Bhutan's Long-Term Low Greenhouse Gas Emission and Climate Resilient Development Strategy (LTS)

Department of Environment and Climate Change
Ministry of Energy and Natural Resources
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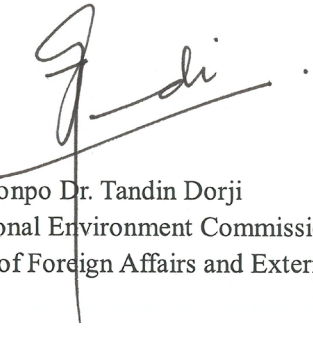
Foreword

Climate change is a cross-sectoral issue and its impacts are irreversible affecting every sector, and the economy of the country is largely dependent upon climate-sensitive sectors such as agriculture, hydropower, and forestry. We must mainstream climate change in our national policies, plans, programs, and strategies. Bhutan's Long-term Low Greenhouse Gas Emission and Climate Resilient Development Strategy (LTS) builds on Bhutan's initiatives in the development of the different sectoral Low Emission Development Strategies (LEDS) with an aspiration to undertake till 2050 considering both climate aspects and socio-economic development.

The LTS is prepared with the objectives of always remaining carbon neutral and decoupling GHG emissions from economic growth. The strategy presents the scale of transformation needed to bring national climate action that will ultimately help achieve the global goal of reducing emissions. Further, the strategy covers implementation arrangements and provides a basis for accessing international climate finance and exploring domestic financing opportunities.

The development of this strategy is successful with the support of the 2050 Pathway Platform and through guidance from the UNFCCC process to our national engagements including a rigorous technical assessments process, and consultations with a wide range of stakeholders across different sectors, from national agencies to regional and local planners, civil society, and the private sector. This strategy will not just serve as our communication under the Paris Agreement but will also play a critical role in identifying opportunities and challenges to pursue low-carbon resilient development in aligning with national priorities. Overall, this strategy is developed to guide mainly mitigation and adaptation components in achieving its long-term goal (2050).

I would like to extend my sincere gratitude to the LTS formulation team, the thematic working groups, the project support team from the NEC Secretariat, all stakeholders involved in the preparation of this document, and the reviewers for their invaluable contributions. I would also like to thank the European Climate Foundation (ECF) for its financial support. Lastly, I look forward to your continued support for the implementation of the strategy to make Bhutan more climate resilient by reducing emissions and pursuing in low carbon development.



Lyonpo Dr. Tandin Dorji
Chairman, National Environment Commission and
Minister, Ministry of Foreign Affairs and External Trade.

Executive Summary

According to Article 4, paragraph 19 of the Paris Agreement, "all Parties should strive to formulate and communicate long-term low greenhouse gas emission development strategies, mindful of Article 2 taking into account their common but differentiated responsibilities and respective capabilities, in the light of different national circumstances" and Bhutan has undertaken the task of developing the "climate Resilient and Low Carbon Development Strategy" (LTS) with the objective of remaining carbon neutral for all times to come as pledged at the 15th Conference of Parties (COP) of the United Nations Framework Convention on Climate change (UNFCCC) and subsequently reiterated in all the COPs and Meeting of Parties (MOPs) of the Paris Agreement. The secondary objective of the LTS is to decouple socio-economic growth in the form of GDP, employment, and an improved balance of payment from GHG emissions. The LTS is also developed to identify key interventions to ensure that socio-economic development remains carbon resilient and required adaptation measures are developed for vulnerable sectors as identified in Bhutan's Second Nationally Determined Contribution (NDC) to the UNFCCC.

While Bhutan is currently carbon neutral with the forests sequestering more greenhouse gas (GHG) than the total national emissions, there has been a rapid increase in emissions due to economic development. The latest greenhouse gas (GHG) inventory compiled for the Third National Communication of Bhutan to the UNFCCC showed that in 2015, the gross emission was 3814.09 $GgCO_2e$ and sequestration of 9386,59 $GgCO_2e$ resulting in a net sequestration of 5572.50 $GgCO_2e$.

GHG emission projections to 2050 using available data from 2000 to 2015 estimates emissions in 2025 at 5230.95 $GgCO_2e$, 2030 at 5702.02 $GgCO_2e$, and 2050 at 7526.03 $GgCO_2e$. At the same time, owing to pressures on forest land for development activities and forest disturbances in the form of outbreaks of pests and diseases and wildfires will lead to reduced sequestration estimated at 9327 $GgCO_2e$ in 2025, 8870 $GgCO_2e$ in 2030 and 7255 $GgCO_2e$ in 2050. This means that following a Business-as-Usual (BAU) approach to development puts Bhutan's carbon neutrality pledge at risk by 2047-2048 as shown in *Figure 1. GHG emissions and removals: historical trend and projections.*

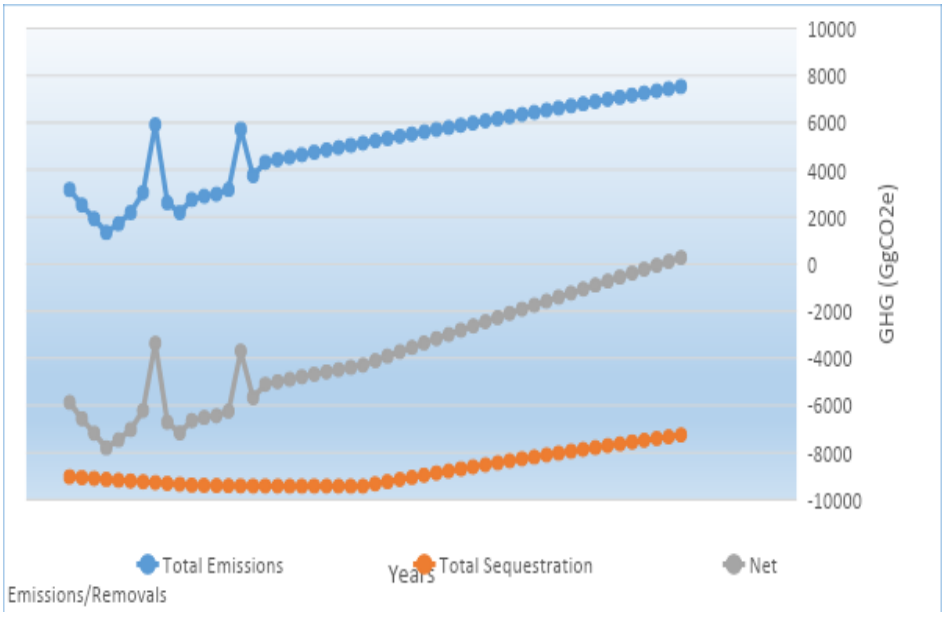


Figure 1. GHG emissions and removals: historical trend and projections

The mitigation assessment of economic sectors builds up on the work done while developing the sectoral Low Emission Development Strategies (LEDS) for manufacturing industries, food security (agriculture and livestock), transport and human settlements while the vulnerability assessment builds on the work carried out for Bhutan's first National Adaptation Plan (NAP) focusing on energy, water, agriculture, transport, forest & biodiversity and human health.

The mitigation strategy follows the Intergovernmental Panel on Climate Change (IPCC) categories of Energy, IPPU, AFOLU and Waste with a combined cumulative emission reduction target of 3785.72 $GgCO_2e$ by 2025, 12,507.36 $GgCO_2e$ by 2030 and 48,652.84 $GgCO_2e$ by 2050.

Category/ Target Years	**Targets (Cumulative emission reduction, GgCO2e)**			**Costs (USD Millions)**
	2025	**2030**	**2050**	
Energy	1866.01	5602.61	21856.78	201.62
IPPU	1422.91	4980.18	19209.28	5.90
AFOLU	301.15	1239.77	4945.51	9.10
Waste	195.65	684.80	2641.27	3.50
Total	**3785.72**	**12507.36**	**48652.84**	**220.12**

The total cost implication for implementing these measures is estimated at USD 220.12 Million[1] spread over from 2023 to 2050.

Considering the importance of adaptation in the context of Bhutan with its tough geographic terrain, limited mineral resources, and dependence on a few economic activities, the adaptation measures cover the sectors of energy, water resources, agriculture, transport, and human health.

In the energy sector, particular attention has been paid to the energy security of the country particularly faced with the risk of erratic river discharges and the vulnerability of the hydropower infrastructure to climate-induced natural disasters such as GLOF and flashfloods through interventions including research and development in the energy sector, cascading and pump storage hydropower projects, promotion of alternative renewable energy as well as demand side management.

To enhance food security through climate-resilient agriculture and livestock development, the key vulnerabilities due to extreme weather events, water availability for agriculture, climate-induced pests and diseases and natural disasters, loss of soil fertility, human-wildlife conflict and difficulties of crops and livestock to adapt to a rapidly changing climate are addressed through various interventions. These interventions include innovative irrigation infrastructure, improved breed of livestock animals, crop insurance schemes, etc.

Climate change can impact the forest and biodiversity sector through extreme weather and climate patterns resulting in more pronounced forest fires, loss of endemic species, change in migratory patterns, and incidences of invasive species, pests, and diseases. Adaptation measures include policy measures, increased research and monitoring, prevention and management of wildfires as well as pest and disease management.

Climate change creates the dual problem of water scarcity (drinking, irrigation, energy production) as well as water abundance in the form of GLOF and floods. The main issue is the change in seasonal precipitation, temperature, and wind speed and these are to be addressed through interventions such as enhanced weather and climate observation, development of watershed and river management plans, lowering levels of dangerous glacial lakes, early warning systems and innovative water technologies including drip irrigation and pressurized water distribution systems.

In the transport sector which serves as the lifeline of the Bhutanese economy considering the landlocked nature of the country, climate change exacerbates the

[1] The cost estimates are tentative based on expert judgement and are subject to change when detailed project reports are developed.

issue of already constrained transport infrastructure resulting in roads damaged due to heavy monsoon rains, flash floods and landslides. The interventions include building the capacity of local professionals in carrying out vulnerability assessments, designing climate-resilient transport infrastructure as well as climate-proofing the roads to ensure all-season connectivity within Bhutan as well as to the outside world

Climate change can exert an additional strain on the Bhutanese health system due to increased maternal mortality, increased pulmonary diseases, increased cases of cancer (lung, skin, gastrointestinal) as well as vector-borne and water-borne diseases. The responses to these risks include building the professional capacity of medical professionals, upgrading health infrastructure, innovative healthcare systems, and enhanced awareness campaigns.

Considering that Bhutan with its carbon-negative status is the least responsible for causing global climate change and yet bears the brunt of its impact with relatively lower capacities to adapt, the financing for the adaptation works is expected to come from the international community, particularly the international climate funds, multilateral development agencies as well as bilateral assistance. Table 1 summarizes the financing requirement for the adaptation measures of this LTS in the short, medium, and long term.

Table 1. Summary of financing requirement for adaptation

S/N	Sector	Cost (Million USD)	Cost (Million USD)	Cost (Million USD)
		2025	**2030**	**2050**
1	Energy	818.98	1654.49	2817.53
2	Food Security	60.33	124.09	109.63
3	Forest and biodiversity	145.92	82.33	78.52
4	Water	18.52	61.82	21.07
5	Transport	30.5	52.2	103
6	Human health	71.3	130.64	103.95
TOTAL (Million USD)		1145.55	2105.57	3233.7
TOTAL (Million BTN)		85916.25	157917.75	242527.5

A Socio-Economic Model was developed to study the co-benefits of the LTS and this showed the following value addition of the LTS besides GHG mitigation and climate resilience as shown in Table 2 below:

Table 2. Result of the socio-economic model

Socio-Economic Parameter	up to 2025	up to 2030	up to 2050
Total Additional Jobs Created	20,438.22	40,876.43	102,191.08
Total Additional GDP Generated in USD Million	178.86	357.72	894.30
Total Import Requirements in implementing policy levers in USD Million	23.92	47.84	119.61
Total Exports in implementing policy levers in USD Million	88.19	176.38	440.95
Balance of Trade in USD Million[2]	64.27	128.54	321.35

As seen from the table, the implementation of LTS can add 102,191 new jobs to the labor market, USD 894 Million to Bhutan's GDP, reduce import dependence, increase exports, and reduce the overall balance of trade to the tune of USD 321 Million.

The socio-economic model also showed a clear decoupling of GDP growth with GHG emissions, marginally in the first few years of LTS implementation and more pronouncedly in the long term as seen in Table 3 below:

Table 3. Decoupling GDP growth with GHG emissions

	BAU		LTS		Comparison (BAU-LTS)	
Year	GHG (GgCo2e)	GDP (USD) Millions)	GHG (GgCo2e)	GDP (USD) Millions)	GDP USD Millions)	GHG (GgCO2e)
2025	5230.95	3521.46	3969.67	3610.89	-89.43	1261.29
2030	5702.62	3521.46	4209.90	3879.18	-357.72	1492.72
2050	7526.03	3521.46	5975.39	4415.76	-894.30	1550.64

The strategy to implement the short and medium-term action aims to address the financing barrier through accessing direct grants, concessional loans or loans at market rates but backed with government guarantees. International climate finance can be mobilized through avenues such as the Green Climate Fund or from bilateral donors. Also, international market mechanisms are an avenue for

[2] This BoT reflects the net imports as a result of economic activities generated through the implementation of policy levers

generating revenues from the sale of emissions credits. Further, the strategy explores domestic financing opportunities.

Technology and capacity barriers need to be addressed by harnessing technical assistance for central and local governments, private sector and civil society organizations to enable understanding the technology that is being implemented and providing proper maintenance to secure its long-term operability.

1. Visioning the Climate Resilient and Low Carbon Development Strategy

1.1 Vision

To make Bhutan a dynamic, prosperous, resilient, inclusive, and sustainable economy by 2050 while continuing to be carbon neutral, where the aspirations for gross national happiness of the present and future generations are secured under a changing climate with a strong emphasis on low carbon and climate resilient approaches to development.

1.2 Mission

- To remain carbon neutral (for all times) through targeted GHG mitigation in key economic sectors while also enhancing the sequestration potential of the forest and other land use in Bhutan.
- To prioritize adaptation interventions proactively to reduce climate-induced disasters and capitalize on opportunities provided by climate change.
- To improve climate and weather forecasts and modeling through the in-country capacity to build and develop a body of knowledge on climate mitigation and adaptation through local experiments and experiences.
- To finance local mitigation and adaptation interventions through global and regional climate financing instruments, including both market and non-market approaches.
- To continue being a leader in the global community of nations on climate change and sustainable development through rigorous engagement at both regional and global levels.

1.3 Objectives

Enhancing Partnerships

1.3.1 Carbon Neutrality

To ensure Bhutan remains carbon neutral by implementing low emission strategies across all key sectors. Goals of key sectors include:

a. Industry: To decouple industrial growth from growth in GHG emissions, by improving the eco-efficiency of production processes, enhancing competitiveness, and using renewable energy sources.

b. Food security: To implement climate smart and resource efficient practices in the agriculture sector with a primary focus on organic agriculture including both agricultural crops and livestock.

c. Human Settlement: To accelerate the adoption of energy efficient building design, energy efficient appliances, and renewable energy technologies in commercial and residential buildings

d. Surface transport: To minimize the GHG emissions of the surface transport sector through both demand and supply side management by upgradation of the emission norms of ICE vehicles, adoption of electric vehicles (100% light vehicle and bus sales to be EVs by 2045 and 25% heavy vehicles (freight) imports to be EVs by 2050) and use of shared mobility, public transport, and non-motorized transport.

e. Waste Management: Minimize GHG emissions from the waste management sector through the application of zero waste and circular economy concepts including upgradation of technology, infrastructure, and capacity within the country.

f. Energy Security: To enhance national energy security through the adoption and promotion of renewable energy sources including hydro, wind, solar, bio-fuels (where applicable), and innovative energy sources such as green hydrogen.

g. Protection and Enhancement of carbon sinks: Protection and enhancement of forest and other land use in Bhutan which has been sequestering GHGs through sustainable forest management practices, forest fire management, and rehabilitation of degraded and barren forest lands.

1.3.2 Climate Resilience

To ensure mainstreaming the inevitable effects of climate change and climate variability in development planning and to develop adequate capacity and resilience to respond to future climate change hazards including:

- Integrated Water Resources Management
- Climate Resilient Agriculture and Livestock Production
- Disaster risk reduction and climate-proofing infrastructure.
- Mainstreaming climate adaptation into development planning.
- predicting future climate scenarios and carrying out risk and vulnerability studies

1.3.3 Ensuring means of implementation

To note that Bhutan has done more than its fair share in combating climate change and any extra effort both towards mitigating GHG emissions and adapting climate change must be supported.

To ensure that the challenges and opportunities of climate change are addressed at all levels, through adequate means of implementation (finance, technology, capacity building, and awareness).

To mobilize international support mechanisms, including financial, technology transfer, and capacity building for the uptake of climate resilient and low carbon activities.

To participate in regional and global carbon markets to make a contribution towards decarbonization and to finance Bhutan's mitigation and adaptation projects

1.3.4 Integration into development plans and processes

Developing and implementing an effective climate action plan with the objective of decoupling GHG emissions from economic growth and building climate resilience while ensuring socially fair transition, cost-effectiveness, creation of green jobs, diversification of the economy, and enhancing gross national happiness remain the main driving forces.

1.3.5 Enhancing Partnerships

To ensure sustainable implementation, existing partnerships must be strengthened and new partnerships developed. At a national level, partnerships will mean developing implementation mechanisms involving central government and local government agencies, the private sector, civil society organizations, and special interest groups, particularly youth and women groups. At the international level, existing partnerships with multilateral mechanisms, multilateral banks, and development partners must be further strengthened and new partnerships developed, particularly in the areas of climate finance focusing on both mitigation and adaptation.

2. Background

2.1 National Circumstances

2.1.1 Geography, biological diversity, climate, natural resources

Bhutan is a small, landlocked country with an area of 38,394 Km^2 situated on the southern slope of the Eastern Himalayas, bordering China to the north and India to its south, east and west. The country is almost entirely mountainous. With altitudes ranging from about 100 meters in the foothills to over 7,500 meters in the north, the country's north-south border spans over 170 km while the east-west dimension measures around 300 km. The dominant topographic features consist of the high Himalayas in the north with snowcapped peaks and alpine pastures, north–south valleys and ranges forming watersheds, deep valleys created by fast-flowing rivers, rugged foothills, and alluvial plains with broad river valleys.

Figure 2. Administrative Map of Bhutan

Owing to its fragile mountainous ecosystem, Bhutan is highly vulnerable impacts of climate change and extreme weather events. The situation is further worsened by the country's low adaptative capacity, and poor economic status constrained by limited financial, technical, and human capacity. Additionally, the country's economy is still predominantly dependent on climate sensitive sectors like agriculture (more than 60% of rural population depend for livelihood) and hydropower. The mountainous landscape makes communication and transport very fragile and expensive.

2.1.2 Land area

According to the land cover assessment, the land use is classified into the following classes. The forests cover (excluding shrubs) covers 70.77% of the total land area of which 45.94% is broadleaf forests, 13.53% is mixed conifer, 6.02% is chirpine and 2.64% is blue pine. The Alpine Shrub covers 3.39% of the land area, shrubs constitute 9.74%, cultivated agriculture land covers 2.75% and meadows 2.51%. Snow cover constitutes 5.35% and rocky areas is 4.15% while water bodies, built-up areas, non-built-up areas, landslides and moraines each constitutes less than 1%. (FRMD, 2017).

Table 4. Land use and Land cover classification of Bhutan (Source: National Forest Inventory Report 2016, Volume 1)

Land use and land cover class	**Area (ha)**	**% of land cover**	**% of forest area**
Broadleaf	1763899.00	46%	65%
Conifer	953262.20	25%	35%
Shrub	374032.60	10%	
Snow and glaciers	205343.60	5%	
Rocky outcrops	159455.60	4%	
Alpine Scrub	130097.70	3%	
Agriculture	105682.40	3%	
Meadows	96273.61	3%	
Water bodies	25175.78	1%	
Moraines	14393.94	0%	
Built up	7457.03	0%	
Landslides	3730.22	0%	
Non-built up	595.89	0%	NA
Total	**3839399.57**		
Total Forest Area	**2713691.00**		

2.1.3 Climate

The climate of Bhutan is exceptionally diverse. Two main factors affect the variation in average temperature and precipitation: the vast differences in altitude in the country and the influence of the North Indian monsoons. Bhutan's location at the northern periphery of the tropical circulation is an important feature that determines its climate. Bhutan has three distinctive climatic zones: Subtropical: the southern belt with an altitude between 200 and 2000 meters, characterized by high humidity and heavy rainfall. The temperature ranges from 15^0C to 30^0C all year round. Temperate: the central belt with an attitude ranging from about 2000 to 4000 meters, consisting of main river valleys, and characterized by cool winters

and hot summers with moderate rainfall. The temperature ranges from 15^0 C to 26^0C during the monsoon season (June through September) and -4^0C to -15^0C during the winter season. Alpine; the high region in the northern encompasses snowcapped peaks and alpine meadows above 4000 meters with cold winters and cool summers. Bhutan receives about 70% of the precipitation during monsoons, while pre-monsoon rainfall accounts for 20%. The annual precipitation ranges widely in various parts of the country. The northern region gets about 40 mm of annual precipitation, mostly in the form of snow. The temperate central valley receives about 1,000 mm of rainfall, while the southern region gets about 1,500 mm of rainfall annually (NSB, 2018). The monsoons last from late June through late September.

2.1.4 Natural Resources

Forest resources

Bhutan has a total of 70.77 % forest cover (2717161.64 ha) out of the total geographical area (3,839,400 ha) of the country (FRMD 2017). Broadleaved forests constitute around 65% of the forested area, while conifer forests make up about 35%. The forest cover of Bhutan marginally increased from 70.46 in 2010 to 70.77% in 2016.

According to the National Forest Inventory, Bhutan's forests store 645 million tonnes of carbon in the form of biomass carbon and soil organic carbon (SOC). The biomass and soil organic carbon in forest land constitute about 457 million tonnes and 188 million tonnes of total carbon stock respectively (FRMD, 2020).

