increase has been steeper. The IPCC's sixth assessment report projects an increase in heavy precipitation in the Himalayan part of Bhutan in the 21st century.

Increase in both annual and summer monsoons are likely across the rest of the country with larger internal variability. The report also highlighted that the snow cover in the high mountains in Asia has been reducing since the early 21st century and glaciers have thinned, retreated, and lost mass since the 1970s. Increasing temperature and precipitation in this region can increase the occurrence of glacial lake outburst floods and landslides over moraine-dammed lakes[65].

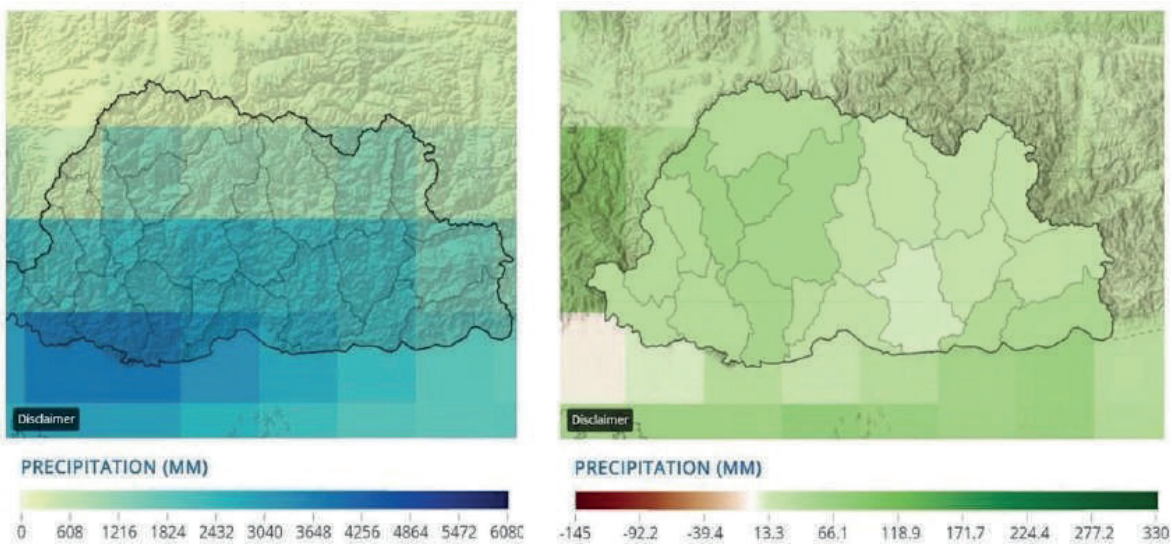


Figure 25: Observed climatology of precipitation in Bhutan (1991-2020) (left) and Annual precipitation.

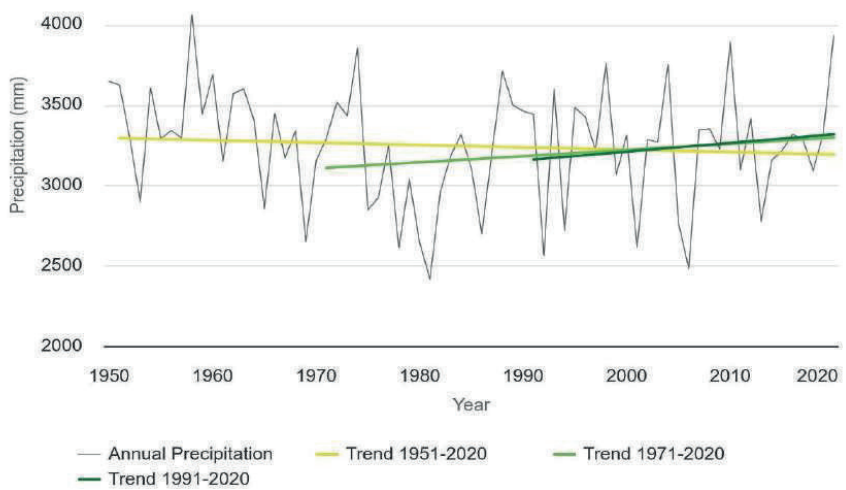


Figure 26: Precipitation annual trend with significance of trend per decade, 1951-2020

65 https://www.nchm.gov.bt/attachment/ckfinder/userfiles/files/Bhutan%20Climate%20Projection%20Report.pdf

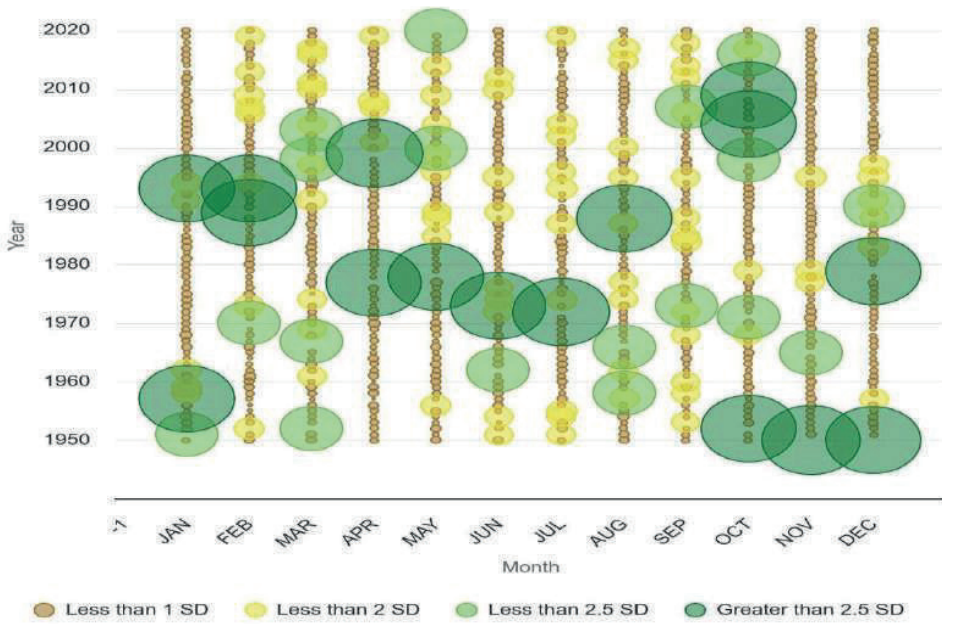


Figure 27: Change in event intensity of average largest 5-day cumulative precipitation 1951- 2020

1.5.3 Present Scenario

Approximately 70% of Bhutan's precipitation occurs during the monsoon season, while pre-monsoon rainfall contributes about 20%. The annual average rainfall (area average) was 1794.30 mm in 2023. The country as a whole received slightly below-normal rainfall against the long-term average. The highest 24-hour rainfall was recorded at Bhur, Sarpang Dzongkhag with 306.0 mm. Gasa Dzongkhag experienced the highest number of rainy days with 200 days (rainy days are defined as rainfall greater than or equal to 1 mm) displayed below. It is to be noted that a greater number of rainy days does not translate to more accumulated rain. However, the highest total annual rainfall was recorded at Phuentsholing, Chukha Dzongkhag with 6549.10 mm, Sipsu, Wangdue Phodrang Dzongkhag with 5604.10 mm followed by Bhur with 5376.20 mm[66].

66 nchm.gov.bt/attachment/ckfinder/userfiles/files/State of Climate%2C 2023.pdf

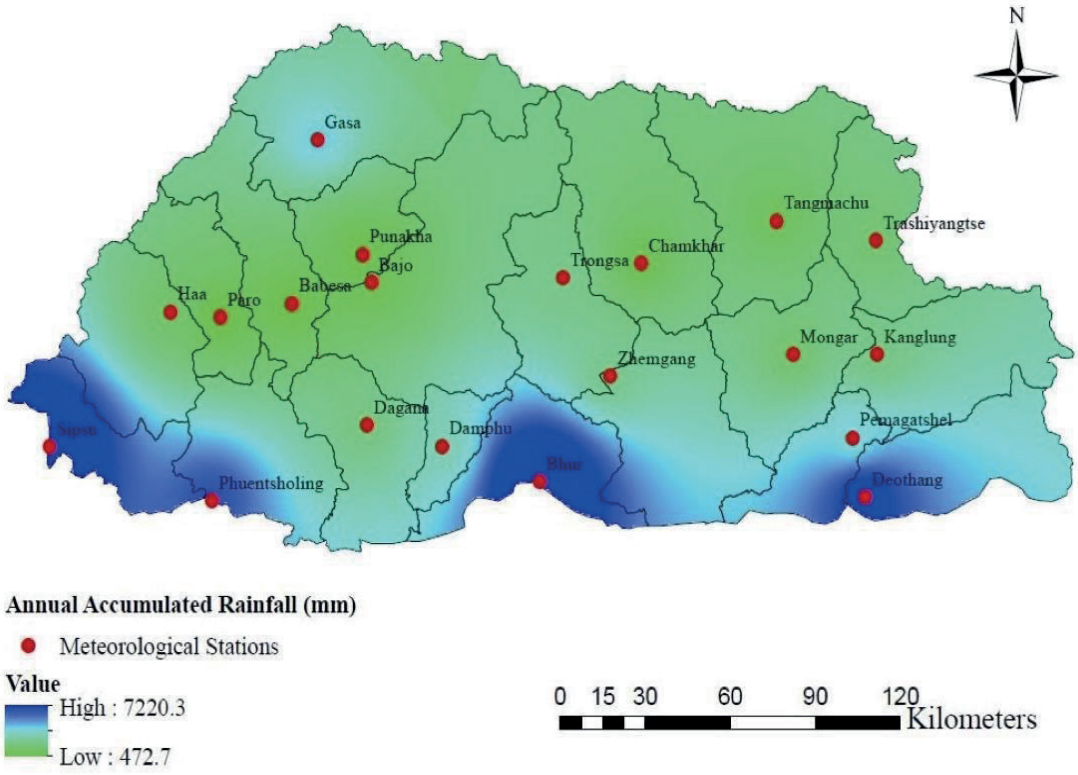


Figure 28: Annual accumulated rainfall[67].

The annual average maximum temperature was 23.18°C and the minimum temperature was 12.18°C across the country. The highest daily maximum temperature was recorded at Phuentsholing meteorological station, reaching 38.5°C while the lowest daily minimum temperature was recorded at Haa Dzongkhag meteorological station, dropping to -10.5°C. Haa experienced a greater number of days with the minimum temperature below or equal to zero with 135 days (minimum temperature <=0)[8].

67 National Adaptation Plan (NAP) of the Kingdom of Bhutan, 2023

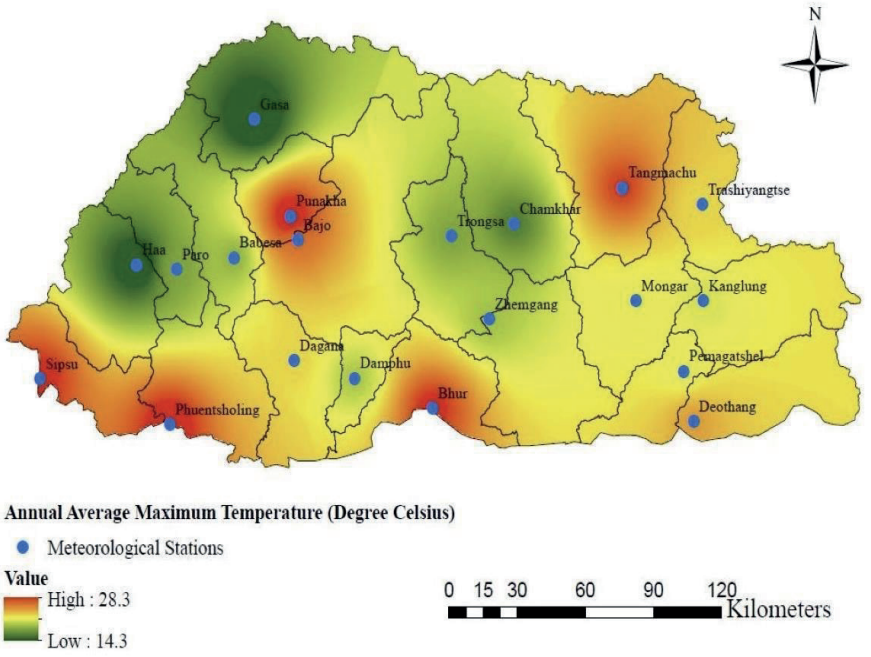


Figure 29: Average annual maximum temperature[68].

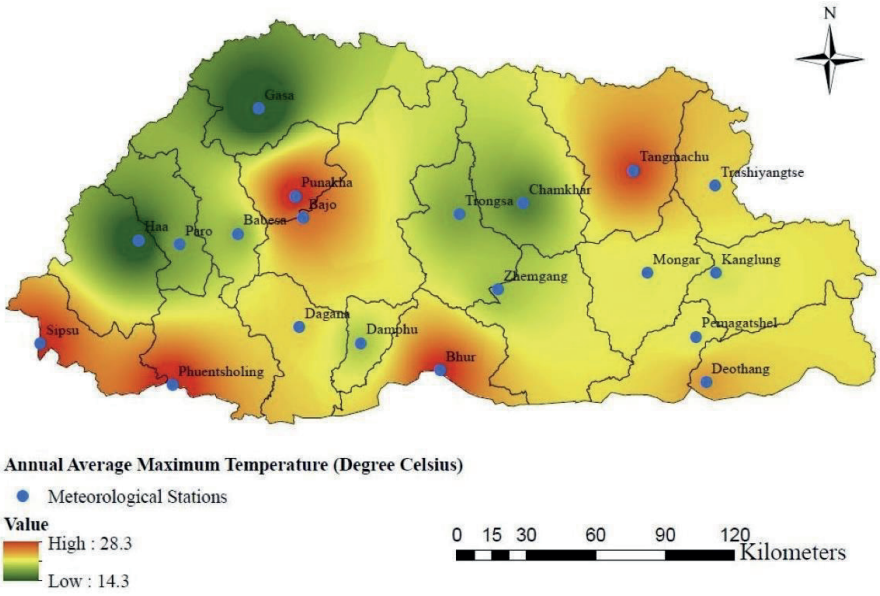


Figure 30: Average annual minimum temperature in 2020[69]

68 National Adaptation Plan (NAP) of the Kingdom of Bhutan, 2023
69 https://www.nchm.gov.bt/attachment/ckfinder/userfiles/files/Tmin.png

1.5.4 Future climate projection

1.5.4.1 Annual precipitation

The figure below shows the projected spatial distribution of total annual precipitation under baseline and changes in total annual precipitation in the near term (by 2040) under different SSPs. Under the baseline scenario, the southern part of Bhutan receives the highest rainfall. Rainfall is relatively less towards the northern parts of the country. Under all three climate change scenarios, although the spatial distribution of changes in rainfall by 2040 is similar, the variation from the baseline is different. North, west, central, and south-western districts are likely to receive more precipitation than baseline. Under the SSP1 2.6 scenario, the highest increase is likely in Wangdue Phodrang followed by Gasa, Punakha, Bumthang, and Thimphu Dzongkhags. Whereas the east and south-eastern districts (Pemagatshel, Samdrup Jongkhar, Sarpang, Trashigang, and Trashi Yangtse) are likely to receive less precipitation than the baseline. Under SSP2 4.5 and SSP3 7.0 scenarios, the increase in precipitation is less compared to SSP1 2.6. However, Punakha, Gasa, Samtse, Thimphu, Paro, and Haa are some of the districts where the increase in precipitation is more.

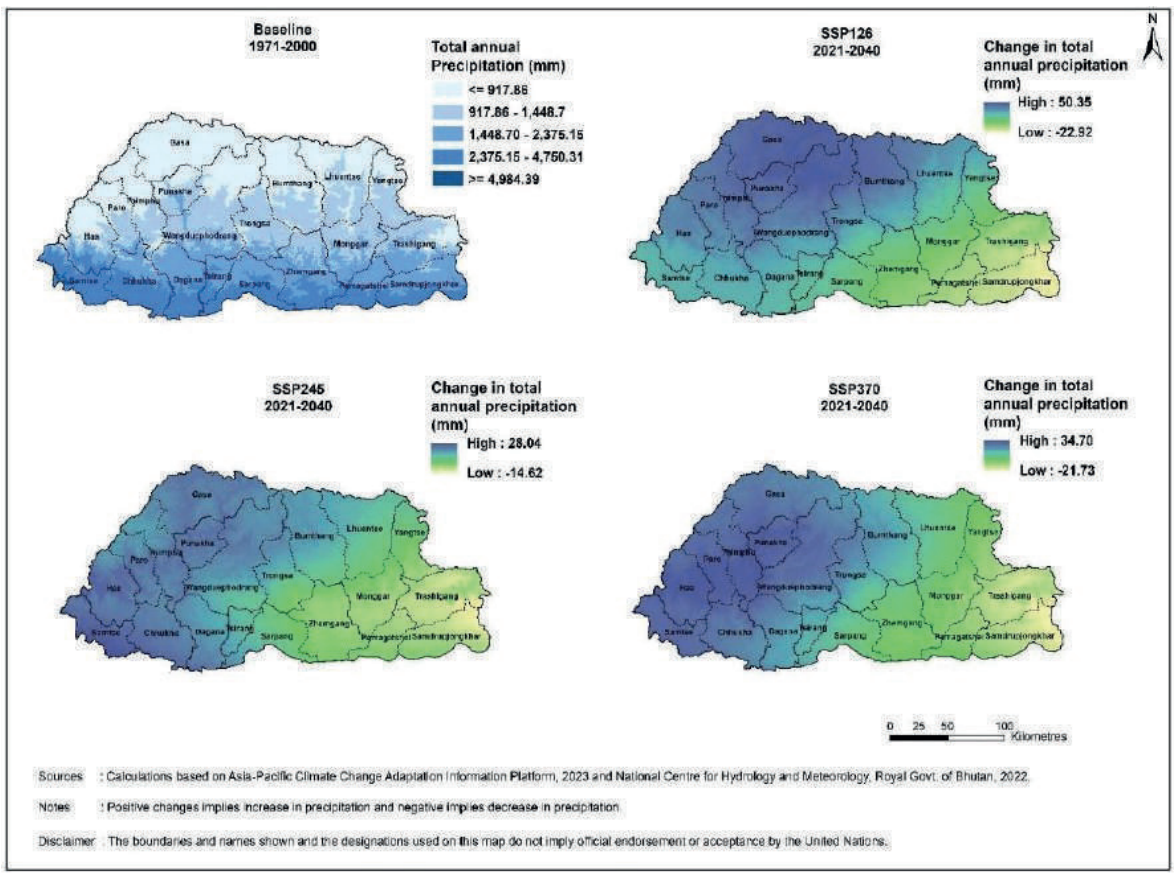


Figure 31: Total annual precipitation under baseline scenario and change in total annual precipitation from baseline under SSP1 2.6, SSP2 4.5 and SSP3 7.0 scenario by 2040

By 2060, the precipitation is likely to increase across the country although the increase is more in the north, west, central and south-western districts and less in east and southeastern districts. Under SSP1 2.6, the total annual precipitation may increase up to 82mm in Punakha Dzongkhag. Under SSP2 4.5 and SSP3 7.0 the projected increase is less than SSP1 2.6 across the country. However, by 2100 the increase will be more in the higher emission scenario. However, Wangdue Phodrang, Gasa, Punakha, Thimphu, Paro, Dagana, Chhukha, Trongsa, and Samtse are expected to receive comparatively higher rainfall than the other districts in all three scenarios. By 2100, all the districts are likely to receive at least 56mm more total annual precipitation than baseline. More than a 100mm increase is likely in Haa, Samtse, Paro, Punakha, Thimphu, Chhukha, Gasa and Wangdue Phodrang. Under SSP2 4.5 the highest increase is likely in Punakha (171 mm) followed by Gasa, Thimphu, Paro, Bumthang and Wangdue Phodrang which are likely to receive around 150mm more precipitation than the baseline. Under the worst-case scenario, all the districts are likely to receive at least 300mm more precipitation from the baseline with the highest increase in Punakha.

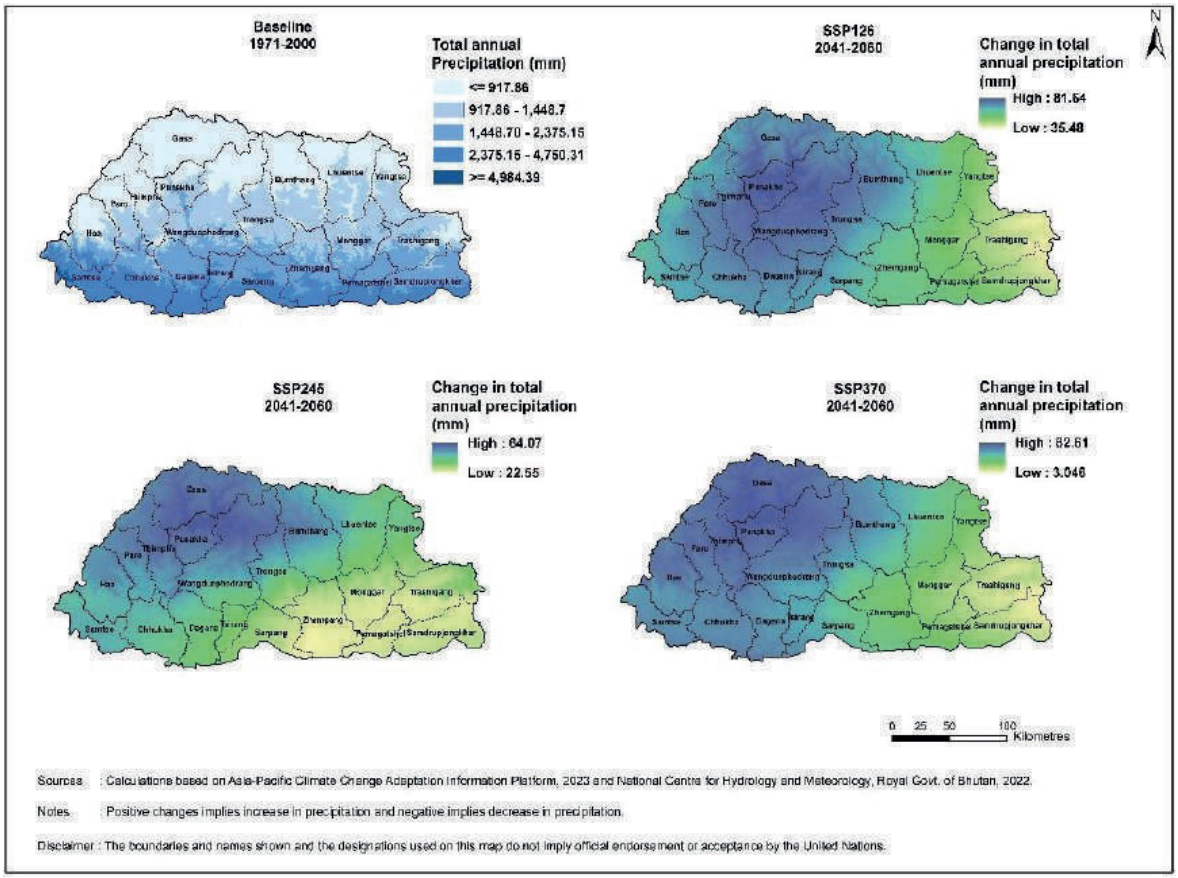


Figure 32: Total annual precipitation under baseline scenario and change in total annual precipitation from baseline under SSP1 2.6, SSP2 4.5 and SSP3 7.0 scenario by 2060

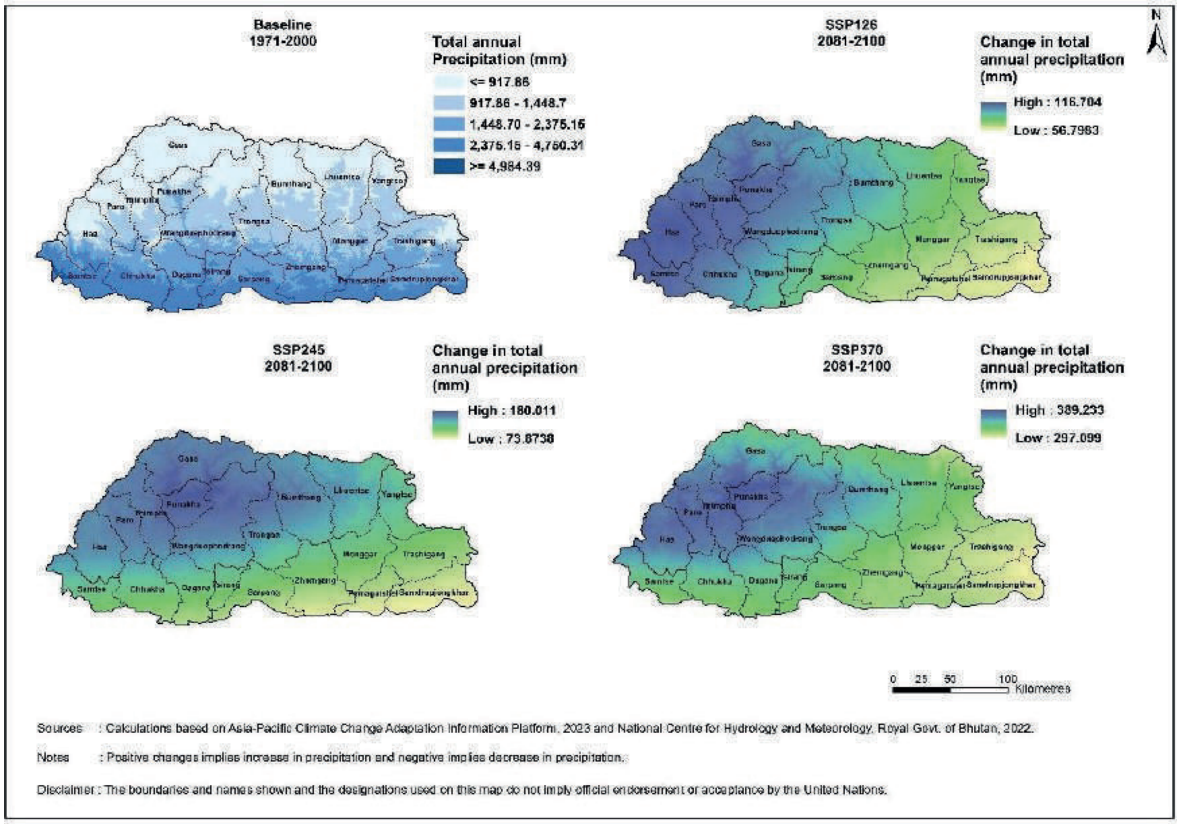


Figure 33: Total annual precipitation under the baseline scenario and change in total annual precipitation from baseline under SSP1 2.6, SSP2 4.5, and SSP3 7.0 scenario by 2100

1.5.4.2 Annual temperature

In Bhutan, temperature varies widely due to the dramatic variations in the elevation. In general, temperatures are higher in the southern part of the country and decrease northwards. IPCC AR6 has highlighted that elevation-dependent warming is likely to continue in the mountain regions in Asia under climate change conditions. Additionally, the rate of warming might be amplified with elevation, for example, the high-mountain environments may experience faster changes in temperature than those at lower elevations. Under climate change scenarios the trend remains the same, however the northern part is likely to experience more increase in temperature than the southern part. The figure below demonstrates the changes in average annual maximum (T_{max}) and minimum temperature (T_{min}) under three different climate change scenarios by 2040.

Across all the scenarios, both the minimum and maximum temperature increases more in the northern districts than the districts in the southern foothill. The maximum increase in T_{max} may reach up to 1.55 °C (Gasa) while T_{min} up to 1.9°C (Gasa) under the worst-case scenario by 2040. In Bumthang, Wangdue Phodrang, Lhuentse, Thimphu, Punakha, Paro and Trongsa the T_{max} is likely to increase by more than 1.4°C and T_{min} by more than 1.7°C under the worst-case scenario by 2040.

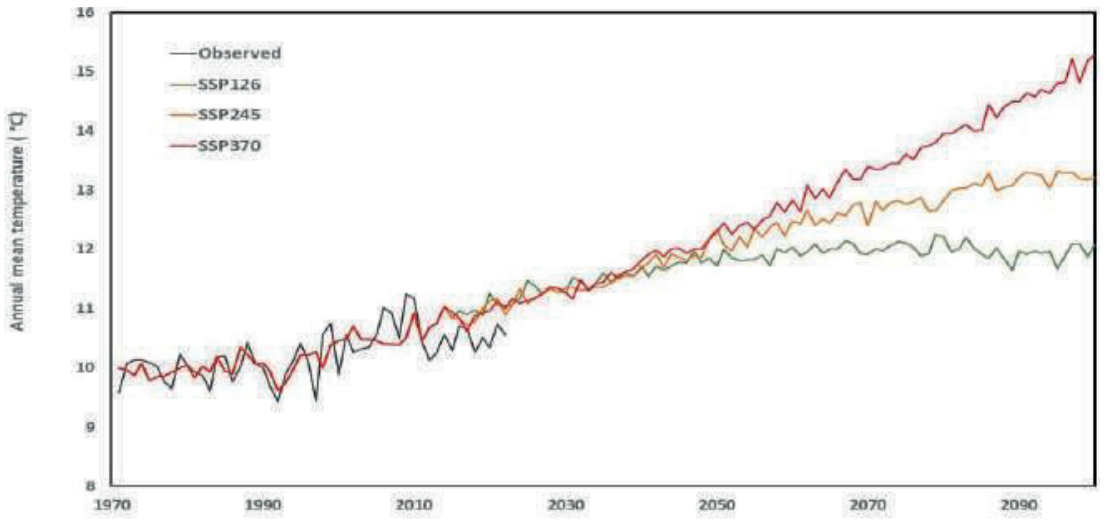


Figure 34: Annual mean temperature projection for three different scenarios (ensemble)

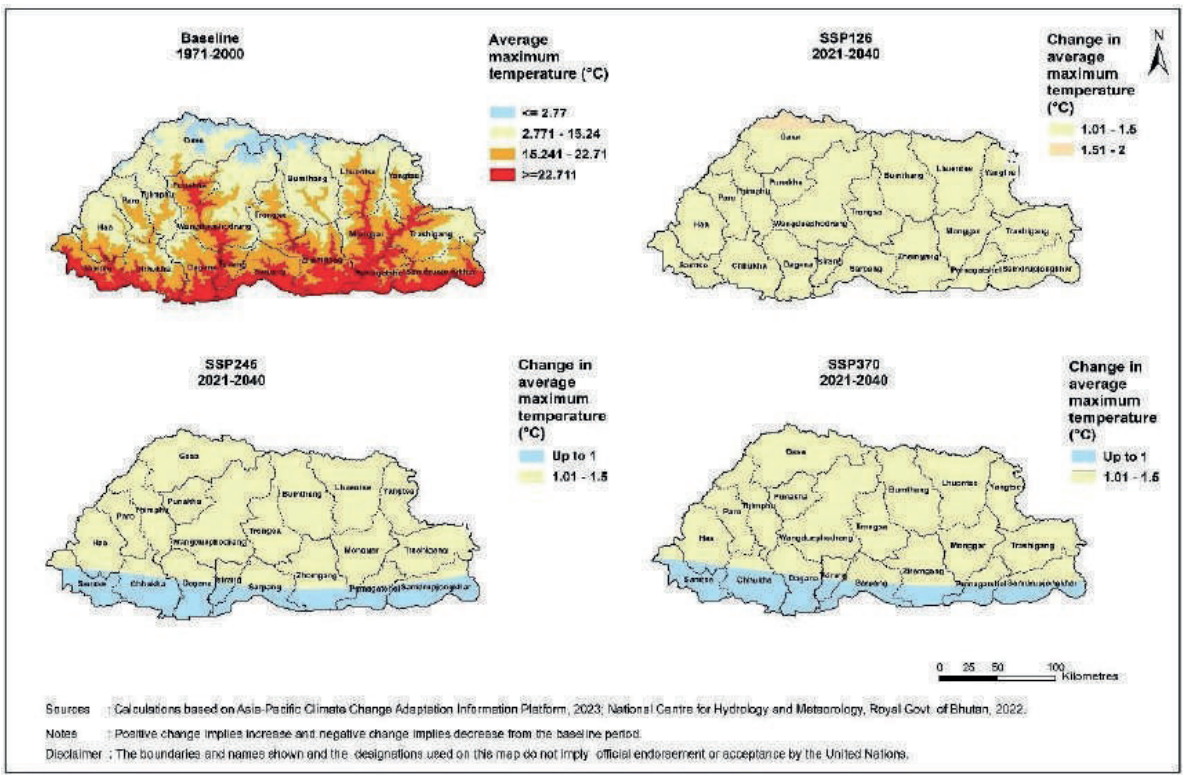


Figure 35: Average annual maximum temperature and change in average annual maximum temperature from baseline under SSP1 2.6, SSP2 4.5 and SSP3 7.0 scenario by 2040

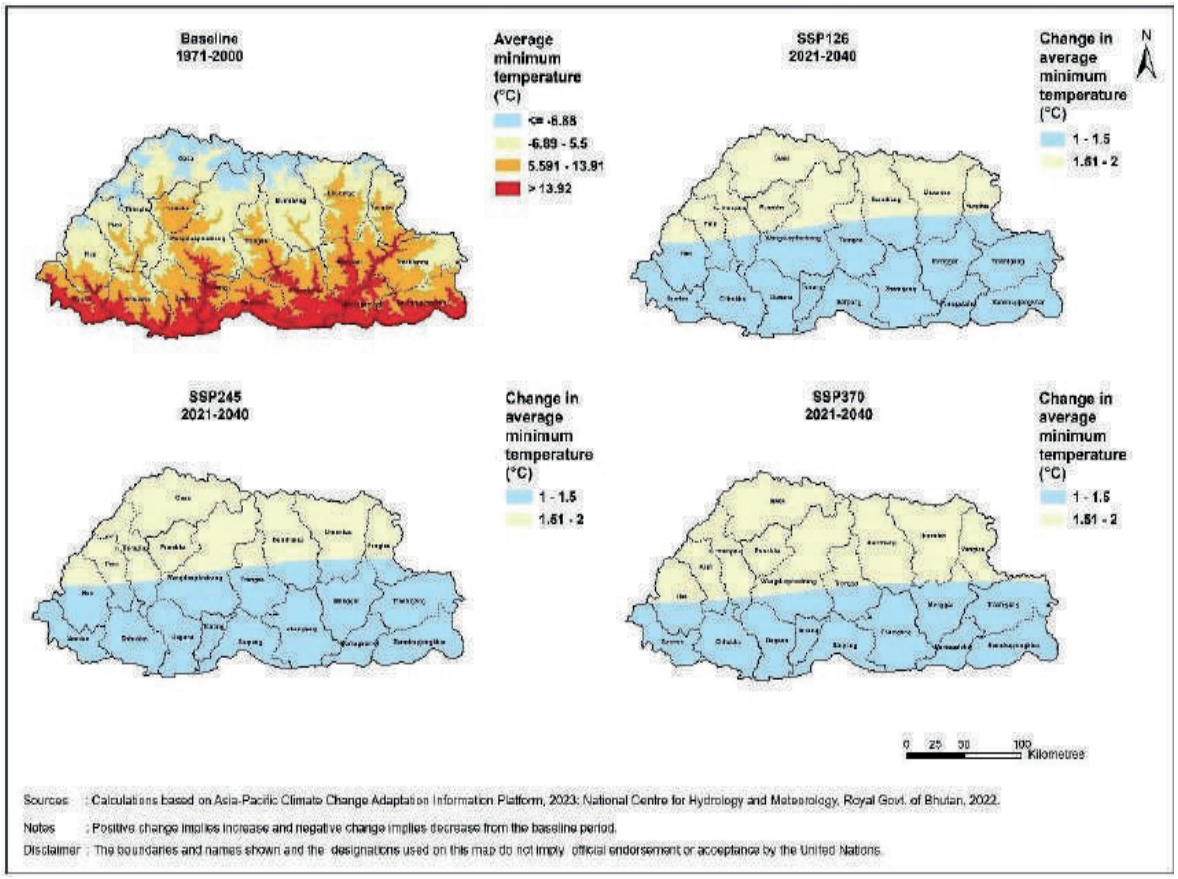


Figure 36: Average annual minimum temperature change in average annual minimum temperature from baseline under SSP1 2.6, SSP2 4.5, and SSP3 7.0 scenario by 2040 in Bhutan

By 2060, the maximum and minimum temperatures will increase more in the northern districts. Maximum increase in T_{max} is likely in Gasa, which ranges between 1.9°C (SSP1 2.6) to 2.5°C (SSP3 7.0). In Bumthang, Wangdue Phodrang, Lhuentse, Thimphu, Punakha, Paro, and Trongsa T_{max} may increase between 1.8°C (SSP1 2.6) to 2.3°C (SSP3 7.0). The increase in T_{min} is more than T_{max} across the country. The Maximum increase is likely in Gasa, which ranges between 2.3 °C (SSP1 2.6) to 3.1 °C (SSP3 7.0). Bumthang, Wangdue Phodrang, Lhuentse, Thimphu, Punakha, Paro and Trongsa increase in T_{min} might range between 2°C (SSP1 2.6) to 2.8°C (SSP3 7.0) by 2060 (***Figure 37*** and ***Figure 38***).

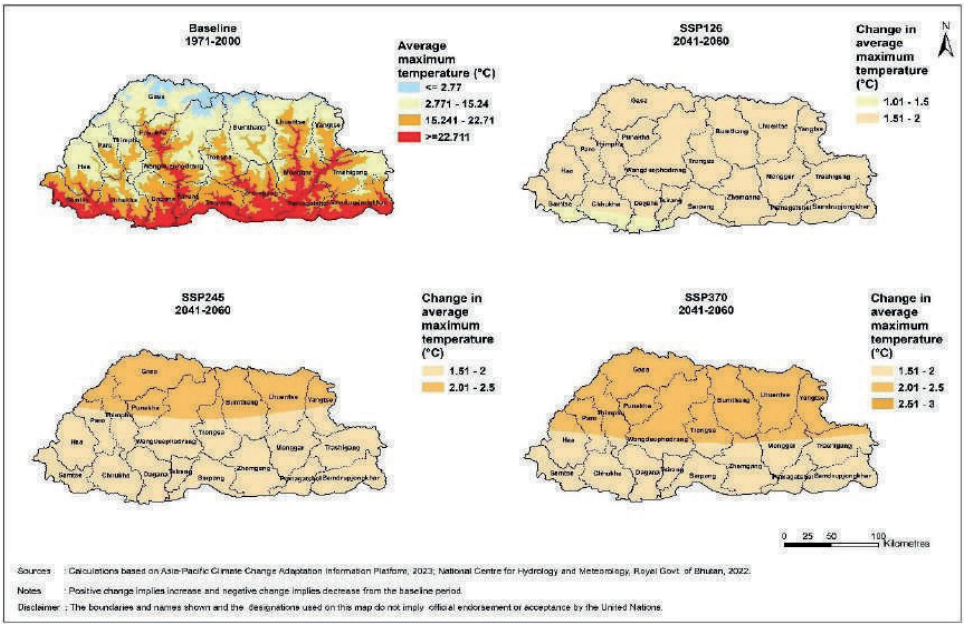


Figure 37: Average annual maximum temperature and change in average annual maximum temperature from baseline under SSP1 2.6, SSP2 4.5 and SSP3 7.0 scenario by 2060

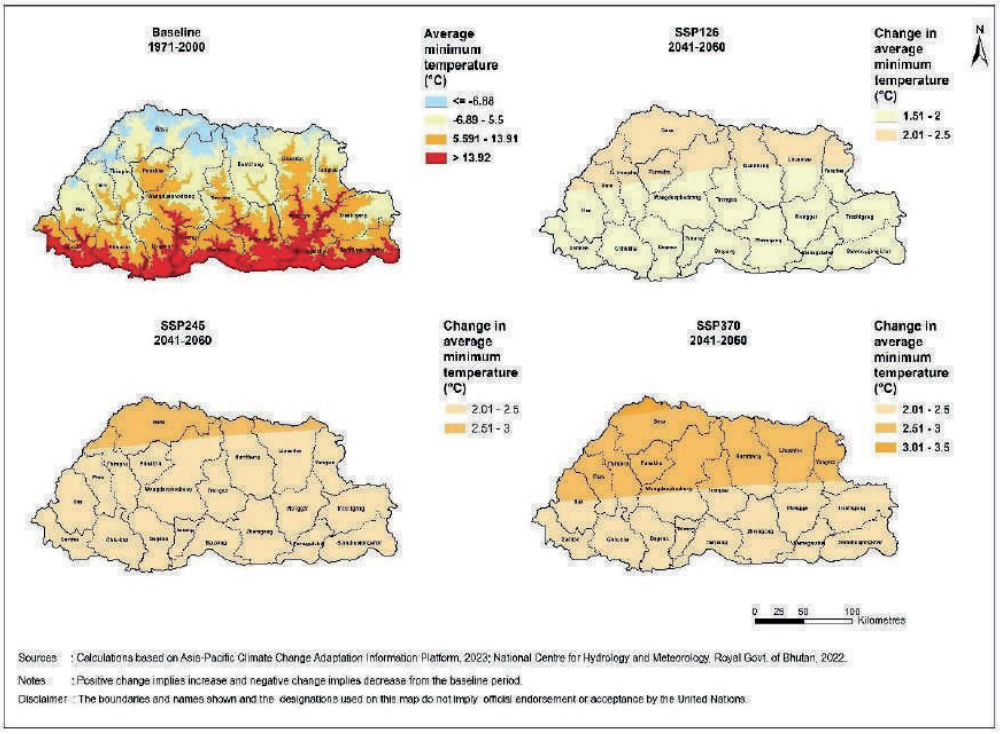


Figure 38: Average annual minimum temperature change in average annual minimum temperature from baseline under SSP1 2.6, SSP2 4.5, and SSP3 7.0 scenario by 2060

By 2100, the maximum increase in T_{min} is likely in Gasa where the rise in T_{min} may reach up to 2.3°C under SSP1 2.6 and may go beyond 5°C under SSP3 7.0. The rise in T_{min} in other districts such as Bumthang, Wangdue Phodrang, Lhuentse, Thimphu, Punakha, Paro, and Trongsa T_{min} may also go beyond 5°C under SSP3 7.0 by 2100, however in best-case scenario it is likely to reach just above 2°C. Likewise, the highest increase in T_{max} may range between 2.1°C to around 5°C (Gasa) followed by Bumthang, Wangdue Phodrang, Lhuentse, Thimphu, Punakha, Paro and Trongsa where an increase in T_{max} may reach more than 4°C (***Figure*** 39 and ***Figure 40***).