Protected Area Network

The protected area (PA) network of Bhutan consists of five National Parks, four Wildlife Sanctuaries, one Strict Nature Reserve, eight Biological Corridors (BC), and a Royal Botanical Park (RBP). The total PA, including BC and RBP, covers 51.44% of the country's area. The PA system in Bhutan is unique in terms of management from the rest of the world. There are human settlements within the PAs that play an essential role in our conservation efforts, unlike in other parts of the world, where communities in the PAs get relocated (MoAF, 2019).

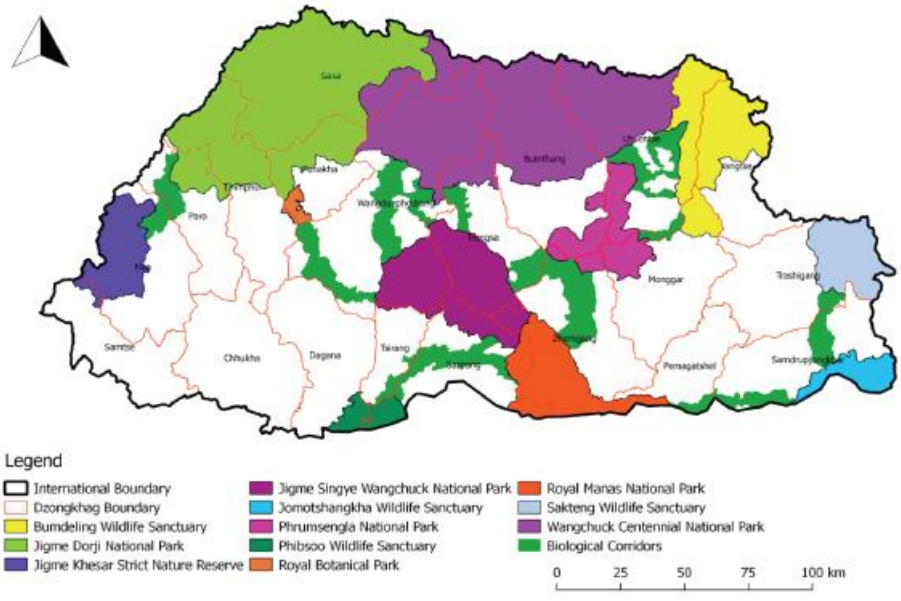


Figure 3. Network of protected areas of Bhutan

Biodiversity

Due to the high forest cover, pristine environment, strong conservation efforts, and a good network of Protected Areas, Bhutan has flourishing populations of some of the rarest flora and fauna on earth. The 2017 Biodiversity Statistics of Bhutan records 11,248 species of all biodiversity groups found in Bhutan, namely 5,114 species under the Kingdom Animalia, 5,369 species under the Kingdom Plantae, 690 species of fungus, 55 species under the Kingdom Chromista, 18 species of Eubacteria, and two species of protozoa under the Kingdom Protista.

The country's biodiversity includes several plants and animal species listed as vulnerable, endangered, or critically endangered in the International Union for Conservation of Nature Red List of threatened species. The country is home to 15 vulnerable, 20 endangered, and 13 critically endangered seed plants, 13 vulnerable, 11 endangered, and two critically endangered mammal species. Likewise, the country has 22 vulnerable, four endangered, and four critically endangered bird species. There are also eight vulnerable and three endangered fish species, 11 vulnerable, five endangered, and two critically endangered amphibians, and one vulnerable butterfly (MoAF, 2018).

Water resources

Most of the major rivers in Bhutan originate from glaciers and are fed by watersheds. The river system is generally distinguished by main rivers that flow from north to south, with tributaries flowing in an east-west direction. The main

rivers are Amochhu, Wangchhu, Punatsangchhu and Manas. Two large rivers, Mangdechhu and Drangmechhu, converge into one river and make up the Manas just before crossing the Indian border. The Manas River covers about half the country. Most of the river discharge results from rainfall, supplemented by an estimated 2-12% glacial melt and another 2% from snow melt. The combined outflow of the rivers is about 70,576 million m^3, or 2,238 m^3/s, which corresponds to a flow of 109,000 m^3 per capita per year, the highest in the region (NEC, 2016).

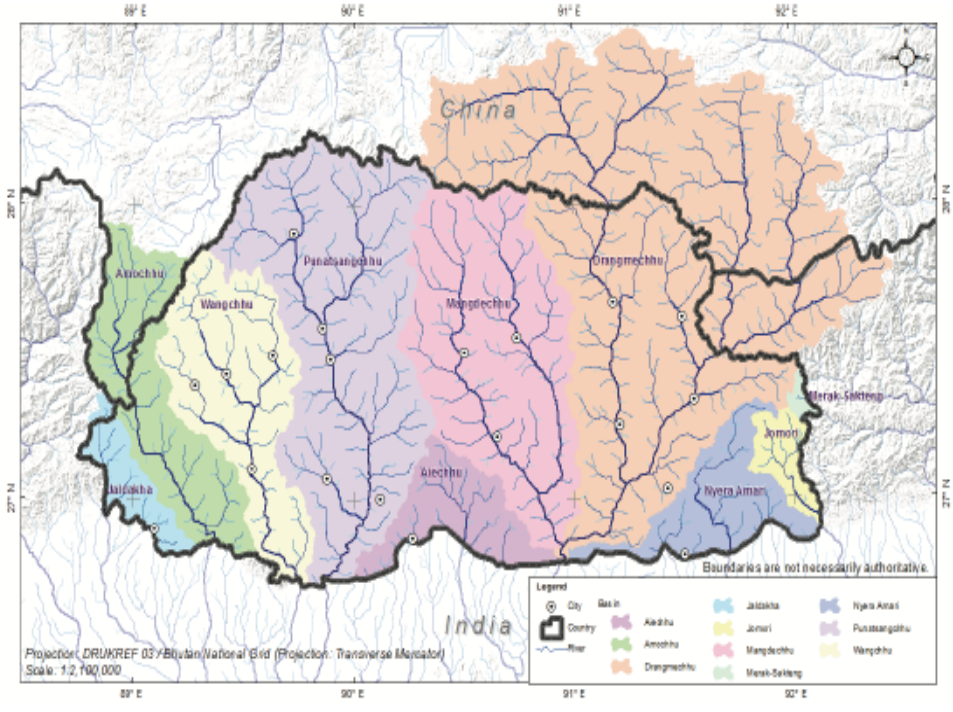


Figure 4. Hydrological basins of Bhutan

However, considering the rugged topography, climate variations, and most settlements occurring on hill-tops and rivers flowing at the bottom of the valley, water scarcity and localized shortages are among the main concerns in the country (WMD, 2018). The impact of climate change on water availability is a concern for drinking water supply, agricultural production, and hydropower generation.

The Watershed Management Division under the DoFPS will be conducting a comprehensive national wetland inventory to establish a national database system for the wetlands. The inventory of wetlands based on study conducted by UWICE and WWF Bhutan in 2010 is presented in the table below.

Table 5. Inventory of water bodies based on study by UWICER and WWF, 2010

Wetland type	Number	Total area m^2	Average area m^2	Largest area m^2	Smallest area m^2
Supra snow lake	110	52,327	475	4,759	36
Supraglacial lake	495	28,554,801	57,686	1,517,436	134
Glacial lake	637	23,230,604	36,468	878,311	115
Lake	1722	49,973,272	29,020	868,049	35
Marsh	63	497,334	7,894	63,811	126

2.1.5 Population

Bhutan is one of the least populated countries in Asia with a total population of 727,145 in 2017 and a PGR of 1.3% per annum as per Population and Housing Census of Bhutan, 2017. As a result of the gradual increase in the population size, the population density of Bhutan increased from 17 persons per Km^2 in 2005 to 19 persons per Km^2 in 2017. The distribution of the population over the land area is not uniform throughout the country. The capital, Thimphu, has the highest population density at 67 persons per Km^2 and Gasa Dzongkhag has the lowest population density of 1.3 persons per Km^2. Since the commencement of the planned socio-economic development in the 1960s, Bhutan has developed from a nascent health system to a closely-knit network of health facilities catering to its people's health needs. As of 2018, there are 211 Basic Health Units, 52 sub-posts, and 551 ORCs at the primary level, 26 hospitals at the secondary level, and three referral hospitals at the tertiary level, spread across the country. Furthermore, the provision of telemedicine (TM) services from 61 TM units and one national TM hospital has enhanced the health services delivery in the country. Health services are provided free of cost and are financed by the Royal Government (MoH, 2018). The 2017 PHCB reported a literacy rate of 71.4% and an adult (aged 15 years and above) literacy rate of 66.6%. There is a marked difference in the literacy levels between the male and female populations with 78.1% of the male population literate as compared to 63.9% of the female population. Overall, the literacy rate is significantly higher in urban areas (84.1%) than in rural areas (63.6%).

Table 6. Population statistics of Bhutan from NSB 2006, 2010 & 2017. Note: Figures for 2000 are estimates from Health Survey 2000. 2005 & 2017 figures are

Population statistics				
	2000	2005	2010	2017
Total population	677,934	634,982	695,822	727,145
Male population	342,324	333,595	363,383	380, 453
Female population	335,610	301,387	332,439	346,692
Population density	14.6	16	18.1	19
Crude Birth Rate (per 1000)	34.1	20	-	15.5
Crude Death Rate (per 1000)	8.6	7	-	6.7
Natural rate of increase	2.5	1.3	-	0.9
Total Fertility Rate	4.7	2.6	-	1.7
Life Expectancy at Birth	-	66.25	-	70.2
Life Expectancy (Male)	-	65.65	-	71.7
Life Expectancy (Female)	-	66.85	-	68.8

2.1.6 Socio-economy

Macroeconomy

Bhutan's economy is primarily driven by four key sectors (hydropower, tourism, industry, and agriculture). The country has a free trade connection with neighboring India and enjoys cordial relations with the other countries in the region. Bhutan's main model of development is the concept of Gross National Happiness and the subsequent GNH index tool. Any form of development is deeply rooted in the realization that *Gross Happiness is more important than the Gross Domestic Product* which has descended from the Fourth Monarch King Jigme Singye Wangchuck. The development philosophy envisions that any economic development should be holistic and emphasize the happiness and overall well-being of the people. The GNH Commission has this crucial role in assessing plans, programs, and projects through the lens of the GNH tool and ensuring that there is a smooth inclusion of GNH at all levels of government functioning. Bhutan is one of the world's smallest economies, with Gross Domestic Product (GDP) in 2020 recorded at USD 2.34 billion. However, global COVID-19 has hit the Bhutanese economy hard resulting in the largest contraction in 2020 triggered by the COVID-19 pandemic. The growth contracted to an all-time low of -10.08% percent as output from tourism-related services, construction, and manufacturing sectors deteriorated (MoF, 2021). GDP per capita increased from USD 2,507 in 2013 to USD 3129 in 2020 (NSB, 2021). Bhutan was categorized as an LDC by the UNGA in 1971. However, over the decades, Bhutan has made remarkable socio-economic advancements, qualifying the country for graduation from this category for the first time at the 2015 triennial

review of the list of LDCs (GNHC, 2019). Bhutan's economic freedom score is 62.9, making its economy the 74th freest in the 2019 index and ranked 16th among 43 countries in the Asia-Pacific region. Its overall rating is above the regional and world averages. The public sector has long been the primary source of economic growth, but the government now recognizes the significance of private-sector growth. Economic diversification is now a higher priority and Bhutan has made progress in modernizing its economic structure and reducing poverty.

Agriculture

Located between China in the north and India in the south, west, and east, the Kingdom of Bhutan occupies a total geographical area of 38, 394 Km^2. Out of the total geographical area, forest covers 70.46%, agriculture 2.75%, barren areas 3.2%, degraded lands 0.54%, meadows 4.10%, shrubs 10.43%, snow cover 7.43%, water bodies 0.72%, human settlements 0.16%, and marshy and non-built-up areas each 0.01%.

The electricity and water sectors account for 14.34%, agriculture, and forestry account for 16.67%, and construction infrastructure account for 15.61% of Bhutan's GDP growth in 2016. More than 58% of its total labor force is engaged in agriculture activities, yet agriculture is practiced on barely 2.75% of existing cultivated land is a cause of low-level food self-sufficiency and its heavy reliance on food imports from India. Bhutan is only modestly food secure. Bhutan's agriculture and forestry sectors provide 58% of employment to rural men and women (MOLHR, 2015).

Most villages across Bhutan are highly vulnerable to climate impacts and have low adaptive capacity attributed to their limited resource base and precarious socio-economic status, including labor shortages; poor grid and road connectivity; unstable dryland agriculture; crop disease, and low-yielding seeds; fledgling cottage industry; and, increased risk and exposure to drought, unseasonal precipitation, and wind events.

Farming is predominantly subsistence level, and most Bhutanese farmers continue to grow traditional crops and crop varieties. Rice and maize are the major staple crops and other commonly grown crops are wheat, barley, buckwheat, millets, oil seeds, grain legumes, orange, apple, and cardamom. Bhutan has over 350 traditional rice varieties grown in different agro-ecological zones.

Bhutan has been divided into six zones agro-climatically. These are Alpine, Cool temperate, Warm temperate, Dry sub-tropical, Humid sub-tropical, and Wet sub-tropical. In the alpine and cool temperate zones, yaks, cattle, sheep, and horses dominate the farming system. Dairy products, barley, wheat, and potatoes are

dominant on dry land. Crop production, rice, and maize are concentrated from warm temperate to wet sub-tropical zones (GNHC-World Bank, 2017).

Livestock

Livestock plays an important role in the lives of Bhutanese farmers. Large areas of the country can be used for the production of livestock. In other areas, livestock forms an integral component of a deeply rooted system of farming. Rapid gains and high productivity are essential for obtaining a higher living standard. There is a heavy dependence on livestock rearing for production in agriculture.

A country's development is highly correlated with climate-sensitive sectors such as agriculture and livestock. The impact of climate change on livestock is eclipsed by the lack of data availability. Climate change-induced extreme weather events impose a major challenge to the well-being of livestock. Climate change also causes reductions or non-availability of feed and water resources thereby impacting the livestock population. Incidents of Glacial Lakes Outburst Floods (GLOFs) have increased due to climate change and hence enhance the vulnerability of livelihoods.

Agriculture and livestock activities contributed 552.87 Gg CO_2e, corresponding to 14.49% of total national emissions in 2015. The majority of the sector's emissions were from livestock that emitted 389.47 Gg of CO_2e, of which enteric fermentation accounted for 348.90 Gg of CO_2e or about 63.03%. In comparison, manure management contributed only 40.98 Gg of CO2e (7.41%), and similarly, rice cultivation emitted 52.98 Gg of CO_2e (9.58%) (NEC, 2021).

Energy

Power generation in Bhutan relies almost exclusively on hydropower. Bhutan has an estimated hydropower potential of 36,900 MW with the potential of generating 154,000-gigawatt hours (GWh) of energy (NSB, 2020). At present, a total of six major hydropower plants are in operation. Four other hydropower plants are in various stages of construction and upon commissioning of these hydropower plants, an additional 2,938 MW of installed capacity would be achieved.

More than 99.97% of households have access to electricity and over 95% of households in the country use electricity as the main source of energy for lighting and cooking (NSB, 2017). Bhutan's total installed capacity is approximately 2.3 gigawatts (GW), of which 99% of the country's installed capacity comes from hydropower plants and accounts for 2,334 MW of the total installed capacity of 2,343 MW as of 2020.

Bhutan exports its surplus electricity to India and this has led to the high economic growth rates in recent years. The economy of the country is largely driven by hydropower generation. Hydropower plants contribute significantly to the Gross

Domestic Product (GDP), both during the construction and operation phases. In 2020, the sector contributed 17.74 % to the GDP.

In 2015, the energy sector's net emission was 707.91 Gg of CO2e which contributed 18.56 % of the total national emissions, excluding the GHG removals by LULUCF. The transport category's energy emissions had the highest contribution to the sector with 60.01%, followed by manufacturing industries and construction at 34.39%, other sectors at 5.32%, solid fuels at 0.27%, and energy industries (electricity generation) at 0.002% only (NEC, 2021).

Currently, Bhutan's power generation is mostly dependent on run-of-river (RoR) type hydropower plants, which are more susceptible to variations in rainfall patterns and the impacts of climate change. The winter season in Bhutan is drier than summer, due to lower average rainfall, which leads to reduced flow volume in the rivers and hence reduced hydropower generation.

Furthermore, with Bhutan located in the cold Himalaya Mountain range, the demand for electricity for heating is also high during the winter months. As electricity demand outstrips supply in winter, the country resorts to imports from India (IRENA, 2019). These imports, although currently much smaller than exports, are increasing on an annual basis. Bhutan relies on imports of coal, diesel, and other petroleum products. Generally, petroleum reserves have not been explored in Bhutan and there are no refineries for crude oil processing in the country.

Transport

As a land-locked least developed country located in a fragile mountainous environment, Bhutan remains highly vulnerable to the impacts of climate change and will disproportionately bear the impacts of climate change. Therefore, an adaptation component is also included in the INDC from Bhutan.

The national road network has expanded rapidly since the construction of the Phuentsholing - Thimphu Highway, the country's first road. As of 2017, there are over 18,181.3 Km of motorable roads, including national highways, district roads, feeder roads, farm roads, urban roads, expressways, power tiller tracks, access roads, and forest roads. As of June 2018, there were 96,307 registered vehicles in Bhutan, and this is increasing by an average of 9.2% annually (RSTA, 2019).

Druk Air, the national airline, has been in operation since April 1981, linking to neighboring countries. Tashi Air Pvt. Ltd is Bhutan's first Private Airline and introduced internal operations in 2011 and international operations in 2013 (NSB, 2018). They commenced domestic operations in 2011, connecting to all three domestic airports in Bhutan.

The transportation sector is a significant contributor to GHG emissions (about 424.75 Gg of CO2e). The research leading to innovative policy and the promotion of viable technologies is needed to ensure carbon neutrality in the transport sector. Currently, there are no academic institutions dedicated to the study of transport in Bhutan (UNDP Bhutan, 2021).

Passenger cars (light vehicles) are estimated to grow exponentially at a CAGR of 5.3% (2020-2050) and will reach 344,785 units by 2050 in a BAU scenario. Growth in the number of passenger cars not only increases congestion on city roads but also contributes significantly to urban pollution. Similarly, the taxi number is expected to grow at a CAGR of 3.0% (2020-2050) and reach 13,935 by 2050. In other words, the growth of light vehicles is expected to surpass the growth of taxis by a huge margin. Currently, the penetration of EVs in light vehicles and taxi segments is very low. Buses (public and private) are expected to grow at ~4% CAGR (2020-2050) and reach a cumulative total of 3,606 units by 2050 (MoIC, 2021).

Medium trucks are expected to grow at a CAGR of 4.9% (2020-2050) and Heavy trucks (HDVs) at a CAGR of 4.3%, reaching a combined total of 41,926 units by 2050, indicating the expected growth in freight trade. Work vehicles like EME, Power tillers, and tractors are expected to grow at 6.4% and 6.2% respectively, reaching 22,435 and 23,142 units respectively by 2050.

Overall, vehicle registration will continue to grow due to an increase in private vehicle ownership. Light vehicles, taxis, and Heavy and Medium vehicles (cargo trucks) will, therefore, contribute significantly to the total vehicle fleet by 2050, resulting in a visible impact on carbon footprints from the transport sector. Thus, the adoption of low-carbon transport interventions is critical for Bhutan to remain carbon-neutral and achieve sustainable development.

The Kingdom of Bhutan is a small landlocked country in the eastern Himalayas that is characterized by mountainous terrain reaching altitudes of over 7,000 meters above sea level. Bhutan is increasingly threatened by climate hazards and extreme events such as flash floods, glacial lake outburst floods (GLOF), windstorms, forest fires, and landslides.

Industries

Most of the industrial establishments in Bhutan are found in the southern region of the country because of easy access to raw materials, labour, transport, and markets. However, this sector faces various limiting factors, such as low technological development and human skills.

The industrial sector has until recently played a relatively small role in the economy. Bhutan has deposits of several mineral resources, including limestone, coal, graphite, gypsum, slate, and dolomite. Most mining activities are limited to relatively small operations, mainly involved in the mining of dolomite, gypsum, limestone, slate, coal, marbles, quartzite, and talc.

The manufacturing industry is dominated by small and cottage industries as the country has good timber resources and favorable agricultural conditions. Wood-based industries comprise mainly small sawmills, furniture-making units, small traditional paper units, one particleboard factory, wood veneering, and resin and turpentine harvesting. Agro-based industries consist of fruit processing and alcoholic beverage production units. Other manufacturing units produce local handicrafts and textiles.

The manufacturing sector contributed 5.95% to the country's GDP a 1.16% drop from 2019 (NSB, 2021).

Tourism

The tourism industry in Bhutan began in 1974, and it contributes an average of more than 9% to the 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 (NSB, 2018). Bhutan remains a favored destination 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. However, owing to the COVID-19 pandemic, the tourism sector took the biggest hit, with international tourist numbers dropping to 6376 in 2020 from 73215 in 2019 (NSB, 2021).

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

2.1.7 Governance Structure

The government of Bhutan is a democratic constitutional monarchy with the executive power vested in the Cabinet (Lhengye Zhungtshog) headed by the Prime Minister (RGoB, 2008). At the central level, the 9 different Ministries are headed by Cabinet Ministers, and at the local level, Bhutan is administratively divided into 20 Dzongkhags (districts), each governed by a district administrator or Dzongda. The Dzongkhags are sub-divided into small blocks or Gewogs. There are 205 Gewogs in the country, grouped under 47 election constituencies.

The National Assembly (Gyelyong Tshogdu) has 47 members elected from 47 constituencies in the country who belong to one of the political parties, either ruling or opposition and The National Council (Gyelyong Tshogdey) has 25

members, of which 20 members are directly elected by the people (one from each Dzongkhag), and the other five are nominated by His Majesty the King.

2.2 Legislation and Institutional Framework

2.2.6 Present institutional and regulatory framework

The institutional arrangements for climate change coordination in Bhutan have evolved over the years since the establishment of the NEC and Bhutan's signing of the Rio Conventions in 1992. Bhutan ratified the United Nations Framework Convention on Climate Change (UNFCCC) on 15 August 1995, and the National Environment Commission Secretariat (NECS) is the national focal point for all the multilateral environmental agreements.

The National Environment Protection Act 2007, Section 20, mandates the National Environment Commission (NEC) as an independent authority and the highest decision-making body on all matters relating to the environment and its management in the country. The Commission comprises nine members with the Prime Minister/ Minister of a relevant Ministry nominated by the Prime Minister as the Chairperson, highest ranking officials representing relevant ministries, and representatives of civil society/ eminent persons as members. The Commission is entrusted with the authority to take all such measures as it deems necessary or expedient for the purpose of protecting the environment and preventing, controlling, and abating environmental harm or pollution. The Commission is supported by the Secretariat and is responsible for implementing the policies, regulations, and directives issued by the National Environment Commission, and for administering the provisions of the National Environment Protection Act, 2007.

The erstwhile Multi-Sectoral Climate Change Committee established in 2010 was revamped as Climate Change Coordination Committee (C4) through the Executive Order of the Prime Minister in October 2016, to serve as a forum to discuss and coordinate matters related to climate change in Bhutan and make recommendations for consideration by the Commission and ensure smooth implementation of climate change policies, projects and programs in the country.

The following provides an overview of the existing bodies and institutional arrangements dealing with climate change:

- The National Environment Commission, supported by the Secretariat, is the *National Focal Agency for UNFCCC*, with the Secretary, NECS serving as the *National Focal Point for UNFCCC*.
- The Commission has also served as the high-level *National Climate Change Committee* since 2000 when the Commission approved the

"Initial National Communication from Bhutan" to UNFCCC. This function is also in line with mandates under NEPA 2007.

- The NECS is also the *Designated National Authority (DNA)* under the Clean Development Mechanism, Kyoto Protocol, to provide national endorsement for CDM projects. The DNA is supported by a National CDM Committee comprising members from the Department of Industries and Department of Hydropower and Power Systems, Ministry of Economic Affairs (MoEA); Department of Forest and Park Services, Ministry of Agriculture and Forest (MoAF); Ministry of Works and Human Settlement (MoWHS); Ministry of Finance; and NECS. The Secretary, NECS, chairs the CDM Committee.
- NECS is the National Designated Entity of the Climate Technology Center and Network (CTCN) of UNFCCC to disseminate relevant information and interact with CTCN about their technology needs.
- In 2009, the NEC approved the establishment of a Climate Change Unit at the Secretariat and later upgraded to a *Climate Change Division*. Currently, the Climate Change Division comprises of one Chief, six Officers, and two Technicians.
- The erstwhile *Multisectoral Technical Committee on Climate Change (MSTCCC)* created by the NEC in 2010 serves as the technical level body for coordinating climate change activities. It was revamped to strengthen further the Committee's function as *Climate Change Coordination Committee* in October 2016. The Committee chaired by the Secretary NECS, with members from line agencies and CSOs, reports to the NEC in their capacity as NCCC.
- The NECS function as the Co-National Focal Agency while the National Center for Hydrology and Meteorology function as the *National Focal Agency* for the Inter-Governmental *Panel for Climate* Change (IPCC) as per the designation by the Ministry of Foreign Affairs in September 2015.
- GNHC serves as the Designated Authority for the Adaptation Fund under the Kyoto Protocol.
- Bhutan Trust Fund for Environmental Conservation (BTFEC) is accredited as the National Implementing Entity for Adaptation Fund.
- GNHC is also the *National Operational Focal Point* and also serves as NDA for the *Green Climate Fund.*
- The Ministry of Foreign Affairs is the *Political Focal Point* for the *Global Environment Facility (GEF)*. The GEF focal points are assisted by a *National GEF Steering Committee* comprising focal persons of the three Rio Conventions (biodiversity, climate change, and desertification).

Bhutan has already made a global commitment to remain a carbon-neutral country for all times to come, which in itself is explicit and more than its fair share of responsibility. Nevertheless, Bhutan continues to effectively participate,

engage, and contribute towards the local, regional, and global climate change programs. Key coordination across the economic sectors to garner their support towards low-carbon and resilient pathways is underway at various levels. Under this, formulation of key national documents like the enhanced Nationally Determined Contributions, and National Adaptation Planning (NAP), have already been completed or are ongoing. Nationally, the government in January 2020 adopted the Climate Change Policy of the Kingdom of Bhutan which is a highly cross-sectoral approach in combating climate change.

In terms of regional networks and cooperation governing environment and climate change, Bhutan is a member of the South Asia Association Regional Cooperation, regional cooperative mechanisms and landmark agreements like Male` Declaration established under the South Asian Cooperative Environment Program, Asia Pacific Adaptation Network and other initiatives in the regional information network facilitated by International Center for Integrated Mountain Development on sharing information on transboundary pollution resulting from atmospheric black carbon.

2.2.7 Policy, Legislation and Strategies

A summary of the relevant policies and legislation on climate change mitigation in Bhutan is provided in the following paragraphs:

The Constitution of the Kingdom of Bhutan (2008)

The Constitution of Bhutan entrusts every citizen to contribute to the protection of the natural environment, conservation of the rich biodiversity of Bhutan, and prevention of all forms of ecological degradation including noise, visual and physical pollution. It accords the rights over mineral resources, rivers, lakes, and forests to the state to be regulated by law. It requires the state to preserve, protect, and promote the country's cultural heritage, including monuments, places, and objects. The state is assigned to ensure a safe and healthy environment, always maintaining a minimum of sixty percent of Bhutan's total land under forest cover. It must secure ecologically balanced sustainable development and sovereign rights of the state over its biological resources, including legislation to ensure sustainable use of natural resources and intergenerational equity. By the constitution, the Parliament can, by law, declare any part of the country to be a National Park, Wildlife Reserve, Nature Reserve, Protected Forest, Biosphere Reserve, Critical Watershed, and such other categories meriting protection.

The National Environment Protection Act (NEPA 2007)

NEPA 2007 is the umbrella legislation on environment conservation and protection and outlines principles and a legal framework that has implications for all spheres of development in Bhutan. It requires that a person taking natural resources or deriving economic benefits from the environment should ensure

sustainable use and management of the resources and ecosystems. It also paves the way for specific legislation such as the Water Act, The Waste Prevention and Management Act, and possibly, specific legislation on climate change.

Environment Assessment Act 2000 and its Regulations

The Environmental Assessment Act 2000 establishes procedures for assessing potential effects on the environment from strategic plans, policies, programs, and projects; and for the determination of policies and measures to reduce potential adverse effects and to promote environmental benefits. The Act makes Environmental Clearance (EC) from the Competent Authority a pre-requisite for a project, and EC sets out environmental terms for the project. The Act also requires the RGoB to ensure that environmental concerns are fully taken into account when formulating, renewing, modifying, and implementing any policy, plan, or program as per regulation that may be adopted within EAA provisions. The Act outlines general procedures for environmental assessment including assessment steps, requirements for EC issuance, consultation; information disclosure; functions and powers of the agencies charged with implementing EAA; monitoring and control of offenses and penalties; and appeals and dispute resolution procedures under EAA. Regulations and guidelines supporting the EA Act include the Regulation for the Environmental Clearance of Projects, Regulation on Strategic Environmental Assessment, Application for Environmental Clearance Guidelines, and Environmental Codes of Practices.

Forest and Nature Conservation Act of Bhutan (1995)

This Act ensures the protection and sustainable utilization of flora, fauna, and other natural resources of Bhutan to benefit present and future generations incorporating the concepts of sustainable development. The Department of Forests and Parks Services is entrusted with the responsibility for sustainably managing, protecting, producing, and regulating all-natural resources within Government Reserved Forests Land and outside. Wild animals and plants listed in Schedule I are declared as totally protected. The Forest and Nature Conservation Rules of Bhutan 2017 have been formulated to support the implementation of this Act.

The Water Act of Bhutan (2011)

The Act determines priorities for water allocation for drinking, agriculture, energy, industrial use, tourism, recreation, and other uses. It requires the location of water to be based on the principle that water is a resource owned by the State and that every citizen has an equal right to these resources. The Act stipulates that the use of water by any person should not result in the denial of water to any individual or community, including downstream and upstream needs, or the discharge of any effluent directly or indirectly to any water resource unless the discharge complies with the Effluent Discharge Standard. This Act is relevant in

enabling safeguard measures in water use for the project activities and the management of drinking and irrigation water within communities that are part of the project areas.

Waste Prevention and Management Act (2009)

This legislation incorporates the Precautionary Principle and the Polluters Pay Principle. Under section 8, the Act stipulates that every person shall take all precautionary measures in maintaining a clean and healthy environment. Further, in section 10, the Act prescribes that a person polluting the environment or causing ecological harm shall be responsible for the costs of avoidance, contamination, abatement, medical compensation, mitigation, remediation, and restoration in the application of the Polluter Pays Principle. The lead implementing agencies and collaborating agencies are responsible for implementing the Act.

Nationally Determined Contribution (NDC) to Paris Agreement, 2015

Bhutan submitted its first Nationally Determined Contribution in September 2015, which looks at mitigating GHG emissions through seven sectoral interventions as outlined below (NEC, 2015):

i. Sustainable forest management and conservation of biodiversity to ensure sustained environmental services through:
- Sustainable management of forest management units (FMUs), protected areas, community forests, forest areas outside FMUs, and private forests
- Enhancing forest information and monitoring infrastructure through national forest inventories and carbon stock assessments
- Forest fire management and rehabilitation of degraded and barren forest lands

ii. Promotion of low carbon transport system by:
- Improving mass transit and demand-side management of personal modes of transport by
- Exploring alternative modes of transportation to road transport such as rail, water, and gravity ropeways.
- Improving efficiency in freight transport
- Promoting non-motorized transport and non-fossil fuel-powered transport such as electric and fuel cell vehicles
- Improving efficiency and emissions from existing vehicles through standards and capacity building
- Promoting the use of appropriate intelligent transport systems

iii. Minimize GHG emissions through the application of zero waste concept and sustainable waste management practices:

- Enhancement of the three R principles including the conversion of waste to resources
- Improving the current system and infrastructure for waste management

iv. Promote a green and self-reliant economy towards carbon-neutral and sustainable development through:

- Improvement of manufacturing processes in existing industries through investments and adoption of cleaner technology, energy efficiency, and environmental management
- Enhance and strengthen the environmental compliance monitoring system
- Promote investment in new industries at higher levels in the value chain and green industries and services.
- Promote industrial estate development and management in line with efficient, clean, and green industry development objectives

v. Promote clean, renewable energy generation:

- Pursue sustainable and clean hydropower development with support from CDM or other climate market mechanisms to reduce emissions within Bhutan and the region by exporting surplus electricity

vi. Promote climate-smart livestock farming practices to contribute towards poverty alleviation and self-sufficiency through:

- Organic livestock farming and eco-friendly farm designs
- Improvement of livestock breeds, including conservation of native gene pool/diversity
- Expansion of biogas production with stall feeding
- Agro-forestry or agro-silvopastoral systems for fodder production

vii. Promote climate-smart agriculture to contribute towards achieving food and nutrition security through:

- Organic farming and conservation agriculture
- Development and promotion of sustainable agricultural practices
- Integration of sustainable soil and land management technologies and approaches

viii. Energy demand-side management by promoting energy efficiency in appliances, buildings, and industrial processes and technologies.

ix. Integration of low emission strategies in urban and rural settlements through green buildings, sustainable construction methods, and climate-smart cities.

National Strategy and action plan for low carbon development, 2012

The National Strategy and Action Plan for Low Carbon Development was prepared to enable Bhutan to fulfill its commitment to remaining carbon neutral. In other words, it will help in ensuring that national emissions of greenhouse gasses (GHG) remain less than the national sequestration capacity. The strategy comprises various scenarios analyzing development paths from 2005 till 2040. As a supplement to the scenarios, the action plan presents several short- and medium-term interventions to achieve sustainable economic development through green growth.

Economic Development Policy 2016

The economic development policy (EDP), which has a total of 252 policy provisions, provides the overall enabling environment to continue creating a transparent and conducive environment for business and investment in the Bhutanese economy**.** The Economic Development Policy sets the agenda and the general direction for the development of sectors with the highest potential. This Policy departs from the usual sector/agency-based approach. It is a document prepared in consultation with a wide range of stakeholders from private to government. Its success depends on an integrated and wholesome involvement of all the stakeholders. A clear, stable, and transparent policy framework is necessary to accelerate economic growth. The document also includes a comprehensive set of incentive packages to boost growth. However, the EDP remains silent on climate change mitigation and adaptation and presumes that climate considerations are included in pollution control measures.

Bhutan Sustainable Hydropower Policy 2008

The policy's key objectives are to mobilize funds and attract investments for accelerated hydropower development, enhance the revenue contribution to the Royal Government, and contribute towards the development of clean energy to mitigate problems related to global warming and climate change. According to section 1 of Bhutan Sustainable Hydropower Development Policy 2008, there is great potential for increased electricity export and, consequently, substantial revenues. Huge energy demand in the region offers a big opportunity for Bhutan to develop its rich hydropower resources for the export market and mitigate climate change in the importing countries.

National Transport Policy (2006)

The National Transport Policy of Bhutan covers policy objectives and a framework for institutional arrangements. It also introduces financing mechanisms and a framework for monitoring and evaluating the outcomes of this policy. As a result, it addresses many of the existing policy gaps in Bhutan's transport sector. In particular, it provides the rationale and guiding principles for

sub-sector policies. For example, it describes the existing landscape for important transport sub-sectors (roads and road transport; urban transport; civil aviation; regional connectivity) and details policy objectives. It also provides policy statements as benchmarks for meeting the objectives.

Transport 2040: Integrated Strategic Vision

The overall transport vision is to provide the entire population with a safe, reliable, affordable, convenient, cost-effective, and environment-friendly transport system. The vision supports strategies for socio-economic development, which includes the goals of accessibility to activities and supplies needed by people and enterprises, efficient use of economic resources, environmental sustainability, and transport safety, especially on roads. It contains nine transport strategies and the first eight strategies cover the main transport sectors, in terms of physical infrastructure, services, and regulation. The final strategy concerns the coordination and management of the overall transport sector. Transport Vision 2040 and the set of supporting transport strategies constitute an integrated approach to the three modes of transport: road transport, urban transportation, and civil aviation.

Climate Change Policy of the Kingdom of Bhutan 2020

The Climate Change Policy of the Kingdom of Bhutan 2020 has the goals of providing strategic guidance to; (i) maintain carbon neutrality and building climate resilience, (ii) ensure effective stakeholder participation, and (iii) ensure effective implementation through mainstreaming with adequate support. In line with the Constitution of Bhutan, Policy Objective states that "*The RGOB shall take appropriate measures to maintain the carbon neutral status of Bhutan towards ensuring 'ecologically balanced sustainable development while promoting justifiable economic and social development' by pursuing a low GHG emissions development pathway".* This objective is supported by a statement to *"Pursue transformative actions and approaches to decouple GHG emissions from industries including mining, transport and waste sectors through the integration of higher value chains in manufacturing.* The policy also defines a Low Emission Development Strategy (LEDS) as "a sectoral or national level development strategy aimed at ensuring socio-economic growth with minimum level of related GHG emissions.

21st Century Economic Roadmap

21st Century Economic Roadmap The 21st Century Economic Roadmap is expected to be a significant driver of economic growth and industrial development for Bhutan in the coming decades. However, during the preparation of the LEDS (Industry), there was limited interaction with the team formulating the 21st Century Economic Roadmap and it is not known to the LEDS team to

what extent climate change actions are included in the roadmap. It is important to ensure coherence and synergies between the 21st Century Economic Roadmap and the sectoral LEDS as this has implications for the Long-Term Strategy on Low GHG Emissions and Climate Resilient Development that Bhutan is preparing under the Paris Agreement along with all other parties to the Agreement.

2nd Nationally Determined Contributions

In presenting the second NDC, Bhutan maintains the commitment to remain carbon-neutral where the emission of greenhouse gases will not exceed carbon sequestration by our forests and sinks as first pledged in 2009 and reaffirmed in the first NDC. At the same time, Bhutan calls on the international community to continue and enhance its support for Bhutan's efforts to mitigate and adapt to climate change. Bhutan reiterates the statement in the first NDC that "*the successful implementation of our intended actions to mitigate will depend on the level of financial and technical support received*". The actions across different priority sectors for mitigation can only be realized with sufficient financial and technical support. Therefore, as Bhutan's NDC is more than the fair share of efforts for climate change mitigation, the actions describing targets, actions, and strategies are conditional on receiving adequate support for implementation.

While Bhutan's first NDC covered broad priority action areas, the second NDC further enhanced actions by elaborating priority mitigation actions in the form of LEDS, roadmaps, and strategies.

The 2nd NDC also addresses that adapting to the adverse impacts of climate change is equally important, if not more challenging issue than mitigation for Bhutan as a nation. Bhutan included an adaptation component in the first NDC and highlighted ten broad areas of priority adaptation needs. Since then, Bhutan has started the process of formulating its National Adaptation Plan (NAP) as part of the NAP readiness support. The NAP support program will result in the preparation of Bhutan's first NAP and put in place essential elements to support the medium to long-term process for adaptation planning and implementation by enhancing institutional coordination, management of climate change data and information, and capacity building of key institutions including academia, civil society, and the private sector.

The 2nd NDC notes that support for implementation will include international support as well as domestic fiscal incentives and measures, policy, and regulatory measures to create an enabling environment for implementation measures in targeted sectors based on the LEDS.

3. GHG Emission and Projections, Climate Vulnerabilities, Mitigation & Vulnerability Assessments

3.1.GHG Emissions and Trends

The data from the Third National Communication's Green House Gas Inventory shows that the total GHG emissions in 2015 was 3,814.098 Gg CO2e that includes 707.917 Gg CO2e from energy, 796.423 Gg CO2e from IPPU, -7203.346 from AFOLU (552.87 Gg CO2e from agriculture and -7756.220 Gg CO2e from Land Use, Land Use Change and Forestry) and 126.506 Gg CO2e from waste.

The total sequestration of forest in 2015 is estimated at 9,386.597 Gg CO2e. However, removals from non-forest lands are not estimated in the inventory due to a lack of data.

The total carbon sink or sequestration by LULUCF in 2015 has increased from the previous estimate of 6,309.63 Gg CO2e for the year 2000 reported in SNC. The gain in total carbon sink is attributed mainly to changes in the use of a definition of managed forest, natural expansion, and plantations. As a result of an increase in forest area, the actual gain is estimated to be about 1,000 Gg CO2e from 2000 to 2015.

Table 7. GHG Emissions and Sequestration in 2015 (Source: TNC 2021)

GHG sources & sinks	GHG, Giga grams				
	CO_2	CH4	N2O	Nox	CO
Energy	691.556	0.361	0.028	0.000	0.000
IPPU	791.834	0.219	0.000	0.000	0.000
Agriculture	1.073	20.549	0.388	0.000	0.000
LULUCF	-7977.606	3.515	0.194	2.244	80.028
Waste	0.000	5.849	0.012	0.000	0.000
Total emission	-6493.142	30.493	0.623	2.244	80.028
CO_2e	-6493.142	640.36	193.00	-56.77	144.05
Net emission			***-5,572.50***		

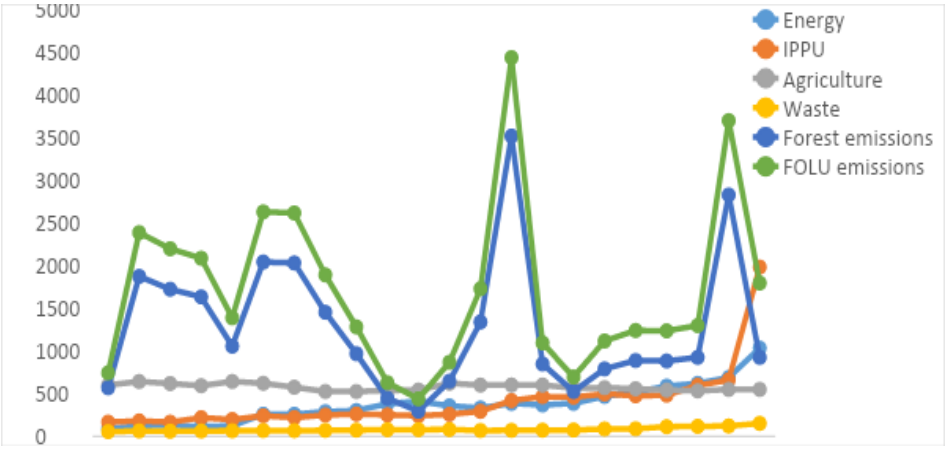


Figure 5. GHG Emissions Inventory from the Third National Communications (NEC 2021)

This supports Bhutan's carbon neutrality claim and demonstrates that Bhutan has and continues to do more than its fair share in combating climate change.

GHG Emission and sequestration estimates up to the year 2020 based on IPCC categories are described in the subsequent sections:

Energy

The energy sector emitted 1034 Gg CO_2e in 2015, an increase of 653% from 1994 and 173% from 2000. The major share of emissions in the energy category comes from road transport, followed by the combustion of fuels for industrial processes and civil aviation. Emission from stationary combustion for energy generation is negligible in Bhutan as 100% of electricity consumed is sourced from renewable sources including hydropower, solar, and wind. The use of biomass for space heating is prevalent mostly in rural areas and in following the IPCC 2006 Guidelines, CO_2 emission from combustion of biomass is included in memo items while non-CO_2 emissions are included under FOLU emissions.

Emissions from this category are expected to increase to 1057 GgCO_2e in 2030 and 1057 GgCO_2e in 2050 following a linear trend of increase between the years 2000 to 2015.