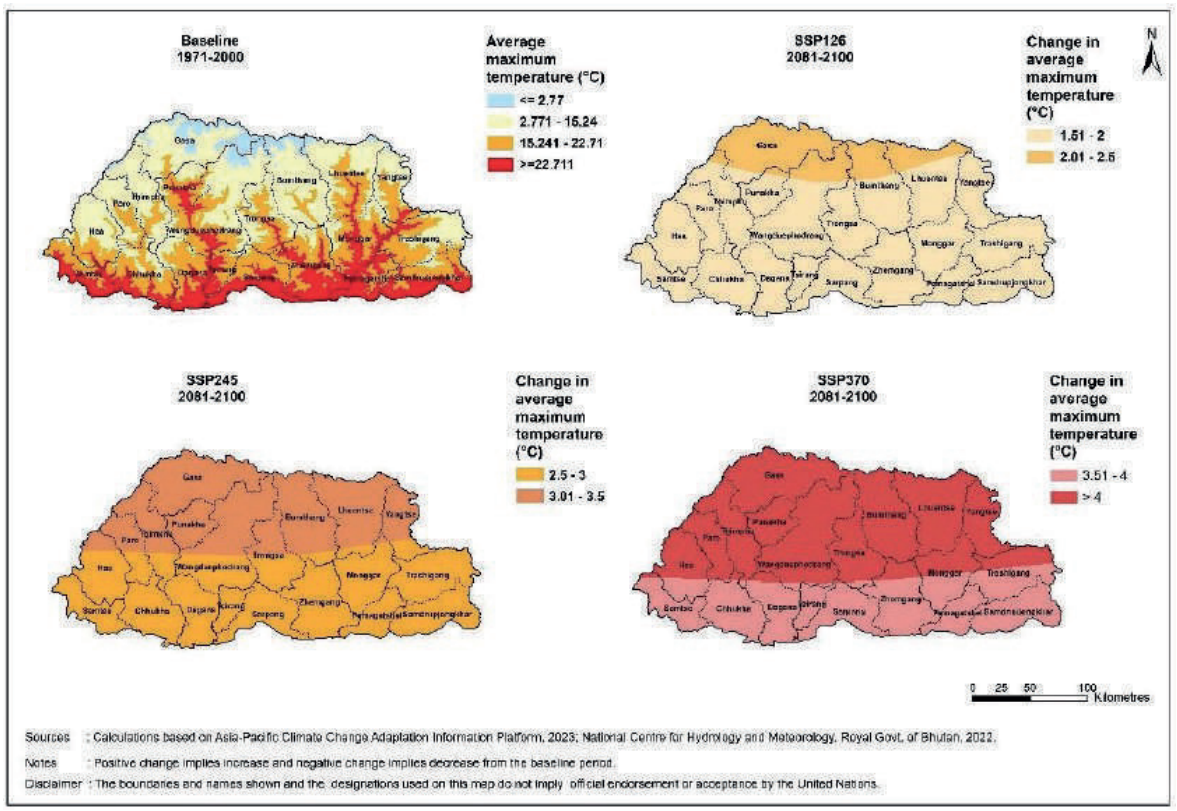


Figure 39: Average annual maximum temperature and change in average annual maximum temperature from baseline under SSP1 2.6, SSP2 4.5 and SSP3 7.0 scenario by 2100 in Bhutan

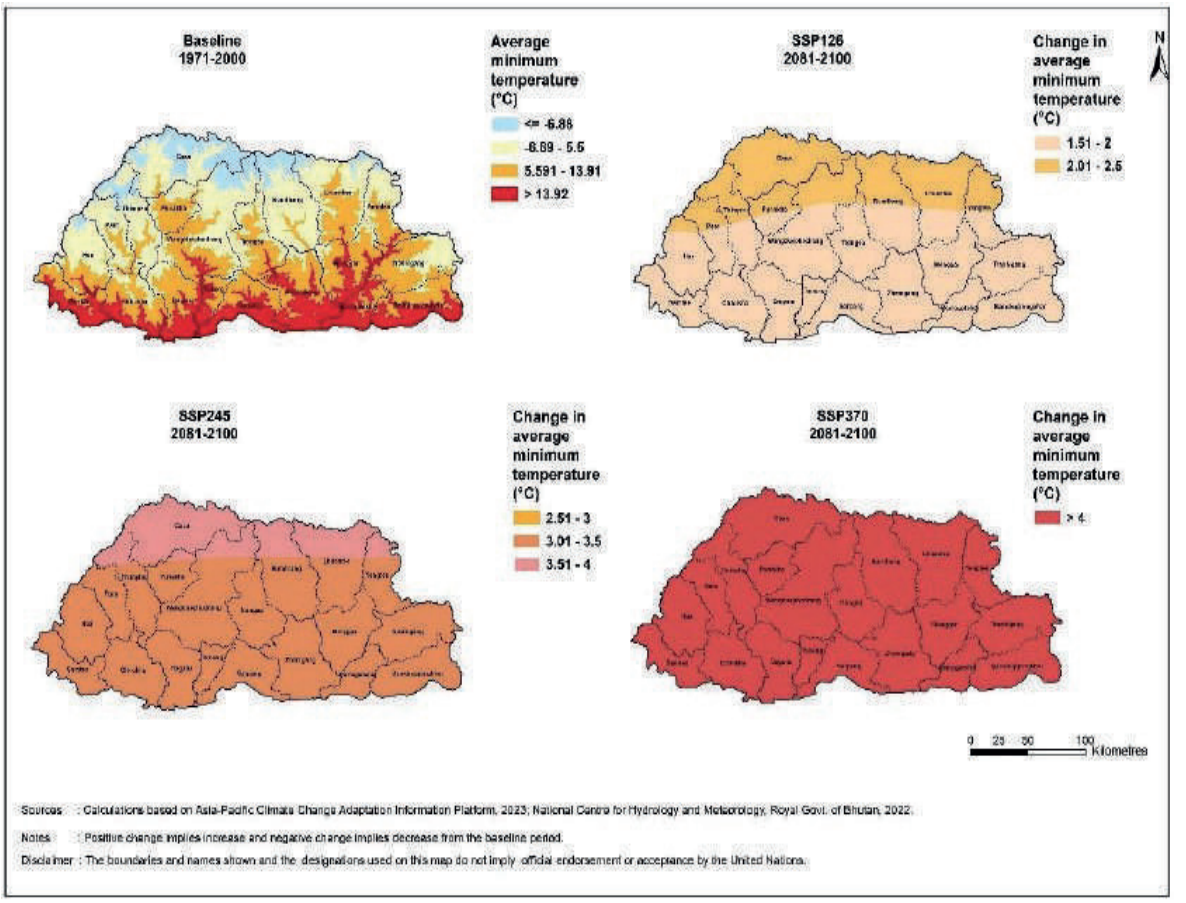


Figure 40: Average annual minimum temperature change in average annual minimum temperature from baseline under SSP1 2.6, SSP2 4.5, and SSP3 7.0 scenario by 2100 in Bhutan

1.6 Solid Waste Management

Bhutan is facing significant challenges in solid waste management, primarily due to rapid urbanization and population growth. According to the National Waste Inventory Survey (NWIS) 2019, Bhutan generates approximately 172.16 metric tons of solid waste daily, with households contributing the largest share at 47.34% (Figure 41)[70]. The average household waste generation is about 0.7 kg per day in urban areas, compared to 0.4 kg in rural areas[71]. However, over 60% of households lack access to proper waste collection services, particularly in rural regions, where only 15% have access to such services[72].

70 https://nsb.gov.bt/wp-content/uploads/2020/10/NWIS-2019-.pdf

71 https://zerowastebhutan.gov.bt/#:~:text=The%20National%20Waste%20Inventory%20Survey,by%20commercial%20units%20with%2039.09%20%25.

72 Zero Waste Bhutan. (2019). National Waste Inventory Survey 2019. https://zerowastebhutan.gov.bt/homepage

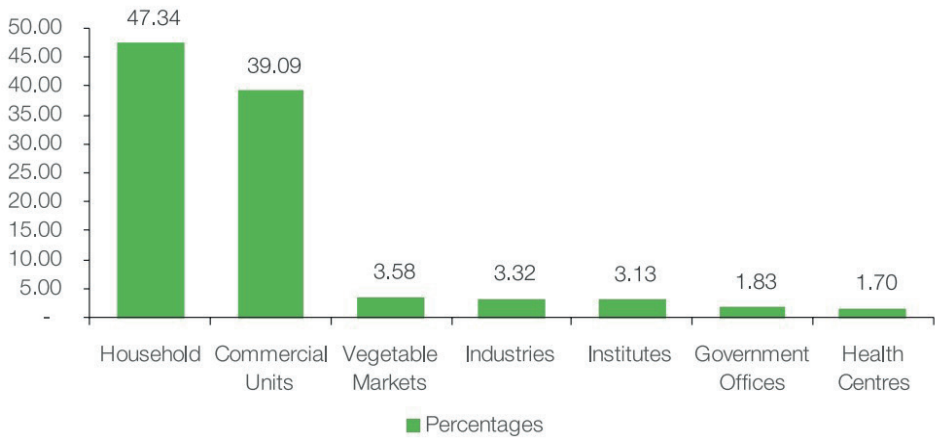


Figure 41: Proportion of wastes from different sectors in percentages[73]

1.6.1 Composition of waste

Figure 42 depicts the composition of waste from different sources expressed as percentages. Out of a total waste generation of 172. MT per day, around 50% is attributed to food waste, which encompasses all kitchen waste, including vegetables, fruits, and leftover food. In second place is plastic waste—comprising soft plastics, PET bottles, and HDPE—accounting for 17.1%. This is followed by paper and cardboard, which make up 15.8 % of the total waste.

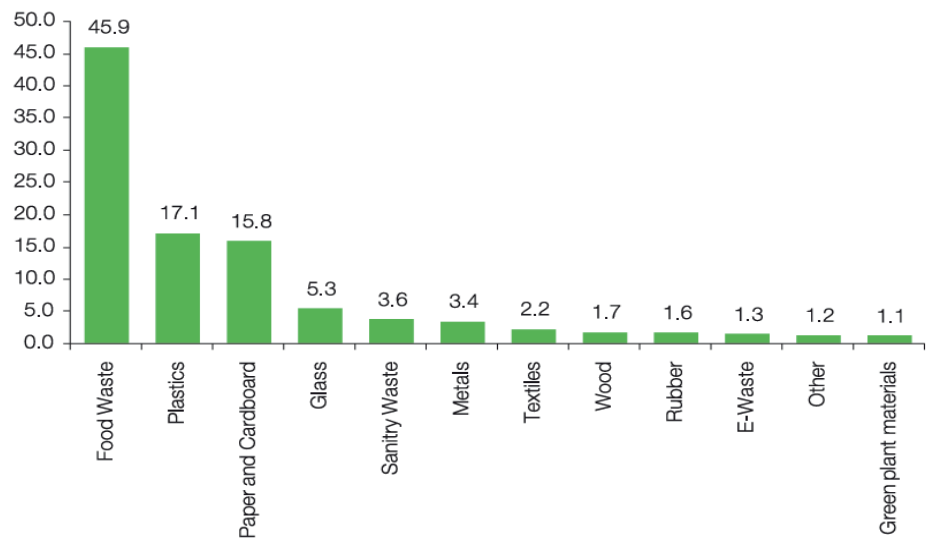


Figure 42: Waste Composition in Percentage[74]

73 National Waste Inventory Survey (NWIS-2019) Bhutan
74 National Waste Inventory Survey (NWIS-2019) Bhutan

1.7 Socio Economic Profile

Bhutan officially graduated from the Least Developed Country (LDC) category as recognized by the United Nations General Assembly (UNGA) in 2023[75].

Bhutan's economic development policy is guided by the overarching philosophy of Gross National Happiness (GNH), which is based on four pillars:

(i) Sustainable economic development;
(ii) Preservation and promotion of culture and tradition;
(iii) Conservation of the environment; and
(iv) Good governance.

However, achieving sustainable economic growth remains a significant challenge, as it is primarily financed by external aid[76].

1.7.1 Macro-economy

Bhutan is one of the world's smallest economies, with a GDP of Nu 249,388.19 million (USD 2,955.13 million), recorded in 2024[77]. Despite this, the country has experienced significant growth, with a GDP growth of 4.88% largely due to investments in the hydropower sector. The per capita GDP increased from Nu 174,400.7 million (USD 2,066.56 million) in 2015 to Nu 229,090.40 million (USD 2,714.61 million) in 2020. However, the COVID-19 pandemic caused a substantial contraction in economic activities, resulting in a drastic growth decline of -10.08 % in 2020. This represents a decrease of 15.83 % points compared to the growth of 5.76 % in 2019. Key sectors contributing to this economic contraction included Mining & Quarrying (-81.84 %), Hotels & Restaurants (-73.46 %), Manufacturing (-20.76 %), Construction (-20.64 %), and Transport & Communication (-14.65 %). Additionally, Finance & Insurance, Wholesale & Retail Trade, and Other Business Services also contracted, further contributing to the overall economic decline in 2020[78].

Table 14: GDP Contribution by Sectors[79]

Years	2010	2011	2012	2013	2014	2015	2016	2017
1. Agriculture, Livestock & Forestry	16.80	16.33	15.96	16.10	16.69	16.71	16.61	17.37
2. Mining & Quarrying	2.23	2.29	2.01	2.65	2.81	3.39	4.33	4.22
3. Manufacturing	8.72	8.29	8.85	8.33	8.08	7.98	7.43	7.25
4. Electricity & Water Supply	17.61	14.02	12.62	14.45	14.08	14.33	13.35	13.22
5. Construction	14.22	16.38	18.13	16.92	15.88	15.63	16.28	15.87

75 https://www.un.org/development/desa/dpad/2023/bhutan-graduates-from-ldc-status/
76 https://www.weforum.org/stories/2021/10/lessons-from-bhutan-economic-development/
77 https://www.nsb.gov.bt/https-www-nsb-gov-bt-wp-content-uploads-dlm_uploads-2024-07-nas-2024-for-web-pdf/
78 https://www.nsb.gov.bt/https-www-nsb-gov-bt-wp-content-uploads-dlm_uploads-2024-07-nas-2024-for-web pdf/
79 12 Five Year Plan

6. Wholesale & Retail Trade	5.18	5.46	6.07	6.48	7.05	7.74	7.91	8.18
7. Hotels & Restaurants	0.84	1.12	1.33	1.54	1.70	1.88	1.92	2.11
8. Transport, Storage & Communication	9.58	10.04	9.50	9.31	9.58	9.00	8.82	9.06
9. Financing, Insurance, Real Estate & Business Services	7.65	8.25	7.61	7.65	7.53	7.38	7.30	7.09
10. Public Administration	7.61	7.63	6.95	6.63	6.73	7.48	7.52	7.07
11. Education & Health	5.17	5.18	4.59	4.32	4.06	3.76	3.54	3.24
12. Private Social & Recreational Services	0.41	0.40	0.40	0.41	0.39	0.38	0.36	0.40
13. Taxes Net of Subsidies	3.99	4.62	5.96	5.21	5.42	4.34	4.60	4.91
Overall GDP	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

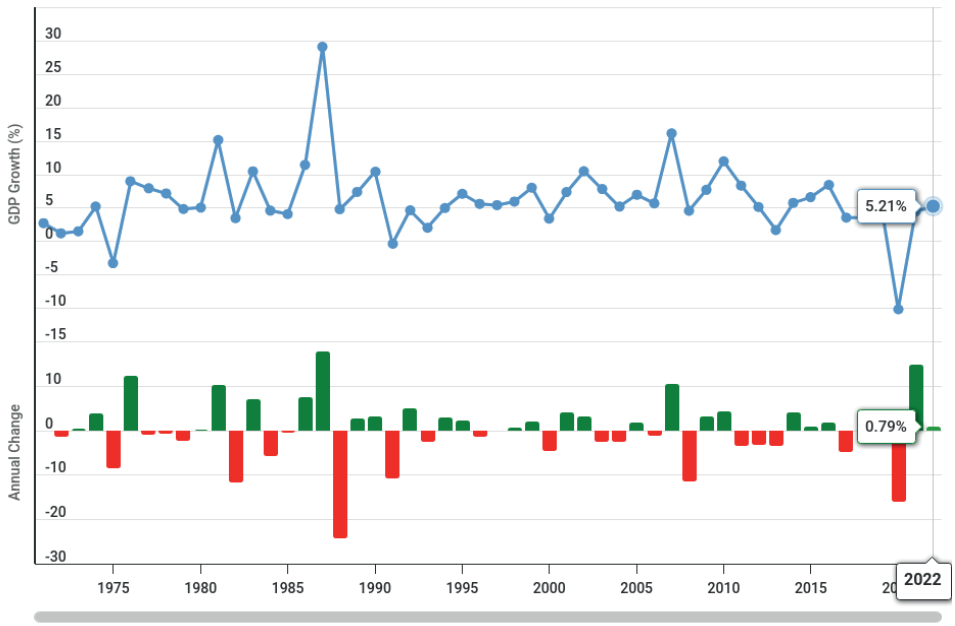


Figure 43: GDP Growth Rate Over the Years of Bhutan[80]

80 https://www.macrotrends.net/global-metrics/countries/BTN/bhutan/gdp-growth-rate#:~:text=Bhutan%20gdp%20growth%20rate%20for,a%202.25%25%20increase%20from%202018

Table 15: GDP Growth Rate (1992-2022)[81]

Year	GDP Growth (%)	Annual Change
2022	5.21%	0.79%
2021	4.42%	14.64%
2020	-10.22%	-15.97%
2019	5.76%	2.25%
2018	3.50%	-0.01%
2017	3.51%	-4.89%
2016	8.40%	1.83%
2015	6.57%	0.85%
2014	5.72%	4.06%
2013	1.66%	-3.44%
2012	5.10%	-3.21%
2011	8.31%	-3.62%
2010	11.93%	4.26%
2009	7.67%	3.14%
2008	4.53%	-11.58%
2007	16.10%	10.46%
2006	5.64%	-1.29%
2005	6.94%	1.78%
2004	5.16%	-2.63%
2003	7.79%	-2.66%
2002	10.44%	3.12%
2001	7.33%	3.97%
2000	3.36%	-4.63%
1999	7.98%	2.07%
1998	5.91%	0.54%
1997	5.37%	-0.19%
1996	5.57%	-1.51%
1995	7.07%	2.12%
1994	4.95%	2.97%
1993	1.99%	-2.61%
1992	4.60%	5.01%

Historically, the public sector has been the primary driver of economic growth; however, the government has recognized the importance of private sector development. Economic diversification has been prioritized, and Bhutan has made strides in modernizing its economic structure and reducing poverty. Nevertheless, challenges to private sector development include an inefficient regulatory framework, significant non-tariff barriers to trade, and a basic investment code[82].

1.7.2 Population and Demographics

Bhutan is among the least populated countries in Asia, with a projected population of 777,224 in 2024. According to the Environmental Accounts Statistics (2024), the annual population growth rate was 1.3%[83]. Population density rose from 17 persons per km² in 2005 to 20.06 persons per km² in 2023, reflecting a gradual increase in population size. However, this distribution is uneven; Thimphu, the capital, has the highest density at 67 persons per km², while Gasa Dzongkhag has the lowest, with just 1.3 persons per km² [(84)].

81 Macrotrends, 2024
82 https://www.moice.gov.bt/wp-content/uploads/2017/07/Bhutans-Labor-Market-Towards-Gainful-Quality-Employment-for-All.pdf
83 https://www.nsb.gov.bt/
84 https://www.nsb.gov.bt/wp-content/uploads/dlm_uploads/2020/07/PHCB2017_wp.pdf

Table 16: Key Demographic Indicators, 2017[85]

Indicators	Area		Sex		Both Sex
	Urban	Rural	Female	Male	
Total Population (numbers)	274,967	452,178	346,692	380,453	727,145
Population Density (per km2)	...	...	...	...	19.0
Number of household	60,394	102,607	NA	NA	163,001
Mean Household Size	4.0	3.8	NA	NA	3.9
Sex Ratio	...	...	...	...	110.0
Total Dependency Ratio	...	...	...	...	47.0
Child Dependency Ratio	...	...	...	...	38.3
Old Age dependency Ratio	...	...	...	...	8.7
Median Age	...	...	26.6	27.2	26.9
Aging Index	...	...	22.7	22.8	22.7
Life Expectancy (years)	...	...	71.7	68.8	70.2
Mean age at first birth (years)	22.0	21.0	...	...	21.0
Crude Birth Rate(per 1000)	17.8	14.0	...	...	15.5
Crude Death Rate(per 1000)	5.5	7.5	6.3	7.1	6.7
Child Surivival Rate	96.2	93.0	...	...	94.1
Total Fertility Rate	1.7	1.8	...	...	1.7
General Fertility Rate	58.0	57.0	...	...	57.3
Infant Mortality Rate	12.0	17.5	13.5	16.6	15.1
Child Mortality Rate	13.3	23.3	18.4	19.4	19.0
Under Five Mortality Rate	25.3	40.8	31.9	36.0	34.1
Disability Prevalance Rate	1.1	2.8	2.3	2.0	2.1

The crude birth rate was 15.5 per 1000 population in 2017. The infant mortality was 12 and 17.5 depending on the area of urban and rural respectively. The total fertility rate in 2017 was reported at 1.7 children per woman, while life expectancy at birth in 2017 was reported at 70.2 years by the NSB in the year 2017 population census.

On the other hand, Bhutan witnesses a shrinking prime working age group (20-39 years of age) due to continuous outward migration in pursuit of greater opportunities. However, Bhutan maintains a balanced gender distribution, with 346,692 female and 380,453 male as of 2017 (*Figure 44*).

85 Population and Housing Census of Bhutan, NSB, 2017

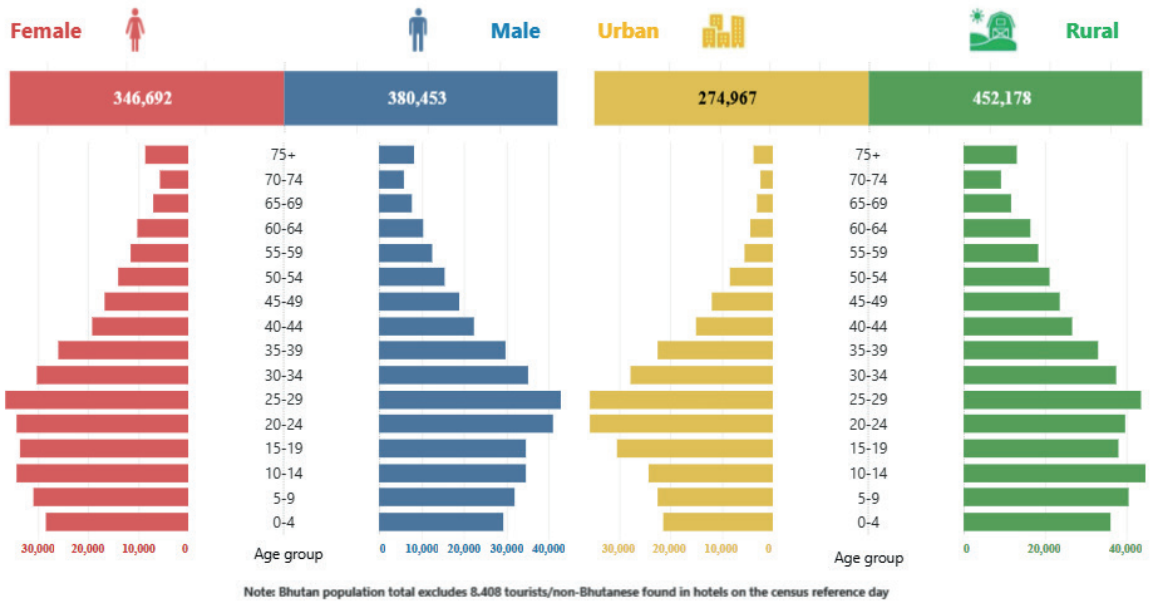


Figure 44: Population Distribution by Gender and Rural-Urban settlement

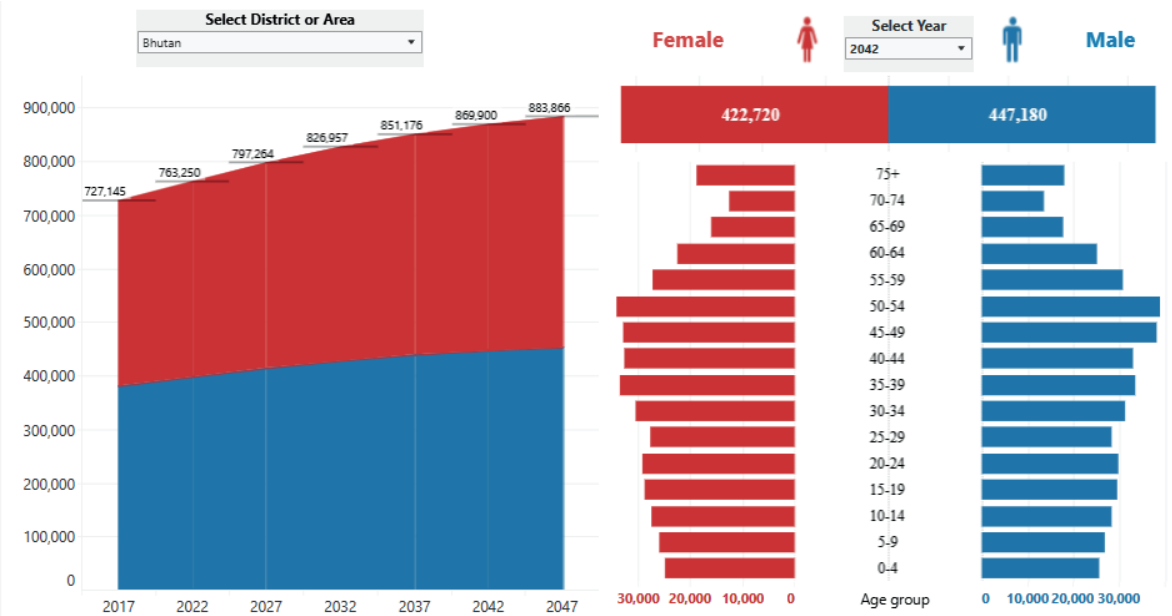


Figure 45: Population Projection of Bhutan

Since the start of planned socio-economic development in the 1960s, Bhutan has transformed its nascent health system into a comprehensive network of health facilities that meet the population's health needs.

As of 2024 per the Annual Health Bulletin, there are 55 hospitals with a total of 1,660 inpatient beds, complemented by 187 PHCs and 51 sub-posts. These facilities are crucial for decentralized healthcare provision across the country, supported by 479 health information service centers (HISCs). The presence of Out-reach clinics (ORCs), totaling 557, underscores Bhutan's commitment to providing essential health services and taking services to an unreached population. The National Health survey 2023 has also found that 72.9% of the population live within travel time of less than 30 minutes from the health facility closest to their household.[86].

Additionally, the availability of traditional medicine services through 76 indigenous units and one national traditional medicine hospital has improved health service delivery. These health services are provided free of charge, and primarily funded by the government.

The Population and Housing Census of Bhutan (PHCB) 2017 reported a national literacy rate of 70.6%, with a youth literacy rate of 97.7%[87]. The study, which drew attention to the Bhutan Living Standard Survey (BLSS) report for 2022, revealed that the literacy rate for males was 77.1 %, while it was 63.6 % for females. Furthermore, the gender gap in youth literacy persisted, with male youth having a literacy rate of 98.3 % compared to 97.2 % for females[88].

1.7.3 Infrastructure in Bhutan

Improving infrastructure is a key development objective for the Government of Bhutan, with significant investments aimed at enhancing various sectors over recent years. The following outlines the current state of infrastructure in Bhutan:

1.7.3.1 Road Network

Bhutan currently has about 18,000 km of roads, of which about 26% are sealed. The country's roads are assigned to seven classes: Asian Highway, Primary National Highway, Secondary National Highway, Dzongkhag Road, Urban Road, Farm Road, and Access Road. Farm roads are the most prolific, accounting for approximately 60% of total road length. National highways (including the Asian Highway) comprise 2,841 km. A summary of roads by class is shown in Table *17*, and a map of the road network appears in *Figure 46*.

86 https://www.moh.gov.bt/wp-content/uploads/Annual-Health-Bulletin-2024.pdf
87 https://www.nsb.gov.bt/
88 https://kuenselonline.com/gnh-study-shows-alarming-gender-disparity-in-literacy/

Table 17: Summary of Road Network of Bhutan[89]

Classification	Total Length (km)	Sealed Length (km)	Jurisdiction
Asian Highway (AH)	149	149	DANTAK
Primary National Highway (PNH)	1,531	1,531	DoST, DANTAK
Secondary National Highway (SNH)	1,161	943	DoST, DANTAK
Dzongkhag Road (DR)	2,073	1,165	Dzongkhags
Urban Road (UR)	417	403	Thromdes
Farm Road (FR)	11,257	151	Dzongkhags
Access Road (AR)	1,677	456	Mixed
Total	**18,265**	**4,798**	

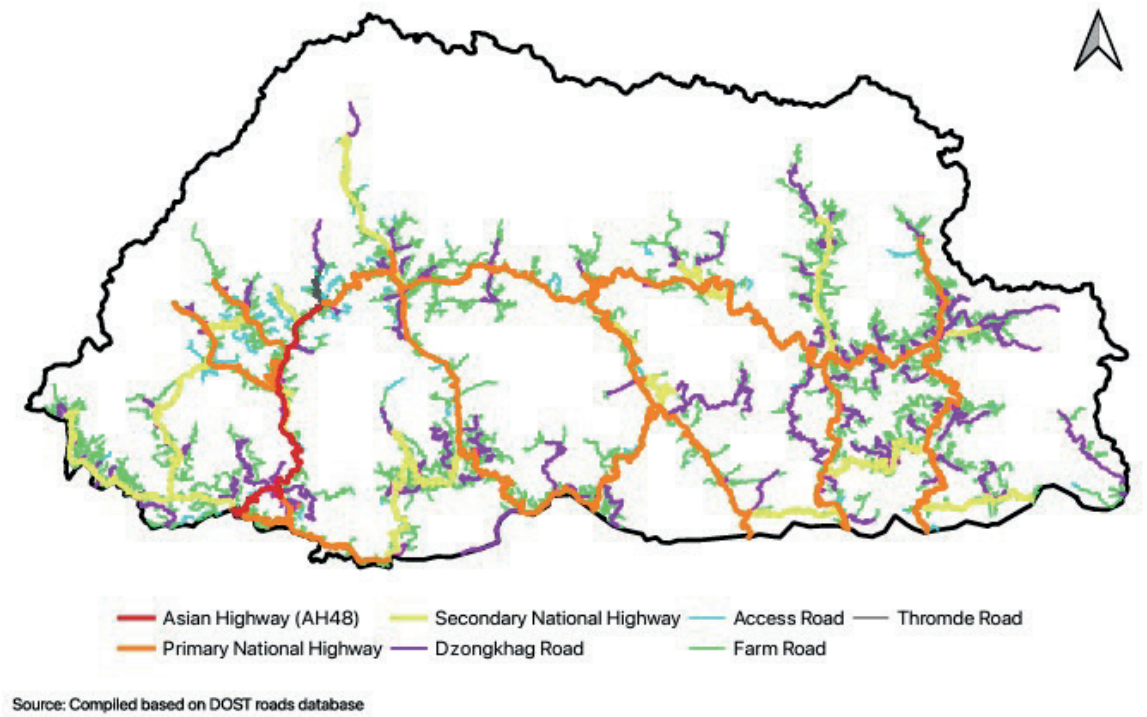


Figure 46: Road Network of Bhutan (2020)[90]

1.8 Tourism

The tourism industry in Bhutan began in 1974, and it contributes more than 9% to GDP as the highest commercial source of convertible currency earnings. The revenue generated from the tourism sector has increased from over USD 2 million in the late 1980s to over USD 79.81 million in 2017[91]. Bhutan remains a favored destination

89 https://www.moit.gov.bt/wp-content/uploads/2024/02/SEA-Scoping-Report-240526-compressed.pdf
90 https://www.moit.gov.bt/wp-content/uploads/2024/02/SEA-Scoping-Report-240526-compressed.pdf
91 NSB, 2018

throughout the global tourism industry because of the pristine state of the country's cultural and natural heritage and its reputation for conservation under the developmental philosophy of Gross National Happiness. Bhutan implements a "high value, low impact" tourism policy to curtail the impact of tourism on its culture and environment[92].

1.9 Institutional Arrangement

1.9.1 Overall Coordination and Oversight of Climate Change Policy

National Climate Change Committee: The NEC acts as the high-level National Climate Change Committee (NCCC), chaired by the secretary of the MoENR. The NEC is the leading cross-sectoral body for environmental policy and regulation, responsible for coordinating efforts related to the protection, conservation, and enhancement of the environment. Its authority comes from several laws, including the National Environment Protection Act (NEPA) 2007, the Environmental Assessment Act (EAA) 2000, the Waste Prevention and Management Act 2009, and the Water Act 2011, among others. In its capacity as the NEC, it addresses all climate change-related policy and regulatory issues. The NEC is assisted by the National Environment Commission Secretariat (NECS), which has now been restructured and renamed the Department of Environment & Climate Change (DECC) under the Ministry of Energy and Natural Resources (MoENR) as of December 30, 2022. The DECC serves as the Secretariat for the NEC[93].

Climate Change Coordination Committee: The Climate Change Coordination Committee (C4) serves as the technical forum for discussing and coordinating climate change issues in Bhutan, making recommendations for the NCCC/NEC's consideration. C4 consists of high-level representatives from various stakeholder agencies and organizations and is chaired by the Director of the DECC. Its mandate stems from an Executive Order issued by the Prime Minister on October 16, 2016. The C4's activities are supported by the Climate Change Division of the DECC, which monitors and guides the implementation of climate change policy, ensuring coordinated action on climate change throughout Bhutan[94].

1.9.2 Resource mobilization and allocation

1.9.2.1 Prime Minister's Office

The Prime Minister's Office (PMO), besides other activities also coordinate the preparation of policies and five-year plans of the country, programming, and prioritization of national priorities. The PMO will support integrating climate change into policies, programmes, and plans and mobilize external resources for implementing climate change programmes and projects.

1.9.2.2 Ministry of Finance

The Ministry of Finance (MoF) is mandated to formulate and implement dynamic fiscal policies and sound financial management through maximization of resource generation, efficient allocation, prudent expenditure and debt management, and proper accountability of public resources.

92 Third National Communication
93 http://www.nec.gov.bt/secretariat/division/climate-change-division
94 http://www.nec.gov.bt/secretariat/division/climate-change-division

The mandates and functions of the MoF are governed by the Public Finance Act, Public Debt Policy, Income Tax Act, Revised Taxes and Levies Act, Fiscal Incentives 2017, and the PPP Policy. In line with provisions of the various legislations, MOF has a mandate for resource mobilization and budget allocation and also provides fiscal incentives and other instruments to support private sector lending to support policy implementation.

1.9.3 Climate Data and Information

National Centre for Hydrology and Meteorology: NCHM is responsible for providing a national source of hydro-meteorological data, services, and guidance to meet the needs of the public, emergency services, and specialized users. NCHM offers hydro-meteorological data and information, climate modeling and scenarios, as well as early warning services[95].

1.9.4 Academia

The Royal University of Bhutan (RUB) is mandated to research to provide evidence-based policy recommendations. Colleges can provide the service by seasoned researchers by either doing research or participating in national-level forums and discussions. Following is the summary of the role of RUB in addressing Climate Change in the Country and beyond

1. Human Resources: RUB is one of the key players in the country to help build human capital with the knowledge of Climate Change and the Environment.

    a) The two colleges, Sherubtse College and College of Natural Resources offer various programmes such as PhD in Climate Change, MSc in Development Practices, MSc in Natural Resources Management, and Degree Programmes in Sciences such as BSc in Agriculture, Livestock and Forestry, Sustainable Development and many more. These graduates take up key positions in the Government and private sectors.

    b) RUB faculty and staff are members of various national technical committees such as the Water Committee, Biodiversity Committee, and Climate Change Coordination Committee to help support the evidence-based policy development of the Country.

2. Infrastructure: The university has 10 Research Centres dedicated to studying the various Sciences of Climate Change and Environment, namely:

95 http://www.nec.gov.bt/secretariat/division/climate-change-division

Table 18: Research Centre in Various RUB Universities

	College	Centre Name
1	College of Science and Technology	Centre for Renewable and Sustainable Energy Development (CRSED)
		Centre for Disaster Risk Reduction and Community Development Studies (CDRRCSD)
2	College of Natural Resources	Centre for Rural Development Studies (CRDS)
		Centre for Environment and Climate Research
		Centre for Sustainable Mountain Agriculture (CSMA)
3	Sherubtse College	Centre for Climate Change and Spatial Information
		Centre for Science & Environmental Research
4	Jigme Namgyal Engineering College	Centre for Appropriate Technology (CAT)
		Centre for Lighting and Energy Efficiency Studies (LEES)
5	Royal Thimphu College (RTC)	Himalayan Centre for Environmental Humanities (HCEH)

1.9.5 Multilateral Environmental Agreements (MEAs)

Multilateral Environmental Agreements are international treaties or agreements negotiated and adopted by multiple countries to address specific environmental challenges or issues of global concern. These agreements involve cooperation and coordination among participating member countries to work towards common environmental goals and objectives. They are legally binding agreements establishing the signatory countries' rights and obligations. Bhutan is a signatory and party to MEAs governing climate change, ozone depletion, biodiversity conservation, and hazardous waste management[96].

Table 19: Multilateral Environmental Agreement for climate change to which Bhutan is Party

	Convention	Date Adopted	Date Came into Force	Ratification/ Accession/ Succession Date
1	Convention on Biological Diversity (CBD)	June 5, 1992	1995	1995
2	Vienna Convention for the Protection of the Ozone Layer	1985	August 23, 2004	23 August, 2004
3	Montreal Protocol on Substances that Deplete the Ozone Layer	1987	August 23, 2004	23 August, 2004
4	Kigali Amendment to the Montreal Protocol	October 15, 2016	September 26, 2019	27 September, 2019
5	United Nations Framework Convention on Climate Change (UNFCCC)	June 1992	August 25, 1995	25 August, 1995
6	Kyoto Protocol	December 11, 1997	August 26, 2002	26 August, 2002
7	Paris Agreement	December 12, 2015	September 19, 2017	19 September, 2017
8	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	March 22, 1989	May 5, 1992	26 August, 2002
9	International Plant Protection Convention		June 1994	June 1994

96 National Implementation Plan for the System of Environmental-Economic Accounting in Bhutan, 2023

10	Ramsar Convention on Wetlands of International Importance Especially as Waterfowl Habitat	January 10, 2012	September 7, 2012	January 2012
11	UN Convention on the Law of Sea		December 1982	December 1982
12	Convention for International Trade in Endangered Species (CITES)		August 2002	August 2002
13	UN Convention to Combat Desertification		August 2003	August 2003
14	South Asian Wildlife Enforcement Network		January 2010	January 2010
15	Nagoya Protocol (Access and Benefit Sharing)			30 September, 2013

Table 20: Ministries involved in climate change[97]

Agency	Existing mandates	Climate Change Actions
Ministry of Agriculture and Livestock (MoAL)	The MoAL has the mandate to food and nutrition security, improve rural livelihoods and sustaining the management and utilization of natural resource. They derive their mandate through several Acts, Policies, and government directives (Seed Act, Biodiversity Act, Food and Nutritional Policy, National Forest Policy, etc.).	Management of soils as carbon sinks and also as areas for ecosystem-based adaptation, management of emissions from agriculture and livestock sector, and resilience of food, livestock sector, and biodiversity.
Ministry of Energy and Natural Resources	Sustainable development of energy and natural resources for the economic transformation of the country while ensuring environmental integrity.	The national agency responsible for environment and climate change planning, monitoring and reporting for the country. To conserve and manage natural resources through the adoption of innovative technologies to ensure socio-economic and environmental well-being. Achieve energy security by harnessing green energy resources, and adoption of transformative and innovative technological solution.
Ministry of Industry, Commerce, and Employment (MoICE)	The MoICE sets the agenda for the economic development of the country through the development of the manufacturing, trading, mining, and energy sectors. The various departments under the Ministry are governed by several different policies.	Integration of low-emission development strategies in energy and industry and provision of incentives for environmental performance as per EDP. Building resilience in energy and industry sectors.
Ministry of Infrastructure and Transport (MoIT)	The MoIT has the mandate to formulate and implement policies, regulations, and plans related to Surface transport, civil aviation physical infrastructure and human settlement.	Building resilience of human settlements and infrastructure. Managing GHG emission from transport, settlements, waste management.