Industrial Processes and Product Use

The Industrial Processes and Product Use emitted 1991 Gg CO_2e in the year 2015 which was an increase of 377% from 1994 and 261% from 2000. The main emissions in this category are from the use of fossil-based reductants in the ferro alloy industries and calcination in cement plants. The mineral industry accounted for the largest share of emissions, with 47.58%, followed by the metal industry with 45.72%, and the chemical industry accounted for 6.70% only.

The emissions from the category are projected to increase to 1778 c by 2030 and 2978 $GgCO_2e$ by 2050.

Agriculture

Emissions from the Agriculture Category which includes emissions from crop farming as well as rearing livestock followed a static trend with negligible increase and decrease over the years. This is mainly because the activities in the agriculture category are constrained by the land available for farming. Emissions in 2015 were 552.87 $GgCO_2e$, corresponding to 14.49% of total national emissions in 2015 comprising 348.90 $GgCO_2e$ from enteric fermentation, 40.98 $GgCO_2e$ from manure management, 52.98 $GgCO_2e$ from rice cultivation, 102.93 $GgCO_2e$ N2O emission from managed soils and 1.07 $GgCO_2e$ from urea application.

Due to the constraint on suitable land for expansion, emissions in this category are projected to remain in the range of 550 – 600 $GgCO_2e$ throughout the projection period up to 2050.

FOLU

The total emissions from the LULUCF sector excluding removals in 2015 was 1630.37 $GgCO_2e$ representing 42.75% of net national emission. The total sequestration capacity of the forest for the same period was -9,386.59 $GgCO_2e$. Emission from forestry (timber removal, firewood, and disturbance) is the highest contributor to net national emission, contributing 42.75% or 1,630.37 $GgCO_2e$ and this sub-category has the highest year-on-year fluctuations owing to different rates of forest fires.

Owing to the impacts of climate change, emissions in FOLU are projected to increase to 2173 $GgCO_2e$ in 2030 and 2679 $GgCO_2e$ in 2050.

Waste

GHG emissions from the waste sector was 126.50 $GgCO_2e$ in 2015 and represented 3.317 % of total national GHG emissions which was an increase of 127% from 1994 and 86% from 2000 levels. Following the increase in the trend of GHG emissions in the Waste category which also follows the rapid rate of urbanization and increase in the waste generation rates, projections for this category for 2030 are 179 $GgCO_2e$ in 2030 and 263 $GgCO_2e$ in 2050.

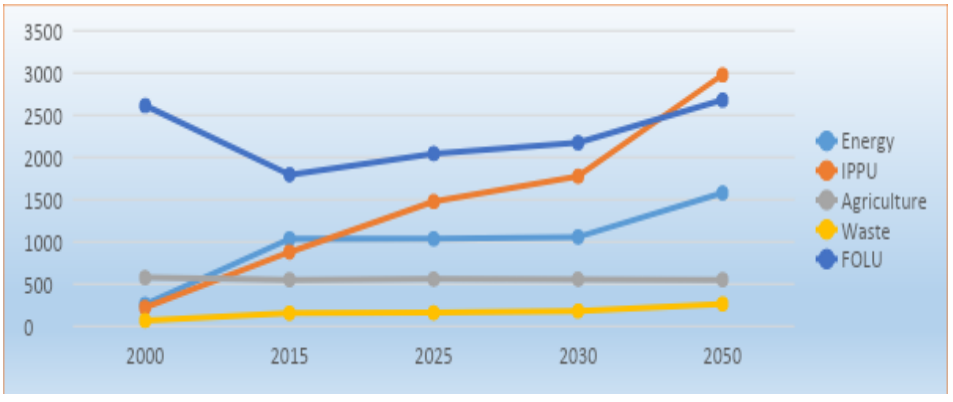


Figure 6. GHG Emissions Projections to 2050 (based on TNC data)

3.2. Emission Projections

GHG Projection from 2020-2050 was developed using a linear trend analysis and sequestration by Bhutan's forest cover assumed to reduce by 1% annually from 2025 onwards due to pressures of development on forest land as well as increased disturbances due to climate change. The results of the projections are shown in the following figure:

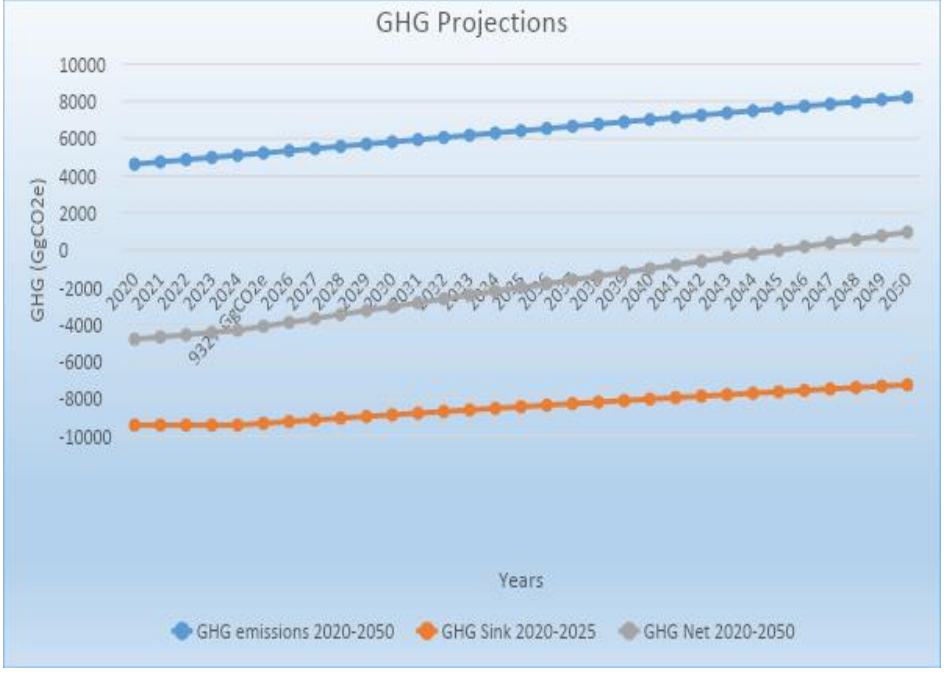


Figure 7. GHG projections to 2050

Given the current trend of development in a Business-as-Usual Scenario, GHG emissions will reach 5,221.63 $GgCO_2e$ by 2025, 5820.79 $GgCO_2e$ 2030, and 8217.42 $GgCO_2e$ by 2050. By 2050, IPPU emissions will constitute the highest

share of emissions with a contribution of 37% followed by FOLU emissions at 33%, Energy (mainly from transport) at 19%, and Agriculture and Waste constitute 11% of emissions. The projections assume that current trends of fossil-based fuels continue in the years ahead.

Bhutan's carbon neutrality pledge banks heavily on the carbon sequestration by its forests estimated at 71% of the total land area and this will come under pressure as additional development activities including urban expansion, industrial activities, and new hydropower projects will need to be developed in the forest areas. Additionally, climate change will increase incidences of wildfires as well as a disturbance in the natural carbon cycle. With this premise, sequestration values are estimated to reduce by 1% annually from 2025 onwards. The resulting sequestration values for 2025 are 9327 $GgCO_2e$, 8870 $GgCO_2e$ in 2030, and 7255 $GgCO_2e$ in 2050.

The increase in GHG emissions and decrease in sequestration puts Bhutan's carbon neutrality under threat by the year 2046 with a net emission projected at 185.93 $GgCO_2e$.

Under the energy category, a major portion of the emissions is attributed to road transport and civil aviation. In 2020, for road transport, Bhutan imported 50.96 million liters of motor gasoline (petrol), 154.62 million liters of diesel, and 2.92 million liters of lubricants for the road transport sector resulting in a GHG emission of 113 $GgCO_2e$, 412 $GgCO_2e$, and 5 $GgCO_2e$ respectively. While official GHG estimates for 2019 are currently being compiled, the assessment for this study indicates road transport emissions to be around 429 $GgCO_2e$. In addition to the road transport sub-category, the country imported 10.1 Megagrams of LPG and 2.9 Megaliters of kerosene for predominantly cooking and space heating resulting in emissions of 8 $GgCO_2e$. The emissions from this category are projected to reach 1057 $GgCO_2e$ by 2030 and 1578 $GgCO_2e$ by 2050.

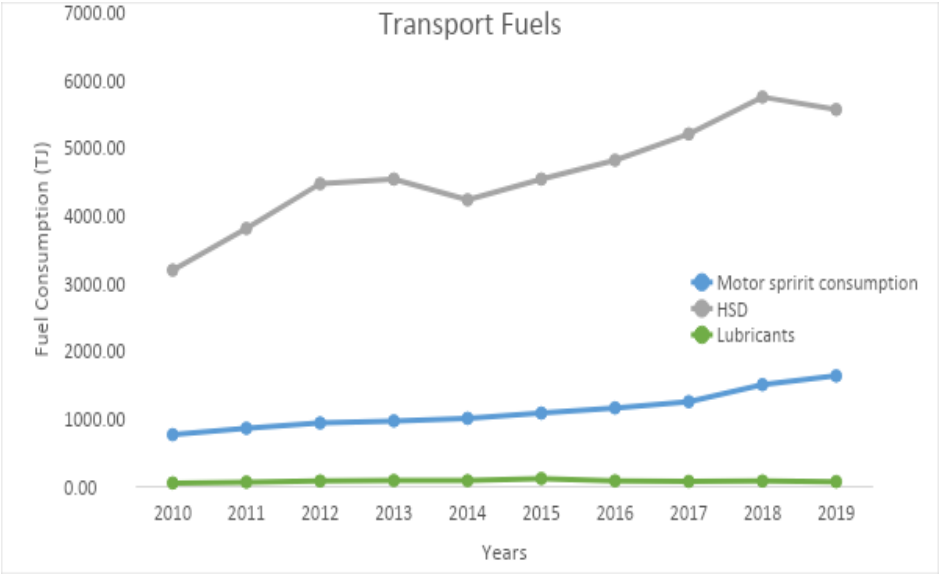


Figure 8. Energy use in the transport sector

Similarly, in the IPPU category, the major portion of GHG is attributed to the use of fossil fuels as reductants in the manufacture of ferroalloys and process CO_2 emissions during calcination in the manufacture of cement. From the 2015 emission estimate of 878 $GgCO_2e$, the emissions from this category are projected to reach 1778 $GgCO_2e$ by 2030 and 2978 $GgCO_2e$ by 2050.

Emissions in the AFOLU sector are comprised of emissions from the agriculture and livestock sectors, emissions from forests due to timber extraction, disturbances and forest fires, and emissions due to land use change. The biggest contribution in this sector is from forest fires with the 2015 emission estimate of 1795 $GgCO_2e$ and projected to reach 2172 $GgCO_2e$ by 2030 and 2679 $GgCO_2e$ by 2050. Due to the constraints of suitable land for farming and shortage in farming villages of labour, emissions in the agriculture sub-category, including both cropping and rearing of livestock is expected to remain fairly constant.

Waste management is an emerging environmental issue in Bhutan and has been recognized as such by the government warranting a Waste Flagship Program at the central level. While emissions from this category constitute less than 3% of national emissions, this is a fast-growing emission sector due to the increasing trend of waste generation both in urban and rural areas. Emissions in this category were 152 $GgCO_2e$ in 2015 and are projected to increase to 179 $GgCO_2e$ by 2030 and 263 $GgCO_2e$ by 2050. A potential source of GHG emissions currently not estimated in the GHG inventory is from domestic and decentralized brown water treatment systems using soak pits and septic tanks.

3.3. Present climate change and future projections

Bhutan lacks a series of long periods of temperature and rainfall data sets. The observed data have only been available since 1996, of which most are in the middle and southern parts of the country. As the data period is short, no accurate inferences could be made on the trend, both for rainfall and temperature. However, over recent years, extreme weather events have been observed to be more frequent and precipitation patterns have altered.

Future climate scenarios focused on two-time slices: a short-term period (2021-2050) and a long-term period (2070-2099). The projection considers two socio-economic scenarios representing trends –Representative Concentration Pathways of high emission (RCP 8.5) and intermediate emission (RCP 4.5) of the IPCC fifth assessment report (2014).

The projection shows a stable increase in temperature across the country under both RCPs. The rise in temperature under RCP 4.5 is about 0.8°C– 2.8°C during 2021-2100 while projections under RCP 8.5 scenario show increases of about 0.8°C to more than 3.2°C towards the end of the century. There are indications of more significant warming during the Spring and Winter seasons. The country would likely experience an increase in temperature with a more considerable increase projected in the highlands.

The mean annual rainfall over Bhutan is likely to increase in the future under both RCPs. Under the RCP 4.5 scenario, the yearly rainfall in Bhutan could increase by about 10% to 30%, with a 5% to 15% increase in summer rainfall/monsoon. The projection also notes a likely increase in rainfall during the winter. However, rainfall levels in some parts of the northern and north-western parts of the country could even decrease.

Under the RCP 8.5 scenario, the mean annual rainfall indicates an increase of about 10-20% between 2021 and 2050. By the end of the century, the projected increase in rainfall levels across the country could be more than 30%. While the projections suggest increasing rainfall during the summer, the winter season is likely to receive a decrease in rainfall in some parts of the country, particularly in the north-western region of Bhutan.

3.4. Mitigation Assessment

The Climate Change Policy of the Kingdom of Bhutan 2020 defines a Low Emission Development Strategy (LEDS) as “a sectoral or national level development strategy aimed at ensuring socio-economic growth with minimum level of related greenhouse gas emissions”. Therefore, the Long-Term Climate Resilient and Low Carbon Development Strategy identifies potential interventions for sectors to achieve national development objectives while minimizing emissions and thereby contributing to the goal of remaining carbon

neutral as reiterated in Bhutan's first Nationally Determined Contribution (NDC) to the Paris Agreement. The updated NDC Synthesis Report by the UNFCCC notes that available NDCs of all 192 Parties taken together, a sizable increase, of about 16%, in global GHG emissions in 2030 compared to 2010 is anticipated which may lead to a temperature rise of about 2.7°C by the end of the century (UNFCCC, 2021). Recognizing the shortfall in the global emission reductions to reach the Paris Agreement goal of limiting global temperature rise by not more than 2°C, it is important for all Parties to the Paris Agreement to redouble efforts in reducing their respective GHG emissions.

While Bhutan is currently carbon neutral with the forests sequestering more greenhouse gas (GHG) than the total national emissions, there has been a rapid increase in emissions concurrent with the pace of economic growth and development.

This chapter identifies mitigation measures, sets potential targets, and determines a conducive environment including policy environment and financial, technological, and capacity building support required following the IPCC categories of GHG emissions.

3.4.1. Energy

The significant emissions under the energy category are attributed to the following sub-categories:

1.A.2. Manufacturing Industries and Construction (Use of coal as an energy source in cement manufacturing, use of diesel as a boiler fuel in food and wood industries).

1.A.4. Other Sectors (Use of LPG and kerosene for cooking and space heating in commercial and residential areas, building energy efficiency, and rollout of solar rooftop systems)

1.A.3. Transport (Use of jet fuel for domestic aviation, diesel and petrol, and lubricants for road transportation).

3.4.1.1 Manufacturing Industries and Construction

Background

The manufacturing sector accounted for 7.2% of the GDP in 2019 (MoF, 2020). Its growth is constrained by a lack of flat space due to the mountainous nature of Bhutan. In addition, heavy industry expansion is hampered by the poor performance of the existing plants with regard to local air and water pollution.

The government promotes the establishment of small manufacturing plants concentrated in food processing, handicrafts, wood, and paper processing. Food processing could become a key sector, given the government's consistent efforts

to promote Bhutan as a 100% organic food production system. Agro-industries can contribute to low emissions development as their emissions intensity is much lower than that of the heavy industries that dominate the industry sector today. However, two industrial parks are currently being developed to house medium and large industries in Sarpang and Samdrup Jongkhar while an industrial park in Samtse is earmarked for environment-friendly (Agro and forest-based) industries.

In terms of GHG emissions in the non-forest sector, industrial processes led to 796 $GgCO_2e$ in 2015 (NEC, 2021). The GHG Emissions under the business-as-usual (BAU) scenario will increase to 2,809 $GgCO_2e$ by the year 2035 and flattens out for want of space for industrial expansion (MoEA, 2021).

Given the significant GHG emissions growth of the industrial sector in the past 15 years and considering that the manufacturing industry is an important sector of the economy, it is imperative to find ways to reduce the growth in GHG emissions while allowing for growth and diversification in the sector.

Current Mitigation Program

There is no mitigation program being implemented currently besides the adoption of the Low Emission Development Strategy in 2021.

Proposed Mitigation Measures

3.4.1.1 Raw Material Pre-Heating Based on Waste Heat Recovery

A considerable amount of heat is wasted in many industrial plants because exhausted gases with relevant heat content are often discharged directly into the atmosphere or must be cooled before the gas treatment process. The cooling process, such as mixing exhausted gases with fresh air, spraying water in a quenching tower, etc., implies additional costs for systems, operations, and maintenance. The exhaust gas temperature is around 300 – 400 degrees Celsius and these need to be cooled down to about 150 degrees Celsius prior to entering the gas cleaning plant (GCP), the heat thus transferred to the cooling tower is generally lost to the atmosphere.

It can be both economically and environmentally convenient to utilize this otherwise dispersed heat to meet heat demands inside or outside the industry premises. If the recoverable heat does not match any internal heat demand or surpasses the internal demand, the transportation of heat to external users or its transformation into electricity could be evaluated, including the supply of steam for neighboring food industries.

It is estimated that roughly 54% of the energy input is wasted through off-gas and the target of the waste to heat recovery system is to recover this waste heat. The waste to heat recovery unit could be taken up individually in each plant and the

recovered heat could be used for pre-heating the raw materials prior to charging them into the furnace or it could be taken as a central unit servicing the ferro alloy units in the industrial estate. However, the centralized option would entail setting up a central gas cleaning plant and marketing recovered heat either to produce steam or electricity using an Organic Rankine Cycle Generator (refer www.turboden.com).

The ferro silicon manufacturing plants have a total of 126 MVA-sanctioned loads and applying a power factor of 80%, the total electricity consumed by the existing ferro alloy plants is 870,912 MWh per annum. As modelled by Filkoski (2009), the waste energy works out to 470,293 MWh which could potentially be captured for pre-heating raw materials. With a conservative approach of utilizing 30% of the waste energy for pre-heating raw materials, the cumulative energy conservation for actual smelting of the raw materials into ferroalloys works out to 235,147 MWh per annum with a mitigation potential of 813 $GgCO_2e$ by 2030 and 2621 $GgCO_2e$ by 2050 respectively.

3.4.1.2 Energy Efficiency in Industries

The future production estimation has been applied to determine the mitigation potential based on electricity savings of assumed 0.4 MWh per tonne of ferrosilicon produced and under application of the Indian grid emission factor. As a result, the cumulated emission reduction potential for 2020-2050 reaches 570 $GgCO_2e$ with an average annual potential of roughly 40 $GgCO_2e$.

Further, electric motor systems can be improved in all industrial sectors; they play a particularly relevant role in the heavy industries (transport of intermediate products and crushing), and food processing. Energy savings of 5% as a result of using energy-efficient equipment will also result in emission reductions. The cumulative mitigation from energy efficiency measures in production processes, motors, and pumps in 2030 works out such that motors can mobilize emission reductions of 2.2 $GgCO_2e$ per annum. The cumulated mitigation potential for the period 2021 to 2050 can reach 64 $GgCO_2e$.

3.4.1.3 Use of RDF in Cement Plants

Besides electricity, cement industries in Bhutan use non-coking coal as an energy source to provide the sustained heat required in calcining the limestone to calcium oxide. There is a potential to use high calorific refuse (waste) such as used tyres, plastics, and others to supplement coal use. For instance, in 2019, the three cement plants in Bhutan consumed a total of 153 kt of non-coking coal. The assessment assumes pelletizing the refuse and supplementing 5-10% of the coal used. This measure would result in an annual average mitigation potential of

41.34 Kt CO_2e resulting in a cumulative mitigation of 372 $GgCO_2e$ by 2030 and 1199 $GgCO_2e$ by 2050.

3.4.1.4 Direct Hot Charge in Steel Plants

Two integrated steel plants are in operation in the Paskha industrial estate and another steel plant has been established at the Motanga industrial estate with the potential for at least two additional steel plants. The direct hot charge system is an improvement on the steel manufacturing technology through direct rolling of the continuously cast billets/ingots without the need for reheating them in a reheating furnace. This requires the induction furnace to be integrated with the rolling mill. The direct hot charge system of TMT Bar manufacturing has already been tested in Lhaki Steels and Rolling Mills and results indicate improved production efficiency and lower process waste with GHG mitigation potential from the avoidance of using the heavy oil-fired reheating furnace.

Based on data provided by Bhutan Rolling Mills Ltd., an emission reduction potential of approximately 9 GgCO2e per year from furnace oil savings could be achieved by Direct Hot Charge (Integrated Steel Production). Considering 5 steel plants of similar capacity coming into operation, the mitigation potential in the steel industries works out to 45 GgCO2e per annum resulting in a cumulative mitigation of

3.4.1.5 Boiler Switch from fossil to electric

The data collected from the industries for the years 2016-2019 (9 food processing industries) show that the boilers are fueled by an assortment of diesel, natural gas, and LPG besides a few industries already using electric boilers. The combined emission from the food processing industry in 2019 was 496.37 tCO_2e. Even assuming a 300% increase in the number of such industries and 100% conversion of fossil-fired boilers to electric ones, the mitigation benefit is less than 2 GgCO2e per annum which is found to be negligible as compared to emission profiles of other industries. An issue that hampers the accuracy of the estimates of emissions is the lack of disaggregated data on fuel use in boilers and in the transport of raw materials and products. A conservative cumulative mitigation of 18 Gg CO_2e by 2030 and 58 Gg CO_2e by 2050 can be achieved.

3.4.1.2 1.A.4. Other Sectors

3.4.1.2.1 Switching of biomass and fossil cooking and space heating to electric

The fuel composition in domestic areas is dominated by biomass. In 2019, biomass accounted for 69 % of energy for cooking as compared to only 14% from electricity and 16% from liquified petroleum gas (LPG) as fuel requirements for cooking. There is a high dependence of rural households on biomass due to its affordability and easy accessibility. Despite decreasing fuelwood use (from 91%

in 2005 to 69% in 2019) a substantial share of households continues to use biomass for cooking and heating with significant effects on emissions and health. The conventional biomass stoves are less energy efficient and contribute to high GHG emissions. Figure 9 presents baseline emissions from extrapolating current trends in cooking until 2030.

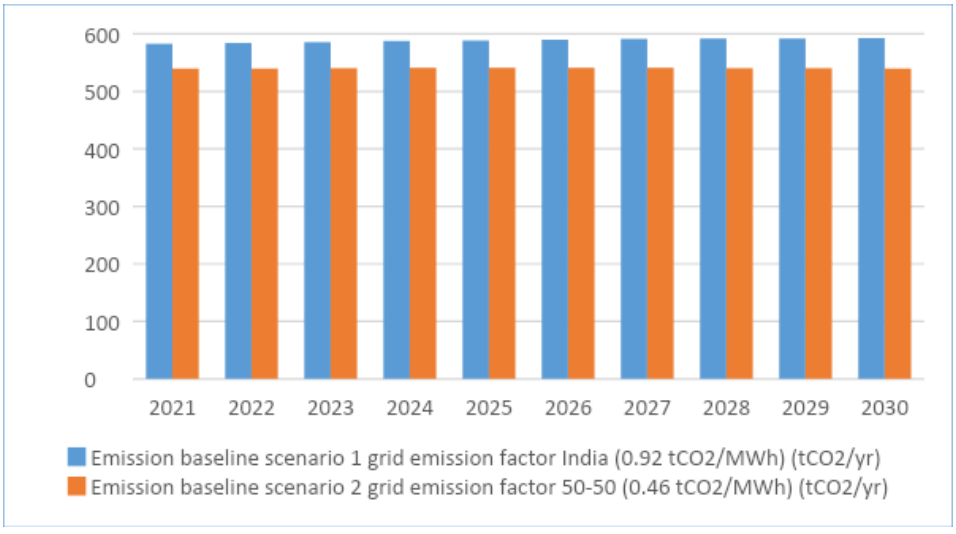


Figure 9. Baseline emissions in cooking

Fuelwood is a common source of energy consumption in households (45,323 m3 in 2019) (NSB 2020c). At the same time, the imports of LPG, which is mainly used for cooking purposes grow (NSB 2020c). Replacing biomass (wood) and LPG for heating and cooking purposes with electricity, e.g. electric stoves, reduces overall emissions of households. The government has plans to implement a sustainable rural biomass programme to roll out energy-efficient cookstoves and to roll out a distribution of electric cookstoves at a subsidized rate in order to incentivize the switch towards cleaner and more efficient cooking fuels.

It was assumed that by 2030 a full transition from cooking with biomass and LPG towards electricity is achieved in both urban and rural households. Furthermore, electric stoves are considered the most efficient with 74% conversion efficiency, compared to 68% for LPG stoves and 24% for conventional biomass cookstoves. The main underlying assumption in the calculation of the costs of this activity is that high-efficiency (5-star) induction stoves are distributed (DRE 2018).

Transition to electricity for cooking yields a mitigation potential of 600.5 GgCO2e until 2030 and 1626.1 GgCO2e

3.4.1.2.2 Buildings

The building sector in Bhutan is characterized by its traditional architecture, with the construction types varying between urban and rural areas. While urban buildings are of a larger scale, up to six storeys high, and use modern construction materials (cement, glass, steel), rural buildings are usually of a smaller scale and use traditional building materials (rammed earth, mud blocks, stone masonry, timber). Nevertheless, new rural buildings, especially those near urban centers and along highways tend to use modern construction materials. In addition, building types can be differentiated according to their use as residential, commercial, and institutional buildings.

Energy consumption in residential buildings comes from activities related to cooking, space heating and cooling, lighting, and the use of other electrical appliances. On the other hand, the use of the centralized heating system, high energy-consuming appliances, and activities related to cooking and lighting contribute to the consumption of energy in commercial and institutional buildings.

In 2019, electricity consumption from residential buildings reached 264.6 GWh (124.5 GWh from rural residential buildings and 140.1 GWh from urban residential buildings), representing a total of 11.6% of total electricity consumption (5.5% and 6.1% respectively) (NSB, 2020). Electricity consumption from the commercial and institutional sectors reached 73.2 GWh (3.2%) and 67.4 GWh (3%) respectively. In addition, 8,828.2 tonnes of LPG (NSB 2020a) and 45,323.88 m^3 of fuelwood were consumed by households for cooking and space heating in 2020 (NSB, 2020). The choice of building material has a strong impact on the emissions intensity of a building. Currently, the building materials used for building envelopes are poor in thermal performance. This is particularly relevant given the different climatic zones found in Bhutan due to the high differences in altitudes: a sub-tropical zone, a temperate zone, a sub-alpine and an alpine zone. In sub-tropical areas, temperatures are high in summer and buildings tend to suffer from heat gain through the building envelope, increasing the cooling load. In temperate to alpine zones that need heating in winter, heat is lost through the walls and by air infiltration through openings.

Figure 10. Baseline emission in buildings with Indian GEF

The National Energy Efficiency and Conservation Policy 2019 and the Energy Efficiency Roadmap DRE 2019 are the central documents detailing activities to be undertaken in the short and medium-term with regard to enhancing the energy performance of buildings and creating an enabling framework for their implementation. The Bhutan Energy Baseline 2019 has been developed as a first step towards the development of energy efficiency building codes of practices. In addition, Energy Auditing and Reporting Guidelines for the Buildings 2020 have been developed and its implementation is to be carried out by 2025.

The calculation of the mitigation potential is based on estimating the average efficiency gains per square meter resulting from the measures described above for three types of buildings - residential, commercial, and institutional. The number of new buildings is based on current population projections and household size[3] (NSB 2020a) for residential buildings and projected growth of the commercial sector, taking GDP projections as a proxy for commercial buildings. The refurbishment rate is assumed to be at 3% p.a. of houses in urban areas and 1.5% p.a. in rural areas. It is assumed that efficiency gains lead to a 20% reduction in energy consumption in urban residential buildings, and commercial and institutional buildings and a 10% reduction in energy consumption in rural residential buildings. The total area available for refurbishment is adjusted for both increased urbanization and the accumulating stock of refurbished areas. Refurbishing the existing stock of buildings and

[3] Assuming a decrease in household size from 4 persons in 2017 to 3.4 persons by 2030 in urban areas and from 3.8 persons to 3.2 persons in rural areas, which corresponds to the decrease observed between the 2005 and 2017 census.

adding new energy efficient housing accumulate energy savings and thus emission reduction potentials, due to the high permanence of the activity.

Measures to promote EE in buildings can lead to total emission reductions of 414.1 GgCO2e until 2030 and 1334 GgCO2e by 2050.

3.4.1.2.3 Solar Rooftop

While there is no direct mitigation benefit to Bhutan by the installation of solar photovoltaic rooftop systems, a mitigation offset system has to be instituted including the mitigation boundary within the territory of India; this is because any surplus electricity in Bhutan is exported to the Indian grid and the assumption is that this exported electricity reduces the demand for electricity generated from the thermal power plants in India. The rollout of this mitigation measure would result in cumulative mitigation of 1728 kt CO_2e by 2030 and close to 3000 GgCO2e by 2050 (MoWHS, 2021).

3.4.1.2.4 Energy-Efficient Appliances and Lighting

The most common appliances in Bhutanese households are rice cookers, induction cookstoves and also air conditioners, refrigerators, washing machines, televisions, water boilers, and electric heaters which are primarily imported from India and Thailand. Overall, the energy consumption of electric appliances is expected to grow significantly until 2030 (DRE 2018). The energy performance of appliances can be improved by replacing the existing stock of inefficient appliances in the market with appliances with improved energy performance. The government foresees to undertake systematic efforts to replace the current stock of appliances with energy efficient appliances in the Energy Efficiency Policy and Roadmap (DRE 2019). This includes the development and implementation of a standards and labeling (S&L) scheme for five appliances until 2030.

The projected import quantities until 2030 were taken from the assumptions underlying the Energy Efficiency Road Map 2019 (DRE 2019) and related goals. Based on these quantities, the energy-saving differential was calculated by comparing 5-star energy efficient appliances against baseline appliances (DRE 2018). The cumulative energy savings based on these data have been further used to calculate emission reduction potentials.

The emission reduction potential from the roll-out of energy efficient appliances until 2030 is 160.4 GgCO2 and 517 GgCO2e by 2050.

3.4.1.2.5 Transport

The transport sector in Bhutan has been identified as the primary source of GHG emission in the energy group and responsible for approximately 425 GgCO2e emissions or 11.14 percent of the total GHG emissions in 2015 and more than 60% of emissions under the energy category (NEC, 2021). This is likely to increase to 1.25 million metric tonnes of CO2e by 2050 under a business-as-usual

scenario, with a significant rise in GHG emissions expected from light vehicles (3.8 times), followed by medium trucks (3.6 times) and heavy trucks (3 times) (MoWHS, 2021).

The GHG inventory of the Third National Communication assumes all motor gasoline, HSD, and lubricant imported are used in the transport sector due to the lack of disaggregated data on fuel split between road transport, agricultural farm machinery, timber logging equipment, and construction machinery. While this would have overestimated the emissions under the road transport sub-category, at a national level, there is not expected to be any overestimation or underestimation of emissions as the entire fuels imported have been considered during the compilation of the inventory.

The LEDS for Human Settlement 2021 identifies 8 mitigation interventions ranging from mass transit, BRTs, and EVs to non-motorized transport systems and regulatory reforms for stringent emission standards as well as phasing out the import of ICE vehicles. These interventions with their potential mitigation are reproduced below:

S/N	Intervention (in the order of priority)	Description	Cumulative emission reductions till 2025 (tCO2e)	Cumulative emission reductions till 2030 (tCO2e)	Cumulative emission reductions till 2050 (tCO2e)
1	Emission Standards	Reducing vehicle emissions by adopting stricter emissions standards (Bharat/Euro) and synchronizing it with fuel economy improvement measures.	55,364	270,772	3,187,366

2	Shared Mobility	Promoting shared mobility to improve average vehicle occupancy and strengthening public transport.	45,153	301,351	2,875,672
3	Electric Passenger Vehicles	Promoting less polluting transport alternatives for all passenger vehicles which include 2W,4W, Bus, etc	30,658	203,343	5,684,962
4	Improving walkways/sidewalks	Promoting non-motorized transport such as walking, by constructing more walkways and side/walks	1,269	5,113	73,397
5	Annual vehicle capping system	Gradual phase out of ICE vehicles and Annual capping system for vehicle import/sales	-	-	2,940,923
6	BRT Electric	Deploying electric buses in a dedicated bus priority lane	3,158	11,985	134,758
7	LRT and Passenger Train	Developing rail network and deploying passenger train	-	20,306	112,444

		connecting cities/towns			
8	Bicycling (PBS)	Promoting non-motorized transport such as bicycling through public/community-based bicycle system	1,389	5,580	79,480
9	Low emission freight truck	Promoting less polluting transport alternatives for all freight transport such as electric trucks	-	3,675	447,342
10	Freight Train	Developing rail network and deploying freight train connecting cities/towns	-	10,370	246,987

3.4.2 Industrial Processes and Product Use (IPPU)

In addition to the Pasakha and Bjemina industrial estates, three new industrial parks in Dhamdum, Jigmeling and Motanga have been established and are in various stages of development (MoEA, 2021). The industrial parks will provide a favorable environment through the provision of common basic infrastructure. The master plan has taken into consideration the development of industries with a cluster approach to benefit from close geographical proximity among industries that are linked by commonalities and complementarities. For example, the Dhamdhum Industrial Park promotes low-polluting industries using cleaner technologies and processes while Jigmeling and Motanga Industrial Parks are earmarked for heavy industries.

Considering the comparative advantages offered by reliable and affordable electricity in Bhutan, the heavy industries primarily ferro alloy industries are expected to take residence in these new industrial parks.

GHG emissions in the IPPU category are attributed to the process emissions from the manufacture of ferroalloys and clinker. The use of fossil-based reductants (anthracite, bituminous coal, semi-coke, etc) is used to reduce the quartz/ quartzite to silicon ions and metal oxides (Fe_2O_3) from mil scales into metal ions which are subsequently bonded under very high temperatures to form ferroalloys. As a result, process emissions from these processes in 2015 was 357 $GgCO_2e$ (NEC, 2021) which is projected to increase to 1748 $GgCO_2e$ by 2050 (MoEA, 2021). Process emissions from the manufacture of clinker in the cement industry was 139 $GgCO_2e$ in 2016 with a marginal projected increase to 200 $GgCO_2e$ by 2050 (MoEA, 2021).

The mitigation options considered are in substituting the fossil-based reductants by charcoal and cement blending to reduce the clinker intensity of cements.

The annual average production during the period 2015 to 2019 of ferrosilicon has been determined to be 112,000 tonnes (t) based on data collected from companies. According to (NEC, 2012), a yearly production increase of 30,000 t of ferrosilicon is expected until the year 2020, however, based on information received from the Department of Industry, the increase in production expected till 2020 did not happen and is expected to take place in the period 2021 – 2030 with industries completing construction in the new industrial estates and commencing operations. Under the current mix of reductant use, the GHG intensity of ferrosilicon is between 1.58 to 2.64 tCO_2e per tonne of ferrosilicon produced and this intensity could be reduced by replacing fossil coal and coke use by biogenic charcoal. Assuming 15 years of increased production from 2020 to 2035 followed by a constant production level from 2035 to 2050, the average annual emission reduction potential for this mitigation measure will be 652 Kt CO_2e as a yearly average over the period 2021 to 2050.

NEC (2012) assumed an annual production capacity of 1.37 million t of cement for Dungsam Cement Corporation Ltd. from 2012 onwards. From the data collection for the period 2016 -2019, only production of around 600,000 tonnes of cement per year has been reported, meaning that about 0.7 million t annual production capacity has not yet been realized. Accordingly, assuming this capacity would be fully used in the future, an average annual emission reduction of 62 GgCO2e between 2021 and 2050 would result from a 5 -10% clinker reduction from blending. This assumes 90% clinker content for the hitherto unutilized production capacity.

3.4.3 AFOLU

The AFOLU category has emissions from agriculture (crop farming and livestock) and emissions from forest and land use change. The Agriculture, Forestry, and Other Land Use sector when excluding removals is the highest contributor to Bhutan's total GHG emissions accounting for 57.24% translating

to 2183.25 Gg of CO2e in 2015. Agriculture sector emission for the period is 552.87 Gg of CO2e translating to 14.49% of net emission while LULUCF (without considering removals) accounted for 42.74% of national emission with 1630.37 Gg CO_2e.

The Low Emission Development Strategy (Food Security) identifies the following mitigation measures in the agriculture sector:

INTERVENTIONS	Cumulative emission reductions until 2025 (t CO2e)	Cumulative emission reductions until 2030 (t CO2e)	Cumulative emission reductions until 2050 (t CO2e)
Switch from synthetic to organic fertilizers	1,600	6,940	57,301
Improved agricultural practices	36,958	133,899	953,233
Increase of biomass sequestration through perennial crop production	169,966	442,505	1,978,232
Small scale domestic biogas production	52,385	107,054	409,031
Reduction of continuous rice flooding	79	288	1,338
Improved dairy cattle productivity though feeding	5,292	19,404	164,052
TOTAL	**266,280**	**710,090**	**3,563,187**

Considering that agriculture emissions are lifeline emissions for the people of Bhutan with more than 60% of the population dependent on the sector and subsistence agriculture practiced predominantly, Bhutan is already following low emission agriculture practices. Improvements in manure management, stall

feeding, and the introduction of perennial crops would lead to significant emission reductions.

3.4.4 Waste

The current recycling rates in Bhutan are low. Therefore, Bhutan's National Waste Management Strategy (2019) aims to improve waste management (including maximum material recovery) and the application of the 3R concept (reduce, reuse, recycle). It proposes a number of short- and medium-term measures, ranging from strengthening institutional coordination to mandating good waste management practices to improve MSW management infrastructure. To implement the National Waste Management Strategy, the NEC is leading the National Waste Management Flagship Program (NEC 2020a which aims to reduce the current trend of 80% of waste going into landfills to less than 20% by 2030.

As there is currently no data on the recycling of different waste fractions, conservative assumptions were taken regarding the current recycling rates, and a linear increase until 2030 was assumed in line with the 2030 target. The measures considered therefore focus on increasing the composting and recycling shares of wastes. Composting bio-degradable waste fractions is highly appropriate to small and medium-sized settlements, given that the share of organic waste is high, and the waste can reliably be segregated at the source. In the cold highland areas, composting may be hampered by the low temperatures, while it will work very well in moist sub-tropical and temperate areas. The option to recover landfill gas was not considered as it would not be viable given the high recycling rates. Mitigation potential in solid waste management has the potential to reach 447.2 Gg CO_2e by 2030 and 540 $GgCO_2e$ by 2050.

Wastewater management

There are plans to install nine centralized wastewater treatment systems in municipalities under the 12th FYP. To estimate the emission reductions from wastewater, it was assumed that more than 80% of the population would be connected to sewage systems, with a split of 34% anaerobic and 66% aerobic treatment methods. The emission reduction potential was estimated based on methane capture and energy generation at 110.4 $GgCO_2e$ by 2030 and 237 $GgCO_2e$ by 2050.

3.4.5 Impact of Mitigation Measures

The mitigation measures primarily are geared towards reducing the GHG emissions of Bhutan till 2050 keeping in mind the requirement under the Paris Agreement for ambition of the Parties to progress over time. These measures however also have co-benefits in terms of creating additional jobs, value addition to available local resources, supporting adaptation works, and contributing to the sustainable growth of the economy through reduced imports, increased exports, and increased revenue base for the government.

A summary of their GHG impact is presented in the following figures:

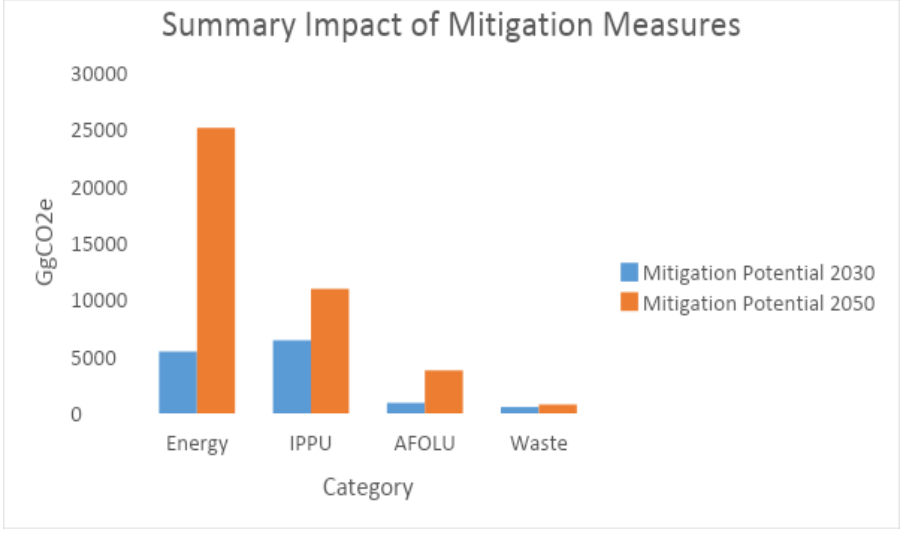


Figure 11. Summary of mitigation potential till 2030 and 2050

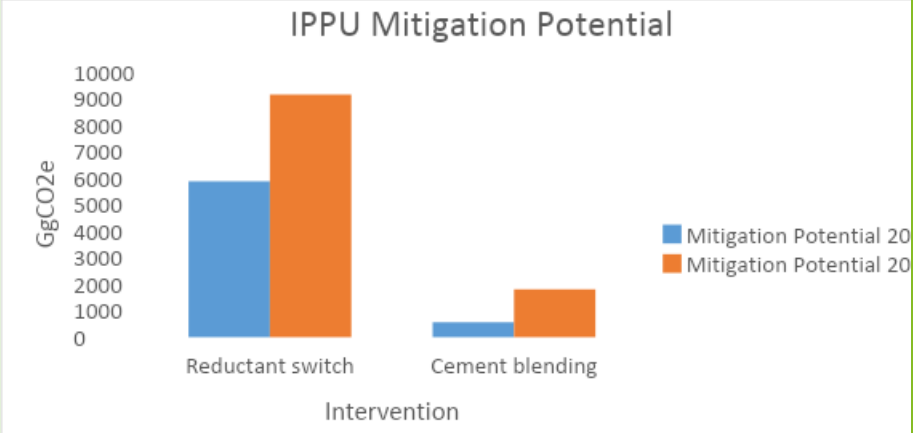


Figure 12. Mitigation potential in the IPPU Sector

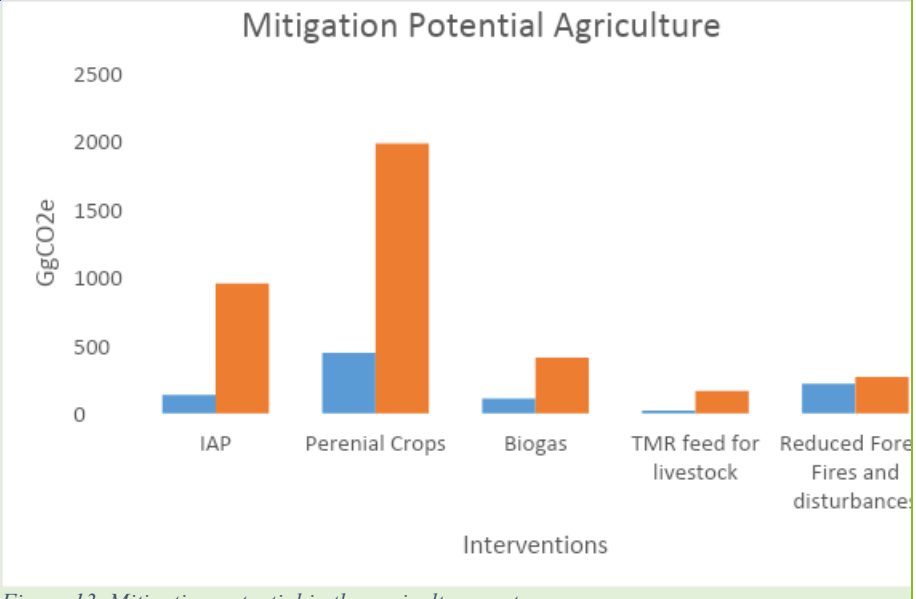


Figure 13. Mitigation potential in the agriculture sector

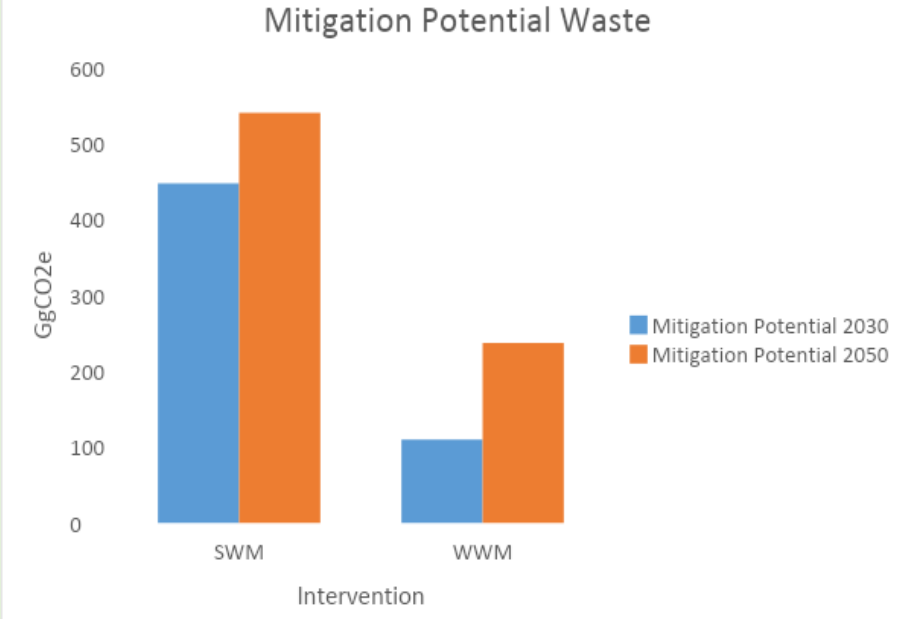


Figure 14. Mitigation Potential in the Waste Sector

3.5. Climate change impact, vulnerability, and adaptation assessment

3.5.1 Water resources

All river basins are projected to see the highest discharge in May, June, and July (14 to 43%) for all the scenarios and time periods except for June in RCP 4.5 (2070 - 2100). Under the RCP 8.5 scenario, the monthly average flow shows an increase from January to November for both future time periods. However, December month flows are lesser in both scenarios. As evident from the results, the increases are concentrated more in the summer months when the flow is relatively high, while the decreases are more apparent in the winter months. Hence, in the future, dry periods are expected to get drier. In contrast, wet periods are expected to get wetter, making the overall system more vulnerable to the impacts of climate change.