97 https://faolex.fao.org/docs/pdf/bhu207787.pdf

Ministry of Health (MoH)	The MoH is mandated to ensure access, equity, and quality health services.	To carry out surveillance and control of climate sensitive diseases, building resilience of critical public health infrastructure against extreme events and long-term climate risks. Enhancing health emergency preparedness to respond to climate- induced disaster and enhancing surveillance and management of climate sensitive and vector borne diseases.
Ministry of Home Affairs (MoHA)	The MoHA is mandated to coordinate and monitor cross-sectoral issues related to immigration, local governance, culture, disaster management, law and order in the country;	Prepare for and respond to climate-induced disasters and local actions on climate change.
Ministry of Education and Skills Development (MoESD)	The MoESD is mandated to provide equitable and inclusive quality education and lifelong learning for all, through the provision of the necessary learning space and opportunity to harness their full potential as productive citizens.	Develop a curriculum on environment and climate change. Impart knowledge of climate change at different levels of the education system.
Ministry of Foreign Affairs and External Trade (MoFAET)	A professional Foreign Service that is responsive to Bhutan's interests and aspirations.	Guide on matters that are political for multilateral engagements.
Ministry of Finance (MoF)	Formulate and implement dynamic fiscal policy and strengthen public financial management (PFM) for effective resource mobilization, efficient allocation, prudent expenditure, and debt management with proper accountability of public resources.	Overall, the Ministry of Finance ensures adequate financial resources support Bhutan's climate change goals and sound economic policies. The MoF contributes to Bhutan's efforts to build a resilient and low-carbon future by effectively managing public finances and promoting sustainable development. MoF also provides or seeks green funds for climate change.
National Commission for Women and Children (NCWC)	The NCWC has the mandate to integrate gender and child-related issues into the policies, plans, and Programmes of all agencies.	Provide support in mainstreaming gender-responsive climate actions.
Other stakeholders (CSOs, NGOs, and Private Sector)	Private sector associations such as Bhutan Chamber of Commerce Industries, Association of Bhutanese Industries, Association of Wood Based Industries etc.	Facilitate and implement climate change actions.

1.9.6 Acts and Policies related to climate change and environment in Bhutan

The Constitution of the Kingdom of Bhutan: The policy aligns with the principle of state policy under Article 9.2 for the state to "strive to promote those conditions that will enable the pursuit of Gross National Happiness" and also Article 5 including the obligation for the royal government to "protect, conserve and improve the pristine environment and safeguard the biodiversity of the country" and "ensure a safe and healthy environment".

Table 21: Acts and policies related to environment and climate change in Bhutan

Acts/Legislation	Lead responsible agency (i.e., source data providers and users of the accounts)
Constitution of the Kingdom of Bhutan 2008	All relevant agencies on environment and biodiversity, with oversight by the Parliament of Bhutan
National Environment Protection Act (NEPA), 2007	DECC as the lead agency
Water Act of Bhutan, 2011	DoW (lead) DECC and others as relevant
Waste Prevention and Management Act of Bhutan, 2009	DECC, MoIT, Thromdes, Dzongkhags, Implementing Agencies under the Act
Waste Prevention and Management Regulation, 2012 and 2016	Implementing agencies: • Municipal waste Thromdes, • Medical waste – DoPH, • Industrial waste – DOI, • E-waste – Department of Information Technology (DoIT)/GovTech Agency Monitoring and evaluating agency – DECC under MoENR
Land Act of Bhutan 1979, revised 2007	National Land Commission Secretariat (NLCS)
Biodiversity Act of Bhutan 2003, revised 2023.	National Biodiversity Centre (NBC) Ministry of Agriculture and Livestock (MoAL)
Electricity Act of Bhutan, 2001	Bhutan Electricity Authority (BEA) (DOE) of the MoENR
Environment Assessment Act, 2000	DECC
Forest and Nature Conservation Act, 1995 (Updated version – Forest and Nature Conservation Act, 2023)	DoFPS, MoENR
National Biodiversity Strategic Action Plans	NBC, MoAL
Mine and Mineral Management Act, 1995	DGM, MoENR
Mines and Minerals Management Regulations, 2020	DGM, MoENR
Climate Change Policy of the Kingdom of Bhutan, 2020	DECC, MoENR
National Forest Policy 2011	DoFPS, MoENR
Pesticides rules & regulations of Bhutan 2019 Pesticide guidelines	DoA, MoAL
Pesticides Act of Bhutan 2000	DoA, MoAL
Livestock Act of Bhutan 2001	DoA, MoAL
Disaster Management Act of Bhutan 2013	DDM/DLGDM, MoHA

1.9.7 NDC Obligations and Commitments

Bhutan's Second Nationally Determined Contribution (NDC), submitted in June 2021, reaffirms the country's commitment to remaining carbon neutral, a pledge first made in 2009. As a small landlocked nation with a fragile mountainous ecosystem, Bhutan is particularly vulnerable to the adverse impacts of climate change, especially given its reliance on climate-sensitive sectors such as hydropower and agriculture. The NDC outlines priorities for low GHG emission development across sectors, emphasizing the need for international support.

Since the ratification of the Paris Agreement, Bhutan has integrated climate change into its national development planning, identifying "Climate Neutrality, Climate and Disaster Resilience" as a key result area in the 12th Five-Year Plan (2018-2023). This integration has led to the development of programmes aimed at both mitigation and adaptation. The government has also introduced fiscal incentives to promote environmentally friendly technologies and renewable energy projects, enhancing private sector participation in sustainable practices.

The Climate Change Policy of the Kingdom of Bhutan, 2020 aims to ensure that Bhutan remains carbon neutral while adapting to climate change efficiently. It emphasizes stakeholder participation and the need for adequate implementation resources. To coordinate climate actions, the Climate Change Coordination Committee (C4) has been revitalized, and a multi-stakeholder platform is being established to enhance collaboration across climate-sensitive sectors.

Bhutan has made significant strides in renewable energy development, with the Renewable Energy Master Plan outlining strategies for implementing various renewable technologies. The Sustainable Hydropower Development Policy integrates climate resilience measures and emphasizes adaptation strategies to address decreasing water flows affecting hydropower generation.

Furthermore, Bhutan's National Environment Strategy has been updated to incorporate climate change as a cross-cutting issue, ensuring that environmental policies address emerging challenges. The country has also implemented the REDD+ readiness Programme and established a National REDD+ Framework to support forest conservation efforts.

To facilitate low-emission development, several Low Emission Development Strategies (LEDS) have been developed, focusing on key sectors such as agriculture, human settlement, industry, and transport. These strategies aim to integrate low-carbon measures into national priorities while addressing gender considerations in climate action.

Despite facing challenges in securing support for Nationally Appropriate Mitigation Actions (NAMAs) and transitioning to zero-emission mobility through electric vehicles, Bhutan remains committed to achieving its climate goals. The National Waste Management Strategy aims for a circular economy by reducing landfill waste significantly by 2030.

Overall, Bhutan's Second NDC reflects a comprehensive approach to addressing climate change through mitigation and adaptation strategies while emphasizing sustainability and resilience in its development framework.

CHAPTER 2:
NATIONAL INVENTORY REPORT OF ANTHROPOGENIC EMISSIONS BY SOURCES AND REMOVALS BY SINKS OF GREENHOUSE GASES

2.1 Introduction

This chapter describes Bhutan's Greenhouse Gas Inventory for the inventory years 2021-2022. The inventory for the three main gases emitted, namely carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) is estimated while carbon monoxide (CO) and nitrogen oxide (NO_x) are not estimated for energy, IPPU and waste sectors as they are precursors to N_2O and CO_2 and it is assumed that eventually they get oxidized. However, NOx emission was estimated for manure management and others under category 3.A. The chapter also contains information on data sources, uncertainties, and QA/QC activities carried out. The inventory is prepared in accordance with annex to decision 18/CMA.1 on the Modalities, Procedures and Guidelines for the Enhanced Transparency Framework and paragraphs 8-24 of the Annex to Decision 17/CP.8 (UNFCCC, 2002), meant for reporting of National Communications (NC) from Non-Annex I Parties to the UNFCCC and the BUR Guidelines for NAI countries. The update is consistent with capacities, time constraints, data availability and the level of support received for reporting. This inventory is organized according to the 2006 IPCC Guidelines and covers the following sectors: Energy; IPPU; AFOLU; and Waste. GHG removals by sinks occur in the AFOLU sector as a result of improved forest management and reforestation. The inventory was prepared following the 2006 IPCC Guidelines using the IPCC 2006 Software.

2.2 Institutional Arrangement of GHG Inventory Process

The Department of Environment and Climate Change (DECC) under the Ministry of Energy and Natural Resources (MoENR) is the Designated National Authority on Climate Change issues and is also the National Focal Point to the United Nations Convention on Climate Change (UNFCCC). The DECC, through its Climate Change Division (CCD) led the Biennial Transparency Report (BTR) formulation process with support from the Global Environment Facility channeled through the Food and Agriculture Organization (Country Office-Bhutan) as the implementing agency (GEF Agency). The Bhutan Ecological Society and Druk Consult International Private Limited were assigned to support National Thematic Working Group (NTWG) in compiling the BTR.

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories provide detailed methodologies to estimate emissions and sequestrations for all the sectors and sub-sectors. A system of methodological tiers has been developed by IPCC to represent different levels of methodolog-

ical complexity. Tier 1 uses an IPCC default value; Tier 2 uses country specific emission factors that are based on either measurements or IPCC Tier 2 emission factors, and Tier 3 is the most demanding in terms of complexity and data requirements. Considering national circumstances related to data availability and efforts required to estimate emissions, the emission and sequestration estimates in the inventory for Bhutan mainly uses data sourced from national statistics and default emission factors under Tier 1.

To estimate emissions in CO_2 equivalents, a global warming potential (GWP) is used. GWP is a quantified measure of the globally averaged relative radiative forcing of a particular GHG (Table 5). It is defined as the accumulated radiative forcing within a specific time horizon caused by emitting 1 kilogram (kg) of the gas, relative to that of the reference gas CO_2. Direct radiative effects occur when the gas itself absorbs radiation. Indirect radiative forcing occurs when chemical transformations involving the original gas produces a gas or gases that are GHGs, or when a gas influences other radiative important processes such as the atmospheric lifetimes of other gases. All calculations in the present report use the Global Warming Potential (GWP) of GHGs for 100 years presented in the IPCC Fifth Assessment Report (IPCC AR5) as tabulated in Table 1 below.

Table 22: GWP of selected GHGs from IPCC AR5

Gas	Chemical Formula	GWP
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	265

In general, each method was applied based on the availability of data and analysis of key categories. The collection of data and information is still a challenge when compiling the GHG inventory for Bhutan. The data and information often come from national aggregated levels, but some are collected from point or direct sources. Considering the absence of national or regional emission factors, most of the calculations relied on IPCC default values and therefore uncertainty values for emission factors are relatively high.

For the energy, IPPU and waste emissions, precursor to GHGs (CO, NOx and NMVOCs) have not been estimated with the assumption that these will eventually be converted into CO_2, CH_4 or N_2O as provided in the IPCC 2006 Guidelines as "default CO_2 emission factors assume that 100% of the fuel carbon is oxidized to CO_2. This is irrespective of whether the carbon is emitted initially as CO_2, CO, NMVOC or as particulate matter.

Bhutan aspires to gradually improve its reporting by adopting higher tier methods as local capacity develops, and more disaggregated data becomes available. Bhutan's GHG inventory has been prepared using data from national statistics, surveys and activity data provided by different sectors.

For the national GHG inventory, in accordance with paragraph 12 of Decision 17/CP.8, to the extent possible, the key categories are analyzed, pursuant to IPCC Good Practice Guidance, to identify the subsectors that should be prioritized in terms of methodological refinement, taking into consideration the national circumstances, as well as the contribution of the identified subsectors to the total emissions.

A summary of methods and emission factors used for the National GHG Inventory is provided in Table 23.

Table 23: Overview of methodologies and emission factors used for estimating emissions and sequestrations for GHG Inventory

Gas	CO_2		CH_4		N_2O	
Categories	**Method**	**EF**	**Method**	**EF**	**Method**	**EF**
1- Energy						
1.A - Fuel Combustion Activities	T1	D	T1	D	T1	D
1.B - Fugitive emissions from fuels	T1	D	T1	D	T1	D
2 – IPPU						
2.A - Mineral Industry	T1, T2	D	T1	D	T1	D
2.B - Chemical Industry	NO	NO	NO	NO	NO	NO
2.C - Metal Industry	T1	D	T1	D	T1	D
2.D - Non-Energy Products from Fuels and Solvent Use	T1	D	T1	D	T1	D
2.E Electronic Industry	NO	NO	NO	NO	NO	NO
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NE	NE	NE	NE	NE	NE
2.G - Other Product Manufacture and Use	NO	NO	NO	NO	NO	NO
3 - Agriculture, Forestry, and Other Land Use						
3.A - Livestock	NO	NO	T1	D	NO	NO
3.B – Land	T1,T2	D,CS	T1	D, CS	T1	D, CS
3.C - Aggregate sources and non-CO2 emissions sources on land	T1	D	T1	D	T1	D
3.D – Other	NE	NE	NE	NE	NE	NE
4 – Waste						
4.A - Solid Waste Disposal	NE	NE	T1	D	NE	NE
4.B - Biological Treatment of Solid Waste	NE	NE	T1	D	NE	NE
4.C - Incineration and Open Burning of Waste	T1	D	NE	NE	NE	NE
4.D - Wastewater Treatment and Discharge	NE	NE	T1	D	T1	D
5 – Other	NE	NE	NE	NE	NE	NE

The output from the IPCC software 2.93 in the form of .json file was uploaded to the UNFCCC inventory reporting tool and the output was compared to the output of the IPCC inventory software. It was found that the ETF reporting tool reported lower emissions compared to the IPCC software and on closer scrutiny, it was found that emission estimates, particularly for CH4 and N2O were not converted using the GWP values. While the CRTs from the ETF reporting tool are annexed to this submission, the inventory team believes that any review should be done on the NAI reporting tables generated by the IPCC software and annexed to this submission.

While compiling the inventory, the team had issues on the IPCC software, particularly in filling the values for the wetland category as the software had no provision to fill in the values. Support was sourced from the UNFCCC secretariat and through them the IPCC, however, the issue hasn't been resolved and the current submission does not contain estimates of emissions and sequestration from the wetlands sub-category under AFOLU.

2.3 Quality Control and Quality Assurance

According to the 2006 IPCC Guidelines, national inventories have to be transparent, well documented, consistent, complete, comparable, assessed for uncertainties, and should be subjected to verification and QA/QC exercise. The quality system includes several procedures such as training of personnel, inventory planning and preparation, QA/QC procedures, peer-reviewed publications, data storage, and follow-up and improvements. The QA/QC plan also includes a scheduled timeframe describing the different stages of the inventory from its initial development to final reporting. The quality system ensures that the inventory is systematically planned, prepared, and followed up in accordance with specified quality requirements so that the inventory is continuously developed and improved.

1.8.8 Quality Control (QC)

Quality control is the check that is made during the inventory preparation on different types of data, emission factors and calculations that have been made. The quality control takes place according to general requirements (Tier 1) which applies to all types of data used as support material for the reporting, and the specific requirements for quality control (Tier 2) which are applied to certain types of data and/or emission sources. In this inventory preparation, the inventory team carried out general Tier 1 QC measures in accordance with the 2006 IPCC Guidelines comprising of the following:

- Check whether assumptions and criteria for the selection of activity data, emission factors, and other estimation parameters were documented, compared with international agency estimates.
- Check for transcription errors in data input and references.
- Check that emissions and removals are calculated correctly.
- Check that parameters and units are correctly recorded and that appropriate conversion factors are used.
- Check the integrity of database files.
- Check for consistency in data between source categories.
- Check that the movement of inventory data among processing steps is correct.
- Check that uncertainties in emissions and removals are estimated and calculated correctly.
- Check time series consistency.
- Check completeness.
- Compare the reference and sectoral approach.
- Check whether assumptions and criteria for the selection of activity data, emission factors, and other estimation parameters were documented, compare with international agency estimates.
- Check for consistency in data between source categories, particularly crosschecking data derived from national statistics with sectoral data.

The QC conducted for this submission included checks on AD and EF by the Consultant Team and the NTWG.

1.8.9 Quality Assurance (QA)

According to IPCC Good Practice Guidance, good practice for QA procedures requires an objective review to assess the quality of the inventory and to identify areas where improvements should be made. In this inventory preparation exercise, the approval by the National Environment Commission is considered as a part of the QA process.

CHAPTER 3:
NATIONAL EMISSIONS AND SEQUESTRATION ESTIMATES

Bhutan recorded a total GHG emissions of 1,742.51 Gg CO_2e in 2022 which includes 559.38 Gg CO_2e from Energy, 673.93 Gg CO_2e from IPPU, 410.18 Gg CO_2e from agriculture, and 99.01 Gg CO2e from Waste. The total sequestration is estimated at 11,450.45 Gg CO_2e (By forest, cropland, and grasslands) in the same year. At the same time, sequestration increased as compared to previous years due to addition of sequestration in below ground biomass, by perennial crops, including agroforestry and orchards. The net emission in 2022 was -9707.94 Gg CO_2e.

As shown in Table 24, Figure 47, emissions dropped in 2022 as compared to the reference year of 2019 owing to the COVID-19 pandemic and its impacts, as policies and measures to revive the Bhutanese economy were recently introduced.

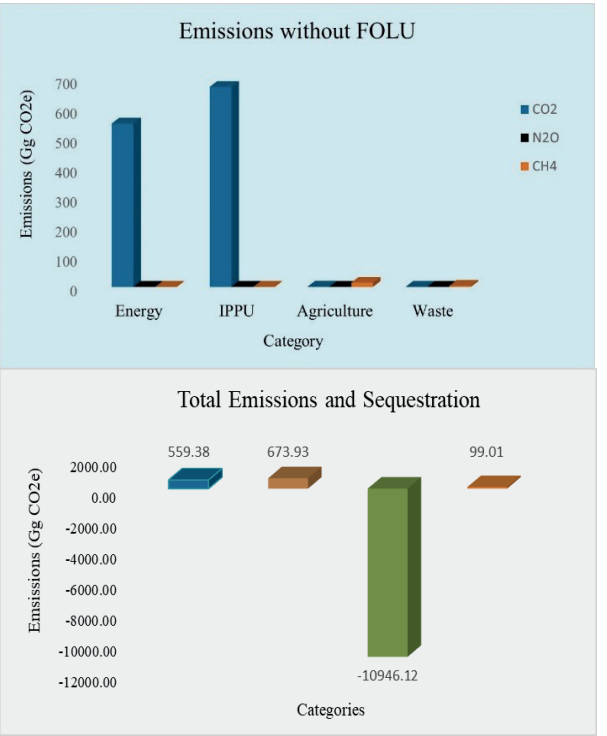


Figure 47: National emissions and sequestration estimates

Table 24: National Emissions and Sequestration Estimates

	Emissions (Gg)			Emissions (Gg CO2e)
Category	**CO2**	**CH4**	**N2O**	
Energy	550.44	0.06	0.03	559.38
IPPU	673.93	0	0	673.93
Agriculture	0.73	13.89	0.08	410.18
Waste	0.003	3.54	0	99.01
FOLU	-11356.30	0.00	0.00	-11356.30

3.1 Energy

The energy sector, which includes the consumption of fossil fuels and their associated fugitive emissions, is the second highest GHG emitting sector in Bhutan in 2022 contributing to 39% of the total GHG emissions with a total emission of 559.38 Gg CO_2e.

Emissions in the energy sector in Bhutan can be attributed to the 1.A.2- manufacturing industries and construction (fossil fuel use as energy sources for the manufacture of TMT bars and cement), 1.A.3- transport (civil aviation and road transport) and 1.A.4- others (use of kerosene and LPG as energy sources in the residential and commercial sectors). As energy is sourced from clean and renewable hydropower sources, Bhutan has no emissions in 1.A.1- energy industries and reliable data is not available to estimate emissions from the diesel generator sets used as back-up power source during grid failures.

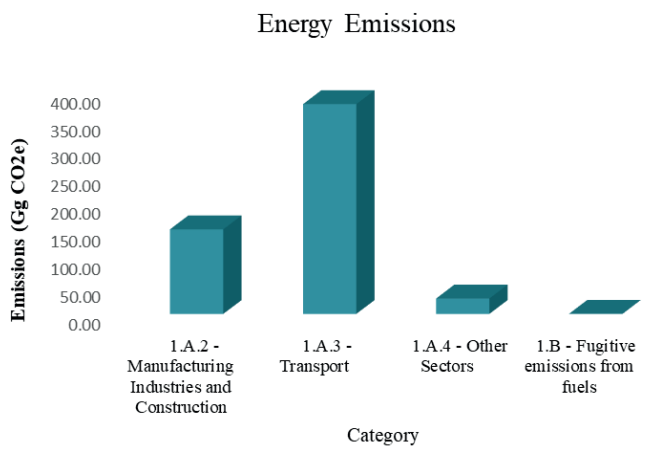


Figure 48: Emissions from Energy sector

3.1.1 Energy Industries

While there are no heat plants in the country or petroleum refinery, it is assumed that there are no emissions from electricity generation, as the primary source of electricity in the country is run-of-the-river hydropower plants whose emissions

are considered to be zero. While attempts have been made to collect activity data in the form of diesel oil used to power back-up generators, not every generator owner has kept diesel quantities used in 2021 and 2022 and therefore, diesel fuel used for electricity generation is considered to be zero. However, it is ensured that there is no underestimation of emissions as any diesel use not accounted for under the electricity generation is already assumed to be used in the transport sector and corresponding emissions estimated.

3.1.2 Manufacturing industries and construction

The manufacturing industries in Bhutan meet a significant portion of their energy requirement from the national electricity grid except for a portion of the energy requirement in the iron and steel and cement industries. The energy related emissions are mainly from diesel consumption in boilers, coal used in cement plants and furnace oil/ residual fuel oil used in the rolling mills to re-heat billets. As disaggregated data on fuel use in the construction industry is not available, emissions arising from the combustion of fuels in the construction sector are attributed under transport sector (1A.3).

The activity data for this category is sourced from the Bhutan Trade Statistics 2019-2022 published by the Ministry of Finance and validated from the Annual National Environment Accounts published by the National Statistics Bureau. The entire coal imports and a portion of the diesel imports as reported by individual industries are reported in this category. The IPCC emission factors were used in the absence of country-specific fuel characteristics and emission factors. In 2022, emissions from this category using the default emission factors were 152 Gg CO_2, 0.01 Gg CH_4 and 0.002 Gg N_2O.

3.1.3 Transport

As a landlocked country heavily reliant on road transport, emissions in 1.A.3 are also considered lifeline emissions. Energy use in the transport sector relied partially on published sources for gasoline/diesel and aviation kerosene imports, namely the Bhutan Trade Statistics (2019-2022). To avoid overestimation from double-counting fuels in the energy industries, manufacturing industries, and transport, the activity data used in transport includes all imports of diesel and gasoline. Emissions from the Transport category were from road and air transportation. A tier one methodology was adopted using fuel import data, and default IPCC emission factors resulting in emission of 370 Gg CO_2, 0.05 Gg CH_4 and 0.02 Gg N_2O. 90% of gasoline and 5% of diesel imports were allocated to transport by cars while 10% of gasoline imports and 15% of diesel imports were allocated to Light Duty Trucks. 80% of diesel imports were attributed to heavy duty trucks based on expert judgement from industry professionals and fuel dispensers.

Emission from domestic aviation was 1.16 Gg of CO2 in 2022 and this is attributable to limited domestic commercial flights in operation in the three domestic airports. In addition, the flight time between these domestic airports is less than an hour's journey.

The data on the split between domestic and international aviation was obtained from the Department of Air Transport under the Ministry of Infrastructure and Transport. While previous estimates assumed a split of 70% and 30% for international and domestic aviation respectively, the current estimate reflects actual fuel use resulting in a split of 95% and 5% between international and domestic aviation.

3.1.4 Others

Energy use in this subcategory includes the consumption of biomass and fossil fuels (LPG and kerosene) in the residential and commercial/ institutional sectors. Electricity generated from hydropower meets most of the energy demand in Bhutan, and biomass is used as a source of energy for cooking and space heating, especially in rural areas. In contrast, LPG is used mainly for cooking and kerosene for space heating in urban areas. The emission is estimated based on the fuel import data from the Bhutan Trade Statistics (BTS) 2019-2022 and results in an emission of 27.75 Gg CO2 in 2022. While 100% of the kerosene imports were attributed to residential sectors, the commercial-use LPG imported was allocated to the commercial sector.

3.1.5 Fugitive emissions from fuels

Bhutan has five surface coal mines, and production data from the mine and default emission factors are used to estimate the fugitive emissions under mining and post mining seam emissions of 0.26 Gg and 0.35 Gg of CO_2 in 2021 and 2022 respectively. The activity data for this estimate is sourced from the annual production data maintained with the Department of Geology and Mines under the Ministry of Energy and Natural resources.

3.2 Industrial Processes and Product Use (IPPU)

In Bhutan, several important industrial processes account for the emissions of greenhouse gases. Major industries include those in the "mineral products" category (e.g., cement production), chemical industries, silicon carbide and metal industry (ferroalloys). Each of these categories is discussed in the sections below.

IPPU was the largest emitter of anthropogenic GHG emissions in Bhutan accounting for 674 Gg CO_2 in 2022. The industrial sector's activity data was obtained from annual trade statistics and the national industrial license database. While efforts have been made to obtain plant specific activity data, numerous discrepancies were observed in the quantity of reductants imported.

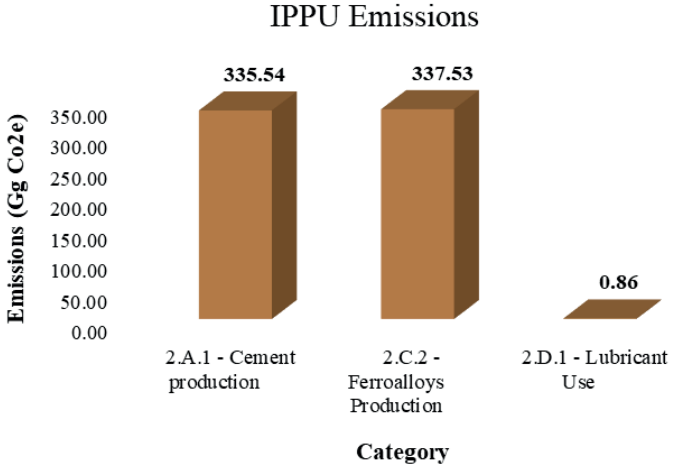


Figure 49: IPPU Emissions

3.2.1 2.A.1 Cement Production

Bhutan has three large cement plants and 1 small plant producing various types of cements. The key emission in this category is from the production of clinker where the calcination of limestone occurs resulting in the emission of process emissions (CO_2). Activity data on clinker production was taken from the industries and default emission factors were used to estimate the process emissions. As clinker data was used and not cement production data, the emission estimates are more accurate than those reported in previous submissions. The production of clinker in Bhutan resulted in a total emission of 335.54 Gg CO_2 in 2022.

3.2.2 2.C.2 Ferroalloys production

The metal industry (Ferro alloys) accounted for the largest share of emissions with 337.5 Gg CO_2 in 2022 and this is one of the fastest growing industries in Bhutan. The non-energy use of fuels, particularly fossil based reductants (non-coking coal, semi coke, coal) reduce the silica in quartz/quartzite and metal containing ores which then fuse to form the ferro alloys, particularly, ferro silicon and ferro manganese. While efforts were made to collect plant specific activity data, reliability of these data was questionable and national level data were used to estimate the emissions. In the Bhutan Trade Statistics (2019-2022), import of semi coke was attributed to the ferro alloy sector and while these may lead to reduced accuracy in emission estimates, the overall inventory would not contain underestimations as all imported fuels were accounted for.

3.2.3 Lubricant Use

The import data on lubricants was sourced from the Bhutan Trade Statistics and default emission factors were used to estimate the emission from this category resulting in the emission of 0.86 Gg CO_2 in 2022. Since the activity data reflects only those quantities of lubricants imported through import licenses and open borders exist between India and Bhutan, industry experts feel that the quantities reported are much lower than actual imports. The inventory team, however, does not have sufficient data to estimate the actual imports.

3.3 Agriculture, Forestry, and Other Land Use (AFOLU)

In 2022, Land Use Land Use Change and Forestry (LULUCF) was a CO_2 sink for -11356.30 Gg CO_2e without non-CO_2 emission from biomass burning in forest land. Sequestration was -11374.09 of Gg CO_2efrom Forest land; -65.02 of Gg CO_2e from Cropland; -11.34 of Gg CO_2e from grassland respectively while emission from Settlements was 25.93 Gg CO_2 e and 68.21 Gg CO_2 e from Other land. Emissions from the livestock sector contributed 365 Gg of CO_2e corresponding to 21% of total national emissions in 2022, mainly in the form of CH4 emission from enteric fermentation (91%) and marginally in the form of N2O from manure management (9%).

Emission from the Agriculture sector contributed 45.18 Gg CO2e corresponding to 2.59% of total national emissions in 2022, mainly due to CH_4 emission from rice cultivation (62.31%) and marginally due to direct N_2O emission from rom manure managed soils (15.96%); Indirect N2O Emissions from manure management (13.81%); indirect N2O Emissions from managed soils

(6.29%) and due to Urea application (1.62%) of emissions from agriculture.

3.3.1 3.A. Livestock

The livestock sector in Bhutan is dominated by cattle, yaks, goats, pigs, and sheeps. Cattle, with a population of approximately 255,000 heads, are the largest contributors to milk production, while yaks and yak crosses known as zo and zom, numbering around 38,000 are essential for high-altitude communities. Poultry production has seen significant growth, with over 1.2 million birds supporting egg and meat production. Small ruminants, such as goats and sheep, contribute to meat, wool, and other products with a combined population of 70,000. Livestock production systems in Bhutan are evolving, with a shift from traditional free-grazing systems to semi-intensive and intensive production systems especially for dairy, pig, and poultry.

Livestock population could not be characterized/categorized as per the Table 10.1 – Representative livestock categories of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories mainly due to lack of complete disintegrated data. All activity data were adopted from the Annual Livestock Statistics (Department of Livestock 2004-2022) and the Annual Integrated Agriculture and Livestock Census (National Statistics Bureau 2023 & 2024) publication as follows.

a. Cattle:

Cattle populations were categorized into two groups – 1) mature dairy cows (cows that have calved at least once and are used principally for milk production) and 2) other cattle (breeding bull, bullock, heifer, grower bull, calves) as subcategories. For the estimation of the GHG emissions, 37% of the total cattle population estimated were mature cows that have calved at least one calf and produced milk are considered as dairy cows, and the remaining 63% were grouped under other cattle category. Since the overall average lactation yield of the cattle was lower than 1456 kg of milk, mature dairy cows population were not further disintegrated as the high yielding and low producing cows as per Table 10.1 Representative livestock categories, Chapter 10 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Yak population is grouped under cattle for the estimation of GHG emission although yak is considered as the potential "low carbon" ruminant. Yak is reported to produce about 1.7g of methane /kg W0.75 under grazing conditions, which is lower than the cattle between 3.2-4.2g of methane/kg W0.75 (Ding et al., 2010 & Thorpe, 2009). While average body weight for cattle was estimated at 300 Kgs in Bhutan (Samdup ***et al***, 2010) and 328 Kg (Wangdi, 2014), a default value of dairy-cows for Indian sub-continent (ISC) of 275kg and 110kg for other cattle were adopted in absence of empirical evidence on the weight of other cattle categories.

b. Buffalo:

Considering small number of buffalo population in the country, the data were not disaggregated, and for the GHG estimation whole population is considered as a single population

c. Sheep:

Disintegrated data by sub-categories (lamb, growing, ewes) are not available for sheep population in the country. As such, the total sheep population is considered under one

group for the estimation of GHG estimation.

d. Goats:

Segregated information by sub-categories (kids, growing, doe) was not available for goat population. As such, the total goat population is considered under one group for the estimation of GHG emissions.

e. Horses, mule and asses:

The mule and asses population for 2020-2022 was not available, as it was forecasted in excel worksheet using the forecast function for the period.

f. Swine:

Pigs are maintained for breeding purposes to produce parent stocks and piglets, and for fattening purposes to produce pork. Disintegrated data by the sub-categories for the swine population is not available. Local pigs constitute about 10% of the total pig population in the country. Nonetheless, for the GHG estimation the population is not disintegrated into local and improved breed/type. Improved pig breeds reared in the country are Large white, Landrace, Saddle black, and Duroc.

g. **Poultry:**

Poultry population includes both indigenous and improved poultry. It is mainly reared for egg and chicken. As disintegrated data are not available for the broiler and layer, single population of poultry was adopted for the estimation of emissions. The local poultry constitutes about 13% of total poultry population in the country. The poultry population comprises both layer and broiler birds, and the lifespan of broiler was considered similar to layer.

Given the human resource capacity and financial constraint, country specific emission factors could not be established as of date. As such, default emission factors relevant to our country considering the geolocation, production or the farming system and climatic conditions are identified and adopted for this inventory. Following default emission factors were adopted considering the similar nature of livestock farming practices, and environment conditions.

Table 25: Default emission factors adopted for Enteric fermentation

Livestock Species	Emission Factor for Enteric fermentation	Emission factor for Manure Management, uncertainty
High yielding cows (Dairy cattle)	58 kg CH4/hd/year of Indian Subcontinent, Table 10.11	9 Kg CH4/hd/yr, Table 10.14, Asia; Average milk production of 900Kg kg/hd/year
Low yielding cows	58 kg CH4/hd/yr of India sub-continent, Table 10.11	
Bulls used for draft (Other cattle)	27 kg CH4/hd/year, Indian Subcontinent, Table 10.11	9 Kg CH4/hd/yr, Table 10.14, Asia
Bulls used for breeding	47 kg CH4/hd/year	
Calves pre wean	47 kg CH4/hd/year	
Growing fattening	47 kg CH4/hd/year	
Swine	1 kg CH4/hd/yr of developing country, Table 10.10; ±30-±50%	2 Kg CH4/hd/yr, Table 10.14, Asia

Buffalo	55 kg CH4/hd/yr of developing country, Table 10.10, ±30-±50%	4 Kg CH4/hd/yr, Table 10.14, Asia
Sheep	5 kg CH4/hd/yr of developing country, Table 10.10, ±30-±50%	0.1 Kg CH4/hd/yr, Table 10.15, Developing countries
Goat	5 kg CH4/hd/yr of developing country, Table 10.10, ±30-±50%	0.11 Kg CH4/hd/yr, Table 10.15, Developing countries,
Horses	18 kg CH4/hd/yr of developing country, Table 10.10, ±30-±50%	1.09 Kg CH4/hd/yr, Table 10.15, Developing countries,
Mule and Asses	510 kg CH4/hd/yr of developing country, Table 10.10, ±30-±50%	0.60 Kg CH4/hd/yr, Table 10.15, Developing countries,
Poultry – Layer	NA in , Table 10.10, ±30-±50%	0.01 Kg CH4/hd/yr, Table 10.15, Developing countries,
Poultry - Broiler	NA in Table 10.10, ±30-±50%	0.01 Kg CH4/hd/yr, Table 10.15, Developing countries
Fraction of manure N that is lost in the MMS (%): - Frac(lossMS), Table 10.23	Liquid slurry (dairy): 40 Liquid slurry (other): 40 Liquid slurry (swine): 48 Poultry with litter (poultry): 50	
Fraction of managed manure N that volatilizes (%): Frac(GasMS), Table 10.22	Liquid slurry (dairy): 40 Liquid slurry (other): 40 Liquid slurry (swine): 48 Poultry with litter (poultry): 40	Emission factor for N2O emissions from N leaching and runoff [Kg N2O-N/(kg N leached and runoff)] (EF5) = 0.0075
Fraction of managed manure N that leaches (%): Frac(LeachMS), Table 10.22; 2006 IPCC guidelines	Liquid slurry (dairy): 25 Liquid slurry (other): 25 Liquid slurry (swine): 25 Poultry with litter (poultry): 25	
N in organic Bedding (solid storage and deep bedding MMS – otherwise zero) (kg N/animal/yr): N (beddingMS)	NA	

The overall average temperature for the country was estimated, and accordingly the region was adopted for the GHG inventory. The overall average temperature estimated was 17.08 degree Celsius for the country (See https://www.nchm.gov.bt/home/pageMenu/778), which falls between 15 to 25 °C. Therefore, the temperate cold region (>15 to 25 °C) was adopted for this GHG compilation.

The livestock production system is changing with more opting for high producing animals over the period. However, the rate of change remain sgradual with increasing investment required to adopt high yielding animals. To this, traditional livestock practices such as migratory system of livestock farming, and open grazing still persist and remain a dominant cattle farming system in Bhutan. Feeding practices include stall feeding (gaining popularity among the progressive dairy farmers particularly in the peri urban areas), pasture based and open grazing.

The following manure management combination has been adopted for different livestock categories based on expertise judgement for the estimation of the GHG emission.

Table 26: Types of manure management system adopted

Sl. No	Categories	Manure management type	Fraction adopted (%)
1	Dairy	Pasture/Range/Paddock	0.80
		Liquid/slurry	0.20
2	Other cattle	Pasture/Range/Paddock	0.80
		Liquid/slurry	0.20
3	Buffalo	Pasture/Range/Paddock	1
4	Sheep	Pasture/Range/Paddock	1
5	Goat	Pasture/Range/Paddock	1
6	Horse	Pasture/Range/Paddock	1
7	Mules & asses	Pasture/Range/Paddock	1
8	Swine	Liquid/slurry	0.90
		Pasture/Range/Paddock	0.10
9	Poultry	Pasture/Range/Paddock	0.1
		Poultry manure with litter	0.9

In 2022, emissions from the livestock sector contributed 365 Gg of CO2e corresponding to 21% of total national emissions in 2022, mainly in the form of CH4 emission from enteric fermentation (91%) and marginally in the form of N2O from manure management (9%).

Table 27: Emissions from the livestock sector

Livestock	CH4 (Gg)	N2O (Gg)	Emissions (Gg CO2e)
3.A.1 - Enteric Fermentation	11.92	0.00	333.74
3.A.2 - Manure Management	0.97	0.02	31.26

3.3.2 3.B. LULUCF:

Forest and Other Land Use (FOLU) sector deals with greenhouse gas (GHG) emissions and removals resulting from land use such as forestry activities and its land-use change. GHG emissions and removals in this sector consist of carbon stock changes in five carbon pools (aboveground biomass, belowground biomass, dead wood, litter, and soil) in each land use category, such as forest land, cropland, grassland, wetland, settlements and other land in accordance with the 2006 IPCC Guidelines' land-use classification. Methodological tiers used in this sector are shown in Table 1. The land cover data of 1990, 2000, 2010, 2015, 2018 and 2023 produced using Landsat Satellite imagery was used to generate the time series land cover and land use data by interpolation and extrapolation method. The carbon density estimate from National Forest Inventory (NFI) was used to generate the emission factors wherever applicable.

All carbon pools are considered either by using the national statistics of NFI and adopting the default factors from the 2006 IPCC Guidelines, 2013 Wetland Supplement and 2019 Refinement of 2006 IPCC Guidelines based on the land remaining the same land and land undergoing the change. The statistics of timber removals, forest fire disturbance and area brought under plantation are obtained from Forestry Fact and Figures (FFF) or Annual Forestry Statistics (AFS) as well as other records maintained by Department of Forests and Park Services (DoFPS). The information on the paddy land and orchards (perennial crops) are collected from the Department of

Agriculture, Ministry of Agriculture and Livestock, Annual Statistics published by National Statistical Bureau (NSB).

Land-use areas are calculated from land and land cover maps of 1990, 2000, 2010, 2015, 2018 and 2023 by interpolation and extrapolation for intermittent years and years outside available data respectively. Land area have been consistently estimated for all land-use classes 1994 to 20202and new gains and losses are accounted from 1994 as a starting year and any changes before 1994 are not considered for the lack of data and to reduce introduction of potential uncertainties with interpolation and extrapolation. Further, the land under rice ecosystem and perennial crops are reported as land remaining same land in accordance with the Tier 1 methodologies 2006 IPCC Guidelines as prior land use or land cover are unknown. For biomass gains, the time since conversion has been considered. For mineral soils, the carbon stock changes have been estimated using equation 2.25 from 2006 IPCC Guidelines and Tier 1 stock change factors for land undergoing conversion while carbon stock are assumed to remain constant or at equilibrium for all land remaining the land same during the inventory period with default transition time of 20 years.

In line with the IPCC (2006) land use categories, the land type is Bhutan is classified into six broad categories: Forest Land, Cropland, Grassland, Wetlands, Settlements and Other Land. They are defined as:

a. Forest Land:

"Land spanning more than 0.5 hectares with trees higher than five meters and a canopy cover of more than 10%, or trees able to reach these thresholds *in-situ*. It does not include land that is predominantly under agricultural or urban land use." (NFP, 2011). This definition was used for FAO Global Forest Resources Assessment. All Forest Land is considered managed land and no sub-classification of the forest is used in this report as in earlier reporting.

b. Cropland:

All arable and tillage land, and agro-forestry systems where vegetation falls below the thresholds for the forest land category. All croplands are considered managed land and in the context of the inventory, they are classified into four categories with two main categories of Annual Cops and Perennial Crops. The Annual Crop land is further divided into two sub-categories of Annual Crop-Others and Annual Crop-Rice. Similarly, the Perennial Crop land is classified into two sub-categories of Perennial Crop -Bearing and Perennial Crop-Non-bearing.

c. Grassland:

All rangelands and pastureland that is not considered as cropland. It also includes systems with vegetation that fall below the threshold used in the forest land category and are not expected to exceed, without human intervention, the threshold used in the forest land category. All grasslands were considered managed land. No sub-classification of the grassland land into improved grassland and other category is made due to lack of data.

d. Wetlands:

All land that is covered or saturated by water for all or part of the year and that does not

fall into the forest land, cropland, grassland or settlements categories. In the context of GHG inventory, this land includes all rivers, lakes, reservoirs and marshy areas not included in the grassland.

e. Settlements.