The snow cover area for Bhutan estimated for the period 2002 to 2010 was 9030 Km^2, about 25.5% of the total land area (Gurung et al., 2011). The average snow cover area for winter was around 14,485 sq. km (37.7%), for spring 7,411 Km^2 (19.3%), for summer 4,326 Km^2 (11.2%), and for autumn 77,88 Km^2 (20.2%), mostly distributed in the elevation range 2,500–6,000 masl. The total snow cover area from 2002–2010 decreased by about –3.27 ± 1.28%. This decrease was at both annual and intra-annual scales at insignificant rates. The snow cover decline

over the recent decade could result in a decrease in water resource availability in the long run.

To address increased disaster risks, limited access to water resources, and seasonal water shortages, the following adaptation options have been proposed:

- Prepare an action plan based on a detailed multi-hazard zone mapping and set up relevant early warning systems and education.
- Develop Water Safety plans and implement proper water supply systems with an adequate design, and study groundwater use and its risks and potentials across Bhutan.
- Examine the feasibility of storage reservoirs for seasonal storage, build multi-purpose storage reservoirs, and explore technologies for rainwater harvesting and efficient water usage and management.

3.5.2 Agriculture sector

The agriculture sector is vulnerable to changes in the monsoon season's timing (early/late) and the quantity of rainfall. About 61% of dry arable land is rain-fed as there are no adequate irrigation facilities.

Increases in temperature and irregular rainfall patterns have led to decreasing crop yield due to a reduction in agricultural water availability and crop loss due to extreme events like flash floods, windstorms, and pest and disease outbreaks. Most villages across Bhutan are highly vulnerable to climate impacts and have low adaptive capacity. Factors contributing to the villages' low adaptive capacity are their limited resource base and precarious socio-economic status, including labor shortages; poor grid and road connectivity; unstable dryland agriculture; crop disease and low-yielding seeds; and, increased risk and exposure to drought, unseasonal precipitation, and wind events. The impact gets elevated due to the dependence of Bhutan's agriculture on largely rain-fed crops in the dry land.

The main constraints faced in the agriculture sector are climate change-induced water shortages, wildlife predation of crops, pests, and diseases, poor mountainous shallow soils, further worsened by increasing soil loss through surface erosion, and scarcity of farm labor. Adaptation priorities and options for agriculture are as follows:

- Water Shortage: Proper planning and implementation of irrigation projects considering climate change impacts, innovative storage, and pumping facilities; strengthening database/inventory on water resources and capacity building.
- Human-Wildlife Conflict: Proper planning, capacity building, research, and data inventory on animal migration and improved capacity in handling HWC.

- Soil Erosion: As most of the smallholders' farmlands occur on slopping lands, fertile topsoils are frequently lost to soil erosion. Sustainable Land Management (SLM) techniques and practices need to be applied as adaptation measures.
- Alternate Crop Production: Conduct further research on the criteria for adopting new crops in Bhutan and identify site-specific studies and options.
- Marketing and Storage: Improve post-harvest storage and preparation through initiatives like farmer schools where farmers with a good understanding of post-harvest technology and techniques could share their experiences.
- Pests and Diseases: Newer pests and diseases, along with their changing resilience, are huge risks to the agriculture and livestock sector. Develop and apply varieties of both crops and animals that are resilient to pests, diseases, and climate change. Exploring and continued dependence on native livestock breeds that have been able to cope with natural changes over the years instead of only depending on improved varieties is an alternative.
- Extreme Climates: Harsh unprecedented weather conditions, such as heat and cold waves, pose risks to both crops and livestock. Pasture development and providing proper shelters for animals in both hot and cold regions are also necessary to protect them from harsh climatic conditions.

3.5.3 Forests and Biodiversity

Although Bhutan is endowed with rich biodiversity and mostly pristine forests, some of the threats to forest and biodiversity are forest fire, pests and diseases, loss of biodiversity, invasion of alien species, and alteration in ecosystem composition as threats to biodiversity driven by climate change.

Based on the forest types classified in land use and land cover map of Bhutan, 2016, maximum entropy distribution modeling (Maxent) was used to assess the potential impact of climate change on forest types by the years 2050 and 2070 under RCP 4.5 and RCP 8.5 for broadleaf, mixed conifer, blue pine, fir, and Chir pine.

Out of five forest types, Chir pine forest exhibited major potential gain in an area with a suitable climate under future climate change scenarios while remaining forest types are likely to experience a considerable decline. Several factors like anthropogenic land cover changes, dispersal limitation, pests and diseases, biotic interaction, migration, and disturbances such as forest fires are not included in the current model. Studies in central Himalaya indicated that gain in Chir pine forest would encroach and displace oak forest, which is an undesirable phenomenon. The gain in Chir pine forest area and their redistribution could contribute to water

resource depletion. Further, gain in Chir pine forest will expose forests to increased incidences of fire damage and reduce floral diversity due to poor soil nutrients. Some of the adaptation options identified in the forest ad biodiversity sector are:

- *Pest and diseases:* Damages by pests and diseases will have the most immediate and possibly significant impact of climate change on the forest. This is because insects are ectothermic and changes in temperature will directly influence their metabolic rate, consumption, development, survival, dispersal, and destructive potential. Interaction between plant and insects are also dependent on the availability of water. Therefore, an in-depth understanding of the association between climate and forest pests and diseases. Their monitoring is important in enabling relevant authorities to expect, prepare, and respond to changes in pest behaviors, outbreaks, and invasions.
- *Forest fire*: Forest functions as an important carbon sink in the face of global climate change. However, an intense forest fire can potentially reverse this benefit by turning the forest from a sink to a major source. The intensity, size, and frequency of forest fires are expected to change as the temperature rises and precipitation patterns change. Many aspects of post-forest fire conditions will accelerate other natural environmental disturbances, resulting in modified vegetation patterns, land degradation, desertification, and hydrological cycle derangement.
- *Invasion of alien species:* As it is observed that both mean and annual temperature are increasing, exposure to high temperature for a very long time will affect forest flora and fauna inducing changes in forest biodiversity. Intrusion of agriculture farming into forest land is already occurring which will bring invasive weeds and alien species. This shift in mixtures of natural and domesticated plants and biodiversity would require a strong land use policy and measures to protect key biodiversity areas.

3.5.4 Energy Sector

Bhutan's economy is largely dependent on climate-sensitive sectors like hydropower. The hydropower sector depends on the flow of the rivers, making it more susceptible to the impacts of climate change. The impacts of climate change on hydropower are demonstrated in the form of changes in flow, volume, and inter-annual variability in the timing of flow. Heavy and erratic rainfalls during the monsoon, and drier periods in the winter, cause greater variance in total volumes between two consecutive years. Furthermore, it is expected that under a warmer and more variable climate, the onset of monsoons will be erratic, which will cause disruptions in natural cycles affecting hydropower generation. With the increase of frequency of heavy monsoon rains, flash floods and landslides are

expected to occur, which may cause damage to infrastructure, power distribution, and eventually, the economy of the country.

The adaptation option includes diversification of energy sources and economic base, support promotion of renewable and energy-efficient technologies, and investments to harness hydropower energy. Storage of water during the lean season and explore the use of isolated valleys and alpine lakes for regulated storage. Watershed protection and check dams at strategic locations will reduce the sedimentation and siltation of rivers and waterways. The operationalization of the Renewable Energy Development Fund (REDF) is also a measure that could be initiated sooner.

3.5.5 Human Health

Climate change affects social and environmental determinants of health – clean air, safe drinking water, food self-sufficiency, and secure shelter. With climate change, Bhutan is expected to experience a wide range of health risks. Rising temperatures, unpredictable weather patterns, unequal distribution, or water supply to the communities will influence the epidemiological pattern of many diseases, particularly vector-borne, airborne, and water-borne diseases. Diseases such as dengue and chikungunya have emerged over the last few years and indicate a growing trend. Emergency medical health requirements will also rise with climate-induced disasters such as GLOFs, floods, and landslides.

The key adaptation options for the health sector to cope with the challenges and issues are emergency preparedness, enhancing monitoring and surveillance, strengthening the capacity of health workers, deployment of healthcare facilities such as emergency and trauma centers, and promotion of research needs.

Additionally, climate change also poses risks to other development sectors such as energy, manufacturing, and the service sector, including tourism and the hotel industry. Measures to adapt to such impacts should be developed to ensure that climate change does not nullify the gains of the past five decades of planned development.

4. Strategy 2050

The objective of this strategy is to support the efforts of the Royal Government of Bhutan in decoupling economic growth and generation of productive employment while still ensuring Bhutan remains carbon neutral for all times to come.

The strategy is divided into mitigation and adaptation components focusing on three different time scales of short term (2025), medium-term (2030), and long term (2050) while still maintaining the sectoral focus needed during implementation. The strategy contains the goals of the strategy and a brief implementation plan to achieve the goals.

The cost implications in this strategy include additional costs to what is currently being done and do not reflect the total cost of interventions as it is difficult to ascertain the recurrent costs of specific interventions borne by the government as well as the private sector.

4.1 GHG Mitigation Strategy

4.1.1 Emission Reduction in the Energy Sector

The significant emissions under the energy category are attributed to the following sub-categories:

- 1.A.2. Manufacturing Industries and Construction (Use of coal as an energy source in cement manufacturing, use of diesel as a boiler fuel in food and wood industries).
- 1.A.4. Other Sectors (Use of LPG and kerosene for cooking and space heating in commercial and residential areas, building energy efficiency, and rollout of solar rooftop systems)
- 1.A.3. Transport (Use of jet fuel for domestic aviation, diesel and petrol, and lubricants for road transportation).

To reduce emissions from the above sources, the following strategy is to be implemented:

4.1.1.1 Sustainable Low-Emission Surface Transport

The LEDS for Human Settlement 2021 identifies 8 mitigation interventions ranging from mass transit, BRTs, and EVs to non-motorized transport systems and regulatory reforms for stringent emission standards as well as phasing out the import of ICE vehicles. The following interventions are adapted from the LEDS for Surface Transport with revised mitigation assessments, costs, and implementation plans:

4.1.1.1.1 Stringent Fuel Efficiency Standards

The introduction of fuel efficiency measures in the form of vehicular emission standards and fuel quality standards would help to reduce emissions from road transport. The government could further provide incentives for the introduction of clean fuel technologies like electric vehicles and hydrogen vehicles, along with exploring options for retrofitting engines for light vehicles as well as trucks. The stringent enforcement of vehicular emission standard and fuel quality standards must be accompanied by a scrapping policy to ensure that inefficient vehicles are scraped off and the vehicular fleet on the roads are compliant with the standards. The government could also introduce fiscal incentives to promote the import of energy-efficient vehicles.

Targets

Short Term (2025): Cumulative Emission Reduction up to 212.49 Gg CO_2e

Medium Term (2030): Cumulative Emission Reduction up to 743.72 Gg CO_2e

Long Term (2050): 2868.64 Gg CO_2e

Implementing Agencies

- Vehicle Emission Standards: National Environment Commission in collaboration with the Road Safety and Transport Authority
- Fuel Standards: Department of Trade in consultation with the Bhutan Standards Bureau and National Environment Commission.
- Vehicle Scrapping Policy: Road Safety and Transport Authority
- Fiscal Incentives: Ministry of Finance in collaboration with Road Safety and Transport Authority and Ministry of Economic Affairs.

Costs

Standards Development, Publication, and Awareness: USD. 30,000.00

Fiscal Incentives: USD. 100,000.00 per year

Miscellaneous costs: USD. 20,000.00 per year

Implementation Plan

a. Establish Task Force for the formulation of revised vehicle emission standards and fuel quality standards from relevant agencies: 1 Week
b. Formulate fuel and vehicle emission standards: 2 months
c. Adopt Standards: 1 month
d. Carry out awareness on the revised standards, particularly with affected stakeholders: 1 month

e. Formulate a Vehicle/ Machinery Scrapping Policy taking into consideration the average life of the machine/vehicle from the manufacturer, energy efficiency, and pollution potential: 6 months
f. Develop regulation/guidelines for scrapping old and energy-inefficient vehicles/machines: 3 months.
g. Implement the Scrapping Policy/regulation/guideline: After 1 year of adoption.

4.1.1.1.2 Promotion of Low-Emission Vehicles

Fossil fuel-based vehicles would have certain limitations after a point where vehicle efficiency will keep deteriorating. These vehicles will also continue to pollute the environment despite improvements in design and standards. To combat climate change, alternative technologies like electric vehicles and hydrogen vehicles are perceived as game-changing technologies to reduce carbon footprints over the years and to meet global commitments. While emissions from these vehicles are highly dependent on the grid emission factors, electric and hydrogen vehicles are considered low-emission and energy-efficient vehicles as the electricity source in Bhutan is 100% renewables. In this intervention, following the success of the Bhutan Low Emission Transport Project, the focus is on promoting battery electric, hydrogen fuel cell, and plug-in hybrid vehicles as an alternative to the import of conventional vehicles based on the internal combustion engine (ICE) technology.

The success of this intervention would be dependent on the provision of adequate fiscal measures (estimated at USD.1000.00 subsidy per passenger vehicle) and non-fiscal measures such as designated parking spaces at concessional rates, reduced rates of vehicle registration/ renewal fees, and availability of stable grid electricity as well as public charging infrastructure. Further, minimum standards for EVs pertaining to safety and performance are needed while a guideline on the collection and disposal/transfer to manufacturers of used EV batteries needs to be developed.

Targets

Short Term (2025): 378.99 Gg CO_2e

Medium-term (2030):1326.49 Gg CO_2e

Long Term (2050): 5116.47 Gg CO_2e

Implementing Agencies

- Promotion of EVs and Low Emission Vehicles: RSTA in collaboration with NECS
- Developing Standards on EVs and Guidelines on used battery collection and disposal: MoIC, RSTA in collaboration with NECS.

- Fiscal Incentives: RSTA in collaboration with NECS and MoF.

Costs

Fiscal Incentives: USD. 500,000.00 per year

Additional Charging Infrastructure: USD. 1.5 million

Reskilling mechanics and technicians: USD. 300,000.00

Implementation Plan

Many of the pre-requisites for the rollout of the low-emission vehicles are already in place, including the waiver of import duties and taxes and others are in the pipeline, including the free parking spaces for EVs and concessional fees for vehicle registration and renewals (Dawa, 2021). To reduce the financial burden on buyers, a subsidy of USD 1000.00 per EV purchased would make EVs competitive with the ICE vehicles and promote their purchase.

a. Finalize the incentive mechanisms including subsidies (4-6 months).
b. Installation of additional charging infrastructure for EVs (12-24 months).
c. Ensure uninterrupted and reliable electricity supply in consultation with BPC (12-36 months).

4.1.1.1.3 Non-Motorized Transport

Non-motorized transport (NMT) is being pursued as an alternative and sustainable mode of transport in urban and major settlement areas. The benefits of the NMT include the reduction of vehicular emissions, lifestyle diseases (NCD), reduction of nuisance related to traffic congestion, noise pollution, and extra cost of road maintenance.

For the purpose of this strategy, NMT refers to walking, bicycling, and Public Bicycling Sharing as identified in the LEDS for Surface Transport. NMT is a significant option for low-emission transportation in urban areas. It is estimated that more than 75% of trips within 1-2 km are performed by walking or non-motorized vehicles. Promoting walking and bicycling would require the development of related infrastructure including overhead passes, bicycling, and pedestrian lanes as well as campaigns to change the mindset of people. Public Bicycle Sharing (PBS) can play a vital role in promoting bicycling in the country. This concept allows the users to pick up a cycle from any station and return it to any other station, thereby encouraging the use of cycles for short-distance travels, point-to-point, and one-way trips. It can also serve as an alternative transport mode to address the challenges related to “last mile” connectivity. PBS has the potential to prove attractive to students and tourists alike. PBS would require investments in the Public-Private Partnership with associated subsidies and support from the government or facilitated by the government.

Targets

Short Term (2025): 10.19 Gg CO_2e

Medium-term (2030):35.67 Gg CO_2e

Long Term (2050): 137.59 Gg CO_2e

Implementing Agencies

- Development of NMT-related infrastructure: Local Governments in collaboration with MoWHS and TCB.
- Fiscal Incentives to promote bicycling and PBS: MoIC, MoWHS and MoF
- Public-Private Partnership Model on PBS: MoIC in collaboration with relevant Thromdes and MoF.

Costs

USD. 12.0 million

Implementation Plan

Planning on NMT-related infrastructure (ongoing process)

Feasibility study on PBS using the PPP model: MoIC in collaboration with MoF and relevant local government: 6 – 24 months.

Implementation of PBS based on the outcomes of the feasibility study: 6 – 12 months

Fiscal Incentives for NMT: 6-12 months

4.1.1.1.4 Shared Mobility and Alternative Transport Modes

Any mode of transportation that is shared by users on an as-needed basis, from motorcycles to 4-wheelers to mass transit constitutes shared mobility. Shared mobility provides an opportunity for the government to redefine personal mobility in a country having high private vehicle ownership. It is observed that, in Bhutan, the average vehicle occupancy for personal vehicles is 30% and 50% for taxis. Thus, the shared mobility concept has the potential to improve average vehicle occupancy (fleet utilization) by allowing more passengers and goods to travel in the same vehicle. This also makes transportation more affordable as cost is shared among users/goods. While buses and trams also come under shared mobility, for the purpose of this document shared mobility refers to ride sharing in taxis and personal vehicles, and alternative transport modes refer to cable cars and ropeways. Given the rough geographical terrain in Bhutan and the hazards from landslides and monsoon rains, it may be more efficient to connect remote communities with ropeways and cable cars than with farm roads in the long term.

Additionally, urban areas like Thimphu are constrained with space for expansion of road lanes and it may be a better alternative to connect high-density traffic points with elevated cable cars to reduce pressure on the road traffic.

Targets

Short Term (2025): 191.72 Gg CO_2e

Medium-term (2030):670.99 Gg CO_2e

Long Term (2050): 2588.11 Gg CO_2e

Implementing Agencies

Policies and incentives to promote ride sharing: MoIC

Feasibility studies and implementation of ropeways and cable cars to connect rural communities: MoHCA, MoAF and MoWHS

Feasibility Studies and implementation of ropeways and cable cars in urban areas and tourist destinations: MoIC, MoWHS, and Tourism Council of Bhutan.

Costs:

- Policy formulation and implementation on ride-sharing: No additional cost
- Feasibility Studies and Piloting Ropeways: USD. 3.0 million
- Feasibility Studies and Piloting Cable Car System (Gondola): USD 30.0 Million (The Gondolas Project, 2022)

Implementation Plan

a. Formulate Policy and Guidelines on Ride Sharing (2-3 months).
b. Carry out feasibility studies and Pilot 1 ropeway project
c. Carry out feasibility studies and Pilot 1 cable car (gondola) project.