All developed land, including transportation infrastructure such as roads, and human settlements of any size, unless they are already included under other categories. This category also includes airports, parks, yards, farm roads and barns. Settlements are considered managed land.

f. Other Land.

Includes bare soil and rock and vegetated lands on mineral soils, which are not included in any of the above five land categories defined above. All the other land areas are considered as unmanaged land.

Data source on which the areas of land use categories are based is the land use and land cover maps of Bhutan 1990, 2000, 2010 (Gilani et al., 2015), 2015 (FRMD 2016), 2018 and 2023 (FMID, 2024 ***draft report***). The land cover map of Bhutan 1995 (MoA, 1995), 2010 (MoA, 2010), and 2020 (NLCS, 2023) was not used as these products are developed using different satellite images with different spatial resolutions. For example, 1995 land use and land cover maps are produced using aerial photographs and spot images, 2010 was produced using ALOS images and 2020 using Sentinel II imageries. Therefore, forest area used in this inventory preparation may be slightly different from the area reported in global forest resource assessment (FRA) produced by FAO, which uses the statistics from 1995, 2010, 2015 and 2020 land use and land cover map. Data from the Forest Reference Emission Level and Forest Reference Level of Bhutan is used in this inventory as it provides information on the rate of conversion of forest land to non-forest land between 2005 to 2014.

For the purpose of GHG inventory in forestry sector, the activity data and emission factor data are extracted from following documents

- FRMD, 2018; National Forest Inventory Report Volume II
- FRMD, 2016; National Forest Inventory Report Volume I
- FRMD, 2018; Draft Forest Reference Emission Level/ Forest Reference Level
- Ministry of Agriculture, 1997; Atlas of Bhutan, Land Cover and Areas Statistics of 20 Dzongkhags.
- Ministry of Agriculture and Forest, 2010; Land cover Atlas of Bhutan, Land Cover and Area Statistics of 20 Dzongkhags.
- FRMD, 2016; Land use land cover maps of Bhutan
- IPCC Good Practice Guidelines for LULUCF 2003
- Forest Facts and Figure 2015, 2016, 2017, 2018, 2019
- Annual Forestry Statistics 2020, 2021, 2022, 2023
- Forest Information Reporting and Monitoring System (database)
- Forest Reference Emission Level
- Internal Working Document of Forest Reference Emission Level
- Gilani et al., 2015; Decadal land cover change dynamics in Bhutan, Journal of Environmental Management, 148 (2015), pp. 91-100.
- FRMD, 2017: Land use and land cover of Bhutan 2016, Maps and Statistics.

- FRMD, 2017: Land use and land cover of Bhutan 2016, Maps and Statistics.

The land area under different land use categories is obtained by extrapolation and interpolation of land area reported in decadal land cover change dynamics in Bhutan (Gilani et al, 2015) and Land use and land cover of Bhutan 2016 (FRMD, 2017). The land area under different land categories for 1990, 2000, and 2010 was extracted from Gilani et al. (2015); Land area for 2015 was obtained from land cover and land cover statistics of FRMD, 2016; Land area for 2018 and 2023 are extracted from the draft report on land use and land cover change report of 2018 and 2023 developed by DoFPS.

The land area for intermittent years from 1994 to 2022 was generated by linear interpolation method described in 2006 IPCC Guidelines and FAO Guidelines on FRA. While this may not be the best method to generate the land area under different land categories, this is the most appropriate and suitable considering the national circumstances and available data.

A combination of approaches 1 and 2 have been adopted to compute land conversion among the different land categories and following land-use specific assumptions used to produce complete and consistent time series data.

Table 28: Land use specific assumptions and methodologies applied

Categories	Assumptions	Methodologies
Land Categories		
Forest Land	• XC All plantations assumed to be carried out in the grassland. Hence, included as part of Grassland converted to forest land. • Based on the land use and land cover change draft report (2018-2023), the gains and losses in the forest assumed to be spread equally for all calendar years. • The Land Use and Land Cover Change draft report for 2018-2023 shows that forest land has gained from and loss to CL, GL, WL, SL and OL. Forest may have gained from or loss to these land categories by the same percentage for the year 2015-2017 for which there is no information for gains from specific land areas. For years outside 2015 no gains are estimated except the conversion of grassland to forest land (i.e. plantations).	• Forest area is determined by the interpolation of forest area in 2018 and 2023. Gierson and Long (1983)[99] classified Bhutan forest into 11 categories of subtropical forest, warm broad-leaved forest, cool broad-leaved forest, evergreen oak forest, chir pine forest, blue pine forest, spruce forest, hemlock forest, fir forest, juniper-rhododendron scrub forest and dry alpine scrub forest. Due to difficulty in extracting the time series data, determining the gains and losses in each category of forest land and lack of information prior land use and new forest type, this classification of forest is not used in the GHG Inventory d resulting from gains. • Therefore, it has been decided to report only one category of forest land.

99 Adapted from National Forest Inventory Field Manual 2020. The forest classification in the land cover and land use statistics are different from this category. However, Department of Forest and Park Services is currently developing forest type map of Bhutan and it is expected standardize the forest classification.

	• The gains in forest from 2005 to 2014 are adopted FREL and FRL of Bhutan • All forest land is managed • Non-CO2 emission from forest fire considered as part of emission from forest	• For the land converted to forest land, both above ground and below biomass is accounted and changes in other carbon pools are assumed to be in equilibrium • Emissions and removals from forest land remaining forest land have been estimated using a combination of Approach 1, 2 and Tier 1 and Tier 2. The country specific activity data, emission factor and removal factor are used for computing the emission and removals where available while IPCC defaults were used in other cases. • Carbon stock change in forest land remaining forest land is estimated using Gain-Loss method (equation 2.7 in 2006 IPCC Guidelines. • Non-forest land converted to Cropland are clubbed with Cropland remaining Cropland as prior land use before conversion is not known.
Cropland	• All land under rice ecosystems assumed to remain under same land category across the time series. • All land under perennial crops assumed to remain under same land category. Hence, no losses are estimated for the crops that reached maturity/harvest cycle or bearing fruits. • All conversion to cropland from non-cropland and losses to non-Cropland are assumed to occur in annual cropland excluding annual cropland under rice ecosystems. • Emission and removals from the crop land remaining cropland are assumed to be zero or in equilibrium except for perennial crops which are not fruiting (non-bearing perennial crops).	• Biomass gain area estimated for non-bearing perennial crops using the default values from IPPC guidelines • The emission under this land category is estimated only for forest land converted to crop land for the entire time series. • Carbon dioxide emissions and removals from changes in the area of perennial woody crops (orchards) are estimated using a Tier1 approach described in IPCC Guidelines for National Greenhouse Gas Inventories

Grassland	• All conversion to grassland from non-grassland and losses to non-grassland assumed to occur in managed. • All grassland area assumed to be managed land • All plantations assumed to be carried out in grassland and accounted as part of grassland converted to forest land	
Wetland	• All wetlands assumed to be managed	
Settlement	• All settlements assumed to be paved surfaces • All land under SL is managed	
Other land	• All land under OL is unmanaged	
Biomass Carbon Stock Change		
	• All SOC is lost when forest land is converted to other land over 20 years transition period • 20% of SOC is lost when forest land is converted into settlement • A default value of SOC in wetland soils 82 t C ha-1 in the 2019 IPCC supplement to 2006 IPCC Guidelines for National GHG Inventories is used for estimating SOC stock change in conversion of forest land to wetland. • Carbon fraction of 0.47 is used for all carbon pools based on IPCC default values which is within the range of carbon content studied in one pocket of Bhutans's forest (Tashi et al., 2017)[100] The study found carbon centration in the range of 46.02–46.81%, which falls within the IPCC default range • When the forest land is converted to the Cropland, entire biomass carbon is assumed be lost	• Emissions and removals from understory vegetation are assumed to balance out as they are generally herbaceous in nature. The carbon stock change in land converted to forest land is estimated using 2.15 of IPCC 2006 Guidelines.

100 Sonam, Tashi, Claudia Keitel, Balwant Singh and Mark Adams, Allometric equations for biomass and carbon stocks of forests along an altitudinal gradient in the eastern Himalayas. Forestry-An International Journal of Forest Research, 2017.

Mineral Soil Carbon Stock Change		
	• All SOC is lost when forest land is converted to other land over 20 years transition period • 20% of SOC is lost when forest land is converted into settlement • A default value of SOC in wetland soils 82 t C ha^{-1} in the 2019 IPCC supplement to 2006 IPCC Guidelines for National GHG Inventories was used for estimating SOC stock change in conversion of forest land to wetland. • Land use and land cover conversion in the base year (1994) are assumed to be the first year of the conversion and the transition period of 20 years is counted from 1994 to avoid introduction of new errors.	
Gains in Carbon Stock		
	• Biomass gain occurs in both aboveground and below biomass • Gain in other carbon pools (dead wood, litter and soil organic carbon) assumed to be zero or in equilibrium • Default biomass growth rate of plantations (5 t.d.m $ha^{-1}yr^{-1}$), which is two times higher compared to annual increment in natural forest of Bhutan, which is estimated to be 2.43 t.d.m $ha^{-1}yr^{-1}$ (FRMD, 2023). Therefore, this growth factor is used both for natural forest and plantations as well as land converted to forest land.	• Annual change in living biomass in forest remaining forest is the net result of uptake due to forest growth and losses due to forest harvesting. • Biomass growth is only estimated for the aboveground living tree biomass • Growth of biomass in understory vegetation is not estimated due to lack of data. • The annual increase biomass is estimated using 2.9 in IPCC guidelines, 2006 for aboveground living tree biomass. • 2.43 t.d.m $ha^{-1}yr^{-1}$ (FRMD, 2023) is applied for estimating the gain in carbon stock in land converted to forest land

Carbon Stock Loss		
	• Wood removal-timber harvesting • Fuelwood collection - Carbon stocks lost through consumption of fuelwood from the residential sector are assumed to be collected as whole tree • Forest disturbance - During the fire disturbance, there is no change in DOM and herbs and shrubs carbon pools. Forest damaged by fires is not generally accompanied by land use change but remains as forest land and they regrow within one to two years • The average biomass expansion factor of Bhutan's forest is 1.561 and average wood density is 0.553.	• The entire volume of round timber and firewood harvested from the forest are considered as instantaneous emission and no separate estimates are made for harvested wood products due to lack of technical capacity. • Both CO2 emission (as part of disturbance) and non- CO2 emission from forest fire disturbance is estimated using IPCC default emission and combustion factor • Annual loss in biomass due to harvesting and forest disturbance is estimated using equation 2.11 of IPCC 2006 guidelines • Loss in carbon stock due to wood removals is estimated using equation 2.12 of IPCC 2006 • Country specific biomass conversion and expansion factor is applied to estimate the loss of carbon from the round timber. The instantaneous loss of carbon is assumed for aboveground biomass and loss of belowground biomass, dead wood, litter and soil carbon is assumed to be zero due to lack of data. • The loss of carbon stock due to fuel wood removal is estimated using equation 2.13 of IPCC 2006 • Any wood removed from fire damaged area are accounted and included as part of wood removal and therefore no separate estimation of CO2 emission from fire is carried out in this inventory

3.3.3 3.C. Agriculture

There is no published data on the categorization of the rice production system in Bhutan. Hence, BUR 1 data were considered for the categorization of the rice production system in Bhutan which itself is based on the expert judgment from Agriculture Research and Development Centre under the Department of Agriculture.

Based on the expert judgment, the irrigated rice production systems are divided into following categories:

i. Continuously flooded [15%]
ii. Intermittently flooded single aeration [14%]
iii. Intermittently flooded multiple aeration [21%]
iv. Regular rainfed [25%]
v. Drought prone [25%]

All rice cultivation systems were categorized under warm temperate moist as Bhutan's rice cultivation system falls under subtropical domain which has two regions namely, warm temperate moist and warm temperate dry. From these two regions, the warm temperate moist is the most appropriate for rice cultivation in Bhutan. The soil type of Bhutan are mostly Cambisols that comes under high activity clay minerals. High Activity Clay Minerals are selected under soil type. The Ration of below-ground biomass to above-ground biomass (t root C/t shoot C) is taken as 1:3 that is 0.33. The cultivation period is less than 180 days (generally its 160 days in the country). The base line emission factor is default value 1.3. The scaling factor to account for the differences in water regime in the cultivation period is as follows.

Table 29: Scaling factor to account for the differences in water regime in the cultivation

Rice ecosystem	Water regime	The scaling factor to account for the differences in water regime in the cultivation period	Scaling factor to account for the differences in water regime in the pre-season before thecultivation period	Scaling factor for both type and amount of organic amendment applied
Irrigated	Continuously flooded	1	1	1
	Intermediately flooded (multiple aeration)	0.52	1	1
	Intermediately flooded (single aeration)	0.6	1	1
Rainfed	Drought Prone	0.25	1	1
	Regular rainfed	0.28	1	1
Upland	Upland	0.00	1	1

3.4 Waste

Waste is an emerging issue in Bhutan and the Royal Government of Bhutan has tried addressing the issue through the implementation of a National Waste Flagship Programme in the 12th Five Year Plan and while the flagship programme has been discontinued, activities on waste management is continued through sectoral interventions in the current 13th Five Year Plan. The highest uncertainty in the national GHG inventory would be in the waste category as data is not available both

at disaggregated levels and updated throughout the time series. The only comprehensive national waste data is available for a single year in the form of the National Waste Inventory Survey Report, 2019.

Therefore, using population data and default emission factors, the waste category had an emission estimate of 99.01 GgCO2e in 2022.

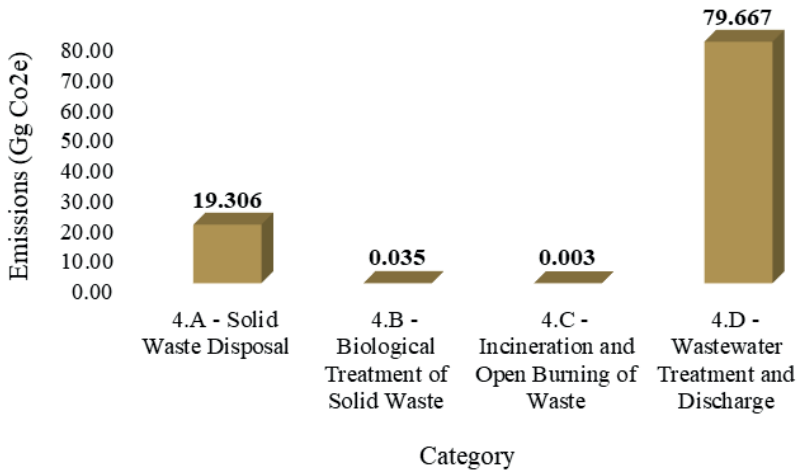


Figure 50: Emission from Waste

3.4.1 Solid Waste Disposal

Using population projection data from the Population and Housing Census 2017, per capita waste generation rate of 0.23 kg waste/capita-day and 50% of waste composition as organic waste from the National Waste Inventory Survey Report (2019), emission estimates were developed assuming that waste disposal on land happens in both landfills and unclassified waste disposal methods. IPCC default emission factors were used with these activity data to generate the emission estimates resulting in 0.69 Gg CH_4 in 2022.

It must however be noted that the surrogate data (population projection) is not the actual population of Bhutan and that no updated statistics is available to correctly reflect the annual population. Additionally, the waste characteristics and generation rates need further review to improve the accuracy of the emission estimates.

3.4.2 Biological Treatment of Solid Waste

There is no published data on the amount of waste being composted and the inventory team had to rely on the expert judgement of the Dzongkhag Environment Officers and ***Thromde*** officials to allocate 5% of waste generated as being composted. IPCC default emission factors were used with the assumed activity data resulting in the emission of 0.04 $GgCO_2e$ in 2022.

3.4.3 Incineration and open burning of waste

While it was reported that medical and infectious wastes from the hospitals were incinerated, actual quantities of such wastes being incinerated were not available. During the consultation meetings, it was also informed that cardboard and packaging wastes were occasionally subjected to open burning, and it was through a collaborative effort that 5% of cardboard and packaging wastes were open burnt. Using IPCC default emission factors and assumed activity data, emission of 2.7 t CO_2 for 2022 was derived.

3.4.4 Wastewater Treatment and Discharge

Bhutan has only two lagoon treatment systems in Phuentsholing and Gelephu and 1 large compact treatment system in Thimphu with several compact treatment systems in most of the urban areas. In the absence of actual wastewater characteristics and quantities and in accordance with IPCC guidelines, population data was used as a surrogate with default emission factors. For industrial wastewater, production data from the breweries and distilleries were used to estimate the emissions. This resulted in the emission of 79.67 $GgCO_2e$ for this category in 2022.

3.5 Key Category Analysis

Key categories are defined as sources of emissions or removals that have a significant influence on the inventory, in terms of emission levels, the trend, or both. When summed together in descending order of magnitude, key categories add up to over 95% of total emissions (level assessment) or the inventory trend in absolute terms. The analysis of key categories was performed based on sectoral distribution and the Tier 1 approach for level estimates. The key categories from the analysis are presented in Table 34 and Table 35.

The analysis of key sources followed the 2006 IPCC Guidelines. IPCC Software Version 2.93 was used to populate the activity data and estimate the emissions. Two approaches can be used to determine the key categories: the level approach if only one year of data is available, and the trend approach if there are two comparable years.

Table 30: Level of Approach

A	B	C	D	E	F	G	H
IPCC Category code	IPCC Category	Greenhouse gas	2019 Year Estimate Ex0 (Gg CO2 Eq)	2022 Year Estimate Ext (Gg CO2 Eq)	Trend Assessment (Txt)	% Contribution to Trend	Cumulative Total of Column G
2.C.2	Ferroalloys Production	CARBON DIOXIDE (CO2)	121.68	337.53	0.01	0.25	0.25
2.A.1	Cement production	CARBON DIOXIDE (CO2)	490.05	335.54	0.01	0.22	0.46
1.A.3.b	Road Transportation - Liquid Fuels	CARBON DIOXIDE (CO2)	493.44	369.60	0.01	0.18	0.64
3.A.1	Enteric Fermentation	METHANE (CH4)	400.03	333.74	0.01	0.10	0.75
1.A.2	Manufacturing Industries and Construct	CARBON DIOXIDE (CO2)	64.09	132.68	0.00	0.08	0.82
3.B.1.a	Forest land Remaining Forest land	CARBON DIOXIDE (CO2)	-11983.19	-11350.33	0.00	0.04	0.86

3.B.1.a	**Forest land Remaining Forest land**	**CARBON DIOXIDE (CO2)**	**-11983.19**	**-11350.33**	**0.00**	**0.04**	**0.86**
3.B.2.a	**Cropland Remaining Cropland**	**CARBON DIOXIDE (CO2)**	**-95.81**	**-70.43**	**0.00**	**0.02**	**0.89**
1.A.2	**Manufacturing Industries and Construct**	**CARBON DIOXIDE (CO2)**	**31.96**	**18.91**	**0.00**	**0.02**	**0.91**
3.C.7	**Rice cultivation**	**METHANE (CH4)**	**37.57**	**28.15**	**0.00**	**0.01**	**0.92**
1.A.4	**Other Sectors - Liquid Fuels**	**CARBON DIOXIDE (CO2)**	**36.33**	**27.76**	**0.00**	**0.01**	**0.93**
1.A.4	Other Sectors - Biomass - solid	METHANE (CH4)	8.77	0.00	0.00	0.01	0.94
3.A.2	Manure Management	METHANE (CH4)	32.66	27.03	0.00	0.01	0.95
3.B.5.b	Land Converted to Settlements	CARBON DIOXIDE (CO2)	17.63	25.93	0.00	0.01	0.96
3.B.6.b	Land Converted to Other land	CARBON DIOXIDE (CO2)	58.39	68.21	0.00	0.01	0.97
3.B.3.b	Land Converted to Grassland	CARBON DIOXIDE (CO2)	-6.48	-11.34	0.00	0.01	0.97
3.B.2.b	Land Converted to Cropland	CARBON DIOXIDE (CO2)	0.79	5.41	0.00	0.01	0.98
3.B.1.b	Land Converted to Forest land	CARBON DIOXIDE (CO2)	-20.47	-23.76	0.00	0.01	0.98

3.5.1 Trend Assessment

Table 31: Trend Assessment

A	B	C	D	E	F	G
IPCC Category code	IPCC Category	Greenhouse gas	2022 Ex,t (Gg CO2 Eq)	|Ex,t| (Gg CO2 Eq)	Lx,t	Cumulative Total of Column F
3.B.1.a	**Forest land Remaining Forest land**	**CARBON DIOXIDE (CO2)**	**-11350.33**	**16463.08**	**0.89**	**0.89**
1.A.3.b	**Road Transportation - Liquid Fuels**	**CARBON DIOXIDE (CO2)**	**369.60**	**369.60**	**0.02**	**0.91**
2.C.2	**Ferroalloys Production**	**CARBON DIOXIDE (CO2)**	**337.53**	**337.53**	**0.02**	**0.93**
2.A.1	**Cement production**	**CARBON DIOXIDE (CO2)**	**335.54**	**335.54**	**0.02**	**0.95**
3.A.1	**Enteric Fermentation**	**METHANE (CH4)**	**333.74**	**333.74**	**0.02**	**0.97**
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CARBON DIOXIDE (CO2)	132.68	132.68	0.01	0.97
4.D	Wastewater Treatment and Discharge	METHANE (CH4)	79.67	79.67	0.00	0.98
3.B.2.a	Cropland Remaining Cropland	CARBON DIOXIDE (CO2)	-70.43	70.43	0.00	0.98
3.B.6.b	Land Converted to Other land	CARBON DIOXIDE (CO2)	68.21	68.21	0.00	0.99
3.B.3.b	Land Converted to Grassland	CARBON DIOXIDE (CO2)	-11.34	43.18	0.00	0.99
3.C.7	Rice cultivation	METHANE (CH4)	28.15	28.15	0.00	0.99
3.B.5.b	Land Converted to Settlements	CARBON DIOXIDE (CO2)	25.93	27.94	0.00	0.99
1.A.4	Other Sectors - Liquid Fuels	CARBON DIOXIDE (CO2)	27.76	27.76	0.00	0.99
3.A.2	Manure Management	METHANE (CH4)	27.03	27.03	0.00	0.99

3.5.2 Level Assessment

The inventory provides emissions for four years; therefore, both the level and trend assessments for key category analysis were performed. For the trend assessment, the emission estimates for 2019 and 2022 were used. The most significant sources of GHG emissions in Bhutan are forest land remaining forest (CO2), ferro alloys production (CO2), road transportation (CO2), enteric fermentation (CH4) and cement production (CO2). The approach 1 trend assessment resulted in forest land remaining forest (CO2), ferro alloys production (CO2), road transportation (CO2), enteric fermentation (CH4), cement production (CO2, manufacturing industries and construction- solid fuels (CO2), rice cultivation and other sectors (liquid fuels-CO2) as key categories.

3.6 Uncertainty Assessment

An uncertainty assessment is an essential element of the GHG emission inventory to prioritize efforts to improve future inventories' accuracy. In Bhutan, uncertainties are associated with data access/constraints, potential unsuitability of generic emission factors, and an incomplete understanding of emission processes.

Uncertainty and time series assessments were conducted using the Tier 1 methodology in accordance with the 2006 IPCC Guidelines and good practices, taking 2020 as the inventory year for the uncertainty level. Based on expert judgment, activity data collection uncertainty for almost all the sector ranges between ± 3% and ±20%. The default emission factor's uncertainty values were taken to analyze the uncertainty for all sectors. The uncertainty analysis resulted in a total inventory uncertainty of 2.9% and a trend uncertainty of 3.8%.

Attention in two areas could help reduce uncertainty in Bhutan's GHG inventory. First, improving the accuracy of some emission factors to calculate emissions from various sources is vital. Most of the emission factors correspond to IPCC default factors. For example, the accuracy of current emission factors for enteric fermentation by animals at high altitude remains uncertain in the absence of local sampling and testing activities. Secondly, the availability of detailed activity data will support the refinement of inventory estimates. Although methodologies have been used to estimate emissions for some sources, problems arose in obtaining activity data at a level of detail in which aggregate emission factors can be applied. Addressing these areas through additional capacity strengthening and the development of dedicated observation networks will enhance future emission inventories' quality and accuracy.

Table 32 Uncertainty Assessment

Base year for assessment of uncertainty in trend: 2019, Year T: 2022						
A	B	C	D	E	F	G
2006 IPCC Categories	Gas	Base Year emissions or removals (Gg CO2 equivalent)	Year T emissions or removals (Gg CO2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)
1.A - Fuel Combustion Activities						
1.A.4.b - Residential - Biomass - solid	N2O	0.00	0.00	5.00	250.00	250.05
1.A.3.b.i - Cars - Liquid Fuels	CH4	0.03	0.03	5.00	244.69	244.74
1.A.3.b.iii - Heavy-duty trucks and buses - Liquid Fuels	CH4	0.02	0.01	5.00	244.69	244.74
1.A.3.b.ii - Light-duty trucks - Liquid Fuels	CH4	0.01	0.01	5.00	244.69	244.74
1.A.4.b - Residential - Liquid Fuels	N2O	0.00	0.00	5.00	236.36	236.42
1.A.2.e - Food Processing, Beverages and Tobacco - Liquid Fuels	CH4	0.00	0.00	5.00	228.79	228.84
1.A.2.a - Iron and Steel - Liquid Fuels	CH4	0.00	0.00	5.00	228.79	228.84
1.A.2.e - Food Processing, Beverages and Tobacco - Liquid Fuels	N2O	0.00	0.00	5.00	228.79	228.84
1.A.4.a - Commercial/Institutional - Liquid Fuels	N2O	0.00	0.00	5.00	228.79	228.84
1.A.2.a - Iron and Steel - Liquid Fuels	N2O	0.00	0.00	5.00	228.79	228.84
1.A.2.f - Non-Metallic Minerals - Solid Fuels	N2O	0.00	0.00	5.00	222.22	222.28
1.A.3.b.iii - Heavy-duty trucks and buses - Liquid Fuels	N2O	0.02	0.01	5.00	209.94	210.00
1.A.3.b.i - Cars - Liquid Fuels	N2O	0.01	0.01	5.00	209.94	210.00
1.A.3.b.ii - Light-duty trucks - Liquid Fuels	N2O	0.00	0.00	5.00	209.94	210.00
1.A.2.f - Non-Metallic Minerals - Solid Fuels	CH4	0.01	0.01	5.00	200.00	200.06
1.A.4.b - Residential - Liquid Fuels	CH4	0.00	0.00	5.00	200.00	200.06
1.A.4.a - Commercial/Institutional - Liquid Fuels	CH4	0.00	0.00	5.00	200.00	200.06
1.A.4.b - Residential - Biomass - solid	CH4	0.31	0.00	5.00	200.00	200.06
1.A.3.a.i - International Aviation (International Bunkers) - Liquid Fuels	N2O	0.00	0.00	5.00	150.00	150.08
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	N2O	0.00	0.00	5.00	150.00	150.08
1.A.3.a.i - International Aviation (International Bunkers) - Liquid Fuels	CH4	0.00	0.00	5.00	100.00	100.12
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	CH4	0.00	0.00	5.00	F	100.12
1.A.4.b - Residential - Biomass - solid	CO2	0.00	0.00	5.00	17.57	18.27
1.A.2.f - Non-Metallic Minerals - Solid Fuels	CO2	64.09	132.68	5.00	12.46	13.43
1.A.4.b - Residential - Liquid Fuels	CO2	24.35	19.91	5.00	6.14	7.92
1.A.2.e - Food Processing, Beverages and Tobacco - Liquid Fuels	CO2	21.57	15.01	5.00	6.14	7.92
1.A.4.a - Commercial/Institutional - Liquid Fuels	CO2	11.98	7.85	5.00	6.14	7.92
1.A.2.a - Iron and Steel - Liquid Fuels	CO2	10.39	3.90	5.00	6.14	7.92

CHAPTER 4:
INFORMATION NECESSARY TO TRACK PROGRESS MADE IN IMPLEMENTING AND ACHIEVING NATIONALLY DETERMINED CONTRIBUTIONS UNDER ARTICLE 4 OF THE PARIS AGREEMENT

Information necessary to track progress made in implementing and achieving nationally determined contributions under Article 4 of the Paris Agreement

4.1 Description of Bhutan's NDC under Article 4 of the Paris Agreement

Bhutan is already carbon neutral and has achieved the goal for net zero emissions at least until 2047-48 per Bhutan's Long-Term Low Greenhouse Gas Emission and Climate Resilient Development Strategy (LTS)-2023. Bhutan first pledged to remain carbon neutral in 2009 during COP 15 and reaffirmed its commitment through the submission of Intended Nationally Determined Contribution (INDC) to the Paris Agreement in September 2015. With the submission of enhanced Nationally Determined Contribution (NDC2.0) in 2021, Bhutan reiterated its commitment to maintain its carbon neutral status.

Bhutan's NDC target is to maintain the carbon neutral status whereby quantifiable information is based on National GHG inventories. It is a multi-year target, and uses 2020 as base year in line with the BUR submitted in 2022. The methodology used for the development of the Forest Reference Emission Level (FREL) and Forest Reference Level (FRL) which estimates the carbon sink is consistent with National GHG Inventories. To support the target of maintaining carbon neutrality, Bhutan has prepared sectoral Low Emission Development Strategies, the National REDD+ Strategy and Action Plan and other sectoral plans, and programs with the implementation period of at least until 2030.

Key sectors covered include Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and other Land use (FOLU) and Waste. The GHGs covered are CO_2, CH_4, and N_2O. Additionally, Bhutan views cooperative approaches in market and non-market mechanisms under Article 6 of the Paris Agreement as an important instrument to raise mitigation ambition with environmental integrity while promoting sustainable development and welcomes the opportunity to participate in cooperative approaches.

Bhutan being carbon neutral, NDC does more than its fair share of efforts for climate change mitigation. Therefore, the implementation of strategies, programs and action plans to realize the intended mitigation targets are conditional upon receiving adequate financial and technical support.

Bhutan's Nationally Determined Contribution under Article 4 of the Paris Agreement

Target(s) and description, including target type(s), as applicable	Bhutan's NDC target is to maintain the status as carbon neutral country, whereby quantifiable information is based on National GHG inventories with the estimation of the net GHG emissions and removals.
Target year(s) or period(s), and whether they are single-year or multi-year target(s), as applicable	A multi- year target from 2020-2030
Reference point(s), level(s), baseline(s), base year(s) or starting point(s), and their respective value(s), as applicable	The NDC target is to maintain the status as carbon neutral country, and it will use 2020 as base year in line with the BUR submitted in 2022. The methodology used for the development of the FREL and FRL is consistent with the National GHG Inventories.
Time frame(s) and/or periods for implementation, as applicable	Bhutan's enhanced mitigation efforts under the NDC to remain carbon neutral includes sectoral targets, strategies, and activities from the year 2021 to 2030 based on the references provided above.
Scope and coverage, including, as relevant, sectors, categories, activities, sources and sinks, pools and gases, as applicable	The NDC target is to maintain the status as carbon neutral country, whereby quantifiable information is based on National GHG inventories. It covers key sectors- Energy, Industrial Processes and Product Use, Agriculture, Forestry and other Land use (FOLU), and Waste. The GHGs covered are CO2, CH4, and N_2O.
Intention to use cooperative approaches that involve the use of ITMOs under Article 6 towards NDCs under Article 4 of the Paris Agreement, as applicable	Bhutan views cooperative approaches in market and non-market mechanisms under Article 6 of the Paris Agreement as an important instrument to raise mitigation ambition with environmental integrity while promoting sustainable development and welcomes the opportunity to participate on cooperative approaches.
Any updates or clarifications of previously Reported information, as applicable	NA

Description of selected Indicators

Bhutan's NDC covers sectors and categories equivalent to the national GHG inventory. It uses net GHG emissions and removals as an Indicator to track progress towards implementation and achievement of NDC. This approach is in line with our NDC is to maintain the status as carbon neutral country. The most recent information, as well as historical information for this indicator can be found in the National GHG inventory, which reports net GHG emissions and removals.

Indicator	Description
Net GHG emissions and removals	
Information for the reference point(s), level(s), baseline(s), base year(s) or starting point(s)	The NDC target is to maintain the status as carbon neutral country, and it uses 2020 as base year in line with the BUR-2022 and the National GHG Inventory reports. Multi- year target from 2020-2030 will be used to track progress towards the implementation and achievement of the NDC with the estimation of net GHG emissions and removals
Updates in accordance with the GHG inventory, if any	NA
Definitions needed to understand indicator	Bhutan is already a carbon neutral country, and the NDC reiterates the commitment to remain so. For the economywide target of remaining carbon neutral, quantifiable information is based on National GHG Inventories for Bhutan as contained in the National Communications to the UNFCCC and subsequent Reports. Hence, Bhutan's overall national target is to maintain the carbon neutral status.
Relation to NDC	The NDC is based on net GHG emissions and removals, and the selected indicator of the NDC is an economywide multi-year target from 2020-2030.
Most recent information	Bhutan's total GHG emissions in 2022 was 4,544.31 Gg CO2 eq. excluding LULUCF

4.2 Methodologies and accounting approaches

Bhutan's NDC will be accounted for based on net GHG emissions and removals using 2020 as base year. Our accounting approaches are equivalent to those provided in the national GHG inventories, which uses 2006 IPCC Guidelines for National GHG Inventories. Most emission estimates were derived using Tier 1 methodology provided in the 2006 IPCC Guidelines. Where default conversion and emission factors were used, they were taken from the 2006 IPCC Guidelines as well, unless otherwise stated. The Chapter on national GHG inventory of this BTR provides further details on our accounting approaches and methodologies.
As such, Bhutan's NDC accounting is consistent with Article 4, paragraphs 13 and 14. To the extent possible, in accounting for our emissions, we promote environmental integrity, transparency, accuracy, completeness, comparability and consistency, and ensure the avoidance of double counting. Bhutan also takes into account, where appropriate, existing methods and guidance under the Convention.

4.3 Tracking Progress towards implementation and achieving the NDC

Bhutan is already carbon neutral and is on track to maintain the status until 2030 as per the NDC's defined indicator for this BTR1. With the most recent inventory data on net emissions and removals in 2022, and looking at the emission trend/ projection, Bhutan is on track to remain carbon neutral.

Indicator	Description			
Net GHG emissions and removals				
Information for the reference point(s), level(s), baseline(s), base year(s) or starting point(s)	Bhutan's NDC is an economy-wide target to maintain the status as carbon neutral county. Multi- year target from 2020-2030 will be used to track progress towards the implementation and achievement of the NDC with the estimation of net GHG emissions and removals.			
Information for previous reporting years during the implementation period of its NDC under Article 4	**Year**	**Total Emission (Gg CO2e)**	**Sink capacity (Gg CO2e)**	**Net emission/removal (Gg CO2e)**
	2020	1,658.92	11,444.86	-9.785.94
	2021	1,884.17	11,736.39	-9,852.22
	2022	1,742.51	11,450.45	-9,707.94
Most recent information	Bhutan's total GHG emissions in 2022 was 1,742.51 Gg CO_2e. excluding the contribution of LULUCF.			
Progress made towards the NDC, as determined by comparing the most recent information for each selected indicator, including for the end year or end of period, with the reference point(s), level(s), baseline(s), base year(s) or starting point(s)	The most recent information for the indicator of net GHG emissions and removals is -9,707.94 Gg CO_2e in 2022. Bhutan is on track to remain carbon neutral with net GHG emissions and removals provided in the above table from 2020 and the net GHG emission is estimated to be (negative) -6,452.27 GgCO2e in 2030 even without the implementation of mitigation measures.			
Where applicable, information on GHG emissions and removals consistent with the coverage of its NDC under Article 4	Bhutan's indicator coverage is as provided in the NDC			
Contribution from the LULUCF sector for each year of the target period or target year, if not included in the inventory time series of total net GHG emissions and removals, as applicable	The inventory time series includes the contribution from the LULUCF sector.			
Total net GHG emissions and removals, taking into account the contribution from the LULUCF sector	The inventory time series includes the contribution from the LULUCF sector.			
Definitions needed to understand indicator	Bhutan is already a carbon neutral country, and the NDC reiterates the commitment to remain so. For the economy-wide target of remaining carbon neutral, quantifiable information is based on National GHG Inventories for Bhutan as contained in the National Communications to the UNFCCC and subsequent Reports.			
Information on cooperative approaches that involve the use of internationally transferred mitigation outcomes towards an NDC under Article 4	Dagachhu hydropower plant is a 126 MW run-of-the river hydroelectric plant which is registered as a CDM project and has been generating carbon credits (CERs) since 2015. As the entire power generated by this plant is exported to India through a power purchase agreement with Tata Power in India, mitigation from this power plant happens within the territorial power boundary of India. The annual mitigation benefits are estimated to be 500 ktCO2e. Bhutan is planning for participation in such cooperative approaches that involve the use of ITMOs in future as well.			

4.4 Mitigation policies and measures, actions and plans, including those with mitigation co-benefits resulting from adaptation actions and economic diversification plans, related to implementing and achieving a nationally determined contribution under Article 4 of the Paris Agreement

Bhutan is already carbon neutral and has achieved the goal for net zero emissions by at least 2047-48. Bhutan first pledged to remain carbon neutral in 2009 during COP15 and reaffirmed its commitment through the submission of Intended Nationally Determined Contribution (INDC) to the Paris Agreement in September 2015 and the second NDC in 2021. The total GHG emissions of the country in 2022 was recorded at 1742.51 Gg CO_2e. The GHG sink capacity of Bhutan in the same year was 11,450.45 Gg CO_2e, comprising 69.71% of forest cover.

Approach to reducing emissions

The implementation of the NDC will be guided by the Climate Change Policy of Bhutan 2020, which describes the implementation procedures as well as the process for monitoring and evaluation. Bhutan's overall target is to maintain the status as a carbon neutral country where total GHG emissions do not exceed total removals by sinks including forests. In order to maintain this carbon neutral status, sectoral targets, programs and plans have been prepared as part of sectoral LEDS and National REDD+ Strategy and Action Plan.

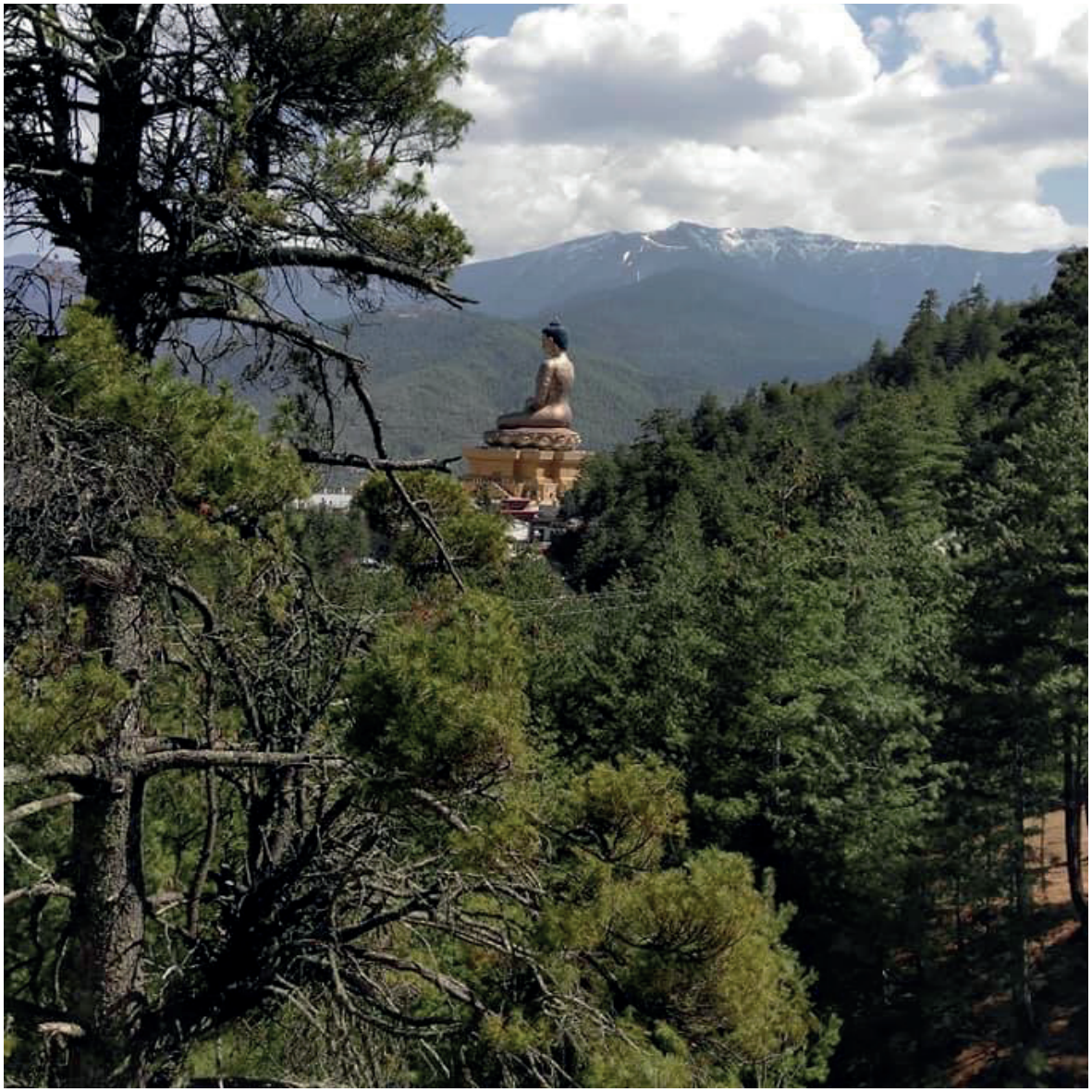
Bhutan being already carbon neutral with sinks exceeding the emissions, its NDC is more than its fair share of efforts for climate change mitigation, and hence the actions, targets and strategies are conditional on receiving adequate international support for implementation. Through the NDC, Bhutan calls on the international community to continue and enhance the support for Bhutan's efforts to mitigate and adapt to climate change. Following are the priority mitigation strategies, measures and actions to maintain Bhutan's carbon neutral status.