4.1.1.1.5 Restrictions on the Import of ICE Vehicles

Discouraging private use vehicles is an important step towards climate change initiative and addressing traffic congestion considering that light vehicles and taxis collectively resulted in climate pollution of 134,464 and 32,922 metric tonnes CO2e respectively (MoWHS, 2021). Medium to long-term solutions like widening roads, constructing bypasses, and urban expressways could be adopted but they are costly interventions. Discouraging private vehicle use is one of the optimum solutions available to policymakers. It is a package of short-term measures to make the optimum and cost-effective use of existing transportation infrastructure and facilities. The number of vehicles doubled in Bhutan from 57618 in 2010-11 to 114646 in 2020-21, with the highest growth of vehicles in the Thimphu region as evidenced by the RSTA annual reports. Left unchecked,

the growth of vehicle population is expected to cross 200,000 by 2030 and this can present additional road congestion, safety, and environmental problems. This can be prevented by presenting more efficient alternative transport modes in the form of mass transit, ride sharing, NMTs, etc while regulating the number of vehicles to be imported based on the carrying capacity of the road infrastructure through controlled import quotas. A portion of the import quotas could be distributed to sections of the society without any vehicles registered while the balance could be auctioned to investment in improving the transport infrastructure.

Targets

Short Term (2025): 196.06 Gg CO_2e

Medium-term (2030): 686.22 Gg CO_2e

Long Term (2050): 2646.84 Gg CO_2e

Implementing Agencies

Policy on vehicle import restriction/quota: MoIC in collaboration with MoF and MoWHS

Implementation of Vehicle import quota: RSTA in collaboration with the Department of Revenue and Customs and Department of Trade.

Cost: Not foreseen as no additional investments are required.

Implementation Plan

Formulate Policy on annual vehicle import quota based on the carrying capacity of transport infrastructure: 6 months – 24 months.

4.1.1.1.6 Sustainable Freight Transport

Electric-powered Heavy and medium commercial trucks are less polluting freight transport alternatives and possible interventions to reduce climate pollution (greenhouse gas emissions) and local air pollution stemming from the rising use of fossil-fuel-powered trucks being used for freight/logistics operations.

In 2020, the registered number of heavy and medium vehicles (of 7.5 tonnes to 16 tonne Gross Vehicle Weight and an approximate payload of 4 to 10 tonnes) in Bhutan stood at 11,800. Each of these vehicles, under business-as-usual (BAU) conditions, emits 14.8 metric tonnes of CO2e per year. Seen collectively, in 2020, heavy vehicles resulted in climate pollution levels of 173,759 metric tonnes of CO2e.

Under a BAU scenario, the number of registered trucks is expected to increase by about 255% (from 11,800 to 41,926 trucks) between 2020 and 2050 and a

corresponding increase in GHG emission to 0.52 million metric tonnes of CO2e in 2050.

While current technology development and affordability of EV and hydrogen fuel cell trucks may not seem attractive for Bhutan, it is expected that both the technology and affordability will be relevant to Bhutan post-2025. Therefore, the scenario refers to the plausible outcomes from approximately 14% of the truck fleet in Bhutan becoming electric trucks by 2050 starting at 0.05% fleet conversion in 2026 and growing at 0.2 to 0.4% in the intervening years.

Targets

Short Term (2025): 29.82 Gg CO_2e

Medium-term (2030): 104.38 Gg CO_2e

Long Term (2050): 402.98 Gg CO_2e

Implementing Agencies

Feasibility studies and piloting electric and hydrogen fuel cell trucks for freight transport: MoIC in collaboration with MoF, MoEA, MoWHS and Local Governments.

Fiscal Incentives for electric freight transport: MoIC in collaboration with MoF.

Costs

Feasibility studies and piloting of electric freight transport: USD.1.5 million

Fiscal Incentives for promoting EV/Hydrogen fuel Freight Transport: USD 3.0 Million per year

Implementation Plan

Feasibility studies and piloting electric freight transport: 12-24 months.

Promoting electric and/or hydrogen fuel cell trucks with incentives: post-2025

4.1.1.1.7 Electric Bus Rapid Transport System and Electric Buses

Electric-powered BRT buses are a less polluting public transport alternative and possible intervention to reduce greenhouse gas emissions and local air pollution stemming from the anticipated reduction in import, and subsequent use, of fossil-fuel-powered private passenger vehicles and taxis.

Compared to Diesel-powered BRT buses, electric buses lead to even lower per-passenger-km GHG emissions due to the significantly lower climate impacts of its electricity-generating source.

In 2020, the registered number of private passenger vehicles and taxis in Bhutan stood at 72,818 and 5,782 respectively. Each of these vehicles, with an approximate passenger load factor of 1.4 and 2.5, respectively, under business-as-usual (BAU) conditions, emits 1.9 and 5.8 metric tonnes of CO2e per year, respectively.

Public transport systems, such as a bus rapid transit system, provide a compelling and direct means to drastically reduce GHG emission per passenger transported for the same distance traveled relative to personal transport vehicles. On a per-passenger-km basis, the GHG emission from a light vehicle in Bhutan in 2050 is estimated to be 109 grams CO2e/passenger-km. In contrast, the emissions for the same person traveling in a public electric-powered bus are significantly lower at 2 grams CO2e/passenger-km. Therefore, in effect, an electric public bus is approximately 54 times more efficient than a petrol- or diesel-powered private car and creates 98% less climate and air pollution.

Thimphu City Bus Service has plans to introduce electric buses by 2023 and data from the operation of these electric buses could be used in planning the interventions.

This intervention would require subsidies from the government to meet the top-up cost of electric buses as compared with conventional buses and taxis.

Targets

Short Term (2025): 29.21 Gg CO_2e

Medium-term (2030): 102.22 Gg CO_2e

Long Term (2050): 394.26 Gg CO_2e

Implementing Agencies

Fiscal Incentives for Electric BRT system: MoIC in collaboration with MoF.

Rolling out electric buses for intra as well as inter dzongkhag transport: MoIC in collaboration with local governments.

Designation of BRT Lanes and development of BRT infrastructure: Local governments in collaboration with MoWHS and MoIC.

Costs

Fiscal Incentives for BRT Electric: USD 0.5 Million/year

Subsidy on the purchase of Electric Buses: USD 1.5 Million/year

BRT Infrastructure Development: USD 30 Million

Implementation Plan

Development of fiscal incentives and subsidies to promote BRT and electric buses: 3-6 months

Development of BRT infrastructure: 6 months -36 months

Roll out of Electric Buses and BRT: 6- 12 months

4.1.1.2 Energy Efficiency and Conservation

The energy efficiency and conservation measure encompass improving the energy efficiency (EE) of buildings and appliances, improving energy efficiency in production and manufacturing, and replacing liquid petroleum gas as a fuel of choice for cooking and space heating with electric cooking and space heating. Provided there is the availability of financial support, the development of the EE building codes of practice for new constructions and retrofits in existing buildings could reap the dual benefits of reduced emissions as well as improved well-being. Supplementary activities such as creating a market for EE materials and technology and facilitating technology transfer to local persons with international experts are also needed to be carried out to bring down the upfront cost.

The framework for rolling out EE measures in appliances and manufacturing industries should be supported by exploring how those measures, in particular the standards and labelling scheme could be developed and incentivized.

Targets

EE Intervention	Annual	Short Term (2025)	Medium Term (2030)	Long Term (2050)
Energy Efficiency Buildings	13.80	41.41	96.62	372.69
Energy Efficiency Appliances	5.35	16.04	37.43	144.36
Energy Efficiency Manufacturing	2.20	6.60	15.40	59.40
LPG to electric cooking and space heating	20.00	60.00	140.00	540.00
Total	41.35	124.05	289.45	1116.45

Implementing Agencies

Energy Efficiency in Buildings: DRE in collaboration with MoWHS, BSB, CDB, and CAB

Energy Efficiency in appliances: DRE in collaboration with DoT and MoF and BSB

Energy Efficiency manufacturing: DRE in collaboration with DoI, DRC, and ABI/BCCI

Switching of LPG-based cooking and space heating to electric: DRE in collaboration with DoT, DRC, BEA, and BPC.

Costs

EE in buildings: USD 3.5 Million

EE in appliances: USD 5.0 Million

EE in manufacturing industries: USD 750,000.00

LPG to Electric cooking and space heating: USD 10.0 Million

Implementation Plan

Benchmark EE in buildings, appliances, and processes and develop standards and labels: 3-12 months

Formulate incentives for adoption of EE measures: 3-12 months

Develop and implement incentives to promote electric cook stoves and electric space heaters including infrared stoves, infrared space heaters, heat pumps, etc.: 6 months – 12 months

4.1.1.3 Promotion of alternative renewable energy

Bhutan has a high potential for solar PV (DRE 2016), which could be used to harness renewable energy (RE) from both solar rooftops and solar farms. The viability of both solar and wind has been demonstrated through pilot projects in Wangduephodrang through a 180 KW solar farm and 600 KW windmills. Further promotion of windmills and rooftop solar will not only ensure national energy security but also promote the growth of domestic industries and mitigate GHG emissions through the export of surplus electricity. Another potential alternative renewable energy presents is the manufacturing of green hydrogen using abundant water resources and electricity through hydrolysis. A pilot study is currently planned with ADB financing and the results of the study will inform further courses of action.

Targets

RE Intervention	Annual (Gg CO_2e)	Short Term (2025)	Medium Term (2030)	Long Term (2050)
Roll out of Solar PV Rooftop	38.40	115.20	268.80	1036.80
Planned Utility Scale Solar PV	32	66	224	864
Wind Energy	1.20	2.18	30.22	362.66
Green Hydrogen (targets not set, pending outcomes of the feasibility study)				
Total	39.96	117.70	299.99	1403.82

Implementing Agencies

Rollout of Solar PV Rooftop: DRE in collaboration with BPC

Planned Utility Scale PV: DRE in collaboration with DGPC and BPC

Wind Energy: DRE in collaboration with BPC

Green Hydrogen: DRE in collaboration with DGPC and DHPS

Costs

Rollout of Solar PV (Subsidy Component): USD 3.0 Million

Planned Utility Scale Solar PV: USD 27.0 Million

Wind Energy: USD 60.0 Million

Green Hydrogen Pilot: USD 12.0 Million

Implementation Plan

Revise Alternative Renewable Energy Policy to include provisions on green hydrogen, feed-in tariff, and specific incentives for the uptake of alternative renewable energy: 3-6 months

Assessment of Grid infrastructure to roll out solar rooftop: 6-12 months

Pilot solar rooftop projects in urban and rural settings: 3-6 months

Develop DPRs of alternative renewable energy projects (solar and wind)

Initiate and upscale projects based on pilots and DPRs: 24 – 120 months

4.1.1.4 Fossil substitutes for energy Sources in manufacturing industries

Coal is used as an energy source in the cement industries to fire the kilns while diesel and natural gas are used in boilers in the food industry, particularly for the manufacture of beer and fizzy drinks. This intervention is about substituting a portion of the coal used in the cement industry with refuse-derived fuel and switching from fossil-fired boilers to electric ones in the food industry. Further, in the manufacture of ferroalloys, an estimated 30-45% of the energy used is wasted as heat energy and escapes into the ambient environment through the flue gas as well as furnace openings and trapping this heat through a central heat exchanger to use it to pre-heat raw materials would result in energy savings in the manufacturing process.

Targets

Intervention	Annual (Gg CO2e)	Short Term 2025	Medium Term (2030)	Long Term (2050)
Waste to heat in ferro alloys manufacturing	97.07	291.22	679.52	2621.00
RDF in cement industry	44.37	133.11	310.59	1198.00
Direct hot charge in steel industry	48.33	145.00	338.33	1305.00
Boiler switch from fossil fired to electric ones	2.15	6.44	15.04	58.00
Total	191.93	575.78	1343.48	5182.00

Implementing Agencies

Waste to heat in ferro alloys manufacturing: DoI & ABI in collaboration with MoF, GNHC & NEC

RDF in the cement industry: DoI & ABI in collaboration with MoF, GNHC & NEC

Direct Hot Charge in Steel Industry: DoI & ABI in collaboration with MoF, GNHC & NEC

Boiler Switch from fossil-fired to electric ones: DCSI, DoI & ABI in collaboration with MoF, GNHC & NEC.

Costs

Waste to heat in ferro alloys manufacturing: USD 25 Million

RDF in the cement industry: USD 14 Million

Direct Hot Charge in Steel Industry: USD 5.0 Million

Boiler Switch from fossil-fired to electric ones: USD 2.5 Million

Implementation Plan

Carry out the detailed design of interventions based on pilots already carried out and experiences from the private sector: 6 - 12 months

Carry out resource mobilization from international financing mechanisms to implement the interventions in a cost-sharing mechanism: 12 -24 months

Design fiscal incentives to promote these interventions in new industries: 3-6 months.

4.1.2 Climate Resilient and Low Carbon agriculture and livestock development for enhanced food security.

The strategy for the agriculture and livestock sectors focuses on emission reductions through the following interventions:

4.1.2.1 Switch from Synthetic to Organic Fertilizers

The National Organic Framework (NOF) is the cornerstone of national policy as it sets the target for the conversion of current farming systems to sustainable, natural, and organic management systems. Urea is the main nitrogen synthetic fertilizer imported into Bhutan. One of the objectives of the National Organic Flagship Program is to reduce the use of imported synthetic fertilizers and replace them with organic fertilizers that will help to improve soil fertility. This mitigation action focuses on the shift from synthetic to organic fertilizers assuming no change in the nitrogen dose.

Targets

Short Term (2025): 1.60 $GgCO_2e$

Medium Term (2030): 6.94 $GgCO_2e$

Long Term (2050): 57.30 $GgCo_2e$

Implementing Agencies

Department of Agriculture in collaboration with the NCOA, NSSC, NSC, NECS, DOL, and farmers.

Costs

USD 2.5 Million

Implementation Plan

Create awareness of the advantages of organic fertilizers over synthetic ones: 3-6 months

Design incentive and subsidy mechanisms for uptake of organic fertilizer production: 6 – 12 months

Build capacity to plan, design and implement organic fertilizer production: 3 – 12 months

Pilot organic fertilizer production from municipal solid waste: 6-24 months

Promote organic product certification and audits: 12-24 months.

4.1.2.2 Improved Agricultural Practices

The NOF targets an improvement of agricultural practices like conservation agriculture (tillage management), precision farming, protected agriculture (inside greenhouses), water management as well as improved and efficient nutrient management. The objective is to implement practices that are aligned with Bhutan's standard for Good Agricultural Practices (GAP) but also the principles of Climate Smart Agriculture and Agroecology. This mitigation action focuses on improved and sustainable agricultural practices among those listed above that can increase Soil Organic Carbon (SOC) stocks. According to IPCC guidelines, the level of fertilization (described as a level of inputs in the guidelines) as well as the level of tillage are the main factors influencing SOC. Following IPCC guidelines, for three farming types, parameters of improved agricultural practices involve shifting from the current practices to organic management with reduced tillage and high organic fertilization.

Targets

Short Term (2025): 36.96 $GgCO_2e$

Medium Term (2030): 133.90 $GgCO_2e$

Long Term (2050): 953.23 $GgCo_2e$

Implementing Agencies

DoA in collaboration with the ARDCs, AMC, FMCL, NPPC, LGs, and farmers.

Costs

USD. 2.0 million

Implementation Plan

Create awareness of improved agricultural practices: 3-6 months

Demonstrate IAP by the RDCs: 6-24 months

Incentivize IAPs through product certification and fiscal subsidies: 6-24 months.

4.1.2.3 Increase of biomass sequestration through perennial crop production

This intervention targets the increase of area under perennial crop production thereby increasing above ground as well as below ground extent of carbon stored in biomass. The plantations would consist of cash crops such as apples, citrus, areca nuts, hazelnut fodder trees, and improved pasture/ rangeland for livestock development. This intervention besides promoting carbon sequestration, also provides supplementary income to the growers.

The total new area that will be planted under perennial crop production between 2018 and 2050 (from 2019 onwards) reaches 33,099 ha from the baseline of 1345 ha in 2019. Since the area projected under perennial crops is larger than the current available fallow land (approx. 23,000ha), plantation on degraded shrubland and dry land is expected to be taken up.

Targets

Short Term (2025): 169.97 $GgCO_2e$

Medium Term (2030): 442.51 $GgCO_2e$

Long Term (2050): 1978.23 $GgCo_2e$

Implementing Agencies

DoA in collaboration with DAM, ARDCs, NSC, DOL, and farmers

Costs

USD. 15 million

Implementation Plan

Develop and implement policy guidance on perennial cropping, particularly in leasing barren SRFL to interested growers: 3-6 months

Design low-interest loans and grant schemes to take up perennial cropping: 6-12 months

Promote perennial cropping products from Bhutan in the international market using the Brand Bhutan baseline:6-24 months

4.1.2.4 Small-scale domestic biogas production

A total of 6983 biogas plants are operational across the country. Small-scale biogas plants are defined as those plants with a capacity of 4-10m3, while medium-scale ones as those with 11-100m3. The biogas generation potential considered to replace LPG was derived from IRENA (2016), assuming fixed dome plants and the same penetration rate by size as currently observed. This intervention besides providing GHG mitigation will also improve national energy security, particularly in the areas of cooking and space heating, and therefore reduce dependence on imported LPG as well as improve Bhutan's balance of trade with India.

Targets

Short Term (2025): 52.92 $GgCO_2e$

Medium Term (2030): 107.05 $GgCO_2e$

Long Term (2050): 409.03 $GgCo_2e$

Implementing Agencies

DOL in collaboration with DRE, DOA, farmers, and energy traders.

Costs

USD 2,400,000.00

Implementation Plan

Create an enabling policy environment to promote biogas as an alternative energy source: 3-6 months

Develop incentive mechanisms to support the uptake of biogas projects: 3 – 12 months

Build in-country capacity to design and build modern biogas plants:6-12 months

4.1.2.5 Reduction of continuous rice flooding

The increase in rice self-sufficiency is one of the main policy targets for the agriculture sector in Bhutan. Given the high pressure on land due to urbanization, rice fields are expected to decrease in the coming years (Draft, IFPRI 2020). Therefore, maximizing productivity will be crucial for increasing rice self-sufficiency.

The need for mitigation related to rice production is mentioned in several policy documents. Emissions related to rice production are related to water management for paddy field irrigation. Methane emissions are particularly important in flooded fields where organic material decomposes under anaerobic conditions. The mitigation action considers a linear decrease of continuously flooded rice fields of 200 ha per year into intermittently flooded single aeration (100 ha/year) and intermittently flooded multiple aerations (100 ha/year). The productivity level of continuously flooded rice fields is similar to the productivity of fields under intermittent flooding management (6.0 t/ha).

Targets

Short Term (2025): 0.08 $GgCO_2e$

Medium Term (2030): 0.29 $GgCO_2e$

Long Term (2050): 1.34 $GgCo_2e$

Implementing Agencies

DOA in collaboration with ARDCs, LGs, and farmers.

Costs

USD. 800,000.00

Implementation Plan

Create awareness on reduced flooding rice production practices: 3-6 months

Demonstrate reduced flooding rice production practices by the RDCs: 6-24 months

Incentivize reduced flooding rice production practices through product certification and fiscal subsidies: 6-24 months.

4.1.2.6 Improved dairy cattle productivity through improved feeds

Livestock forms an integral part of the agricultural system in Bhutan. About 90% of farming households keep one form of livestock or the other. The cattle population currently stands at 302,589 heads, of which 40% are improved cattle breeds (DOL 2019). The TNC identifies those enteric emissions as representing 63% of the emissions identified under the agriculture sector (552.9 ktCO2e). Thus, targeting those emissions presents a significant opportunity for reducing the overall contribution of the sector to national emissions. This intervention therefore includes breed improvement of livestock, improved pasture development, TMR feeds, and stall feeding.

Targets

Short Term (2025): 5.29 $GgCO_2e$

Medium Term (2030): 19.40 $GgCO_2e$

Long Term (2050): 164.05 $GgCo_2e$

Implementing Agencies

DOL in collaboration with LGs, DoFPS, RLDCs, BLDCL, and farmers.

Costs

USD 1,500,000.00

Implementation Plan

Develop enabling policy environment for low-emission livestock development: 3-6 months

Pilot TMR and Stall feeding: 6- 12 months

Develop fiscal incentives to promote high-yield animal breeds and stall feeding: 3- 6 months

Provide supply chain support to market livestock products: 6 – 24 months

4.1.3 Reducing Forest carbon emissions and enhancing biodiversity conservation

Conservation of forest cover is key to maintaining Bhutan's carbon neutrality pledge and even though forest sequesters more GHG than the country emits, emissions from forests are by far the highest emission, even higher than the sectors dependent on fossil fuels. Significant sources of forest emissions come from disturbances due to wildfire and land use changes from forest to agriculture or settlements. Emissions from forest fires using data from 2000 to 2020 indicate that annual emissions range from 97 Gg CO2e to 2017 Gg CO2e. Protecting forests from forest fires and climate-induced pests and diseases will enhance forest biodiversity besides increasing carbon sequestration.

Interventions in the forest sector, therefore, include preventing and managing wildfires and improved monitoring and response to outbreaks of pests and diseases. Interventions are also provided in 4.2.3 on forest and biodiversity adaptation.