1. **Forest conservation and management under the National REDD+ Strategy**

   Bhutan's National REDD+ (reducing emissions from deforestation and forest degradation-plus) Strategy (NRS) focuses on continuing to strengthen the conservation of existing forests and increase the adaptive capacity to climate change impacts without compromising opportunities for future economic development and prosperity.

   The forest cover of Bhutan which currently stands at 69.71% of the total land area with 52% designated as protected area, is the cornerstone of maintaining the country's carbon neutral status. The Constitution of Bhutan mandates that minimum 60% of the land area remain under the forest cover for all time.

   Bhutan continues to improve forest management and conservation through several activities such as periodic assessment of forest resources by carrying out National Forest Inventory, forest management planning and implementation under sustainable forest management practices, management planning for other effective conservation areas or high



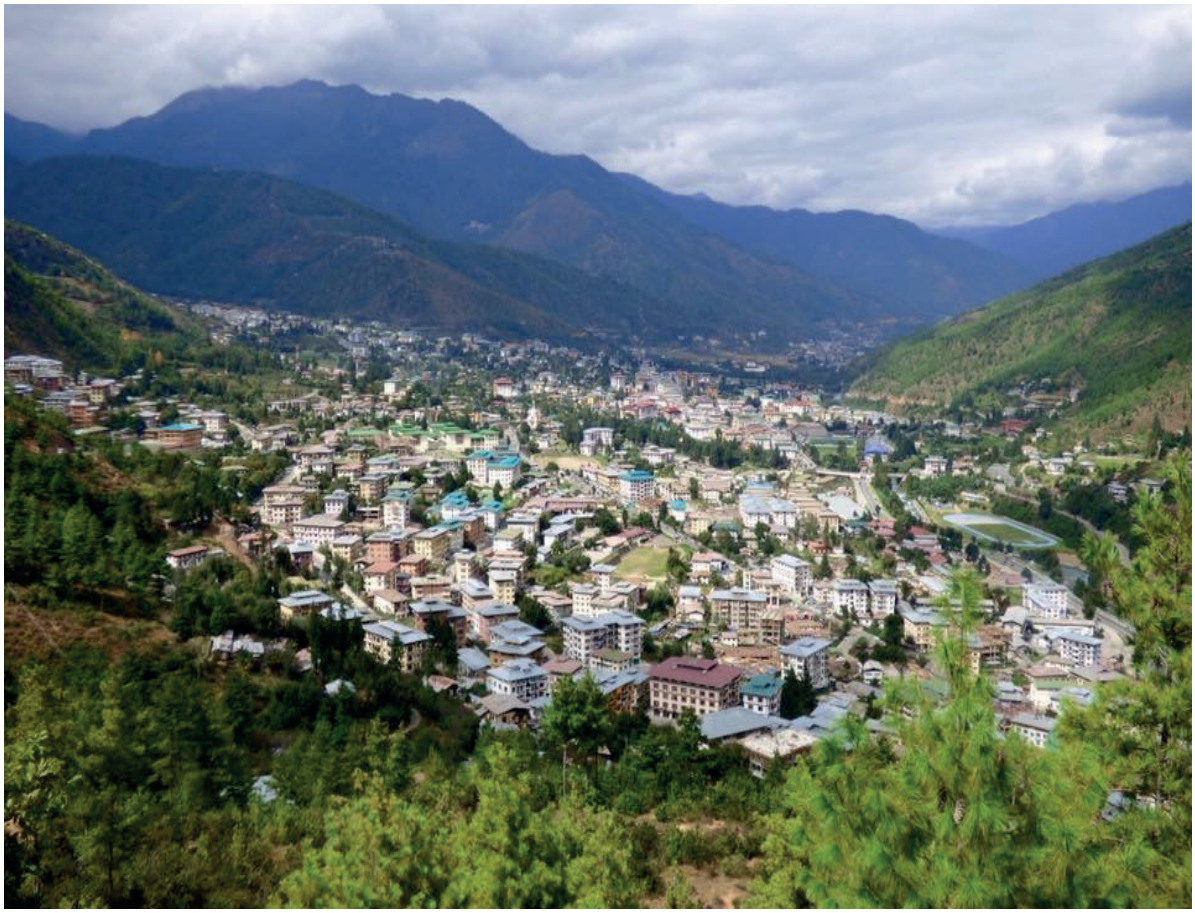
conservation areas and capacity building for improved forest management, promote agro forestry, and Enhancement of forest carbon stock through climate smart restoration.

With the launch of the reports on State of Forest, State of Forest Carbon, and Forest Cover Mapping in August 2023, it was reported that Bhutan's sequestration capacity of its forest has increased to over 11 million tonnes of carbon dioxide at the sequestration rate of 4.18 tonnes CO2 per hectare per year. This is an increase from 9.5 million tonnes estimated in 2015 primarily owing to the improved forest management and increase in number of trees by about 26% from 2015.

2. Low Emission Development Strategy for Food Security (LED-FS)

Agriculture and livestock remain essential components of the Renewable Natural Resource (RNR) sector and underpin the sustainability of Bhutan's food systems. Historically there has not been a significant increase in emissions from agriculture and livestock activities and neither is it expected to increase significantly soon. Nonetheless, the sector's contribution to the overall national emissions stands at 18.83% per BUR 2022, and is dubbed as the survival emission.

Recognizing the need to enhance food production while considering Bhutan´s commitment to remain carbon neutral 'for all times', the LEDS for Food Security is a key strategic planning document. The strategy introduces actions to mitigate GHG emissions from the agriculture and livestock sectors, while simultaneously aiming to enhance food security. The LEDS for food security covering the agriculture and livestock sector identifies mitigation measures aimed at reducing emissions and increasing carbon sequestration, that will lead to a cumulative mitigation potential of up to 710 Gg of CO2e from 2021 to 2030. Some of the measures are switching from synthetic to organic fertilizer, improvement of agricultural practices, increased biomass through increased perennial crop production, small and medium scale domestic biogas production, improved dairy cattle production through breed improvement and feeding management.



3. Low Emission Development Strategy for Human Settlement (LEDS-HS)

Activities in the human settlement sector were considered across energy in buildings, transport infrastructure (street light), waste management and land-use in urban areas.

Emissions from the human settlement sector are linked to the rapid construction of new buildings with poor thermal performance (insulation), inefficient household appliances, deficiencies in waste and wastewater treatment, a car-oriented development and rapid conversion of land uses.

The strategy document provides the prioritized mitigation measures that will lead to a cumulative mitigation potential of up to 4,122 Gg CO2e from 2021 to 2030. The measures include rolling out of solar PV on buildings, replacement of LPG and firewood by electricity, increase in composting and recycling, energy efficient and green building design, efficient street lighting, wastewater management, roll-out of energy efficient appliances and adoption of solar water heaters.

4. Low Emission Development Strategy for Industries

Industrial growth in Bhutan is important for economic growth and diversification. However, it is also likely to lead to significant increase in greenhouse gas (GHG) emissions over the next decades unless proactive GHG mitigation strategies are undertaken to decouple industrial growth from emissions growth. The BUR 2022 reported that the highest contributor to the national emission is from the Industrial Processes and Product (IPPU) category with a share of 29.11%.

Although the LEDS for Industries of 2021 identifies opportunities for mitigation through technical measures and promoting industries with higher value-addition and manufacturing products with cross cutting benefits in other sectors, the need for initial support required for detailed technical assessments and studies, capacity building, policy and regulatory measures was estimated to be US$3.52 Million, which is yet to be mobilized. This enabling activity will result in the full and detailed assessment of mitigation potentials in the industries sector and facilitate the participation of the private sector in low emission development. The process related mitigation measures include reducing fossil origin reductants with renewable charcoal and cement blending, while the energy efficiency measures are recovery of waste heat, refuse derived fuels in cement plants, energy efficiency in production processes, direct hot charging for integrated production, energy efficiency improvement of electric motor systems and conversion of diesel boilers to electric boilers.

Nevertheless, the private industries have been implementing cleaner production measures at the plant level. If the LEDS for industries were fully implemented, the cumulative mitigation potential from the industrial processes is estimated to be 11,082 Gg CO2e from 2021 to2030.

5. Low Emission Development Strategy for Surface Transport

Transport in Bhutan has been identified as the primary source of GHG emission in the energy sector, which is responsible for more than 60 percent emission.

Significant investments required in the transport sector are in the areas of infrastructure development to introduce low emission transport modes with the overall total investment requirement of USD 3,233 Million from 2021 to 2030.

The interventions which have been prioritized for implementation in the short/medium term are the promotion of electric vehicles and shared mobility, enhancing fuel efficiency and emission standards, mass transit through improvements in bus systems and the introduction of open-bus rapid transit (BRT) network (electric and diesel) and light rail transit, non-motorized transport system through public bicycle systems, improving and expanding pedestrian footpaths, and rationalizing personal vehicle ownership through restriction on the import of fossil-fuel vehicle

The mitigation measures if implemented fully will have a cumulative mitigation potential of 832.5 Gg CO2e from 2021 to 2030.

6. Waste Management

Waste sector in Bhutan accounts for the lowest GHG emission, and as per the BUR 2022 the contribution from the Waste Sector to the total national GHG emissions was 4.68% in 2020 accounting to 127.37 Gg CO_2e. However, the emission from waste sector in 2022 was reduced to 99.01 Gg CO_2.

Through the implementation of National Waste Management Strategy 2019, Bhutan has set the goal to achieve Zero Waste Bhutan whereby the current trend of disposing over 80% to the landfill is reversed to less than 20% by the year 2030 based on the principles of circular economy.

Towards the realization of the Zero Waste Bhutan, the National Waste Flagship Programme was implemented in the 12th Five Year Plan (2019-2023). For the 13th FYP (2024-2029), the government will focus on reducing waste going to the landfills and recovery through waste recycling value-chain to promote the

development of circular economy by emphasizing on effective source segregation and maximum material recovery. The cumulative mitigation potential from the waste sector (composting, recycling and wastewater treatment system) is estimated to be 684.8 Gg CO2e from 2021 to 2030.

7. Generation of clean and alternative renewable energy

Hydropower plants generate over 99% of Bhutan's electricity, and it has been a strategic and important renewable energy resource for Bhutan. It has enabled economic growth and industrialization and has been fundamental in achieving prosperity of the people. Bhutan's clean hydropower enables low GHG emissions in ensuring the carbon neutral status. Further development of hydropower projects can mitigate emissions beyond Bhutan in the region at large. Alternative renewable energy programs consisting of mini hydro, solar and wind are pursued as a priority program with the aim to reduce deforestation in rural communities and diversify the energy portfolio as adaptation measures to changing water flows, particularly in the dry seasons.

There are four hydropower projects under construction that are anticipated to be commissioned before 2030 are Punatsangchuu-I (1200MW), Punatsangchhu-II (1020MW), Khorlochhu (600MW) and Nikachhu (118MW). There are other Hydroelectric projects that are in pipeline to be pursued based on evolving national circumstances. The Alternative renewable energy programs that will be pursued include 71.11 MW of utility scale solar and wind energy, roof mounted solar PV on 300 rural households, 80-kW decentralised solar PV plant at Ajaney, 50 Solar Water Heating Systems (SWHS) of 1000 litres per day (LPD) capacity, 500-kW mini-hydel for Lunana community and the feasibility study and implement a waste to energy plant of utility scale in Thimphu, and the preparation of the Green Hydrogen Roadmap including the initiation of feasibility studies and pilot projects.

8. Implementation of National Energy Efficiency & Conservation Policy 2019 and Energy Efficiency Roadmap 2019

The National Energy Efficiency & Conservation Policy and Energy Efficiency Roadmap (NEECP) adopted in 2019 establishes the impact of energy efficiency (EE) on the country's GHG emissions in line with the first NDC and the energy saving potential of 155 GWh annually corresponding to about 590 Gg CO2e emission reduction potential from implementation of EE&C measures including the use of energy efficient equipment, appliances and construction materials in the building, appliance and industry sector. The action plan aims to contribute towards the NDC mitigation measures by enhancing demand side management through (i) promotion of EE in appliances, (ii) buildings and (iii) industrial processes and technologies. Several of the actions and measures in the EE policy and action plan are also being integrated into the different LEDS for human settlements, transport, and Industries.

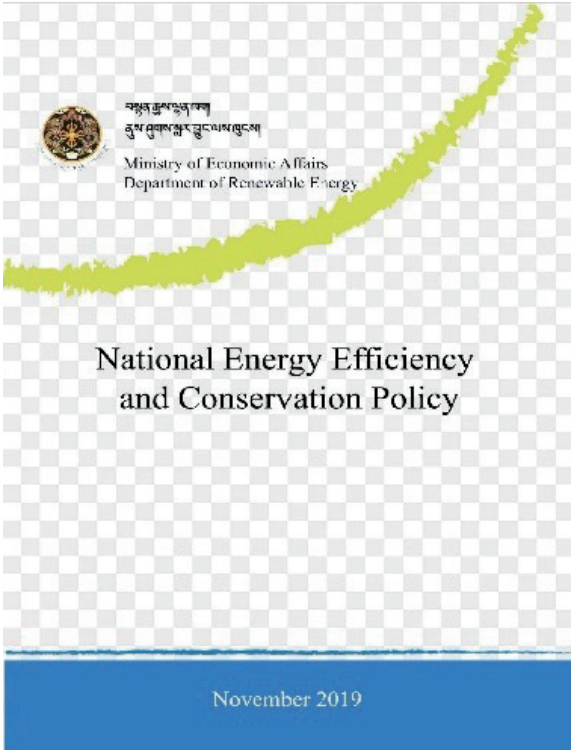


Table 33: List of mitigation measures and progress

Name of mitigation measures/strategies	Description	Objective	Type of Instrument	Status	Sectors and Gases affected	Implementation period	Focal Agency for implementation	Cumulative Emission reduction Potential by 2030 (Gg CO2e)
Forest conservation and management under the National REDD+ Strategy	Improve forest management and conservation, maintain at least 50% of land area under protected area (PA) and climate smart restoration through plantation and restoration works	To maintain forest carbon stock and sink capacity to remain carbon neutral, and increase the adaptive capacity to the impacts of climate change.	Regulatory, economic and others	Carbon neutral status achieved with the latest estimated net GHG emission of (negative) -6,800.62 Gg CO2e in 2022. The sink capacity recorded in the same year was 11,334.93 Gg CO2e. This is will remain as a regular activity for Bhutan and ensure the emissions do not exceed the sink capacity through continuous conservation, reforestation/ afforestation and enrichment efforts.	Forestry and Landuse; and CO2	Continuous	Dept. of Forest and Park Services (DoFPS), Ministry of Energy and Natural Resources (MOENR)	NA
Low Emission Development Strategy for Food Security	The mitigation action includes switch from synthetic to organic fertilisers, improve agricultural practices, increase biomass through increased perennial crop production, biogas production, and improve dairy cattle production through breed improvement and feeding management.	Increase agricultural & livestock productivity while reducing environmental impact, create renewable energy source and reduce use of firewood	Technology, economic and Others	Adopted and implementation ongoing – 1191 metric tonnes organic manure produced within the country; organic manure production units revived and established across the country with a capacity to produce 4800 metric tonnes annually; completion of the implementation of National Organic flagship program bringing 3623 ha of land under improved agricultural practices; completion of the 3rd phase of Million Fruit Tree Plantation program with the plantation of 3,280,693 fruit trees; installation of 8687 units of small/medium biogas units; use of sex-sorted semen to artificially inseminate the cattle to increase the reproduction of improved milch cattle, practice cattle stall-feeding to ensure proper nutrition and manure management.	Agriculture, Livestock, and landuse; CO2, N2O, CH4	2021-2030	Department of Agriculture (DoA), Department of Livestock (DoL), Ministry of Agriculture and Livestock (MoAL)	710

Low Emission Development Strategy for Human Settlement	Activities in the human settlement sector cover energy in buildings, energy efficient appliances, transport infrastructure (street light), and land-use in urban areas.	To provide an overarching framework for low carbon and eco-friendly development in the human settlement sector.	Technology, infrastructure, economic, and others	Adopted and implementation ongoing – Initiatives are currently underway to install 8MW Solar PV on public buildings in Paro & Thimphu, and targeting 50W by 2030; 304 HHs identified as prosumers, and the installation started in Dagana, Pemagatshel and Lhuntse dzongkhags (districts), further in the phase 2, an additional 200 HHs under feasibility study in Zhemgang; developed Energy Baseline for building sector, guidelines for energy efficient building, energy efficient (EE) code of practice towards development EE and green building system, and conducted capacity building/training on mechanised rammed earth; four major municipalities have about 95% energy efficient (LED) streetlights; Standards and Labelling Scheme for Energy Efficient appliances under development; installed 76 solar water heating systems in public buildings and is currently planned for upscaling.	Energy and Waste; CO2, N2O, CH4	2021-2030	Department of Human Settlement (DHS), Ministry of Infrastructure and Transport (MoIT), Department of Energy (DoE), MoENR.	3,364.5

Low emission Development strategy for Industries	Identifies opportunities for mitigation through technical measures and promoting industries with higher value-addition and manufacturing products. The include replacing fossil origin reductants with renewable charcoal, cement blending, waste heat recovery, energy efficiency improvement/increase in electric motor systems, direct hot charging-integrated production in steel plant, conversion of diesel boilers to electric boilers.	To decouple industrial growth from emissions growth, increase industrial competitiveness and support economic diversification. Overall, ensure sustainable socio-economic growth with minimum level of related GHG emissions.	Technology, Infrastructure, Economic, and others	At the plant level, the industries are trying to increase the use of renewable charcoal, however this is contingent on its fixed carbon content, moisture content and the market price; the three cement plants are striving to produce PPC types by replacing some of the clinker with industrial by-products or other materials like fly ash, slag and silica fume to produce blended cement and at least reduce the clinker use by 5%; in 2024, SD Ferro silicon plant in S/jongkhar) has initiated to trap waste heat from its furnace to use for Boiler with the capacity of 8TPH for its brewery plant that has the brewing capacity 10,000 KL/per annum. The same boiler otherwise would use fossil fuel (around 470 kg/h) to produce steam; to keep up with the emerging technologies, manufacturing industries have started with various interventions to improve/increase energy efficiency, as follows: -Unit 1 (billet production) of Lhaki steel and rolling plant recently installed 22.5MT Green Induction Melting Furnace with energy efficient technology. -Replacement of AC motors with variable frequency drives (VFDs) to reduce energy consumption by matching the frequency and voltage supplied to the motor to its load, thus improving the overall efficiency, precision and reduce wear and tear of electrical equipment. -Replacing IE1&2 (International Efficiency) motors with IE3 motors (latest/premium motors with higher efficiency and higher output per unit of energy consumed and lower energy loss). -Increase capacitor bank rating and/or installing additional capacitor bank to increase power factor from around 0.8 to 0.98. -Replacement of incandescent and sodium vapour lamps with LED Lights for lighting in and around the plants wherever necessary. -Tashi Beverage Pvt. Ltd replaced the diesel boiler (800kg) with an Electric Boiler in 2023. -Bhutan Brewery Ltd. has recently installed 3TPH electric boiler on trial.	Industrial Processes; CO2, N2O, CH4	2021-2030	Department of Industry (DoI, MoICE) and Department of Environment and Climate Change (DECC), MoENR.	11,082

Low Emission Development Strategy for Surface Transport	Transport in Bhutan is identified as the primary source of GHG emission in the energy sector. The opportunities range from low-cost policy interventions and enabling environment to capital intensive investment in the areas of infrastructure development and subsidies. Mass transit improvements, Promotion of electric passenger vehicles, Non-motorized transport system, Improve fuel-efficiency/standards are some of the intervention options.	To promote sustainable and convenient transport modes, integrate landuse and transport planning and transition of vehicle fleets to clean fuels, all of which is to contribute to the overall reduction of carbon emission.	Regulatory, Technology, Economic, and others	Adopted and implementation ongoing – Total of 199 public buses ply between the districts; 46 intra-city busses ply in Thimphu municipality, including one electric bus (procured in 2023) and 27 ICE bus (procured in 2021) and implemented smart card system in public busses; recently developed a project proposal “Bhutan Green Transport Project (BGTP)” for GCF funding, comprising of the following components: i. Priority bus service infrastructure, fleet, and systems, including creation of a Bus Priority Lane and procurement of 50 Electric-Buses ii. Pedestrianization of the City Centre (along norzin lam) and NMT improvements iii. Institutional and Policy Strengthening; Promotion and increase of EV uptake by supporting 300 EV taxis through subsidy and other fiscal incentives in 2021-2023; replaced 19 government ICE vehicles with EVs; established 46 Charging Stations (EVCS) across the country, and expansion underway along the pry. national highway; introduced efficient fuel (standard- BS/Euro VI) in 2022 and the strict compliance will be initiated from 2027; as a part of ICE vehicles ban, Bhutan restricted vehicle import through a moratorium in 2012 for two years and four months, and second import was restricted in August 2022 till August 2024.	Energy Transport; CO2, N2O, CH4	2021-2030	Department of Surface transport (DoST), MoIT	832.5

Waste management	Key challenges of waste management in Bhutan include littering, inadequate segregation at source, scarcity of land for landfills and illegal dumping of mixed waste. The waste management under this will be the implementation of National Waste Management Strategy 2019	To continuously promote 'Zero Waste Bhutan by 2030' by preventing and minimizing the generation of waste at source, and diverting materials to be refused, re-used, recovered, and recycled, including composting in order to minimise the amount of waste going to the landfill, and wastewater treatment system.	Legislative/ Regulatory, economic, infrastructure, and others	Adopted and implementation ongoing – To realize Zero Waste Bhutan by 2030, Bhutan implemented the National Waste Flagship Programme (2019-2023). Some of the outcomes of the program are: -Establishment of 25 Waste collection facilities & nine waste collection facilities or drop off centres in Thimphu, -Installation of incinerators at Memelakha landfill in Thimphu, Mongar, Punakha, Paro. -Development of Zero Waste Bhutan App as a tracker for waste-related offenses. -Over 300 street litter bins were distributed for waste segregation in public places. -A material recovery facility at Taba in Thimphu is currently under construction. -The first National Waste Inventory Survey was conducted in 2019. For the 13th FYP (2024-2029), the government will focus on reducing waste going to the landfills and recovery through waste recycling value-chain to promote the development of a circular economy by emphasizing on effective source segregation and maximum material recovery. -Established Bhutan Waste Bank project in April 2024, an initiative under a private waste mgt. firm (Greenerway) to address Thimphu's waste challenges by incentivizing waste collectors for collecting trash such as plastics, bottles, rubber waste, paper and cardboards. Through such initiatives, around 175 tonnes (about 20%) of dry wastes in a month are recycled which otherwise would land in landfill and is expected to increase with more public awareness. - Plans are underway to establish a recycling hub, an integrated waste management facility at Bjemina - Thimphu Thromde is developing project proposals with external partners to establish composting facilities to convert organic waste into compost/fertilizers for local agriculture, and a pilot project is underway in Thimphu.	Waste; CO2, CH4, N2O	2020-2030	DECC, Respective Local Governments and Competent Authorities	684.8

Generation of clean and alternative renewable energy	Development of hydropower as per the Sustainable Hydropower development Policy, and implementation of alternative renewable energy program, including the study of Green Hydrogen potential.	Ensure energy security, diversify energy mix and enhance climate resilience.	Economic, Technology, Infrastructure, and others.	Adopted and implementation ongoing – Punatsangchuu HEP-I (1200MW); Punatsangchhu HEP-II (1020MW) to be commissioned fully by mid-2025; Khorlochu HEP (600MW)-construction started; Nikachhu HEP (118MW) – completed in February 2024; Dorjilung HEP (1125 MW)- DPR being updated; Nyera Amari HEP (404MW)-DPR being updated. Sochhu, Burgangchhu and Yungichhu small Hydroprojects to be completed in 2024-2025, and Jomori, Gamri, Bindu, Begana to be completed by 2028; 22 MW Solar power plant under construction in Sephu to be completed by 2025; Detailed Project Report for 23 MW Gaselo wind project to be reviewed and updated and project finance being explored; 33 KW solar mini-grid (off-grid) at Shangsa village commissioned in September, 2024; Development of 500kW mini hydropower being pursued; Tariff structure for Solar is under development; National Hydrogen Roadmap completed and feasibility study was carried out in Bjemina for generation of 1MW; Currently in the process of developing 1MW Bioenergy project; Last mile connectivity in high altitude areas to be completed by 2029; Developed Guidelines for the development of Distributed Energy Resources systems, to provide an opportunity to a consumer in Bhutan to be self-reliant in the production of electricity for self-consumption and supply of excess electricity from its DERS into the distribution system; Currently developing National Energy Policy, a holistic policy that will merge all the existing policies such as Sustainable Hydropower Development Policy 2021, National Energy Efficiency and Conservation Policy 2019, and Alternate Renewable Energy Policy 2013.	Energy; CO2	Until 2030	DoE, Druk Green Power Corporation (DGPC)	Not Estimated

Implementation of National Energy Efficiency & Conservation (EEC) Policy 2019 and Energy Efficiency Roadmap 2019	Enhancing demand side management through promotion of EE in appliances, Buildings and industrial processes and technologies	To improve energy security by reducing energy intensity, and create enabling environment for adoption of EE&C measures	Economic, Technology and Others	Adopted and implementation ongoing – Development of Standards & Labelling scheme is underway with focus on top 3 appliances under the voluntary phase; Pilot distribution of 650 smart electric-cookstoves to switch to clean and energy efficiency cooking technologies; Developed Energy Auditing and Reporting Guideline for Buildings, Industrial processes and technologies, and Energy Efficiency Codes of Practices Capacity building initiatives for Energy Auditors are being planned.	Energy; CO2	2019-2030	DoE	Included in LEDS-HS and LEDS-Industries above

4.5 Projection of GHG emissions and removals

For the economy wide target of remaining carbon neutral, quantifiable information is based on National GHG Inventories for Bhutan as contained in the National Communications to the UNFCCC and subsequent Biennial Update Reports. Bhutan's target is to maintain the status as a carbon neutral country, and this is expressed in relative terms of total GHG emissions against total removals of GHG for each relevant target year. Bhutan's forest reference emission level (FREL) and forest reference level (FRL) submitted and assessed in 2020 utilizes historical reference period of 2005-2014. The 2nd NDC uses 2020 as base year in line with the BUR submitted in 2022.

The GHG emissions projection was developed using the linear trend analysis of all the five sectors (Energy, IPPU, Agriculture, Waste and FOLU) including the sink capacity until 2030 based on the emissions reported from 1994 to 2019 in BUR 2020) and the latest GHG inventory of 2020-2022. It can be seen that Bhutan will remain carbon neutral.

Table 34: Emissions Projection (Gg CO2e) from 2020-2030

Year	Energy	IPPU	Agriculture	Waste	FOLU	Total Emissions	Sink Capacity	Net Emission/ Removal
2020	676.15	683.70	458.45	84.32	2,103.76	4,006.38	-12781.30	-8774.92
2021	1,251.70	871.54	458.73	77.28	2,110.37	4,769.62	-11790.67	-7021.05
2022	855.42	1,093.95	402.44	78.15	2,114.35	4,544.31	-11344.93	-6800.62
2023	947.76	1,053.77	491.63	111.78	1,279.00	3,883.93	-10,514.32	-6630.38
2024	978.96	1,089.48	487.07	113.56	1,305.70	3,974.78	-10,579.71	-6604.94
2025	1,010.17	1,125.20	482.51	115.35	1,332.39	4,065.62	-10,645.11	-6579.49
2026	1,041.37	1,160.92	477.95	117.13	1,359.09	4,156.46	-10,710.51	-6554.05
2027	1,072.58	1,196.63	473.39	118.91	1,385.79	4,247.30	-10,775.91	-6528.60
2028	1,103.78	1,232.35	468.83	120.69	1,412.49	4,338.15	-10,841.30	-6503.16
2029	1,134.99	1,268.07	464.27	122.48	1,439.19	4,428.99	-10,906.70	-6477.71

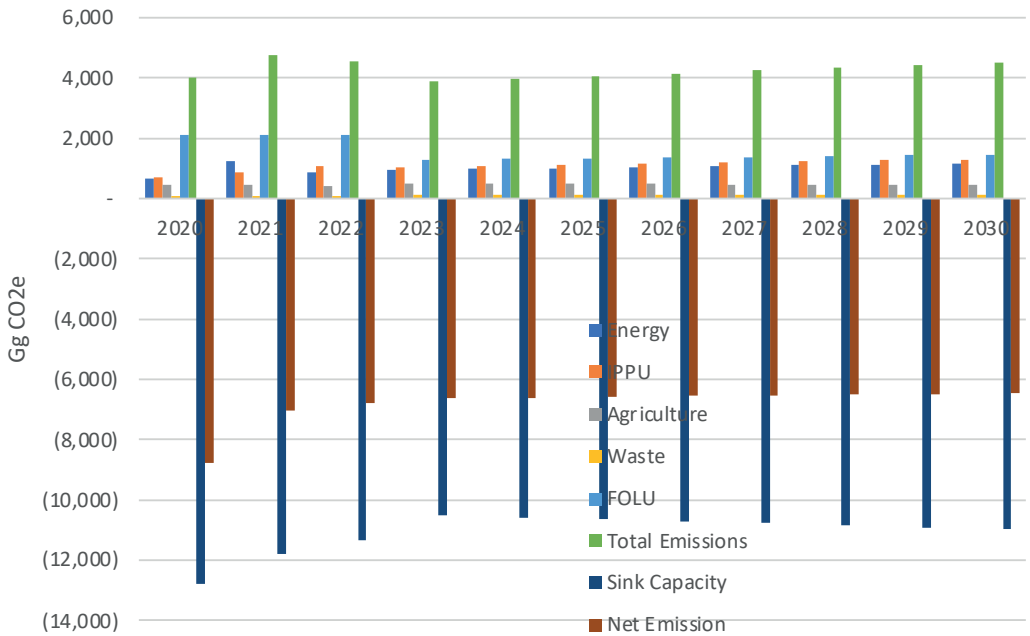


Figure 51: GHG emission from different sectors in the future

4.6 Projection of emissions with mitigation measures

The mitigation measures include the implementation of activities listed above from 2021 to 2030. With the exclusion of emission reduction potential from the hydropower generation and alternative renewable energy programs, the cumulative mitigation potential from the implementation of Low Emission Development Strategies for food security, human settlement, industries and surface transport, and energy efficiency and conservation measures is 16,673.88 Gg CO2e from 2021 to 2030, while the total projected GHG emission during the same period is 42,928.99 Gg CO2e (including LULUCF).

Table 35: Emission reduction potential

Sectors	Mitigation potential from 2021-2030 (Gg CO2e)	Projected emissions under BAU scenario from 2021-2030 (Gg CO2e)	Projected Emissions with mitigation measures (excluding forest sequestration) by 2030 (Gg CO2e)
Energy	8,139	10,562.93	2,423.93
IPPU	7,140	11,395.70	4,255.70
Agriculture	7,10.08	4,666.52	3956.44
Waste	684.80	1,099.59	414.70

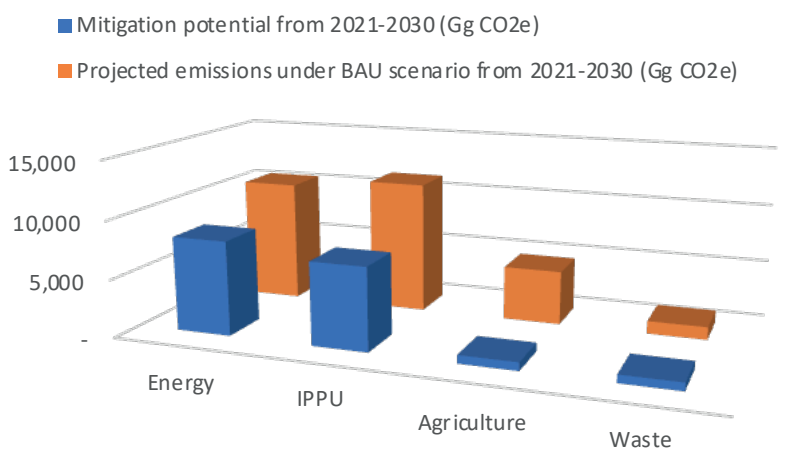


Figure 52: GHG mitigation potential from different sectors in the future

Nevertheless, it is important to note that the achievement of the mitigation measures and targets will depend on the level of technical and financial support available for implementation from the international community, and is therefore conditional on support received as stated in the NDC document.

CHAPTER 5:
INFORMATION RELATED TO CLIMATE CHANGE IMPACTS AND ADAPTATION UNDER AARTICLE 7 OF THE PARIS AGREEMENT

The National Adaptation Plan (NAP) of Bhutan, published in 2023 by the Department of Environment and Climate Change, is a strategic framework aimed at enhancing the country's resilience to climate change impacts. The NAP is a response to the increasing vulnerabilities faced by various sectors due to climate variability, including agriculture, water resources, health, and biodiversity. It builds upon Bhutan's previous experiences with adaptation through the National Adaptation Programme of Action (NAPA) and aligns with the Climate Change Policy of the Kingdom of Bhutan, 2020.

The NAP is vital for several reasons:

- **Holistic Approach**: It provides a comprehensive approach to identifying adaptation priorities and needs across different sectors, ensuring that climate considerations are integrated into national development planning.

- **Framework for Action**: The NAP establishes a clear framework for implementing adaptation measures, facilitating coordination among government agencies, local communities, and stakeholders.

- **International Commitment**: It aligns with Bhutan's commitments under the Paris Agreement and supports national reporting requirements related to climate change adaptation.

- **Resilience Building**: The NAP aims to enhance the resilience of communities and ecosystems against climate impacts by addressing vulnerabilities and promoting adaptive capacity.

5.1 Climate Risk Assessment

Climate risks in Bhutan have been evaluated across five key sectors: water, agriculture, forests and biodiversity, energy, and human health, as outlined in the Third National Communication (TNC) 2020. This general assessment identified vulnerabilities within these sectors and provided a basis for further detailed evaluations. As part of the National Adaptation Plan (NAP) preparation, in-depth climate risk assessments (CRA) were conducted for water, forests, agriculture, and human health, alongside a comprehensive vulnerability assessment that mapped adaptive capacity across different administrative regions.

The five technical assessments supporting the NAP formulation include:

1. Assessment of Climate Risks on Agriculture (2021)

2. Assessment of Climate Risks on Forests and Biodiversity (2021)

3. Assessment of Climate Risks on Health (2021)

4. Assessment of Climate Risks on Water Resources (2021)

5. Climate Change Vulnerability Analyses and Mapping (2021)

While sectors such as energy and human settlements were not directly assessed, they were partially addressed within the water sector evaluation. The adaptation priorities recommended in these reports were reviewed by the NAP drafting committee and thematic working groups. A summary of the findings regarding climate risks from these assessments is detailed in subsequent sections of the NAP.

Table 36: Summary of climate risks across sectors in the Third National Communication 2020

Water	Agriculture	Forest and biodiversity	Energy	Human health
1. Increased disaster risks, 2. Limited access to water resources and seasonal water shortages.	1. Climate change-induced water shortages, 2. Wildlife predation of crops, 3. Pests and diseases, 4. Poor mountainous shallow soils, worsened by increasing soil loss through surface erosion and scarcity of farm labor	1. Potential shifts in forest structure and distribution 2. Damages by pests and diseases in the forest. 3. Forest fire may reverse carbon sink 4. New invasive and alien species	1.High dependence on hydropower 2. The hydropower sector adversely affected by water availability and extreme events	1. Climate change impacts on determinants of health 2. Changes in the pattern of vector-borne, airborne, and water-borne diseases. 3. Increased stress on emergency medical health services

5.2 Climate Change Vulnerability Analyses

The Climate Change Vulnerability Analysis (CCVA) is a comprehensive assessment aimed at understanding the impacts of climate change on Bhutan's Geographic and socio-economic levels. The 2021 CCVA in Bhutan focused on integrating socio-economic, non-climatic, and developmental data to enhance the understanding of climate change's effects across Dzongkhags and Gewogs.

The Climate Change Vulnerability Analysis (CCVA) in Bhutan identified significant risks posed by climate change across Dzongkhags, emphasizing the interplay of climate hazards, population exposure, and socio-economic vulnerabilities.

The findings revealed that the districts of Samtse, Mongar, Sarpang, Punakha, and Dagana are the most vulnerable to climate impacts due to their high population densities and existing socio-economic challenges (Figure 7). These risks are compounded by climate variability and development pressures. The assessment highlighted that risk

is a function of three key factors: hazards, exposure, and vulnerability, with these Dzongkhags experiencing the highest levels of combined risk. By providing a detailed risk and vulnerability index for each Dzongkhag and visualizing the findings through GIS mapping, the CCVA underscores the critical need for targeted interventions in these areas. The analysis offers essential insights to inform Bhutan's National Adaptation Plan (NAP) formulation, ensuring a robust response to current and future climate risks.

Figure 53: Present risk ranking across Dzongkhags

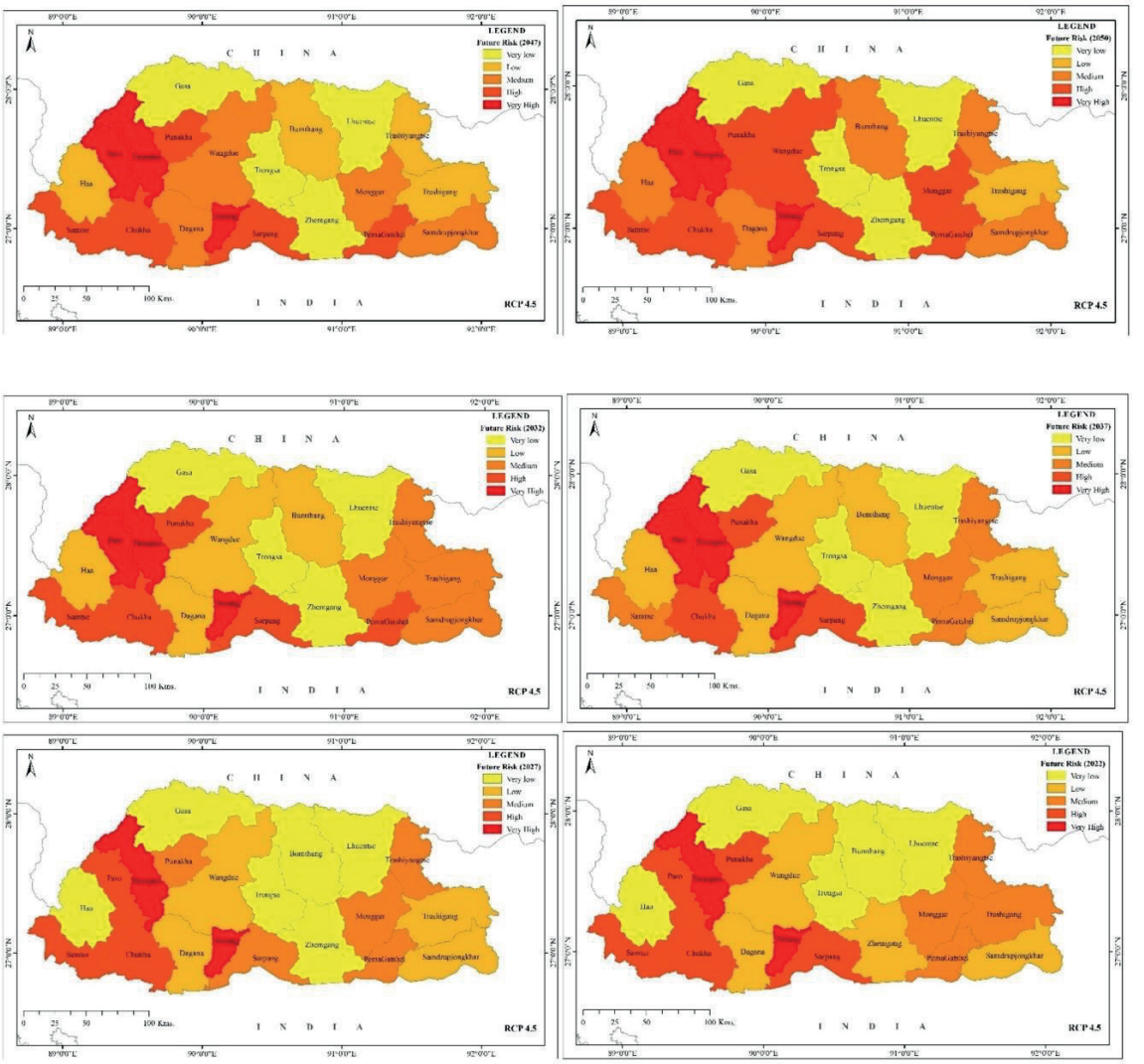


Figure 54: Future climate risk across Bhutan under RCP 4.5

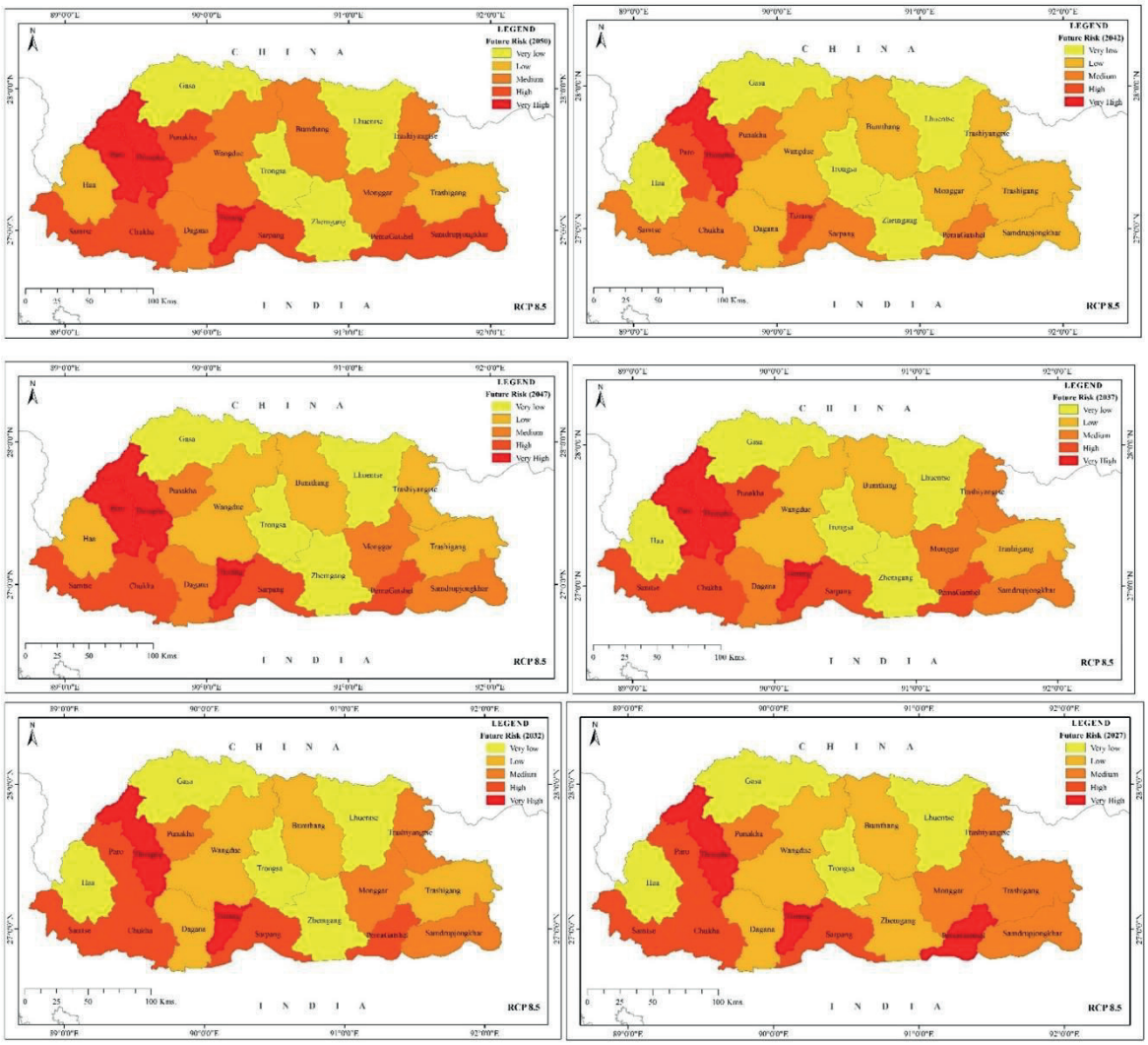


Figure 55: Future climate risk across Bhutan under RCP 8.5

Figures 8 and 9 demonstrate the future risk of socioeconomic growth and climate change under RCP 4.5 and RCP 8.5 scenarios respectively. By 2050, under RCP 4.5, Tsirang, Paro, Samtse, Thimphu, and Pema Gatshel show very high risk which means a total population of 469,595 will be exposed to a very high climate change risk.

5.3 Assessment of climate risks on water resources

- Conducted through a combination of bottom-up regional consultations and top-down model-based analysis.

- Disaster risk is conceptualized based on definitions by IPCC (2012) and UNDRR (2016), focusing on hazard, vulnerability, and exposure.

- A four-step risk characterization process was followed:

    1. Identify the main types of water-related problems/disasters.
    2. Define hazard, exposure, and vulnerability indicators for each problem.
    3. Perform model-based analysis to quantify hazards at gewog and sub-catchment levels.
    4. Summarize findings through hazard maps and risk tables.

5.3.1 Current Risks and Hazards:

- Consultations revealed increasing climate-related hazards such as drying water sources, floods, and landslides.

- Historical data on temperature, rainfall, and river flows confirm some perceptions but show high uncertainty regarding the causes (climate change vs. anthropogenic pressures).

5.3.2 Future projections indicate:

- Increased total annual precipitation but more erratic rainfall patterns.
- Rising temperatures, especially at higher altitudes.
- Medium-high confidence in increasing risks of floods and landslides.
- Potential increase in the duration and frequency of dry spells (medium confidence).
- Increased risk of Glacial Lake Outburst Floods (GLOFs).

5.3.3 Future Risks:

- Risks of local dry spells at the Gewog level are expected to increase under climate change for large parts of the country enhancing the drying of sources that are already clearly visible to date.

- Local dry spells expected to increase significantly, leading to challenges in meeting growing water demand for drinking, industrial, and irrigation purposes.

- Uncertain risks of low flows in main rivers; projections show both decreases and increases in dry spells depending on the timeframe (short-term vs. long-term).

- High risks of increased floods, especially pluvial and riverine; serious reports of flash floods already exist.

- Melting glaciers will continue under rising temperatures, increasing GLOF risks.

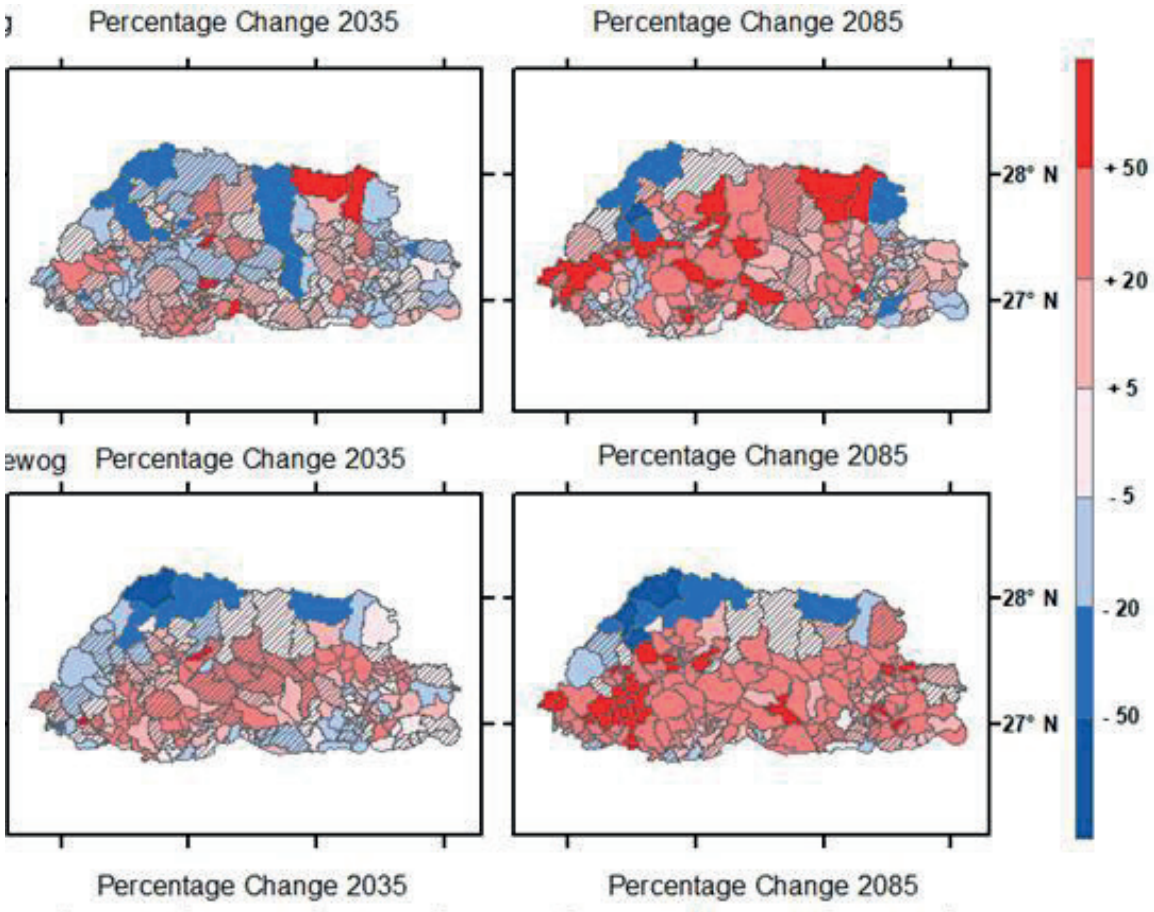


Figure 56: Expected relative change (%) at Gewog level in dry spell duration (upper) and frequency (lower panels) under climate change (RCP4.5) compared to historic climate

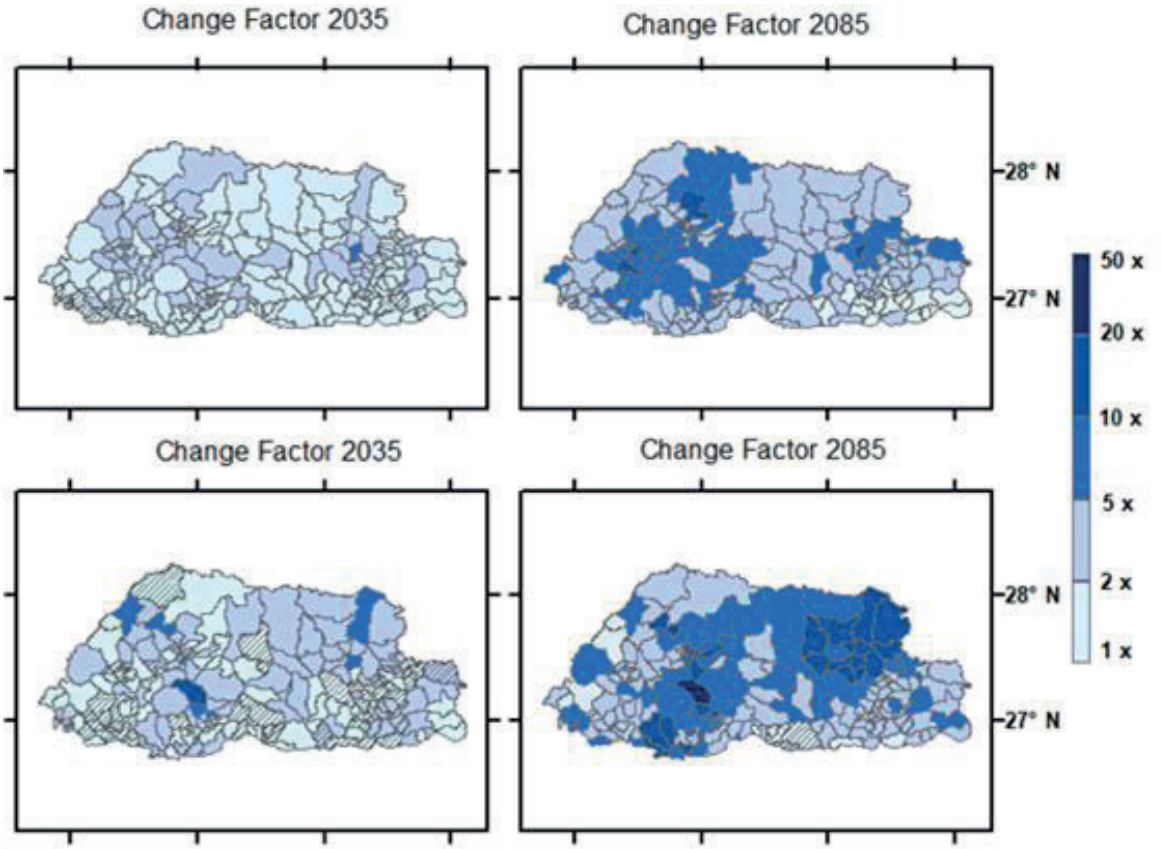


Figure 57: Expected relative change (factor) at gewog level in extreme daily precipitation for the 1/10 year return period (upper) and 1/30 year return period (lower panels) under climate change (RCP4.5) compared to historic climate

5.3.4 Adaptation Options for Water Resources

Based on the climate risk assessment findings, several adaptation options have been identified:

1. **Strengthening Ecosystems:**
   - Enhance watershed protection and management to improve natural infiltration and water buffering capacity.
   - Implement wetland restoration, and reforestation, prevent overgrazing, and adopt erosion-minimizing agricultural practices.
2. **Improved Flood Risk Management:**
   - Maximize river discharge capacity by establishing no-build zones, removing bottlenecks, and constructing emergency storage or bypasses.
3. **Infrastructure Protection:**
   - Apply flood mitigation structures, slope stabilization measures, and improved drainage systems in urban areas to protect critical infrastructure.

4. **Resilient Infrastructure Development:**

   - Plan roads and settlements to avoid high-risk areas; design climate-resilient infrastructure with a focus on maintenance for rapid recovery.

5. **Enhanced Early Warning Systems:**

   - Expand existing early warning systems for GLOFs and flash floods; ensure mechanisms for quick response funding are in place.

6. **Robust Water Supply Systems:**

   - Increase the resilience of water supply systems for drinking and irrigation by generating additional water buffers during drought periods.

   - Implement household-level rainwater harvesting and community-level storage solutions.

7. **Hydropower Sector Resilience:**

   - Enhance the resilience of existing hydropower facilities to cope with erratic flow patterns through improved watershed management upstream.

8. **Capacity Building:**

   - Train local experts in planning and operations related to climate adaptation strategies; research groundwater contributions to seasonal water availability.

   - These adaptation measures aim to improve the resilience of Bhutan's water resources against climate change impacts while supporting sustainable development goals across various sectors.

5.4 ASSESSMENT OF CLIMATE RISKS ON AGRICULTURE

The climate risk assessment for agriculture in Bhutan utilized the Decision Support System for Agro-technology Transfer (DSSAT) model and Geographic Information System (GIS) mapping at the Gewog level. The assessment followed the IPCC's framework, focusing on evaluating vulnerability, exposure, and hazards. A total of 11 crops were assessed, including various cereals, vegetables, fruit crops, and spices that are economically and nutritionally significant for Bhutan.

5.4.1 Current Issues:

The agricultural sector in Bhutan faces significant challenges due to its vulnerability to climate change. Key issues include:

- Limited Arable Land: Approximately half of the population relies on agriculture and livestock rearing, but the availability of arable land is constrained by poor mountainous soils and difficult terrain.

- Climate Vulnerabilities: Current vulnerabilities include uncertain weather conditions, pest outbreaks, diseases, and climate hazards such as high variability in rainfall, thunderstorms, hailstorms, and windstorms.
- Extreme Events: Flash floods and landslides disrupt agricultural land and supply chains, threatening food production.

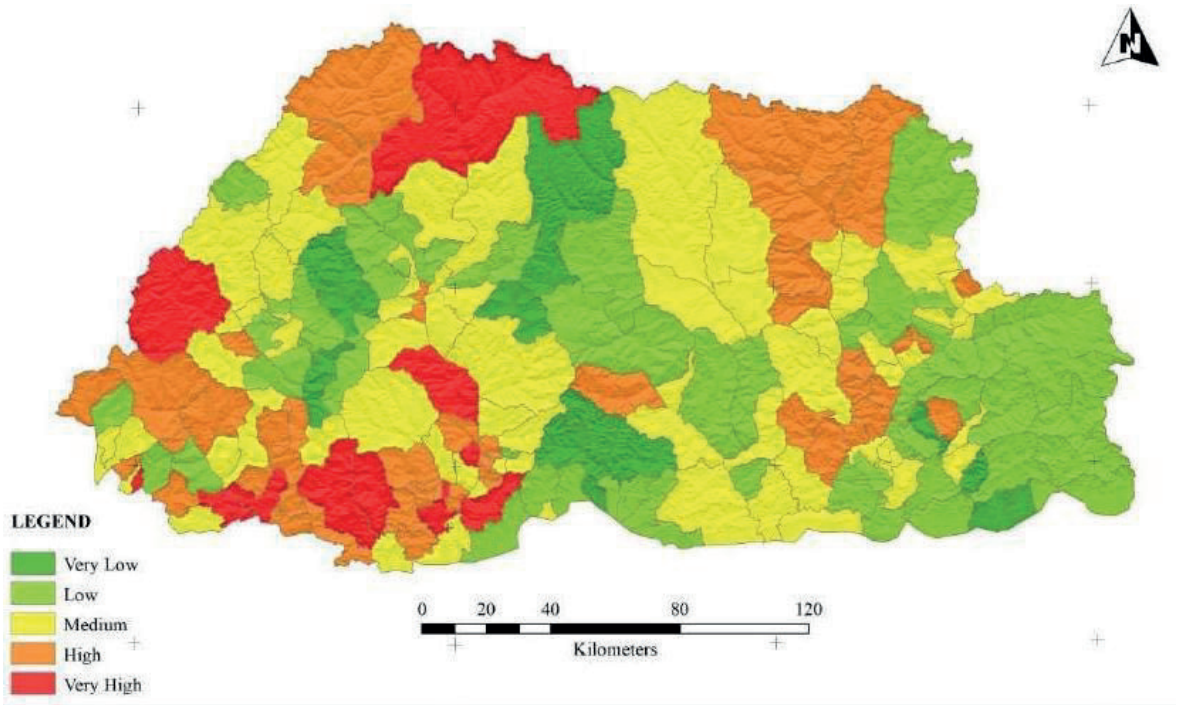


Figure 58: Composite vulnerability map for agriculture

5.4.2 Key Findings:

The crop modelling exercise in Bhutan identified key opportunities for expanding the cultivation of various crops across different Dzongkhags. The findings indicate that paddy can be cultivated in eight Dzongkhags: Bumthang, Haa, Samdrup Jongkhar, Sarpang, Trashigang, Trashi Yangtse, and Trongsa. Maize can be grown in all Dzongkhags except Bumthang, Gasa, Haa, and Paro. Additionally, quinoa has the potential for expansion in eight Dzongkhags: Bumthang, Haa, Pema Gatshel, Samdrup Jongkhar, Sarpang, Thimphu, Trashi Yangtse, and Wangdue Phodrang.

For vegetables, the assessment found that:

- Chillies and potatoes can be expanded in Bumthang, Haa, Paro, Thimphu, and Wangdue Phodrang.
- Tomato crops are suitable for expansion in Chhukha, Haa, Paro, Punakha, Thimphu, and Wangdue Phodrang.
- Onion cultivation is feasible only in Lhuentse, Trongsa, and Wangdue Phodrang.

In terms of fruits:

- Citrus fruits can be expanded in Dagana, Mongar, Samdrup Jongkhar, Sarpang, Trashigang, Tsirang, and Zhemgang.
- Apple cultivation can be expanded in Bumthang, Chhukha, Lhuentse, Paro, Thimphu, and Trashi Yangtse.
- Kiwi can be grown in Dagana, Samdrup Jongkhar, Sarpang, and Tsirang.

Cardamom, a spice crop, shows potential for expansion in Dagana, Haa, Samtse, and Sarpang Dzongkhags.

5.4.3 Recommendations for Adaptation:

Based on the climate risk assessment findings, several adaptation options have been proposed:

1. **Enhance Water Use Efficiency and Sustainable Management:**
   - Improve the resilience of irrigation infrastructure.
   - Increase water use efficiency and management practices.

2. **Strengthen Agro-Meteorological Services and Climate Information Systems:**
   - Enhance agro-meteorological services to provide timely and accurate climate information.

3. **Promote Sustainable Land Management (SLM):**
   - Implement sustainable land and soil management practices.
   - Develop and promote climate-resilient crop varieties and climate-smart technologies.
   - Establish pest surveillance systems and strengthen diagnostic facilities.

4. **Development of Integrated Agriculture Landscape Systems:**
   - Adopt an integrated approach to agricultural landscape management.

5. **Promote Landscape-Based Organic Farming:**
   - Encourage organic farming practices to enhance production and sustain livelihoods.

6. **Innovative Solutions to Reduce Crop Loss:**
   - Implement practices to reduce food waste, improve post-harvest technologies, and establish financing mechanisms to protect farmers from climate-induced disasters.
   - Develop an integrated food framework, promote crop insurance, and create qualified market development for exports.

7. **Climate-Resilient Livestock Management:**
   - Enhance livestock management practices to increase resilience against climate impacts.

8. **Increase Institutional Capacity and Investment in Research:**
   - Invest in climate change research to inform adaptation strategies.

9. **Enhanced Climate-Smart Information and Knowledge Management:**
   - Improve information dissemination and knowledge management related to climate adaptation strategies.

5.5 Climate-mediated fire risks assessment on forests and biodiversity

The risk assessment for forest fires in Bhutan involved modeling fire behavior under two climate scenarios: RCP 4.5 and RCP 8.5. The assessment was conducted for three time frames: short-term (2021-2051), mid-term (2052-2069), and long-term (2070-2100). This modeling focused on key parameters such as flame length and rate of fire spread to evaluate the potential impacts of climate change on fire risks.

5.5.1 Current Issues:

Forest fires pose significant threats to Bhutan's biodiversity and ecosystem services, with an average of 57 fire incidents occurring annually, affecting approximately 200 hectares. The Dzongkhags most impacted include Thimphu, Wangdue Phodrang, Punakha, Mongar, Lhuentse, and Trashigang. The primary causes of these fires include:

- Agricultural debris burning
- Children playing with ignition sources
- Activities by lemon grass harvesters, smokers, cattle herders, roadside workers, picnickers, campfires, and electrical short circuits.

5.5.2 Key Findings:

The assessment revealed several critical findings regarding forest fire risks:

- Climate change is expected to increase both flame length and the rate of fire spread.
- Nearly 90% of chir pine forests are projected to be at high risk of fire from now until 2050, with over 60% of blue pine forests also facing high risk.
- Broadleaved forests below 2000 meters above sea level are particularly vulnerable, with over 9,000 km² projected to be at high fire risk in the same timeframe.
- An estimated 1,747 households within the chir pine zones and 598 households within blue pine zones will face high fire risks by 2050.
- Overall, approximately 18,490 households and 549 religious structures across Bhutan are projected to be at increased risk from forest fires moving forward.

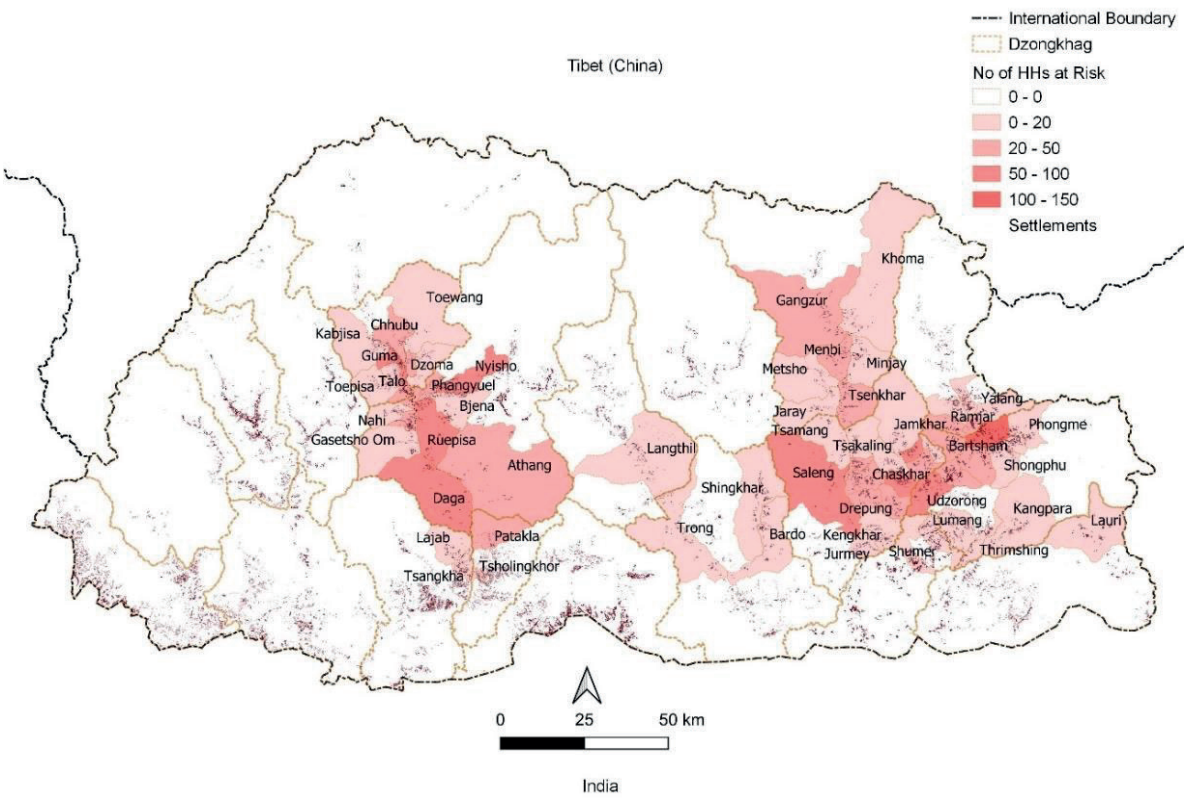


Figure 59: Gewogs with most houses at risk in Chir pine forests under RCP 4.5 from now till 2050

5.5.3 Next Steps and Recommendations for Forest Fire Management in Bhutan

Short-Term Focus:

In the short term, the highest risk of forest fires is identified in mid-altitude temperate montane forests and extends to subtropical vegetation zones. Both flame length and fire spread rates are expected to increase under climate change scenarios (RCP 4.5 and RCP 8.5), leading to more intense fires and a higher likelihood of crown fires. As a result, adaptation efforts should be prioritized in high-risk forest types and nearby settlements.

Key Recommendations:

1. **Strengthen Adaptive Fire Management:**

- Encourage controlled burning in chir pine forests, especially in areas with lemon grass, to manage fuel loads.

- Initiate research on optimal burning cycles, seedling recruitment, burn intensity, mortality, and recovery rates.

- Implement scientifically determined thinning prescriptions in blue pine forests to reduce flammability and promote tree growth.

2. **Secure Infrastructure at Risk:**

   - Actively pursue fire risk mitigation measures to protect communities and critical infrastructure from forest fire threats.

   - Remove woody fuels within 10 meters of structures at risk and prune remaining trees to raise their crowns.

   - Establish water storage systems and fire hydrants around key infrastructure, utilizing solar-powered systems for reliability.

3. **Reduce Causes of Forest Fires:**

   - Address electrical short circuits from power lines by establishing a systematic maintenance Programme for cross-country electrical transmission corridors.

   - Continue public awareness campaigns targeting human activities that lead to forest fires.

4. **Strengthen Response Capability:**

   - Equip the Department of Forests and Park Services (DoFPS) and partner agencies with essential firefighting equipment.

   - Develop a daily fire forecasting system based on weather forecasts to enhance response times.

   - Create a national fire cache for long-duration fires, including tents, sleeping bags, food, and tools.

5. **Integrate Local Forest Plans:**

   - Ensure that local forest management plans are integrated to achieve coherent resource management and fire protection objectives.

   - Secure consistent budgetary support for the implementation of these plans.

6. **Outreach and Capacity Building:**

   - Implement a multi-year training Programme covering incident management, equipment handling, safety procedures, prescribed burn techniques, and coordination with local governance for first response capabilities.

5.6 Change risk assessment on the health sector

The Climate Risk Assessment for the health sector in Bhutan was conducted using the Risk-Impact framework proposed by the Fifth Assessment Report of the IPCC. This framework evaluates climate risks as a function of hazard (H), exposure (E), and vulnerability (V). The assessment involved reviewing existing academic and grey literature to understand the linkages between climate change and health-related diseases.

5.6.1 Methodology

1. **Hazard Assessment:** Key hazards were identified, focusing on climate variability, extreme weather events, and incidences of vector-borne diseases (VBDs) and water-borne diseases (WBDs). Dzongkhags such as Chhukha, Punakha, and Sarpang ranked

highest for VBDs and WBDs due to factors like temperature changes, rainfall patterns, humidity, floods, and glacial lake outburst floods (GLOFs).

2. **Exposure Assessment:** Population density was used as a key indicator of exposure. Thimphu had the highest population density (67 persons/km²), while Bumthang, Haa, Lhuentse, and Gasa had the lowest (4-5 persons/km²).

3. **Sensitivity Assessment:** Sensitivity reflects how vulnerable a community is to climate impacts. Factors such as demographic profiles, urbanization, poverty levels, and health indicators were considered. Punakha, Dagana, Zhemgang, and Mongar showed high sensitivity to VBD impacts.

4. **Adaptive Capacity**: This component assessed the ability of communities to cope with climate impacts based on factors like knowledge, infrastructure, and access to healthcare. Thimphu, Sarpang, and Bumthang had higher adaptive capacities compared to Gasa, Dagana, Tsirang, and Zhemgang.

5. **Risk Calculation:** The overall risk was calculated by combining socio-economic vulnerabilities with climate hazards and population density. Samtse, Chhukha, Punakha, and Tsirang ranked highest for VBD risks.

5.6.2 Future Risk Assessments

5.6.2.1 Future projection for Dengue in Bhutan

- **Future Projections:** Based on historical data and climate scenarios (RCP 4.5 and RCP 8.5), it is projected that dengue cases could rise to approximately 3,000 annually over the next 30 years under a business-as-usual scenario. The most affected Dzongkhags will be Chhukha, Samtse, and Thimphu.

- **Long-Term Outlook:** By 2070-2099, cases may increase to about 4,400 per year with significant concentrations in Thimphu, Samtse, and Chhukha.

- **Population at Risk:** Approximately 44% of Bhutan's population is projected to be at risk of dengue under both RCP scenarios.

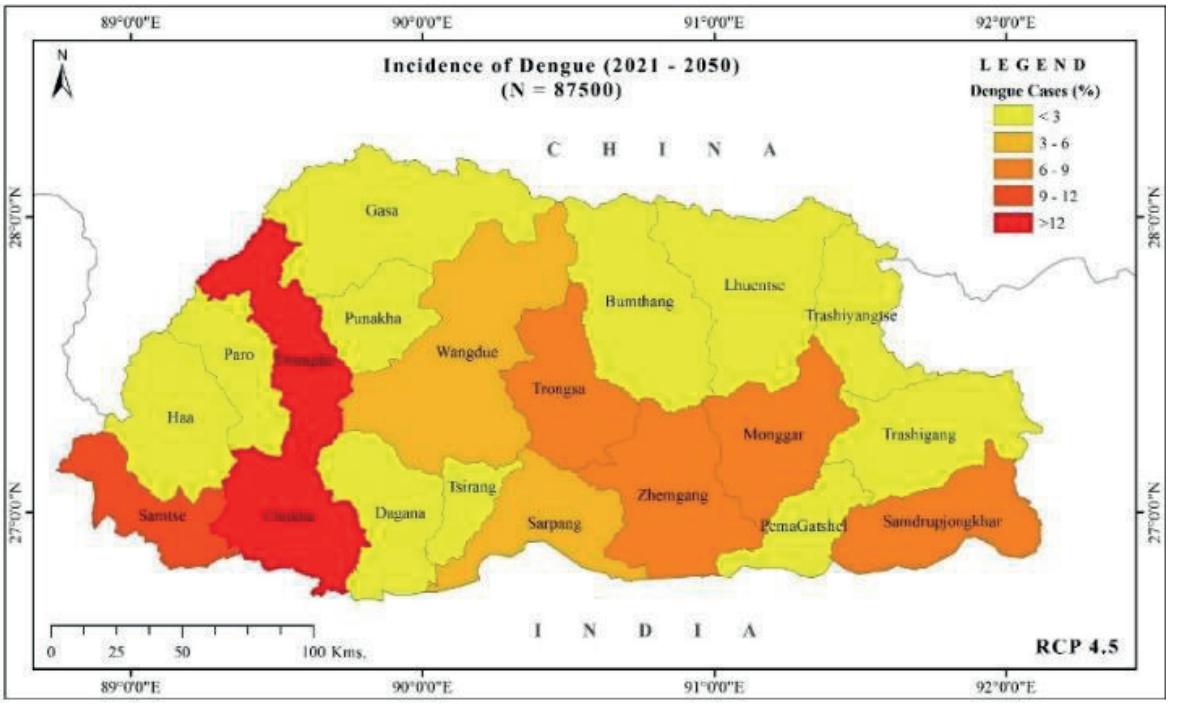


Figure 60: Future projection for climate risk to Dengue under RCP 4.5 (2021-50)

5.6.2.2 Future projection for Malaria in Bhutan

- **Current Situation:** Presently observed malaria cases are concentrated in Sarpang, Chhukha, Samtse, Samdrup Jongkhar, and Wangdue Dzongkhags.

- **Future Projections**: In a business-as-usual scenario under RCP 4.5, malaria cases could double to around 150 annually over the next 30 years. The eastern Dzongkhags on the southern border are expected to see a higher share of cases.

- **Long-Term Outlook**: By 2070-2099 under RCP 8.5 scenarios, annual cases may rise to approximately 191.

- **Population at Risk:** About 14% of Bhutan's population is projected to be at risk of malaria.

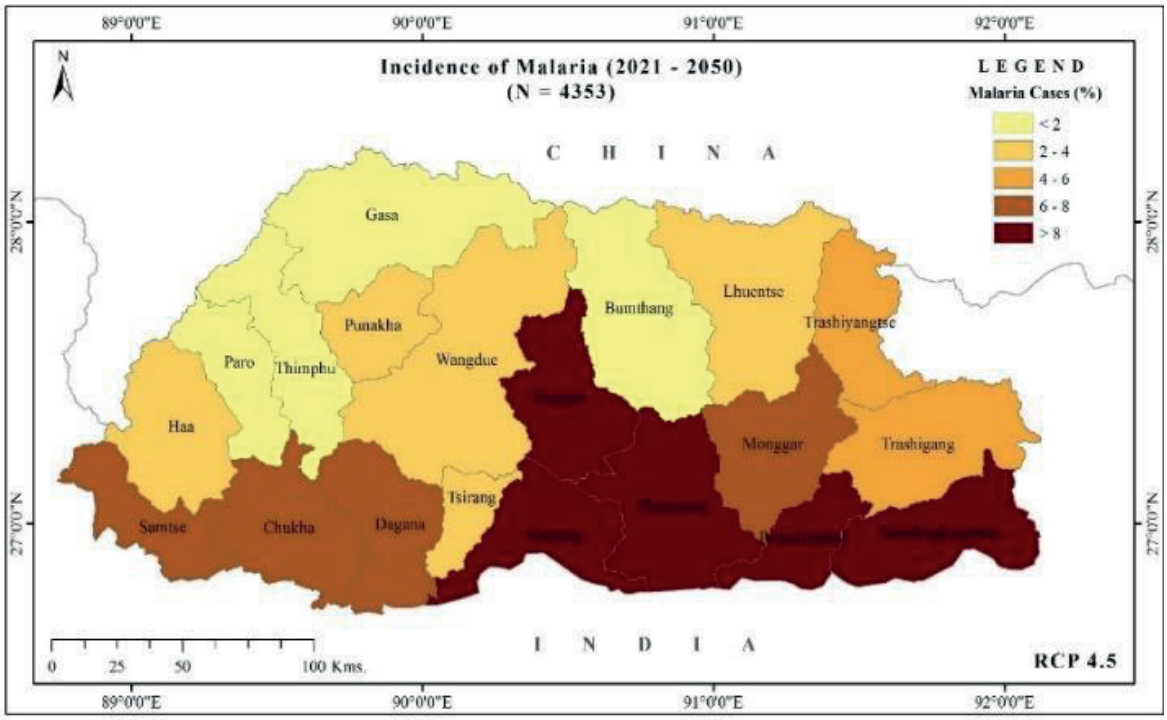


Figure 61: Future projection for climate risk to Malaria under RCP 4.5 (2021-50)

5.6.2.3 Future projection for Diarrhoea in Bhutan

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Analysis Findings: Various models were applied to future projections of diarrhea; however, no significant correlation was found between climatic factors and diarrhea cases at the dzongkhag level.

- **Data Limitations:** The lack of consistent correlation patterns may stem from issues in the disease data collected from 2016-2020 or insufficient observed data on temperature and precipitation.

5.6.3 Recommendations

Based on the findings from the risk assessment:

- Prioritize adaptation planning for high-risk Dzongkhags such as Chhukha, Punakha, and Samtse (common for both VBDs and WBDs), followed by Paro and Tsirang.

- Develop an integrated framework for adaptation planning that includes interventions at national, regional, and local levels.

- Enhance public health infrastructure and awareness campaigns targeting vector-borne diseases.

- Strengthen monitoring systems for disease outbreaks linked to climate change impacts.

5.7 Adaptation Priorities in Bhutan's NAP

The National Adaptation Plan (NAP) of Bhutan outlines a comprehensive set of adaptation priorities aimed at enhancing the country's resilience to climate change impacts. These priorities are crucial for addressing the specific vulnerabilities identified through thorough assessments of climate risks, ensuring that Bhutan can effectively adapt to changing environmental conditions. Below is a detailed explanation of the adaptation priorities as outlined in the NAP.

5.7.1 Water Management

Objective: To ensure sustainable water resource management and enhance resilience against climate variability.

- **Integrated Water Resource Management (IWRM)**: Implementing IWRM practices will help optimize water use across different sectors, ensuring that water resources are managed holistically. This approach involves collaboration among various stakeholders, including government agencies, local communities, and private sector actors, to develop and implement effective water management strategies.

- **Rainwater Harvesting**: Encouraging the construction of rainwater harvesting systems can improve water availability during dry seasons, particularly in rural areas where access to reliable water sources may be limited. This practice not only enhances water security but also reduces dependence on groundwater and surface water sources.

- **Flood Risk Management**: Developing infrastructure such as flood control systems, improved drainage, and retention basins can mitigate the impacts of increased rainfall and flooding. These measures are essential for protecting communities, agricultural lands, and infrastructure from climate-related disasters.

- **Hydrological Monitoring**: Establishing robust monitoring systems for hydrological data will inform decision-making processes related to water management. Accurate data on rainfall patterns, river flows, and groundwater levels is vital for planning and implementing effective water resource management strategies.

5.7.2 Agriculture and Livestock

Objective: To enhance the adaptive capacity of agricultural systems and livestock management in response to climate change.

- **Climate-Smart Agriculture**: Promoting practices such as crop diversification, agroforestry, and organic farming can increase resilience and productivity in agriculture. These methods help mitigate risks associated with climate variability by improving soil health, enhancing biodiversity, and reducing reliance on chemical inputs.

- **Access to Resilient Seeds**: Ensuring farmers have access to climate-resilient seed varieties will help them adapt to changing climatic conditions and improve yields. This includes developing and distributing seeds that are drought-resistant or tolerant to extreme weather conditions.

- **Training Programmes for Farmers**: Implementing training programmes focused on sustainable farming techniques will empower farmers with knowledge and skills necessary for adapting to climate impacts. These programmes can cover topics such as soil conservation, integrated pest management, and efficient irrigation practices.

- **Early Warning Systems**: Establishing early warning systems for extreme weather events can help farmers prepare for adverse conditions, protecting crops and livestock. Timely information about impending storms or droughts allows farmers to take proactive measures to safeguard their livelihoods.

5.7.3 Forests and Biodiversity

Objective: To protect forest ecosystems and biodiversity, which are vital for ecological balance and community livelihoods.

- **Community-Based Forest Management**: Strengthening community involvement in forest conservation efforts will enhance stewardship and sustainable use of forest resources. Engaging local communities in decision-making processes fosters a sense of ownership and responsibility for forest conservation.

- **Reforestation Initiatives**: Promoting reforestation and afforestation projects will restore degraded lands while improving carbon sequestration and biodiversity. These initiatives contribute to enhancing ecosystem services such as soil stabilization, water regulation, and habitat provision for wildlife.

- **Biodiversity Assessments**: Conducting assessments to identify vulnerable species and habitats will inform conservation strategies aimed at preserving biodiversity. Understanding the specific needs of different species is essential for developing targeted conservation efforts.

- **Integration into Land Use Planning**: Ensuring that biodiversity considerations are integrated into land-use planning processes will help mitigate habitat loss due to development. This includes establishing protected areas and implementing sustainable land-use practices that prioritize ecological health.

5.7.4 Human Settlements and Climate-Smart Cities

Objective: To develop resilient urban areas capable of withstanding climate impacts while promoting sustainable urbanization.

- **Climate-Smart Urban Planning**: Implementing planning strategies that consider future climate scenarios will help cities adapt to potential risks associated with urbanization. This includes assessing vulnerabilities in infrastructure, housing, transportation, and public services.

- **Infrastructure Resilience**: Enhancing the resilience of infrastructure by incorporating climate risk assessments into design processes will reduce vulnerability to extreme weather events. This may involve retrofitting existing structures or designing new ones with climate resilience in mind.

- **Green Spaces Development:** Promoting the creation of green spaces within urban areas can mitigate heat effects, improve air quality, and enhance community well-being. Urban

greenery also provides recreational opportunities while supporting biodiversity.

- **Community Awareness Programme:** Developing programme focused on disaster preparedness will empower communities to respond effectively to climate-related emergencies. Training residents in emergency response protocols enhances community resilience during crises.

5.7.5 Health

Objective: To strengthen health systems' resilience against climate-related health risks.

- **Disease Surveillance Systems:** Enhancing surveillance systems for monitoring climate-sensitive diseases will allow for timely responses to public health threats. This includes tracking outbreaks of vector-borne diseases such as malaria or dengue fever that may be exacerbated by changing climatic conditions.

- **Public Health Campaigns:** Promoting awareness campaigns focused on hygiene, nutrition, and disease prevention can mitigate health vulnerabilities exacerbated by climate change. Educating communities about healthy practices is essential for improving overall public health outcomes.

- **Healthcare Infrastructure Improvement:** Upgrading healthcare facilities to withstand extreme weather events will ensure continued service delivery during crises. This may involve reinforcing buildings or ensuring that medical supplies are protected from flooding or other disasters.

- **Training Healthcare Professionals:** Providing training on the health impacts of climate change will equip healthcare providers with the knowledge needed to address emerging health challenges effectively. This includes understanding how climate change affects disease patterns and patient care needs.

5.7.6 Energy

Objective: To promote renewable energy sources and enhance energy security in the face of climate change.

- **Investment in Renewable Energy Technologies**: Supporting the development of solar, wind, and hydropower projects will diversify energy sources while reducing greenhouse gas emissions. Transitioning to renewable energy is essential for achieving long-term sustainability goals.

- **Energy Efficiency Measures**: Implementing energy efficiency initiatives across sectors can reduce overall energy demand while enhancing sustainability. This may involve promoting energy-efficient appliances or encouraging conservation practices among consumers.

- **Private Sector Engagement**: Encouraging private sector investment in renewable energy projects can stimulate economic growth while addressing energy needs. Public-private partnerships can leverage resources and expertise for successful project implementation.

- **Grid Resilience Enhancement**: Improving the resilience of energy infrastructure will ensure reliable energy supply during extreme weather events. This includes investing in smart grid technologies that enhance monitoring and response capabilities during disruptions.

5.7.7 Climate Services and Disaster Risk Reduction

Objective: To improve disaster preparedness and response capabilities while providing accurate climate information for decision-making.

- **National Disaster Risk Reduction Framework**: Establishing a comprehensive framework that incorporates climate change considerations into disaster risk reduction strategies is essential for enhancing national preparedness. This framework should outline roles, responsibilities, and procedures for effective disaster management.

- **Strengthening Early Warning Systems**: Enhancing early warning systems for natural hazards such as floods, landslides, and droughts will improve community preparedness and response capabilities. Timely alerts enable communities to take necessary precautions before disasters strike.

- **Public Access to Climate Information:** Ensuring that communities have access to accurate climate information through improved communication channels fosters informed decision-making. Providing accessible data empowers individuals to make choices that enhance their resilience.

- **Training Exercises for Emergency Responders**: Conducting regular training exercises focused on disaster management protocols will enhance the capacity of emergency responders. Preparedness drills help build skills necessary for effective response during actual emergencies.

5.8 NAP implementation strategy

The Implementation Strategy section of Bhutan's National Adaptation Plan (NAP) outlines a comprehensive approach to integrating climate adaptation into national development. Here's a detailed summary of its subsections:

5.8.1 Integration of NAP into Development Planning

This subsection emphasizes the necessity of embedding adaptation strategies within existing national and local development frameworks. It aims to ensure that climate resilience is prioritized in sectoral planning, resource allocation, and project implementation.

5.8.2 Approaches to Implementing the Adaptation Priorities

Various implementation methodologies are proposed, including:

- Community-based approaches: Engaging local populations in decision-making and project execution.

- Public-private partnerships: Collaborating with the private sector to leverage resources and expertise.

- Technology and innovation: Utilizing modern technologies to enhance adaptive capacities.

5.8.3 Potential Financing Sources

Identifying funding mechanisms is crucial for the successful execution of adaptation initiatives. This section discusses potential sources such as:

- Government budgets: Allocating national funds specifically for adaptation projects.
- International aid: Seeking financial support from global climate funds and donor agencies.
- Private investment: Encouraging private sector involvement through incentives.

5.8.4 Communication and Outreach

Effective communication strategies are vital for raising awareness and fostering community engagement. This subsection outlines plans for:

- Public awareness campaigns: Informing citizens about climate risks and adaptation measures.
- Stakeholder engagement: Involving various groups in the planning process to ensure diverse input and support.

5.8.5 Roles and Responsibilities

Clearly defined roles among stakeholders are essential for accountability. This section delineates responsibilities among:

- Government agencies: Leading implementation efforts and policy formulation.
- Local communities: Participating actively in adaptation actions.
- Non-governmental organizations: Supporting capacity building and outreach efforts.

5.9 Loss and Damage

Article 8 of the Paris Agreement addresses loss and damage associated with the adverse effects of climate change. It recognizes the importance of averting, minimizing, and addressing these impacts, particularly concerning extreme weather events and slow-onset events. As climate change progresses, the frequency and intensity of disasters are expected to increase, exacerbating the challenges faced by vulnerable communities in Bhutan.

5.9.1 Increasing Incidence of Climate-Induced Disasters in Bhutan

Bhutan is highly vulnerable to disasters, mainly induced by climate change. It is because of its location and mountainous terrains, as mentioned in the previous section. However, many such disasters have occurred in the country. Some of them have been identified based on the increasing trend of climate change-induced disasters as follows:

- **Floods and Flash Floods**: These are among the most frequent disasters in Bhutan, causing significant mortality and damage.
- **Glacial Lake Outburst Floods (GLOFs):** A critical concern due to the melting glaciers in the Himalayas.
- **Drought**: Increasingly impacting water availability for agriculture and drinking.
- **Landslides**: Commonly triggered by heavy rainfall and unstable terrain.
- **Windstorms/Cyclones**: These events can cause extensive damage to crops and infrastructures.

- **Heat Waves and Cold Waves**: Extreme temperature variations pose health risks.

5.9.2 Vulnerability to Natural Disasters

Urban areas in Bhutan are particularly susceptible to urban flooding and extreme heat, especially in the southern regions. Historical data shows that flooding is responsible for the largest percentage of mortality related to natural disasters. According to historical data, flooding occurs most frequently and is responsible for the largest percentage of mortality. The country also has high risk for wildfires, particularly in the Centre and southern portions of the country. Climate change could impact the intensity and frequency of flooding, landslides, GLOFs, and windstorms while also increasing the risk of wildfire.

The majority of Bhutan's agricultural land and infrastructure is located along drainage basins that are highly vulnerable to flooding from heavy monsoon rains and glacial melt. Risk concentration is notably high in central and northwestern regions, including Samtse Dzongkhag. Additionally, wildfires pose a significant risk, particularly in central and southern Bhutan[101]. The most relevant disaster data is according to the Risk and Resilience Portal - Methodology (2021) of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP)[102].

Based on the EM-DAT (1970 - 2021), four floods with 222 deaths and 1600 people were affected in Bhutan. Similarly, there were two cyclones with 29 lives lost and affecting 65,000 people - which is almost 8.3% of the total population.

Further the analysis also mentioned that floods are causing some US$ 82.9 million of loss which is some 3.4% of GDP, followed by drought costing US$ 67 million (2.7% of GDP) and multi-hazard with US$ 169.3 million (6.9% of GDP).

Table 37: Estimated Annual Loss due to Disasters in Bhutan

Average Annual Loss (AAL), Current

	USD, Millions	% GDP
Drought	67.0	2.7
Floods	82.9	3.4
Tropical cyclone	0.0	0.0
Tsunami	0.0	0.0
Earthquake	14.5	0.6
Biological	4.0	0.2
Multi-hazard	169.3	6.9

101 Bhutan - Vulnerability | Climate Change Knowledge Portal
102 https://rrp.unescap.org/sites/default/files/media/Methodology.pdf

The chart below provides overview of the most frequent natural disaster in Bhutan based on the World Bank Knowledge Portal.

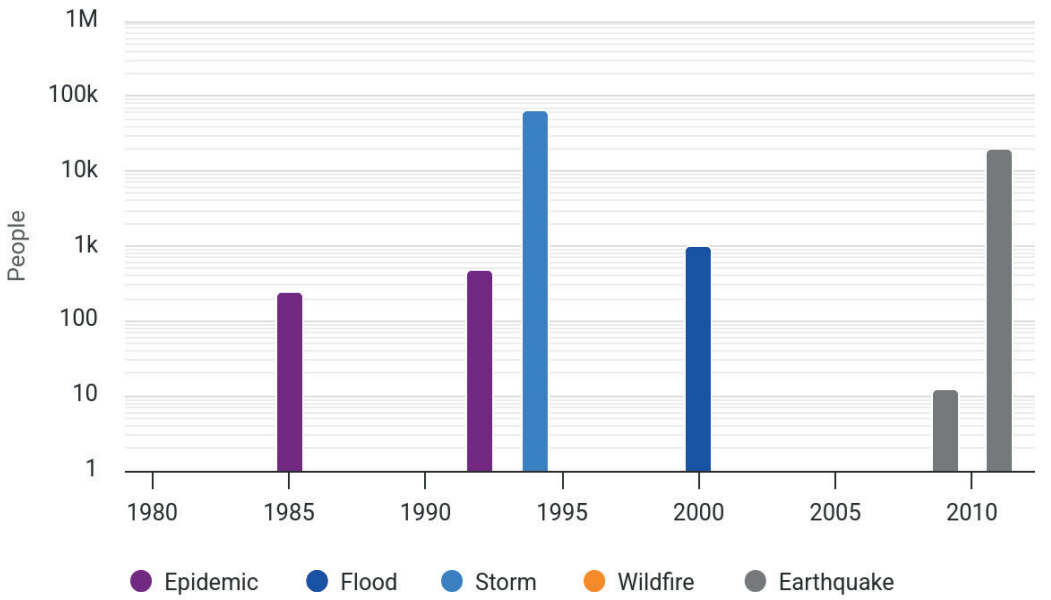

Figure 62: People affected due to hazards in Bhutan 1980-2020 (NCHM 2021)

The ESCAP study has also projected the future loss due to climate change in Bhutan under different scenarios. An increase of 2 ^{0}C in temperature, Bhutan will have impact of up to US$173.8 million, which is around 7.1 % of GDP, and US$171.9 million, (7.0 % of GDP) with 1.5^{0}C increase in temperature.

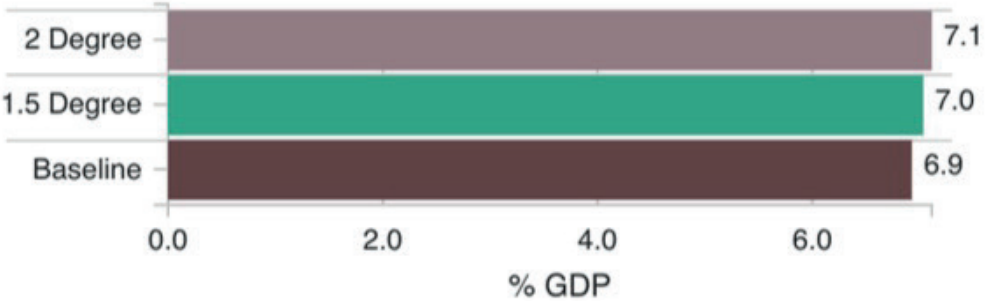

Figure 63: Average Annual Loss under different Climate Scenarios in Bhutan (ESCAP 2021)

The adaptation options identified by the same report are Strengthening Early Warning System; Resilient Infrastructure; Managing water resources more resilient; Improving dryland agriculture crop production; and, Nature Based Solutions in order.

5.10 Historical data from Bhutan

The following table provides a comprehensive overview of various disasters events that has occurred in Bhutan over recent years compiled by NCHM Bhutan. It details specific dates, locations, and the impacts of these incidents, illustrating the ongoing threat posed by climate-related disasters.

Flooding in Bhutan is not merely a natural occurrence; it is a complex issue intertwined with the country's Geography, climate change impacts, and socio-economic factors. The table highlights incidents ranging from flash floods caused by heavy rainfall to more severe events like Glacial Lake Outburst Floods (GLOFs). Each entry reflects the immediate consequences of these disasters, such as damage to infrastructure, loss of crops, and threats to human safety.

Table 38: List of Disasters in Bhutan

Year	Date/ month	Time	Event	River basin/ sub-basin	Dzongkhag	Village/ Gewog	Reported damage
2017	April25	Night	Flash flood	Punatsang-chhu	Gasa	Tashithang	A section of the road at Tashithang along the Punakha-Gasa highway was washed away.
2017	May 5	Night	Flash flood	(Manas)	Trashigang	Bartsham Gewog	Damaged farm roads and washed away crops in fourof the five chiwogs. Debris and boulders that washed down the slope where Bartsham Central School is located covered the multipurpose hall and partially damaged a hostelafter the rain flooded the hostel.
2017	June 26	6 pm	Nakpola and Kuktur-gang streams caused a flash flood	Manas (KholongChu)	Trash-Yangtse	Bumdeling	Washed away three RCC bridges, two wooden bridges, and an excavator inthe gewog and destroyed paddy fields, irrigation water sources, and fallow lands belonging to 16 households.
2017	July 17	Night	Swollen streams caused flooding	Manas (KhomaChhu)	Lhuentse	Shawa in Gangzur	Around 20 households lost at least 17 acres of crops. Washed away a few domestic animals, an electric pole, irrigation canals, and a mini hydropower supply water

2017	July 18	Morni ng	Flashflood	Manas (Mangdi-chhu)	Trongsa	Thruepang	Flooded Thruepang Palace compound. Destroyed the town's drinking water source.
2017	July 22	Night	Heavyrain causedflash flood	Phuntsharge (Sankosh)	Wangdue	Lopokha	The bridge was washed away, and crops were damaged.
2017	July 28		Heavyrain causedflash flood	Manas	Lhuentse	Kilung	Damaged a suspension bridge affecting about 50 households and students of Thimyul Lower Secondary School in Lhuntse.
2017	August8		Flashflood	Manas (DhaulaRiver)	Gelephu	Gelephu	Rainwater that flooded the border gate area soon dried up, not requiring evacuation. Further up around eight kilo-meters away at the Aie-slip, a major landslide blocked traf-fic flow untillate afternoon.
2017	August 10		Heavy rain caused flooding	Aichhu (Mao River)	Gelephu	Jampheling	Gelephu Thromde evacuated at least three families from the low-lying areas in Jam-pheling Demkhong after their makeshift huts were flooded with rainwater.
2017	August 13	8:45 pm	Smallflash-flood	Wangchhu (Cheri-chhu)	Thimphu	Cheri	Had no major impact.
2017	August 9-11	3 days	Flood	Punatsang-chhu	Punakha	PHPA II	The dam site was filled with water and debris from the flooding the Punatsangchhu spilled over the cofferdam.
2017	August 30	9.30-10 am	Flash flood	Aichhu	Gelephu	Gelephu	Washed away 100 meters of the temporarily reinstated Ge-lephu-Assam highway which was washed away on August 25 by the overflow from the reservoir below the airport.

2017	Sept. 4	Night	Heavy Rainfall caused flood	Dhaula River	Sarpang	Serzhong	Washed away more than 200 meters of Serzhong Gewog Centre road. Also washed away drinking water source about two kilometers away from the Shershong gewog centre which benefited the people of Norbuling and Chuzargang gewog.
2017	October 12	Night	Flood	Manas	Mongar	Tsakaling	Damaged crops, more than 250 orange trees were also washed away.
2018	June 13	6:30 pm	Flash flood	Manas	Lhuentse	Slilibe in Maedtsho Gewog	Washed away a labor camp consisting of 13 temporary sheds and a motorbike, affected some portions of the gewog road and farm roads. Also damaged was the under-construction RCC bridge that connects a native cattle-breeding centre of Sertsham to the grazing area located on the other side of the river.
2018	July 22	7:13 pm	Flash flood	Manas (Mithim-drang stream)	Trashigang	Rangshikhar	Although no major damages were reported, the meat shop and the ground floor of the vegetable market including two huts and the children's park were completely covered in muck. Four vehicles including two trucks were also stuck. Drinking water sources for the town and water pipelines in three different locations were also washed away.
2018	August 1		Flash flood	Manas (Buna stream)	Trashigang	Rangjung	About 12.5 km from Trashigang towards Rangjung, the flood completely washed away the road along the stretch. A farmer lost 1.7 acres of his paddy field to the flood.

						Dramang	Washed away a semi-commercial poultry farm including the road in the area. Also washed away three wooden structures including rice and corn mills. Around 400 pullets were also killed in the incident.
2019	April 29		Flash flood	Manas (Lek-pa-gangchu stream)	Lhuentse	Na-key-thang	Damaged the water sources that catered to residents living near a car automobile workshop at Jabin, an open-air gym at Nakeythang, and the ECCD centre.
2019	June 24	2-3 am	Heavy Rain	Aichhu (Stream beneath the bridge)	Gelephu	Gelephu	The reinforced concrete cement bridge (10 meters) near the domestic airport was completely washed away. A mini-tripper truck belonging to Sashastra Seems Bal (SSB) was also washed away.
2019	July 25	11 pm	Flash flood	Manas	Lhuentse	Gangzor gewog	Two women; a mother and a daughter were washed away by the flashflood.
2019	July 26		Flash flood	Wangchu	Chukha	Baunijhora P/ling	Sediments submerged the new Baunijhora bridge
2020	July 20	12:30 am	Flood	Mao River	Gelephu	Maochu Gelephu	16 people were stranded near the water treatment plant who were rescued the next morning. Four soldiers lost their lives. The flooding has also caused minor damage to the paddy plantation located near the riverbank. However, the damages to the water treatment plant could not be assessed yet.

2019	August 6		Flood	Punatsang-chhu	Punakha	Jarogang	Four workers of PHPA II went missing after the vehicle they were travelling in was washed away by the swollen river. Also damaged a house in Jarogang. About 700ms of the highway was completely submerged under the water.
2020	Octo-ber1	5:30 PM	Flash Flood	Manas (Chamdey Gangchu stream)	Trongsa	Bjeezam	Swept away belongings of six families near Bjeezam leaving them homeless. A shop, two huts, and the bridge to Nubi Gewog Centre were washed away. An artificial dam has been formed at the Mangde-chu River due to the flash flood debris. AWLS/AWS and manual gauge stations at Bjizam are submerged due to the backflow from the dam formation and are not operational. The Mangdechhu Hydro Pow-er remains shut down
2020	Oct 4	Mid-night	Flash flood	Punatsang chhu	Wangdue Phrodrang	Ruechey-kha, Ruebi-sa Gewog	Damaged more than three acres of ripe paddy belonging to 11 households. Damaged farm roads to Jala village. Ruecheykha village didn't have electricity for two days as the flash flood disrupted power lines.
2021	June 15	3:55-4 PM	Flash Flood	Khenba chhu	Trongsa	Chendebji village, Tangsibji Gewog	Damaged bridges, Mini Hydro-power houses, cow sheds, and timber logs in the nearby area but there are no casualties according to local people. People's access route was made difficult as they had to cross the other side of the river to do daily farming work.
2021	June 16		Flash flood and land-slide	Punatsang-chu	Gasa	Laya	10 people died and 5 others were injured.

2021	August 8	2:45 Pm	Flash Flood	Manas	Trashi- Yangt-se	Serkang stream	3 Human casualties reported
2021	August 26	2:00 Am	Flash Flood	Punatsang Chhu	Gasa	Gasa Taschu	Four Concrete structures including one shop were washed away. There was no report of human casualties. All seven hot spring ponds and bridges damaged
2021	August 25		Flood	Maochhu	Sarpang	Gelephu	Breached a gabion wall constructed along the Shetikhari stream in Gelephu. Washed away temporary boulder wall connecting the Reinforced concrete wall at the confluence. Stranded more than 20 people
2023	July 20		Flash Flood		Lhuentse		At least 6 people were killed and 17 others are still missing. A section of the Yungichhu Hydro Power Project was also damaged.
2024	August 10		Flash Flood		Thimphu	Dechen-choling	49 households have been severely impacted. Damaged 10 buildings in the area including 4 under construction. One car was washed away, eight remain in good condition, and the rest are damaged. 84 households in the RBG campus have also been impacted. Sixty-four students were affected. The flood also affected 62 foreign workers from 6 construction sites in the Dechencholing town

Fund for Responding to Loss and Damage

In response to the increasing recognition of loss and damage associated with climate change, the Loss and Damage Fund was established under the United Nations Framework Convention on Climate Change (UNFCCC). This fund aims to provide financial support to developing countries that are particularly vulnerable to climate impacts, enabling them to address loss and damage resulting from extreme weather events and slow-onset phenomena such as sea-level rise.
In 2022 at COP27 countries agreed to establish new funding arrangements for assisting developing countries that are particularly vulnerable to the adverse effects of climate change.

The following year, at COP28, countries reached a historic agreement on the operationalization of this fund. As part of that decision, the World Bank was invited to "operationalize the Fund as a World Bank hosted financial intermediary fund (FIF) for an interim period of four years", subject to a set of conditions to be met by the World Bank. The role of the World Bank will be to host the Fund secretariat, and to provide trustee services for the Fund.

The Loss and Damage Fund was fully operationalized at COP29, the United Nations Climate Change Conference held in Baku, Azerbaijan from November 11 to 22, 2024.

CHAPTER 6:
FINANCIAL, TECHNOLOGY DEVELOPMENT AND TRANSFER, AND CAPACITY BUILDING NEEDED AND RECEIVED UNDER ARTICLES UNDER ARTICLES 9–11, AND ARTICLE 13 OF THE PARIS AGREEMENT

In Bhutan, the National Environment Commission (NEC) is the apex body overseeing climate policy, governance, action, and transparency efforts. The NEC is supported by the Department of Environment and Climate Change, which is the national focal point for coordinating with government agencies and other stakeholders.

The Department of Macro-Fiscal and Development Finance (DMDF), Ministry of Finance, acts as the main coordinating body for climate finance including external support extended to the Royal Government of Bhutan. Its responsibilities include resource mobilization, expenditure planning, public debt management, capital market development, and engagement with bilateral and multilateral financial institutions.

To enhance its capacity for meeting the UNFCCC's Enhanced Transparency Framework requirements, Bhutan has established a National Thematic Working Group (NTWG), comprising experts on emissions inventory, climate policy, adaptation planning, and capacity building from relevant agencies. The NTWG serves as the main platform for preparing the Biennial Transparency Report (BTR). It is expected to initiate a data-sharing protocol and an inter-agency framework and arrangement to identify, track, and report FTC support needed and received, ensure compliance and reporting mechanisms under the MPGs, and engage non-governmental organizations, private sector, and international development partners for FTC-related activities. The NTWG operates with a focus on thematic areas critical to Bhutan's climate goals and promotes collaboration and data integration across sectors.

Consultations with diverse climate actors including the private sector, academia and civil societies is integral to fostering climate transparency efforts. A participatory approach to identify, track and report FTC has been key for both the BUR and the BTR processes. Bhutan will continue to build capacity of the climate stakeholders for an inclusive and all-of-society transparency reporting framework.

6.1 Identifying, Tracking, and Reporting FTC: Institutional Gaps and Challenges

Significant institutional gaps exist in meeting the requirements for identifying, tracking, and reporting financial, technological, and capacity-building support are needed and received under the UN-

FCCC. As the coordinating entity, the Department of Environment and Climate Change lacks an established system for monitoring, documenting, and archiving climate-related data, leading to ad hoc reporting efforts that undermine consistency and sustainability. The Bhutan Climate Platform, which was established to serve as a central hub for climate action coordination, is currently defunct and requires revitalization. There is limited accountability and audit mechanisms, compounded by conflicting priorities and insufficient coordination among ministries. Additionally, there is insufficient understanding of roles and responsibilities among agencies within Bhutan's climate governance structure, which affects the effective implementation of FTC tracking systems.

Systems and frameworks for tracking FTC are often developed only during reporting periods, preventing the establishment of sustainable and structured processes. There is an absence of standard operating procedures for data management and reporting which has resulted in inconsistent practices across agencies. A formal memorandum of understanding between the Department of Environment and Climate Change and agencies is required to standardize and regularize data-sharing processes and inter-agency coordination with clear roles and responsibilities. These procedural gaps must be addressed to ensure Bhutan's reporting systems align with the requirements of the ETF and other UNFCCC mechanisms.

Insufficient data management, sharing, and integration presents an additional challenge for transparency reporting. Without a centralized platform and system for data storage, integration, and archiving that ensures consistency and accessibility, retrospective reporting becomes cumbersome, and data inconsistencies, such as gaps in coverage across reporting periods and inadequate tracking of climate action progress, hinder Bhutan's ability to meet transparency obligations. There is an absence of a climate finance tracking tool making it difficult to monitor and report on financial flows aligned with national and international climate priorities. Addressing these procedural and data-related gaps is critical for Bhutan to align its reporting systems with the Enhanced Transparency Framework (ETF) and other UNFCCC mechanisms.

Inadequate human capacity remains a critical barrier across all sectors including public, private, and civil society organizations to fulfill its reporting obligations. There is a significant lack of trained personnel and technical expertise to develop and manage monitoring, reporting, and verification (MRV) systems. Sectors rely on ad hoc frameworks during reporting periods undermining the efficiency and reliability of data management processes. The strengthening institutional and technical capacities for enhanced transparency in the implementation and monitoring of Bhutan's Nationally Determined Contribution (NDC) is currently being implemented with a total funding of USD 1.46 million to:

- Enable Bhutan to submit Paris Agreement-compliant transparency reports by 2024.
- Develop inventories of GHG emissions and sinks using advanced guidelines.
- Track progress against Bhutan's NDC targets for mitigation and adaptation.

6.2 Information on Financial Support Needed by Developing Country Parties Under Article 9 of the Paris Agreement.

Bhutan outlines the need for financial support through its strategic national policies and plans aimed at sectors and specific areas of need. Bhutan's 13th Five-Year Plan (FYP) is a strategic framework for sustainable development, with an emphasis on climate-resilient development that integrates low-emission strategies across sectors while decoupling GDP growth from greenhouse gas emissions and enhancing community and ecosystem resilience. The total outlay for the 13th FYP is projected at BTN 512.283 billion. While Bhutan's development agenda integrates climate change-related concerns and issues into its strategic plans and policies, its domestic resources are constrained and estimated at BTN 327.34 billion of the available BTN 456.34 billion for the plan period. Bhutan will still require leveraging global partnerships and climate financing mechanisms if it is to transition to a low-carbon, climate-resilient economy as targeted and committed, to the amount of 55.93 billion from deficit financing and BTN 125 billion from grants.

Underscoring Bhutan's commitment to sustainable and climate-resilient growth on the one hand, and the Paris Agreement and global climate action on the other, Bhutan has developed its National Adaptation Plan (NAP), the NDC 2.0, and corresponding Low-Emission Development Strategy (LEDS), LTS, and roadmaps for specific and critical sectors. Table 39 shows climate-related plans and strategies with the total finance required to achieve the targets.

Table 39: National Plans and Finance Needed

Sector	Amount
Summary of Bhutan's 13th Five-Year Plan	BTN 512.283 billion
Water	USD 204.896 million
Agriculture & Livestock	USD 95.215 million
Forest and Biodiversity	USD 48.470 million
Human Settlements	USD 13,088,922,705.
Health	USD 19.661 million
Energy	USD 486.086 million
Climate Services and Disaster Risk Reduction	USD 1.300 million
Industries	USD 3.2 million
Surface Transport	USD 3222.00 million
Waste Management	Not Available
Long Term Low GHG Emission & Climate Resilient Strategy	USD 1145.55 Million (by 2025) USD. 2105.57 Million (by 2030) USD 3233.7 Million (by 2050)

Note: Financial figures are sourced from individual documents mentioned in the first column under plans/strategies

6.3 Information on Support for Development and Transfer of Technology Needed by Developing Country Parties Under Article 10 of the Paris Agreement

Bhutan faces significant gaps in its technological capacity to effectively manage climate change issues, primarily due to limited institutional frameworks, technical expertise, and access to advanced, context-specific solutions and finances. The last Technology Needs Assessment (TNA) was carried out in 2013. There is a critical need to update and draft a systematic and comprehensive TNA to identify and prioritize technologies tailored to Bhutan's unique socio-economic and environmental conditions. While not com-

prehensive, technology needs for Bhutan broadly include sustainable infrastructure and urban development (e.g. green building systems), renewable energy and energy efficiency technologies, climate-resilient agriculture and food systems, sustainable transport systems, climate observation and early warnings, industrial efficiency and emission reduction technologies, natural resource management monitoring and policy support tools, water resource management technologies, financial mechanisms, and market-based solutions, etc.

More importantly, the Technology Needs Assessment must focus on building a sectoral understanding of existing and emerging technologies, as well as identifying those that align with Bhutan's development and climate resilience goals. This includes fostering cross-sectoral awareness and technical knowledge to enable informed decision-making and targeted adoption of effective, context-appropriate solutions. Further to that, the TNA process should entail adequate engagement of private sector actors, communities, and other non-public entities to identify specific technology needs and advance the adoption of sustainable technologies.

6.4 Information on Capacity Building Support Needed by Developing Country Parties Under Article 11 of the Paris Agreement

Skills Assessment for NAP: Bhutan carried out a skills assessment to evaluate the country's readiness to implement the National Adaptation Plan. The evaluation identified technical, managerial, and participatory skills required for effective adaptation planning, implementation, and monitoring under the NAP framework across central agencies, local governments, the private sector, and non-profit organizations. Key constraints also included a lack of inter-agency coordination for data sharing and adaptation planning, insufficient institutional memory due to high turnover, limited training mechanisms, absence of a consolidated capacity development strategy that integrates climate adaptation into broader policy frameworks.

Capacity Building Initiative for Transparency: As part of the improvement plan of the last Biennial Update Report, the capacity-building initiative for the transparency project is being implemented to enhance the institutional and technical capacities of Bhutan to meet the transparency requirements outlined in the Paris Agreement.

Bhutan's capacity-building needs are at individual, institutional and systems levels. At the individual level, building skills and fostering knowledge are essential. From technical skills and scientific knowledge across sectors to navigating international climate financing platforms and pathways need targeted training programmes. Sector-specific research and development and data gaps need to be addressed. At the institutional level, the focus lies on improving collaboration across sectors and coordination among agencies. At the systemic level, creating an enabling environment through economic incentives, regulatory frameworks, and cohesive policies is essential to strengthen the overall capacity for climate action. Given the gaps and challenges at all levels, it warrants a comprehensive capacity needs assessment across all sectors with sufficient engagement of private sectors, academia, civil societies, and vulnerable groups.

6.5 Information on Financial, Technology and Capacity Building Support Received by Developing Country Parties Under Article 9, 10, and 11 of the Paris Agreement

Table 40: Detailed Finance, Technology, and Capacity Building Received (Jan 2021- Dec 2022)

Project Title	Project Duration	Status	Implementing Agency	Funding				Type of Funding			Sectoral Scope	Sub-Sector
				Source	Financial Instrument	Disbursed Amount	Committed Amount	Financial Support	Capacity Building	Technology Support		
Strengthening REDD+ & Watershed Management in Bhutan (BTN-RS-004)	Nov 2020 -May 2023	Completed	WMD/ DoFPS	GCF /UNOP	Grant	$350,000.00	$595,000.00	✓	✓	✓	Forestry	Forestry, Watershed & Agroforestry
Enhancing Sustainability and Climate Resilience of Forests and Agriculture	Oct 2017-2023	Ongoing	GNHCS	GEF/ LDCF/ SCCF	Grant	$4,899,806.00	$13,900,000.00	✓	✓	✓	Agriculture and Forest	Agriculture, Livestock & Forestry
Advancing Climate Resilience of the Water Sector in Bhutan	Aug 2023-2028	Ongoing	DoA, BCTA, MoIT, DLGDM, NCHM	GEF Trust Fund/ LDCF	Grant		$9,032,420.00	✓	✓	✓	Water	Watershed, water Infrastructure
Sustainable Low-emission Urban Transport System	Mar 2018-Feb 2021	Completed	MOIC	GEF	Grant		$2,639,726.00	✓	✓	✓	Transport	
National Adaptation Programme of Action (NAPA 3)	2017 - 2022	Completed	DOST	GEF-LDCF	Grant		$1,224,000.00	✓	✓		Agriculture	
Enhancing sustainability and climate resilience of forest and agriculture landscape and community livelihood (NAPA III)	2018-2023	ongoing	DPBP. MoF	GEF	Grant		$13,900,000.00	✓	✓		Agriculture	Agriculture and Forestry
Mainstreaming Biodiversity into the Tourism Sector in Bhutan (ecotourism)	2021-2026	ongoing	DoT, MoICE	GEF	Grant		$4,800,000.00	✓	✓		Multi Sector	Biodiveristy and Tourism
Small Grant Programme (SGP) during GEF Operational Phase 5, 6, 7	2010-2024	ongoing	UNDP	GEF	Grant		$1,900,000.00	✓	✓		Cross Sector	

Strengthening institutional and technical capacities for enhanced transparency in implementation and monitoring of Bhutan?s Nationally Determined Contribution (NDC) (CBIT) (MSP)	2021-2026	ongoing	DECC, MoENR	GEF	Grant		$1,776,000.00	✓	✓		Cross Sector	
Developing Climate Resilient Communities through appropriate Adaptation and Mitigation Intervention	Oct 2021 – 2023	Completed	Tarayana Foundation	GEF/SGP	Grant	$45,900.00	$45,900.00	✓	✓		Cross Sector	
Bhutan for Life	01.01.2017 - 01.01.2031	Ongoing	NCD	GCF/WWF/ LDCF/ RGOB	Grant		$378,010.00	✓	✓	✓	Forestry	
Supporting Climate Resilience and Transformational Change in the Agriculture Sector in Bhutan	2020-2025	ongoing	DMDF, MoF	GCF	Grant		$25,340,000.00	✓	✓		Agriculture	Agriculture and Forestry
Bhutan for Life Programme	2019-2032	Ongoing	DoFPS	GCF	Grant	$3,636,916.46	$26,500,000.00	✓			Cross Sector	
Adaptation Planning Support for Bhutan (NAP Readiness Project)	2019-2023	Completed	DECC (NECS)	GCF	Grant		$2,700,000.00	✓	✓			
Renewable Energy for Climate Resilience Project	Dec 2022- Dec 2025	Ongoing	DOE, MoENR	ADB	Grant		$18,260,000.00	✓	✓	✓	Energy	Renewable energy generation - solar
Green and Resilient Affordable Housing Sector Project	Dec 2021 - Dec 2027	Ongoing	MoF	ADB	Grant		$12,000,000.00	✓	✓	✓	Infrastructure (Human Settlement)	Water, Urban Infrastructure
Green and Resilient Affordable Housing Sector Project	Dec 2021 - Dec 2027	Ongoing	MoF	ADB	Concessional Loan		$24,000,000.00	✓				

Green and Resilient Affordable Housing Sector Project	Dec 2021 - Dec 2027	Ongoing	MoF	ADB	TA		$1000,000.00		✓			
Water flagship Programme Support Project	Nov-22	Ongoing	MoIT	ADB	Grant		$12,200,000.00	✓	✓	✓	Multi Sector	Urban water supply, Irrigation, Rural water supply services
Bhutan REDD+ Readiness	Jul 2017 - Jun 2022	Completed	WMD/ DoFPS	World Bank	Grant	$1,007,490.49	$4,800,000.00	✓	✓	✓	Forestry, Environment, Land and Water	
Green and Resilient Growth Development Policy Credit	May 23-2022	Ongoing	MOF	World Bank	Loan		$52,500,000.00	✓	✓	✓	Cross Sector	
Strengthening Risk Information for Resilience Project	Jul 2021 - Jun 2025	Ongoing		World Bank	Grant		$3,510,000.00	✓	✓	✓	Cross Sector	Transport, Multi-hazard, climate and hydromet services
Food Security and Agriculture Productivity (FSAPP)	2017-2025	ongoing	DoA, MoAL	World Bank	Grant		$8,000,000.00	✓	✓		Agriculture	Agriculture, Biodiversity and cross cutting
Preparation of Strategic Programme for Climate Resilience (SPCR)	2017-2021	Completed	GHNC	World Bank	Grant		$1,500,000.00	✓	✓			
Living Landscapes: Securing High Conservation Values (HCVs)	2020-2028	Ongoing	DoFPS, RSPN, Tarayana	IKI - Germany	Grant		Euro 8,873,998.00	✓	✓	✓	Multi Sector	Energy, agriculture, forestry, water and sanitation, eco-tourism, sustainable land management

Commercial Agriculture and Resilient Livelihoods Enhancement Programme (CARLEP)	2015-2025	ongoing	DoA, MoAL	IFAD	Grant		$31,526,000	✓	✓	Agricul-ture	Agriculture, Biodiversity and cross cutting
Eco System Based Adapta-tion spring shed manage-ment in Bhutan	Sept- Oct 2022	Complet-ed	Tarayana Foundation	IUCN	Grant	$24,943.00		✓		Water	
The NDC Support Pro-gramme "Gender Respon-sive NDC Implementation in Bhutan")	Jan 2019-Jun 2021	Complet-ed	GNHCS	UNDP	Grant		$802,500.00	✓	✓		

CHAPTER 7:
IMPROVEMENT PLAN

Bhutan's commitment to the Paris Agreement underscores the need for robust and transparent reporting mechanisms which would require continuous improvement plans to enhance the quality and accuracy of future Biennial Transparency Reports (BTRs) and national communications including reporting on mitigation, adaptation and means of implementation. This plan will need to focus on advancing the national capacity for emissions and sequestration estimation, incorporating more greenhouse gases, improving the use of country-specific emission factors, and leveraging more accurate activity data. It also includes measures to automate data collection processes and effectively track Nationally Determined Contributions (NDCs), as well as Finance, Technology, and Capacity Building (FTC) support as summarized in the following paragraphs.

7.1 Enhancing Greenhouse Gas Inventory Quality

7.1.1 Inclusion of Additional Gases

To ensure a comprehensive emissions profile, future BTRs will:

1. Include additional GHGs such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6).

2. Develop methodologies and tools to account for non-CO2 gases in AFOLU and IPPU categories.

7.1.2 Use of Country-Specific Emission Factors

Bhutan will prioritize the development and application of country-specific emission factors to improve accuracy. This will involve:

1. Conducting field studies to generate localized data.
2. Collection, analysis, and archiving of fuel characteristics data on a regular basis.
3. Collaborating with international agencies and technical experts for validation.
4. Establishing a repository for emission factors to facilitate their application across sectors.

7.1.3 Improving Activity Data Accuracy

Accurate activity data is critical for reliable emissions estimates. To achieve this, Bhutan will:

1. Conduct periodic surveys and censuses to capture sector-specific activity data.

2. Establish partnerships with academia and research institutions to refine data collection methodologies.

3. Develop national guidelines for data quality assurance and quality control (QA/QC).
4. Formal institutional arrangements with NSB for transparency and accuracy of AD for GHG emission estimates.

5. In the livestock sector, different manure management practices were adopted in the country, but empirical data on these practices are not available. There is a need to generate empirical information on livestock manure management either through systemic study or through rapid assessment. Research actions to generate empirical information and gearing up to adoption of Tier 2 methods to improve accuracy and reliability of reporting. These will include;

    - Establishing activity data for the livestock population by geographical zone (warm, cool, and temperate, etc.) using geo/satellite instruments and methodology.

    - Establishing science-based information on the livestock production system and feeding practices/system in Bhutan.

    - Capacity building on GHG emission estimation from enteric fermentation such as tools/technologies, and methodology.

    - Develop the capacity of technical staff on the estimation of uncertainty, projections, and trend analysis.

    - Advocacy program for the livestock farmers and different stakeholders on climate change impact and GHG emissions.

    - Training of local experts on the use of IPCC inventory software.

6. Develop annual or biennial land use and land cover maps at the most disaggregated level and correspond with GHG inventory years for BTR reporting as well as study the carbon stock change due to land use and land use change.

    - Forest Land

        - Stratify the forest land into sub-categories to improve inventory estimates, to the extent possible by forest types.

    - Study the carbon stock transfer between the different carbon pools in the forest remaining forest land.

        - Study the loss of a fraction of biomass loss due to disturbance such as forest fire. Forest fire does not necessarily lead to complete loss of biomass as opposed to the default assumption in the IPCC Tier 1 approach in Bhutan.

    - Improve the accuracy of gains and losses in the forest land as they directly influence the annual emissions and removals.

        - A uniform removal factor of 2.43 t d.m. $ha^{-1}yr^{-1}$ has been applied to forest remaining forest land and land converted to forest land including plantations. Study the biomass growth in different lands converted to forest land including gains in the SOC.

- Cropland
    - Map the cropland under annual and perennial crops and to the extent possible determine the land conversions.
    - Enhance the data collection and include the area under agroforestry systems and fallow land.
    - Determine the biomass growth rate in the perennial crops.
    - Determine the carbon stock in the cropland.
    - Collect any information on wood and fuelwood removals.
- Grassland
    - Stratify the grassland into sub-categories to improve inventory estimates, to the extent possible by vegetation covers.
    - Estimate the carbon stock of different grassland ecosystems.
    - Map and report areas under improved grassland.
    - Determine whether there is any burning in the grassland and report for future inventories.
    - Collect any information on wood and fuelwood removals.
- Wet land
    - Stratify the wetlands into sub-categories to improve inventory estimates, to the extent possible into rivers, lakes, and reservoirs.
    - Determine the biomass and SOC carbon stock in the areas mapped as wetland.
    - Collect any information on wood and fuelwood removals.
- Settlement
    - Stratify the settlements into paved surfaces, greenspace, urban, and rural settlements as well as road and other structures.
    - Conduct an inventory of trees and green spaces in the settlements.
    - Collect information on wood and fuelwood removals in settlements.

Automation of Activity Data Collection

Automation offers significant potential to enhance efficiency and accuracy. Planned activities include:

1. Implementing digital platforms to collect and manage activity data and fuel characteristic data in real-time.
2. Utilizing remote sensing and Geographic information systems (GIS) for land use and forestry data.
3. Integrating Internet of Things (IoT) devices in industrial and transportation sectors for real-time emissions monitoring.

Strengthening NDC Implementation Tracking

A transparent tracking system for NDCs is essential. Bhutan will:

1. Develop a centralized database to monitor progress against NDC targets.

2. Implement a dashboard for stakeholders to access real-time updates on mitigation and adaptation activities.

3. Link the tracking system with FTC support data to assess the impact of international assistance on achieving NDC goals.

4. Develop Indicator for NDC.

7.2 Finance, Technology, and Capacity Building (FTC) Support

7.2.1 Tracking Received and Needed Support

1. Establish a standardized reporting framework for FTC support to ensure consistency and transparency.

2. Leverage digital tools to automate data entry and reporting processes.

3. Facilitate quarterly stakeholder consultations to identify gaps and prioritize future needs.

7.2.2 Mobilizing Additional Support

1. Engage with international climate finance mechanisms, including the Green Climate Fund (GCF), Global Environment Facility (GEF), FRLD and any other funding agencies

2. Strengthen partnerships with bilateral and multilateral donors.

3. Promote public-private partnerships to attract investments in mitigation and adaptation projects.

7.2.3 Building National Capacity

1. Conduct sustained training programmes for government officials and technical staff on emissions estimation and reporting.

2. Develop a national curriculum on greenhouse gas inventory and climate reporting.

3. Foster knowledge exchange with other countries to adopt best practices.

7.3 Institutional Arrangements for Enhanced Climate Change Reporting

7.3.1 Strengthening Institutional Linkages

1. Enhance the role of the existing NTWG as a formal inter-ministerial committee to oversee climate reporting and ensure coordinated efforts across sectors and broaden the membership of the NTWG to include members from academia, NGOs and the private sector.

2. Develop clear mandates and responsibilities for all institutions involved in data collection, analysis, and reporting.

3. Foster partnerships with regional and international organizations to share knowledge and resources.

7.3.2 Capacity Building for Institutions

1. Provide regular training programmes for technical staff in emissions estimation, QA/QC processes, and reporting methodologies.

2. Enhance institutional infrastructure, including software and hardware for data management.

3. Promote the development of sector-specific expertise through collaboration with academic and research institutions.

7.3.3 Engagement of Academia, NGOs, and the Private Sector

1. Involve academic institutions in the research and development of country-specific emission factors and activity data.

2. Collaborate with NGOs to raise awareness and build capacity at the community level.

3. Partner with the private sector to leverage technology and innovation for improved data collection and monitoring.

References

Bdr, T., & Katwal. (2010). Multiple Cropping in Bhutanese Agriculture –Present Status and Opportunities. National Biodiversity Centre - Bhutan. https://www.nbc.gov.bt/wp-content/uploads/2010/06/Multiple-Cropping-Paper-Bhutan-for-SAC-1.pdf

Bhutan Biodiversity. (2017). Conservation and protection status. Latest news and updates | Bhutan Biodiversity. https://bt.chm-cbd.net/conservation-and-protection-status

Bhutan Biodiversity. (2024). Protected areas and biological corridors of Bhutan. Latest news and updates | Bhutan Biodiversity. https://bt.chm-cbd.net/protected-areas/protected-areas-and-biological-corridors-bhutan

Department of Climate Change and Environment. (2023). Bhutan's Long-Term Low Greenhouse Gas Emission and Climate Resilient Development Strategy (LTS). UNFCCC. https://unfccc.int/sites/default/files/resource/LTS%20Report_final%20print_copy.pdf

Department of Forests and Park Services. (2023, June). Bhutan State of Forest. https://BHUTAN_STATE_OF_FOREST_REPORT_20230726.pdf

Department of Forests and Park Services. (2023, June). State of forest carbon report. https://bfl.org.bt/wp-content/uploads/2024/05/National-Forest-Inventory-Volume-II_State-of-Forest-Carbon-Report-2023.pdf

DGPC. (2023, August 10). Electricity-rich Bhutan relies heavily on thermal energy. Druk Green Power Corporation. https://www.drukgreen.bt/en/2023/08/10/electricity-rich-bhutan-still-relies-heavily-on-thermal-energy/

GISGeography. (2024, June 9). Bhutan map - Cities and roads - GIS Geography. GIS Geography. https://gisGeography.com/bhutan-map/#Physical-Map

Kuensel. (2021, April 1). Bhutan records 567 glacial lakes, 17 potentially dangerous. Kuensel Online. https://kuenselonline.com/bhutan-records-567-glacial-lakes-17-potentially-dangerous/

Kuensel. (2023, May 30). GNH study shows alarming gender disparity in literacy. Kuensel Online. https://kuenselonline.com/gnh-study-shows-alarming-gender-disparity-in-literacy/

M, S. (2024). Bhutan's graduation from LDC: Opportunities and challenges. IDSA. https://www.idsa.in/idsacomments/Bhutan-Graduation-from-LDC#:~:text=Its%20small%20and%20vulnerable%20economy,graduating%20from%20its%20LDC%20status

Macrotrends. (2022). Bhutan GDP growth rate 1971-2024. Macrotrends | The Long Term Perspective on Markets. https://www.macrotrends.net/global-metrics/countries/BTN/bhutan/gdp-growth-rate#:~:text=Bhutan%20gdp%20growth%20rate%20for,a%202.25%25%20increase%20from%202018

MoENR. (2022). Geoscience and Mining Journal. Department of Geology and Mines. https://www.moenr.gov.bt/wp-content/uploads/2018/12/Geosciences-and-Mining-Journal-2022.pdf

MoENR. (2022). Bhutan energy data directory. Ministry of Energy and Natural Resources. https://www.moenr.gov.bt/wp-content/uploads/2018/11/Final-copy-of-BEED-2022.pdf

MoH. (2020). Overview. Ministry of Health. https://www.moh.gov.bt/about/overview/

MoH. (2024). Report on mapping and study of selected Tsachhus/Hotsprings and Menchhus/Mineral springs in Bhutan. Ministry of Health. https://www.moh.gov.bt/wp-content/uploads/B5_Report-on-Tshachhu.pdf

MoHA. (2024). Dept. Local Governance & Disaster Management. Dept. Local Governance & Disaster Management. https://www.dlgdm.gov.bt/dlg-faq#:~:text=The%20decisions%20of%20the%20Dzongkhag,making%20at%20the%20Gewog%20level

MoIT. (2024, May 26). Bhutan Highways Master Plan to 2040. Ministry of Information and Technology. https://www.moit.gov.bt/wp-content/uploads/2024/02/SEA-Scoping-Report-240526-compressed.pdf

National Centre for Hydrology and Meteorology. (2024). State of the climate 2023. National Centre for Hydrology and Meteorology. https://www.nchm.gov.bt/attachment/ckfinder/userfiles/files/State%20of%20Climate%202023.pdf

National Environment Commission. (2016, March 16). National Integrated Water Resources Management Plan 2016. Asian Development Bank. https://www.adb.org/sites/default/files/project-documents/46463/46463-002-dpta-en.pdf

NBC. (2019, May 22). Biodiversity Statistics of Bhutan. Bhutan Biodiversity Portal. https://biodiversity.bt/biodiv/content/documents/document-0f89f358-790f-40a2-bbca-2da3ee6d8efd/630.pdf

NCHM. (2019). Analysis of Historical Climate and Climate Projection for Bhutan. National Centre for Hydrology

and Meteorology. https://www.nchm.gov.bt/attachment/ckfinder/userfiles/files/Analysis%20of%20Historical%20Climate%20and%20Climate%20Change%20Projection.pdf

NEC. (2020). Climate Change Policy of the Kingdom of Bhutan 2020. FAOLEX Database | Food and Agriculture Organization of the United Nations. https://faolex.fao.org/docs/pdf/bhu207787.pdf

NEC. (2020). National Environment Commission, third national communication to the United Nations Framework Convention on Climate Change (UNFCCC), Thimphu, the royal government of Bhutan, 2020. Bing. https://www.bing.com/search?pglt=2339&q=National+Environment+Commission%2C+Third+National+Communication+to+the+United+Nations+Framework+Convention+on+Climate+Change+(UNFCCC)%2C+Thimphu%2C+Royal+Government+of+Bhutan%2C+2020.&cvid=404d7bb9b6bd4602b2ba707b5ae590af&gs_lcrp=EgRlZGdlKgYIABBFGDkyBggAEEUYOdIBBzk5OWowajGoAgCwAgA&FORM=ANNTA1&PC=U531

NSB. (2018). 2017 Population and housing census of Bhutan. National Statistics Bureau. https://www.nsb.gov.bt/wp-content/uploads/dlm_uploads/2020/07/PHCB2017_wp.pdf

NSB. (2019). Nation's waste on the scale. National Statistics Bureau. https://nsb.gov.bt/wp-content/uploads/2020/10/NWIS-2019-.pdf

NSB. (2023). 12th five-year plan – National statistics bureau. National Statistics Bureau. https://www.nsb.gov.bt/12th-five-year-plan/

NSB. (2024). National accounts statistics 2024 – National statistics bureau. National Statistics Bureau. https://www.nsb.gov.bt/https-www-nsb-gov-bt-wp-content-uploads-dlm_uploads-2024-07-nas-2024-for-web-pdf/

NSB. (2024). Statistical Yearbook of Bhutan 2023. National Statistics Bureau. https://www.nsb.gov.bt/wp-content/uploads/dlm_uploads/2023/10/SYB-2023.pdf

Ramsar Information sheet. (2016, April 4). Ramsar Sites Information Service. https://rsis.ramsar.org/RISapp/files/RISrep/BT2264RIS_1604_en.pdf

RGOB. (2021, June 5). Second Nationally Determined Contribution. UNFCCC. https://unfccc.int/sites/default/files/NDC/2022-06/Second%20NDC%20Bhutan.pdf

Royal Government of Bhutan. (2023). National Adaptation Plan (NAP)of the Kingdom of Bhutan. UNFCCC. https://unfccc.int/sites/default/files/resource/NAP-Bhutan-2023.pdf

Ugyen Wangchuck Institute for Forestry Research and Training. (2011). Inventory of High Altitude Wetlands in Bhutan. UWIFoRT. https://www.uwice.gov.bt/admin_uwice/publications/publication_files/Reports/2011/UWICER-IOHAWIB.pdf

UNDP. (2023, November). Climate risk assessment on water resources for NAP. United Nations Development Programmememe. https://www.undp.org/sites/g/files/zskgke326/files/2023-11/undp-bhutan-climate-risk-assessment-on-water-resources-for-nap-nov-2023.pdf

United Nations. (2023, December 13). Bhutan graduates from LDC status | Department of Economic and Social Affairs. Welcome to the United Nations. https://www.un.org/development/desa/dpad/2023/bhutan-graduates-from-ldc-status/

World Bank. (2016). Bhutan's labor market is towards gainful quality employment for all. MoICE. https://www.moice.gov.bt/wp-content/uploads/2017/07/Bhutans-Labor-Market-Towards-Gainful-Quality-Employment-for-All.pdf

World Economic Forum. (2021, October 25). What Bhutan got right about happiness - and what other countries can learn. WEForum. https://www.weforum.org/stories/2021/10/lessons-from-bhutan-economic-development/

WWF. (2012, January 12). Bhutan joins the Ramsar convention. https://www.wwfbhutan.org.bt/?203094/Bhutan-joins-the-Ramsar-Convention

WWF. (2016). Water in Bhutan's economy. World Wildlife Fund. https://wwfasia.awsassets.panda.org/downloads/water_in_the_economies__policy_brief_for_development_partners_2.pdf

WWF. (2018). Bhutan Water Facts. UWICE. https://www.uwice.gov.bt/admin_uwice/publications/publication_files/Reports/2018/Bhutan%20Water%20Facts%20August-2018.pdf

Zero waste Bhutan. (2024). ZeroWasteBhutan. ZeroWasteBhutan. https://zerowastebhutan.gov.bt/#:~:text=The%20National%20Waste%20Inventory%20Survey,by%20commercial%20units%20with%2039.09%20%25

Annexures

Annexure I: National Thematic Working Group Members/Reviewers

1. Mr. Suraj Chhetri, National Soil Service Center, Department of Agriculture, MoAL
2. Mrs. Choney Zangmo, Department of Agriculture, MoAL
3. Mr. Dorji Wangdi, Department of Forest and Park Services, MoENR
4. Mr. Dawa Zangpo, Department of Forest and Park Services, MoENR
5. Ms. Dechen Pema Yangki, Department of Energy, MoENR
6. Mr. Ugyen Chophel, Department of Energy, MoENR
7. Mr. Karchen Dorji, Department of Industry, MoICE
8. Mr. Leki Wangdi, Department of Industry, MoICE
9. Mr. Jigme Wangdi, Department of Livestock, MoAL
10. Ms. Ganga Maya Rizal, Department of Livestock
11. Mr. Madhav Dungyel, Bhutan Construction and Transport Authority, MoIT
12. Mr. Chet Raj Ghalley, Bhutan Civil Aviation Authority, MoIT
13. Mr. Sangay Ngedup, Department of Surface Transport, MoIT
14. Mr. Tshering Dhendup, Department of Surface Transport, MoIT
15. Mr. Leki Choda, Policy and Planning Division, MoAL
16. Mr. Jigme Lhendup, Policy and Planning Division, MoENR
17. Mr. Sachin Limbu, Waste Management Division, DECC, MoENR
18. Sonam Gyelpo, CCD, DECC, MoENR
19. Mr. Jigme Gembo, Waste Management Division, DECC, MoENR
20. Mr. Singye Wangchuk, Environment Assessment and Compliance Division, DECC, MoENR

Annexure II: National Consultant Team

1. Mr. Sangay Dorji, Team Lead, Energy and IPPU Expert
2. Mr. Nidup Peljor, AFOLU Expert
3. Ms. Tashi Chuki Wangdi, Waste Expert
4. Mr. Dawa Chogyel, NDC Tracking Expert
5. Mr. Chhimi Dorji, National Circumstances and Adaptation Expert
6. Ms. Tshering Lhamtshok, FTC Expert
7. Ms. Tshering Dema, Inventory Coordinator
8. Mr. Yeshey Penjor, Project Coordinator

Annexure III: CRT Tables for GHG Inventory (ETF Reporting Tool) for the 2019-2022 reporting years submitted as excel files.

Annexure IV: NAI Reporting Tables (IPCC Inventory Software)

Inventory Year: 2022			Emissions(Gg)
Categories	**Net CO2 (1)(2)**	**CH4**	**N2O**
Total National Emissions and Removals	-10131.19099	17.489	0.105
1 - Energy	550.4434122	0.0626	0.027
1.A - Fuel Combustion Activities	550.0932162	0.0626	0.027
1.A.1 - Energy Industries	0	0	0
1.A.2 - Manufacturing Industries and Construction	151.5821569	0.0148	0.002
1.A.3 - Transport	370.7534549	0.0455	0.025
1.A.4 - Other Sectors	27.7576044	0.0024	6E-05
1.A.5 - Non-Specified	0	0	0
1.B - Fugitive emissions from fuels	0.350195998	0	0
1.B.1 - Solid Fuels	0.350195998	0	0
1.B.2 - Oil and Natural Gas	0	0	0
1.B.3 - Other emissions from Energy Production	0	0	0
1.C - Carbon dioxide Transport and Storage	0	0	0
1.C.1 - Transport of CO2	0		
1.C.2 - Injection and Storage	0		
1.C.3 - Other	0		
2 - Industrial Processes and Product Use	673.9333613	0	0
2.A - Mineral Industry	335.5410947	0	0
2.A.1 - Cement production	335.5410947		
2.A.2 - Lime production	0		
2.A.3 - Glass Production	0		
2.A.4 - Other Process Uses of Carbonates	0		
2.A.5 - Other (please specify)	0	0	0
2.B - Chemical Industry	0	0	0
2.B.1 - Ammonia Production	0		
2.B.2 - Nitric Acid Production			0
2.B.3 - Adipic Acid Production			0
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production			0
2.B.5 - Carbide Production	0	0	
2.B.6 - Titanium Dioxide Production	0		
2.B.7 - Soda Ash Production	0		
2.B.8 - Petrochemical and Carbon Black Production	0	0	
2.B.9 - Fluorochemical Production			

2.B.10 - Hydrogen Production	0	0	0
2.B.11 - Other (Please specify)	0	0	0
2.C - Metal Industry	337.5306	0	0
2.C.1 - Iron and Steel Production	0	0	
2.C.2 - Ferroalloys Production	337.5306	0	
2.C.3 - Aluminium production	0		
2.C.4 - Magnesium production	0		
2.C.5 - Lead Production	0		
2.C.6 - Zinc Production	0		
2.C.7 - Rare Earths Production	0		
2.C.8 - Other (please specify)	0	0	0
2.D - Non-Energy Products from Fuels and Solvent Use	0.861666667	0	0
2.D.1 - Lubricant Use	0.861666667		
2.D.2 - Paraffin Wax Use	0		
2.D.3 - Solvent Use			
2.D.4 - Other (please specify)	0	0	0
2.E - Electronics Industry	0	0	0
2.E.1 - Integrated Circuit or Semiconductor			0
2.E.2 - TFT Flat Panel Display			0
2.E.3 - Photovoltaics			
2.E.4 - Heat Transfer Fluid			
2.E.5 - Other (please specify)	0	0	0
2.F - Product Uses as Substitutes for Ozone Depleting Substances	0	0	0
2.F.1 - Refrigeration and Air Conditioning			
2.F.2 - Foam Blowing Agents			
2.F.3 - Fire Protection			
2.F.4 - Aerosols			
2.F.5 - Solvents			
2.F.6 - Other Applications (please specify)			
2.G - Other Product Manufacture and Use	0	0	0
2.G.1 - Electrical Equipment			
2.G.2 - SF6 and PFCs from Other Product Uses			
2.G.3 - N2O from Product Uses			0
2.G.4 - Other (Please specify)	0	0	0
2.H - Other	0	0	0
2.H.1 - Pulp and Paper Industry	0	0	0
2.H.2 - Food and Beverages Industry	0	0	0

2.H.3 - Other (please specify)	0	0	0
3 - Agriculture, Forestry, and Other Land Use	-11355.57052	13.89	0.077
3.A - Livestock	0	12.885	0.016
3.A.1 - Enteric Fermentation		11.919	
3.A.2 - Manure Management		0.9653	0.016
3.B - Land	-11356.30382	0	0
3.B.1 - Forest land	-11374.08685		
3.B.2 - Cropland	-65.01798859		
3.B.3 - Grassland	-11.34185239		
3.B.4 - Wetlands	0		
3.B.5 - Settlements	25.93428866		
3.B.6 - Other Land	68.20857542		
3.C - Aggregate sources and non-CO2 emissions sources on land	0.733304	1.0055	0.061
3.C.1 - Burning	0	0	0
3.C.2 - Liming	0		
3.C.3 - Urea application	0.733304		
3.C.4 - Direct N2O Emissions from managed soils			0.027
3.C.5 - Indirect N2O Emissions from managed soils			0.011
3.C.6 - Indirect N2O Emissions from manure management			0.024
3.C.7 - Rice cultivation		1.0055	
3.C.8 - CH4 from Drained Organic Soils		0	
3.C.9 - CH4 from Drainage Ditches on Organic Soils		0	
3.C.10 - CH4 from Rewetting of Organic Soils		0	
3.C.11 - CH4 Emissions from Rewetting of Mangroves and Tidal Marshes		0	
3.C.12 - N2O Emissions from Aquaculture			0
3.C.13 - CH4 Emissions from Rewetted and Created Wetlands on Inland Wetland Mineral Soils		0	
3.C.14 - Other (please specify)	0	0	0
3.D - Other	0	0	0
3.D.1 - Harvested Wood Products	0		
3.D.2 - Other (please specify)	0	0	0
4 - Waste	0.002755777	3.536	0
4.A - Solid Waste Disposal		0.6895	
4.B - Biological Treatment of Solid Waste		0.0013	0
4.C - Incineration and Open Burning of Waste	0.002755777	0	0
4.D - Wastewater Treatment and Discharge		2.8452	0
4.E - Other (please specify)	0	0	0

5 - Other	0	0	0
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3			0
5.B - Indirect CO2 emissions from the atmospheric oxidation of CH4, CO and NMVOC	0		
5.C - Other	0	0	0

Memo Items (5)			
International Bunkers	26.3414151	0.0002	7E-04
1.A.3.a.i - International Aviation (International Bunkers)	26.3414151	0.0002	7E-04
1.A.3.a.i - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOX and NH3			0
1.A.3.a.i - Indirect CO2 emissions from the atmospheric oxidation of CH4, CO and NMVOC	0		
1.A.3.d.i - International water-borne navigation (International bunkers)	0	0	0
1.A.3.d.i - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOX and NH3			0
1.A.3.d.i - Indirect CO2 emissions from the atmospheric oxidation of CH4, CO and NMVOC	0		
1.A.5.c - Multilateral Operations	0	0	0
1.A.5.c - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOX and NH3			0
1.A.5.c - Indirect CO2 emissions from the atmospheric oxidation of CH4, CO and NMVOC	0		

Inventory Year: 2021			**Emissions(Gg)**
Categories	**Net CO2 (1)(2)**	**CH4**	**N2O**
Total National Emissions and Removals	-10434.76792	19.691	0.118
1 - Energy	602.3943756	0.066	0.028
1.A - Fuel Combustion Activities	602.1480849	0.066	0.028
1.A.1 - Energy Industries	0	0	0
1.A.2 - Manufacturing Industries and Construction	214.6449054	0.0215	0.003
1.A.3 - Transport	377.8131224	0.0435	0.025
1.A.4 - Other Sectors	9.6900572	0.001	4E-05
1.A.5 - Non-Specified	0	0	0
1.B - Fugitive emissions from fuels	0.246290676	0	0
1.B.1 - Solid Fuels	0.246290676	0	0
1.B.2 - Oil and Natural Gas	0	0	0
1.B.3 - Other emissions from Energy Production	0	0	0
1.C - Carbon dioxide Transport and Storage	0	0	0

1.C.1 - Transport of CO2	0		
1.C.2 - Injection and Storage	0		
1.C.3 - Other	0		
2 - Industrial Processes and Product Use	698.3461697	0	0
2.A - Mineral Industry	367.4959871	0	0
2.A.1 - Cement production	367.4959871		
2.A.2 - Lime production	0		
2.A.3 - Glass Production	0		
2.A.4 - Other Process Uses of Carbonates	0		
2.A.5 - Other (please specify)	0	0	0
2.B - Chemical Industry	0	0	0
2.B.1 - Ammonia Production	0		
2.B.2 - Nitric Acid Production			0
2.B.3 - Adipic Acid Production			0
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production			0
2.B.5 - Carbide Production	0	0	
2.B.6 - Titanium Dioxide Production	0		
2.B.7 - Soda Ash Production	0		
2.B.8 - Petrochemical and Carbon Black Production	0	0	
2.B.9 - Fluorochemical Production			
2.B.10 - Hydrogen Production	0	0	0
2.B.11 - Other (Please specify)	0	0	0
2.C - Metal Industry	329.89506	0	0
2.C.1 - Iron and Steel Production	0	0	
2.C.2 - Ferroalloys Production	329.89506	0	
2.C.3 - Aluminium production	0		
2.C.4 - Magnesium production	0		
2.C.5 - Lead Production	0		
2.C.6 - Zinc Production	0		
2.C.7 - Rare Earths Production	0		
2.C.8 - Other (please specify)	0	0	0
2.D - Non-Energy Products from Fuels and Solvent Use	0.955122667	0	0
2.D.1 - Lubricant Use	0.955122667		
2.D.2 - Paraffin Wax Use	0		
2.D.3 - Solvent Use			
2.D.4 - Other (please specify)	0	0	0
2.E - Electronics Industry	0	0	0
2.E.1 - Integrated Circuit or Semiconductor			0

2.E.2 - TFT Flat Panel Display			0
2.E.3 - Photovoltaics			
2.E.4 - Heat Transfer Fluid			
2.E.5 - Other (please specify)	0	0	0
2.F - Product Uses as Substitutes for Ozone Depleting Substances	0	0	0
2.F.1 - Refrigeration and Air Conditioning			
2.F.2 - Foam Blowing Agents			
2.F.3 - Fire Protection			
2.F.4 - Aerosols			
2.F.5 - Solvents			
2.F.6 - Other Applications (please specify)			
2.G - Other Product Manufacture and Use	0	0	0
2.G.1 - Electrical Equipment			
2.G.2 - SF6 and PFCs from Other Product Uses			
2.G.3 - N2O from Product Uses			0
2.G.4 - Other (Please specify)	0	0	0
2.H - Other	0	0	0
2.H.1 - Pulp and Paper Industry	0	0	0
2.H.2 - Food and Beverages Industry	0	0	0
2.H.3 - Other (please specify)	0	0	0
3 - Agriculture, Forestry, and Other Land Use	-11735.51122	16.17	0.09
3.A - Livestock	0	15.113	0.018
3.A.1 - Enteric Fermentation		13.974	
3.A.2 - Manure Management		1.1396	0.018
3.B - Land	-11736.39254	0	0
3.B.1 - Forest land	-11816.71263		
3.B.2 - Cropland	1.928927019		
3.B.3 - Grassland	-9.721892485		
3.B.4 - Wetlands	0		
3.B.5 - Settlements	23.16466456		
3.B.6 - Other Land	64.94839312		
3.C - Aggregate sources and non-CO2 emissions sources on land	0.88132	1.057	0.072
3.C.1 - Burning	0	0	0
3.C.2 - Liming	0		
3.C.3 - Urea application	0.88132		
3.C.4 - Direct N2O Emissions from managed soils			0.032
3.C.5 - Indirect N2O Emissions from managed soils			0.013

3.C.6 - Indirect N2O Emissions from manure management			0.028
3.C.7 - Rice cultivation		1.057	
3.C.8 - CH4 from Drained Organic Soils		0	
3.C.9 - CH4 from Drainage Ditches on Organic Soils		0	
3.C.10 - CH4 from Rewetting of Organic Soils		0	
3.C.11 - CH4 Emissions from Rewetting of Mangroves and Tidal Marshes		0	
3.C.12 - N2O Emissions from Aquaculture			0
3.C.13 - CH4 Emissions from Rewetted and Created Wetlands on Inland Wetland Mineral Soils		0	
3.C.14 - Other (please specify)	0	0	0
3.D - Other	0	0	0
3.D.1 - Harvested Wood Products	0		
3.D.2 - Other (please specify)	0	0	0
4 - Waste	0.002755777	3.4549	0
4.A - Solid Waste Disposal		0.6572	
4.B - Biological Treatment of Solid Waste		0.0013	0
4.C - Incineration and Open Burning of Waste	0.002755777	0	0
4.D - Wastewater Treatment and Discharge		2.7964	0
4.E - Other (please specify)	0	0	0
5 - Other	0	0	0
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3			0
5.B - Indirect CO2 emissions from the atmospheric oxidation of CH4, CO and NMVOC	0		
5.C - Other	0	0	0

Memo Items (5)			
International Bunkers	14.09142735	1E-04	4E-04
1.A.3.a.i - International Aviation (International Bunkers)	14.09142735	1E-04	4E-04
1.A.3.a.i - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOX and NH3			0
1.A.3.a.i - Indirect CO2 emissions from the atmospheric oxidation of CH4, CO and NMVOC	0		
1.A.3.d.i - International water-borne navigation (International bunkers)	0	0	0
1.A.3.d.i - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOX and NH3			0
1.A.3.d.i - Indirect CO2 emissions from the atmospheric oxidation of CH4, CO and NMVOC	0		
1.A.5.c - Multilateral Operations	0	0	0

1.A.5.c - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOX and NH3			0
1.A.5.c - Indirect CO2 emissions from the atmospheric oxidation of CH4, CO and NMVOC	0		

Inventory Year: 2020			Emissions (Gg)
Categories	**Net CO2 (1)(2)**	**CH4**	**N2O**
Total National Emissions and Removals	-10161.70565	19.588	0.117
1 - Energy	588.2712326	0.3501	0.031
1.A - Fuel Combustion Activities	588.0992434	0.3501	0.031
1.A.1 - Energy Industries	0	0	0
1.A.2 - Manufacturing Industries and Construction	188.0990435	0.0185	0.003
1.A.3 - Transport	369.3775709	0.0441	0.024
1.A.4 - Other Sectors	30.6226291	0.2875	0.004
1.A.5 - Non-Specified	0	0	0
1.B - Fugitive emissions from fuels	0.171989188	0	0
1.B.1 - Solid Fuels	0.171989188	0	0
1.B.2 - Oil and Natural Gas	0	0	0
1.B.3 - Other emissions from Energy Production	0	0	0
1.C - Carbon dioxide Transport and Storage	0	0	0
1.C.1 - Transport of CO2	0		
1.C.2 - Injection and Storage	0		
1.C.3 - Other	0		
2 - Industrial Processes and Product Use	693.8210735	0	0
2.A - Mineral Industry	490.0526735	0	0
2.A.1 - Cement production	490.0526735		
2.A.2 - Lime production	0		
2.A.3 - Glass Production	0		
2.A.4 - Other Process Uses of Carbonates	0		
2.A.5 - Other (please specify)	0	0	0
2.B - Chemical Industry	0	0	0
2.B.1 - Ammonia Production	0		
2.B.2 - Nitric Acid Production			0
2.B.3 - Adipic Acid Production			0
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production			0
2.B.5 - Carbide Production	0	0	
2.B.6 - Titanium Dioxide Production	0		
2.B.7 - Soda Ash Production	0		
2.B.8 - Petrochemical and Carbon Black Production	0	0	
2.B.9 - Fluorochemical Production			

2.B.10 - Hydrogen Production	0	0	0
2.B.11 - Other (Please specify)	0	0	0
2.C - Metal Industry	202.65894	0	0
2.C.1 - Iron and Steel Production	0	0	
2.C.2 - Ferroalloys Production	202.65894	0	
2.C.3 - Aluminium production	0		
2.C.4 - Magnesium production	0		
2.C.5 - Lead Production	0		
2.C.6 - Zinc Production	0		
2.C.7 - Rare Earths Production	0		
2.C.8 - Other (please specify)	0	0	0
2.D - Non-Energy Products from Fuels and Solvent Use	1.10946	0	0
2.D.1 - Lubricant Use	1.10946		
2.D.2 - Paraffin Wax Use	0		
2.D.3 - Solvent Use			
2.D.4 - Other (please specify)	0	0	0
2.E - Electronics Industry	0	0	0
2.E.1 - Integrated Circuit or Semiconductor			0
2.E.2 - TFT Flat Panel Display			0
2.E.3 - Photovoltaics			
2.E.4 - Heat Transfer Fluid			
2.E.5 - Other (please specify)	0	0	0
2.F - Product Uses as Substitutes for Ozone Depleting Substances	0	0	0
2.F.1 - Refrigeration and Air Conditioning			
2.F.2 - Foam Blowing Agents			
2.F.3 - Fire Protection			
2.F.4 - Aerosols			
2.F.5 - Solvents			
2.F.6 - Other Applications (please specify)			
2.G - Other Product Manufacture and Use	0	0	0
2.G.1 - Electrical Equipment			
2.G.2 - SF6 and PFCs from Other Product Uses			
2.G.3 - N2O from Product Uses			0
2.G.4 - Other (Please specify)	0	0	0
2.H - Other	0	0	0
2.H.1 - Pulp and Paper Industry	0	0	0
2.H.2 - Food and Beverages Industry	0	0	0

2.H.3 - Other (please specify)	0	0	0
3 - Agriculture, Forestry, and Other Land Use	-11443.80071	15.845	0.086
3.A - Livestock	0	14.464	0.017
3.A.1 - Enteric Fermentation		13.37	
3.A.2 - Manure Management		1.0947	0.017
3.B - Land	-11444.86004	0	0
3.B.1 - Forest land	-11425.5547		
3.B.2 - Cropland	-93.26525933		
3.B.3 - Grassland	-8.101932582		
3.B.4 - Wetlands	0		
3.B.5 - Settlements	20.39504047		
3.B.6 - Other Land	61.66681362		
3.C - Aggregate sources and non-CO2 emissions sources on land	1.059329333	1.3803	0.069
3.C.1 - Burning	0	0	0
3.C.2 - Liming	0		
3.C.3 - Urea application	1.059329333		
3.C.4 - Direct N2O Emissions from managed soils			0.03
3.C.5 - Indirect N2O Emissions from managed soils			0.012
3.C.6 - Indirect N2O Emissions from manure management			0.026
3.C.7 - Rice cultivation		1.3803	
3.C.8 - CH4 from Drained Organic Soils		0	
3.C.9 - CH4 from Drainage Ditches on Organic Soils		0	
3.C.10 - CH4 from Rewetting of Organic Soils		0	
3.C.11 - CH4 Emissions from Rewetting of Mangroves and Tidal Marshes		0	
3.C.12 - N2O Emissions from Aquaculture			0
3.C.13 - CH4 Emissions from Rewetted and Created Wetlands on Inland Wetland Mineral Soils		0	
3.C.14 - Other (please specify)	0	0	0
3.D - Other	0	0	0
3.D.1 - Harvested Wood Products	0		
3.D.2 - Other (please specify)	0	0	0
4 - Waste	0.002755777	3.393	0
4.A - Solid Waste Disposal		0.6239	
4.B - Biological Treatment of Solid Waste		0.0013	0
4.C - Incineration and Open Burning of Waste	0.002755777	0	0
4.D - Wastewater Treatment and Discharge		2.7679	0
4.E - Other (please specify)	0	0	0

5 - Other	0	0	0
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3			0
5.B - Indirect CO2 emissions from the atmospheric oxidation of CH4, CO and NMVOC	0		
5.C - Other	0	0	0

Memo Items (5)			
International Bunkers	22.0657437	0.0002	6E-04
1.A.3.a.i - International Aviation (International Bunkers)	22.0657437	0.0002	6E-04
1.A.3.a.i - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOX and NH3			0
1.A.3.a.i - Indirect CO2 emissions from the atmospheric oxidation of CH4, CO and NMVOC	0		
1.A.3.d.i - International water-borne navigation (International bunkers)	0	0	0
1.A.3.d.i - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOX and NH3			0
1.A.3.d.i - Indirect CO2 emissions from the atmospheric oxidation of CH4, CO and NMVOC	0		
1.A.5.c - Multilateral Operations	0	0	0
1.A.5.c - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOX and NH3			0
1.A.5.c - Indirect CO2 emissions from the atmospheric oxidation of CH4, CO and NMVOC	0		

Inventory Year: 2019	**Emissions (Gg)**		
Categories	**Net CO2 (1)(2)**	**CH4**	**N2O**
Total National Emissions and Removals	-10787.73364	20.513	0.126
1 - Energy	627.637711	0.3762	0.037
1.A - Fuel Combustion Activities	627.3427934	0.3762	0.037
1.A.1 - Energy Industries	0	0	0
1.A.2 - Manufacturing Industries and Construction	96.05439588	0.0081	0.001
1.A.3 - Transport	494.9561301	0.0518	0.031
1.A.4 - Other Sectors	36.3322674	0.3164	0.004
1.A.5 - Non-Specified	0	0	0
1.B - Fugitive emissions from fuels	0.294917636	0	0
1.B.1 - Solid Fuels	0.294917636	0	0
1.B.2 - Oil and Natural Gas	0	0	0
1.B.3 - Other emissions from Energy Production	0	0	0
1.C - Carbon dioxide Transport and Storage	0	0	0

1.C.1 - Transport of CO2	0		
1.C.2 - Injection and Storage	0		
1.C.3 - Other	0		
2 - Industrial Processes and Product Use	612.8417135	0	0
2.A - Mineral Industry	490.0526735	0	0
2.A.1 - Cement production	490.0526735		
2.A.2 - Lime production	0		
2.A.3 - Glass Production	0		
2.A.4 - Other Process Uses of Carbonates	0		
2.A.5 - Other (please specify)	0	0	0
2.B - Chemical Industry	0	0	0
2.B.1 - Ammonia Production	0		
2.B.2 - Nitric Acid Production			0
2.B.3 - Adipic Acid Production			0
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production			0
2.B.5 - Carbide Production	0	0	
2.B.6 - Titanium Dioxide Production	0		
2.B.7 - Soda Ash Production	0		
2.B.8 - Petrochemical and Carbon Black Production	0	0	
2.B.9 - Fluorochemical Production			
2.B.10 - Hydrogen Production	0	0	0
2.B.11 - Other (Please specify)	0	0	0
2.C - Metal Industry	121.67958	0	0
2.C.1 - Iron and Steel Production	0	0	
2.C.2 - Ferroalloys Production	121.67958	0	
2.C.3 - Aluminium production	0		
2.C.4 - Magnesium production	0		
2.C.5 - Lead Production	0		
2.C.6 - Zinc Production	0		
2.C.7 - Rare Earths Production	0		
2.C.8 - Other (please specify)	0	0	0
2.D - Non-Energy Products from Fuels and Solvent Use	1.10946	0	0
2.D.1 - Lubricant Use	1.10946		
2.D.2 - Paraffin Wax Use	0		
2.D.3 - Solvent Use			
2.D.4 - Other (please specify)	0	0	0
2.E - Electronics Industry	0	0	0
2.E.1 - Integrated Circuit or Semiconductor			0

2.E.2 - TFT Flat Panel Display			0
2.E.3 - Photovoltaics			
2.E.4 - Heat Transfer Fluid			
2.E.5 - Other (please specify)	0	0	0
2.F - Product Uses as Substitutes for Ozone Depleting Substances	0	0	0
2.F.1 - Refrigeration and Air Conditioning			
2.F.2 - Foam Blowing Agents			
2.F.3 - Fire Protection			
2.F.4 - Aerosols			
2.F.5 - Solvents			
2.F.6 - Other Applications (please specify)			
2.G - Other Product Manufacture and Use	0	0	0
2.G.1 - Electrical Equipment			
2.G.2 - SF6 and PFCs from Other Product Uses			
2.G.3 - N2O from Product Uses			0
2.G.4 - Other (Please specify)	0	0	0
2.H - Other	0	0	0
2.H.1 - Pulp and Paper Industry	0	0	0
2.H.2 - Food and Beverages Industry	0	0	0
2.H.3 - Other (please specify)	0	0	0
3 - Agriculture, Forestry, and Other Land Use	-12028.21582	16.795	0.089
3.A - Livestock	0	15.453	0.018
3.A.1 - Enteric Fermentation		14.287	
3.A.2 - Manure Management		1.1664	0.018
3.B - Land	-12029.14956	0	0
3.B.1 - Forest land	-12003.66166		
3.B.2 - Cropland	-95.01657253		
3.B.3 - Grassland	-6.481972678		
3.B.4 - Wetlands	0		
3.B.5 - Settlements	17.62541637		
3.B.6 - Other Land	58.38523412		
3.C - Aggregate sources and non-CO2 emissions sources on land	0.933738667	1.3418	0.071
3.C.1 - Burning	0	0	0
3.C.2 - Liming	0		
3.C.3 - Urea application	0.933738667		
3.C.4 - Direct N2O Emissions from managed soils			0.031
3.C.5 - Indirect N2O Emissions from managed soils			0.012

3.C.6 - Indirect N2O Emissions from manure management			0.027
3.C.7 - Rice cultivation		1.3418	
3.C.8 - CH4 from Drained Organic Soils		0	
3.C.9 - CH4 from Drainage Ditches on Organic Soils		0	
3.C.10 - CH4 from Rewetting of Organic Soils		0	
3.C.11 - CH4 Emissions from Rewetting of Mangroves and Tidal Marshes		0	
3.C.12 - N2O Emissions from Aquaculture			0
3.C.13 - CH4 Emissions from Rewetted and Created Wetlands on Inland Wetland Mineral Soils		0	
3.C.14 - Other (please specify)	0	0	0
3.D - Other	0	0	0
3.D.1 - Harvested Wood Products	0		
3.D.2 - Other (please specify)	0	0	0
4 - Waste	0.002755777	3.3421	0
4.A - Solid Waste Disposal		0.5881	
4.B - Biological Treatment of Solid Waste		0.0013	0
4.C - Incineration and Open Burning of Waste	0.002755777	0	0
4.D - Wastewater Treatment and Discharge		2.7528	0
4.E - Other (please specify)	0	0	0
5 - Other	0	0	0
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3			0
5.B - Indirect CO2 emissions from the atmospheric oxidation of CH4, CO and NMVOC	0		
5.C - Other	0	0	0

Memo Items (5)			
International Bunkers	79.333254	0.0006	0.002
1.A.3.a.i - International Aviation (International Bunkers)	79.333254	0.0006	0.002
1.A.3.a.i - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOX and NH3			0
1.A.3.a.i - Indirect CO2 emissions from the atmospheric oxidation of CH4, CO and NMVOC	0		
1.A.3.d.i - International water-borne navigation (International bunkers)	0	0	0
1.A.3.d.i - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOX and NH3			0
1.A.3.d.i - Indirect CO2 emissions from the atmospheric oxidation of CH4, CO and NMVOC	0		
1.A.5.c - Multilateral Operations	0	0	0

1.A.5.c - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOX and NH3		0
1.A.5.c - Indirect CO2 emissions from the atmospheric oxidation of CH4, CO and NMVOC	0	

Annexure V: CTF tables for NDC progress tracking submitted as excel files.
Annexure VI: REDD+ Technical Annexure submitted as PDF file.