Targets

Short Term (2025):34.33 GgCO2e

Medium Term (2030): 529.68 GgCO2e

Long Term (2050): 1382.33 GgCO2e

Implementing Agencies

Forest Fire Prevention and Management: DoFPS in collaboration with Dessung Office, RBP, RBA

Forest Monitoring and Response to Pests and Diseases: DoFPS

Costs

Forest Fire Prevention and Management: USD 500,000.00

Forest Monitoring and Response to Pests and Diseases: USD 1.2 Million

Implementation Plan

Continue awareness and outreach activities on forest fire prevention: Annual

Creation of fire breaks particularly in blue pine and chirpine forests: Biennial

Building institutional capacity including equipment and soft skills: Annual

Replacement of fire-damaged trees through afforestation: DoFPS

Forest Monitoring and rapid response to outbreaks of pests and diseases: As required

4.1.4 Reducing GHG Emissions from processes in the manufacturing Industries.

Industrial growth will play an important role in Bhutan's economic growth and diversification and contribute to the realization of the 12th Five Year Plan objective of *"Just, Harmonious and a Sustainable Society through enhanced Decentralization"*. A small number of energy-intensive heavy industries along the southern border produce ferroalloys, cement, and steel and mainly serve the export market besides meeting domestic requirements. The government is now promoting the establishment of small manufacturing plants concentrated in food processing, handicrafts, wood, and paper processing. This directly links to National Key Result Areas (NKRAs) 1,2 and 3. GHG emissions from industrial production in Bhutan will increase by as much as a factor of three between now and 2035 and then plateau until 2050 (NEC, 2020). The emissions will mainly rise due to the growth in the sector, particularly through new industries in Jigmeling Industrial Park, Motanga Industrial Park, and Dhamdhum Industrial

Park. The increase in emissions from these new industries will put Bhutan's carbon neutrality target at risk, as such increases in emissions from the manufacturing sector combined with BAU emissions in the other sectors may exceed the carbon uptake capacity of Bhutan's forests.

The interventions in reducing process emissions target process emissions in ferroalloys manufacturing and cement blending to reduce the quantity of clinker in cement manufacturing. Cement blending, particularly in the manufacture of slag cement by using slag from the iron and steel industry provides an option to not just reduce the GHG intensity of cement but also adds value to the waste from the steel industry.

4.1.4.1 Substituting fossil-based reductants with biogenic charcoal and wood chips

The annual average production during the period 2015 to 2019 of ferrosilicon has been determined to be 112,000 tonnes (t) based on data collected from companies. According to NEC (2012), a yearly production increase of 30,000 t of ferrosilicon is expected until the year 2020, however, based on information received from the Department of Industry, the increase in production expected till 2020 did not happen and is expected to take place in the period 2021 – 2030 with industries completing construction in the new industrial estates and commencing operations. Under the current mix of reductant use, the GHG intensity of ferrosilicon is between 1.58 to 2.64 tCO_2e per tonne of ferrosilicon produced and this intensity could be reduced by replacing fossil coal and coke use by biogenic charcoal.

Targets

Short Term (2025): 1296.64 $GgCO_2e$

Medium Term: (2030): 4536.22 $GgCO_2e$

Long Term (2050): 17496.83 $GgCO_2e$

Implementing Agency

Department of Industry in collaboration with ABI, NEC &MoF

Costs

USD 15.70 Millions

Implementation Plan

Develop disincentives for the import of coal through a carbon tax.

Develop incentives for the domestic charcoal industry based on the sustainable harvest of wood products.

4.1.4.2. Cement blending

From the data collection for the period 2016 -2019, only production of around 600,000 tonnes of cement per year has been reported, meaning that about 0.7 million t annual production capacity has not yet been realized. Accordingly, assuming this capacity would be fully used in the future, an average emission reduction of 62 $KtCO_2e$ between 2021 and 2050 would result from a 5 -10% clinker reduction from blending clinker with steel slag, gypsum fines, micro silica, and other additives. This assumes 90% clinker content for the hitherto unutilized production capacity.

Targets

Short Term (2025): 126.85 $GgCO_2e$

Medium Term: (2030): 443.97 $GgCO_2e$

Long Term (2050): 1712.45 $GgCO_2e$

Implementing Agency

Department of Industry in collaboration with ABI & MoF

Costs

USD 1,200,000.00

Implementation Plan

Promote industrial linkage between blending material producers and cement manufacturers.

Provide fiscal incentives for value addition to domestic industrial waste.

Promote the use of blended cement in collaboration with MoWHS, BSB, and CAB.

4.1.5 GHG Mitigation through sound management of waste

4.1.5.1 Wastewater management

Bhutan currently has only two centralized waste water treatment systems in Thimphu and Phuentsholing and all other towns rely on decentralized treatment systems. There are plans to install nine centralized wastewater treatment systems in municipalities under the 12th FYP which may spill into the subsequent plan

period owing to the disruptions of COVID-19. The emission reductions would occur from methane capture and using the captured methane as either an energy source or for energy generation.

Targets

Short Term (2025): 67.88 $GgCO_2e$

Medium Term: (2030): 237.60 $GgCO_2e$

Long Term (2050): 916.36 $GgCO_2e$

Implementing Agency

Thromdes and Dzongkhag Administrations in collaboration with MoWHS and NECS

Costs

USD 4.0 Million (cost sharing to actual investments)

Implementation Plan

Develop detailed project reports on the centralized waste water treatment systems including methane capture, pressurized packing, and marketing or energy generation.

Promote packed methane or energy generated as green energy to the domestic market.

4.1.5.2 Solid Waste Management

Bhutan's National Waste Management Strategy (2019) aims to improve waste management (including maximum material recovery) and the application of the 3R concept (reduce, reuse, recycle). It proposes a number of short- and medium-term measures, ranging from strengthening institutional coordination to mandating good waste management practices to improve MSW management infrastructure. The measures considered in solid waste management therefore focus on increasing the composting and recycling shares of wastes. Composting bio-degradable waste fractions is highly appropriate to small and medium-sized settlements, given that the share of organic waste is high, and the waste can reliably be segregated at the source.

Targets

Short Term (2025): 127.77 $GgCO_2e$

Medium Term: (2030): 447.20 $GgCO_2e$

Long Term (2050): 1724.91 $GgCO_2e$

Implementing Agency

Thromdes and Dzongkhag Administrations in collaboration with MoWHS and NECS

Costs

USD 3.0 Million

Implementation Plan

Develop detailed project reports on the centralized waste water treatment systems including methane capture, pressurized packing, and marketing or energy generation. Promote packed methane or energy generated as green energy to the domestic market.

4.2 Climate Change Adaptation Strategy

4.2.1 Energy

Bhutan located in the cold Himalaya Mountain range, the demand for electricity for heating is also high during the winter months. As electricity demand outstrips supply in winter, the country resorts to imports from India (IRENA, 2019). These imports, although currently much smaller than exports, are increasing on an annual basis. Bhutan relies on imports of coal, diesel, and other petroleum products. Generally, petroleum reserves have not been explored in Bhutan and there are no refineries for crude oil processing in the country.

The adaptation option includes diversification of energy sources and economic base, support promotion of renewable and energy-efficient technologies, and investments to harness hydropower energy. Storage of water during the lean season and explore the use of isolated valleys and alpine lakes for regulated storage. Watershed protection and check dams are built to reduce the problem of sedimentation and siltation. Proper mapping, planning, preparing contingency plans, and setting up EWS with real-time monitoring will prevent floods, flash floods, and GLOFs.

The details of the adaptation strategy in the energy sector are detailed in Table 5. Energy Sector Adaptation Strategy and Implementation Plan.

Table 8. Energy Sector Adaptation Strategy and Implementation Plan

a. S/N b.	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
1	Flow variability, leading to disruption of hydropower generation, which is exported, in turn makes the economy of country highly vulnerable due to dependence only on one source of energy.	Diversify the energy supply mix to reduce dependence on hydropower which is threatened by climate change. Bhutan has to source out alternative sources of energy.	(a) Policy for RE Development, RE Resource Assessment, Master Plan Development.	0.24	Policy for Grid integrated Mega RE Projects.	0.18	Grid integrated Mega RE Projects. (120 MW, excluding hydro)	121.41	Diversified energy supply mix of county. Increase in the other sources of Renewable Energy (apart hydropower). Hence reduced GHG emissions due to avoidance of other conventional energy sources.
			(b) Establishment of RE (all major RE sources) specific Lab for Testing, Certification, Advanced Research and Capacity Building	32	Mega RE Pilot Projects (40 MW, excluding hydro)	44.62	Advanced Renewable Energy Research and Development (example: Aqua - hydrogen, Green Hydrogen, WtE Projects)	2.15	

a. S/N	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
b.									
			(c) Incentive scheme for Wind, Solar, small/micro-Hydro and other RE Projects Development (12 MW). Promote other forms of alternate renewable energy technologies. Feasibility and development of power supply to the Lunana community	3.49	Work for RE energy generation R&D works.	2.37			
			(d) Development of competitive bidding or other financing methods to improve	0.18					

a. S/N b.	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			competition and private sector involvement for RE Projects						
2	Energy Security of the country is at risk during lean season. Hydropower dependence on precipitation and lean season flows. Shortfall of hydropower production in winter because of climate change.	To ensure energy security during lean season.	(a) To create and develop country-specific hydro-meteorological data.	0.18	Bidding procedure for and other policy instruments for fast-tracking construction of such projects.	0.18	Scaling up and Construction of storage, small and medium Hydro power plant projects. (1000 MW after feasibility)	1200	Improve in the availability of Hydro Projects in lean season, improved energy security. Reduced GHG emissions due to avoidance of other conventional energy sources.
			(b) Schemes for implementation of cascading storage projects	2.16	Construction and completion of (3) pilot project of cascading water storage hydropower.	180	Construction of Projects for hydrogen-based energy usage and financial incentives for construction of such projects. (15 MW)	60	

a. S/N	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
b.									
			(c) DPR for development of Storage (dam) Hydro power plants and cascading water storage hydropower projects	0.18	Pilot Projects (2-3) of energy storage systems - Pumped Storage Hydro Projects, Solar Thermal Projects, Mechanical Storage, Batteries etc. (100 MW)	120			With the increase in the storage hydro projects there will be an expected increase in GHG emission (if there is submergence of forest and vegetation).
			(d) Feasibility studies and Development of energy storage systems example Pumped Storage Hydro Projects, Solar Thermal Projects, Mechanical Storage, Batteries etc.	0.27	Feasibility studies for integrating other RE sources of energy to cover up during the lean season.	0.18			

a. S/N b.	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			Construction of pilot projects for hydrogen-based energy usage and financial incentives for construction of such projects. (100 KW)	0.6	Construction of Projects for hydrogen-based energy usage and financial incentives for construction of such projects. (5 MW)	30			
3	With the change in temperature there is increase in energy consumption for cooling requirements in industry process and buildings is expected to rise.	Measures to address demand side management	(a) Policy formulation, Legal Act or rules and regulations, incentives, subsidies etc for energy efficiency measures in Industry. Development of Carbon Markets (Initial Voluntary and	1.01	Adoption and implementation of energy standardization and labeling for more number appliances and making it mandatory (manufacturing) for appliances of maximum use (industry and domestic).	0.18	Mandating construction of energy efficient buildings (infrastructure) and heating, casting, lighting systems and other energy intensive processes etc. Mandating standardization and labeling for most of the	0.18	Reduced energy consumption due to improvement in energy efficiency and energy intensity of country. Ultimately leading to reduced GHG emissions due to improved efficiency

a. S/N	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
b.									
			Later Mandatory).				appliances (industrial and domestic). Updated or improvement in the criteria of energy efficient labeling and standardization for appliance and buildings.		
			(b) Feasibility studies, Review and formulation of standardization and labeling of energy efficient appliances (industrial and domestic). Initiative as voluntary with the appliance's	0.223	Implementation of Demand Side Management in various sectors (Large Industry, MSMEs, Agriculture, Municipal etc)	0.12	Scaling up of energy efficiency projects of Demand Side Management and making some of the requirements as mandatory to be implemented by utilities.	0.12	

a. S/N	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
b.									
			maximum in use.						
			Rollout nationwide Light Emitting Diodes programme. Grid electrification of 1,429 off-grid HHs ((RGoB=64 Mil and 488 from JICA))	7.82	Mandating certain energy efficient equipment and technologies in industrial sector. Banning the import of inefficient appliances and equipment with the proper monitored disposal of older machineries.	0.12	Energy efficiency as criteria for selection of projects and approval of new establishments (Industrial and institutional both).	0.18	

a. S/N	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
b.									
			(c) Feasibility studies for implementation of Demand side management and IOT for smart operation of systems.	0.18	Energy efficiency as criteria for selection of projects and approval of new establishments (domestic and industrial both). Tax holidays or incentives for use of energy efficient technologies in industrial process and construction of efficient buildings	0.12			
			(d) Development of industry baseline by conducting Energy audits of existing energy intensive	0.18					

a. S/N	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
b.									
			industries or sectors.						
			Promotion of energy efficient equipment and technologies use in industrial sector. Pilot / Demonstration Projects (Energy efficient building, Improved Cook Stoves, efficient lighting systems etc).	0.486					

a. S/N b.	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(e) Scheme for energy efficiency auditors / managers / expert's certification on standards and codes.	0.88					
4	Increased sedimentation and siltation of rivers and waterways affecting the reservoir are possible due to increased monsoon runoff and erratic and intensive rainfalls.	Watershed protection and check dams at strategic locations will help reduce the problem of sedimentation and siltation.	(a) Studies for feasibility of check dams at various locations. Constructing check dams in places of maximum sedimentation. (5 Nos)	15	Planning for Dredging or Desilting (along with the plan for use of excavated soil for farming). Periodic removal and extraction of sediments and silts (Dredging). (5 Nos)	13.91	Periodic removal and extraction of sediments and silts (Dredging). (5 Nos)	12.64	Better flood control due to improved catchment area of dams, Increased energy generation from the older dam-based projects, so more renewable

a. S/N	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
b.									
			(b) Study the feasibility of schemes and planning for Dredging or Desilting (along with the plan for use of excavated soil for farming) (5 Nos) Mandating the construction of check dams for all new hydro projects	0.27	Construction of Check Dams or Cascading Storage Dams (5 Nos)	15	Construction of Check Dams or Cascading Storage Dams (5 Nos)	15	energy and reduced GHG emissions. Availability of better-quality soil after dredging and desilting for agriculture purpose.
			(c) Institution for Research and Development for control of Siltation (Cost considered above)		Ensuring the new projects gets approval basis the requisite provision of Dredging.	0	Ensuring the new projects gets approval basis the requisite provision of Dredging.	0	

a. S/N	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
b.									
5	Threats to hydropower systems and plants due to natural disasters such as floods, flash floods and GLOFs are imminent.	Climate Resilient Hydropower Systems	(a) Review design of existing hydropower plants 1. To improve resilience and watershed management plans. 2. Increase capacity strength of hydropower dams	0.36	The approval and designing of new projects (infrastructure and hydropower) to make them climate resilient. (As per outcome of review of design studies carried out)	0.27	Increase in the forest land cover by afforestation around water catchment areas of hydro projects (For all Existing Large Hydro Projects or 10,000 Ha).	5.85	Increase afforestation and better watershed management. Reduced soil erosion due to forest cover. Reduction in GHG emission due to creation of forest a carbon sink. Reduced impacts of natural disaster due to climate change so reduction in property and life loss due to floods, flash floods, GLOFs etc
			(b) Research and development work for making complete infrastructure of projects (leading roads & bridges, transmission line, switchyards)	0	Renovation, redevelopment & modernization, and Life Extension (LE) works of existing projects to make them climate resilient. (If required as per	70.03	Increase in the capacity (up to 5400 MW) of the existing hydro projects with the criteria mentioned in above action plans	1400	

a. S/N	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
b.									
			considering climate resilience. (Cost considered above)		outcome of feasibility and design review studies, 200 MW Large Projects).				
			(c) Improve land use planning in degraded water catchment areas to promote afforestation. (5000 Ha)	2.43	Increase in the forest land cover by afforestation around water catchment areas of hydro projects (6000 Ha).	3.81	All the new construction should approve and have mandate to for climate resilience.	0	
			(d) Research and development work for establishment of hydro-met infrastructures and facilities 1. Weather forecasting and	2.04	Implementation of EWS for all the projects to ensure no loss of lives, economy and property.	3.4			

a. S/N b.	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			Water Flow Studies for identification of GLOFs, flashfloods and other natural disasters. 2. Early Warning Systems (EWS) considering climate resilience.						
			(e) Increase in the capacity (up to 3500 MW) of the existing hydro projects with the criteria mentioned in above action plans	748.8	Increase in the capacity (up to 4400 MW) of the existing hydro projects with the criteria mentioned in above action plans	1170			
	TOTAL (Million USD)			818.98		1654.49		2817.53	
	TOTAL (Million BTN)			61423.73		124086.47		211314.42	

4.2.2 Food Security: Agriculture and Livestock

Farming is predominantly subsistence level, and most Bhutanese farmers continue to grow traditional crops and crop varieties. Rice and maize are the major staple crops and other commonly grown crops are wheat, barley, buckwheat, millets, oil seeds, grain legumes, orange, apple, and cardamom. Bhutan has over 350 traditional rice varieties grown in different agro-ecological zones (GNHC-World Bank, 2017).

Bhutan has been divided into six zones agro-climatically. These are Alpine, Cool temperate, Warm temperate, Dry sub-tropical, Humid sub-tropical, and Wet sub-tropical. In the alpine and cool temperate zones, yaks, cattle, sheep, and horses dominate the farming system. Dairy products, barley, wheat, and potatoes are dominant on dry land. Crop production, rice, and maize are concentrated from warm temperate to wet sub-tropical zones (NEC, 2020).

Bhutan's economy is threatened by climate change due to its high dependence on agriculture and the significant role of hydropower in economic development. The population growth rate of 2.5-3 % is among the highest in the world and the kingdom's population is expected to double in the next 23 years. As the dominant sector in Bhutan, agriculture provides livelihood, income, and employment to 79 % of the population. Most farmers are subsistence farmers, and the country's main export earnings are from hydropower generation. Dryland crops are entirely dependent on rainfall, making the agriculture sector even more vulnerable to climate risks. The most vulnerable group is the farming community as agricultural activities are highly susceptible to unpredictable and increased variability in the timing of the monsoons. The country's main cash crops are all highly sensitive to water and temperature variations.

Moreover, the agriculture sector has been the hardest hit by erratic and scanty rains during winter, resulting in a decline in crop productivity and production. Bhutanese farmers practice subsistence and mixed farming, raising livestock animals and growing trees for wood, food, and fodder on their farms. The challenges of farming are low productivity due to small land holdings, shortage of irrigation water, poor agricultural practices, and lack of access to markets, credit, and technology. Farmers do not get access to systematic agro-weather advisory bulletins or seasonal forecasts to support them in making decisions at the farm level (GNHC-World Bank, 2017).

To address the vulnerabilities of the agriculture sector, the following interventions are developed to address current and future problems or challenges in the agricultural sector.

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
1	There might be possible crop yield instability **due to reduced water availability**. It is projected that climate change shall render dry areas more dry and wet areas wetter.	Climate proof irrigation infrastructures in place, ensuring adequate irrigation water and improved capacity in handling climate related disasters. Innovative storage and pumping facilities; strengthening data base / inventory on water	(a) Adopt Climate Smart irrigation and water efficient technologies (Install sprinkle (climate smart) irrigation system) [Refer Water Sector Strategy 3 (a)]		Adopt Climate Smart irrigation and water efficient technologies (Install sprinkle (climate smart) irrigation system)	7.02	Adopt Climate Smart irrigation and water efficient technologies (Install sprinkle (climate smart) irrigation system)	7.02	There will be availability of water for agriculture ensuring water efficient utilization. Hence water efficient agriculture practices will be promoted.
			(b) Increasing the use of pressurized systems including drip irrigation, etc [Refer Water Sector Strategy 3 (c)]		Increasing the use of pressurized systems including drip irrigation, etc [Refer Water Sector Strategy 3 (c)]		Increasing the use of pressurized systems including drip irrigation, etc [Refer Water Sector Strategy 3 (c)]		

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
		resources and building capacity.	(c) Strengthening Water Security and Enhancing Management. National Integrated Water Resource Management Plan [Refer Water Sector Strategy 3 (d)]		Strengthening Water Security and Enhancing Management. National Integrated Water Resource Management Plan [Refer Water Sector Strategy 3 (d)]		Strengthening Water Security and Enhancing Management. National Integrated Water Resource Management Plan	0.57	
			(d) Study the feasibility of schemes and Carrying out lake (existing) rehabilitation / water storage. Develop Resource mobilization plan. Feasibility of Dredging or Desilting of Lakes (along with the plan for use of excavated	0.27	Planning for Dredging or Desilting (along with the plan for use of excavated soil for farming). sediments and silts (Dredging). (5 Nos of major lakes)	13.71	Planning for Dredging or Desilting (along with the plan for use of excavated soil for farming). sediments and silts (Dredging). (5 Nos of major lakes)	12.46	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			soil for farming) (5 Nos)						
			Studies for feasibility of check dams at various locations. Constructing check dams in places of maximum sedimentation. (5 Nos) [Refer Energy Sector Strategy 4 (a)]		Studies for feasibility of check dams at various locations. Constructing check dams in places of maximum sedimentation. (5 Nos) [Refer Energy Sector Strategy 4 (a)]		Studies for feasibility of check dams at various locations. Constructing check dams in places of maximum sedimentation. (5 Nos) [Refer Energy Sector Strategy 4 (a)]		
			(e) Water harvesting technology (rainwater and spring water) for Agriculture purpose. (Total Lakes: 1722) 10 Nos of Major Lakes	18.28	Water harvesting technology (rainwater and spring water) for Agriculture purpose. (Total Lakes: 1722) 10 Nos of Major Lakes	24.57	Water harvesting technology (rainwater and spring water) for Agriculture purpose. (Total Lakes: 1722) 10 Nos	22.29	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
							of Major Lakes		
			(f) Bring academic institution on board to conduct **Research & Development and studies** on varying issues. Improve **collaboration and cooperation** with relevant institutions Capacity need assessment and **building capacity.** [Refer Water Sector Strategy 1 (b)]		Bring academic institution on board to conduct **Research & Development and studies** on varying issues. Improve **collaboration and cooperation** with relevant institutions Capacity need assessment and **building capacity.**	0.14	Bring academic institution on board to conduct **Research & Development and studies** on varying issues. Improve **collaboration and cooperation** with relevant institutions Capacity need assessment and **building capacity.**	0.14	
2	Crop productivity is at risk	To ensure optimal crop production.	(a) Strengthen Pest and diseases risk reduction on	0.08	Strengthen Pest and diseases risk reduction on	0.17	Strengthen Pest and diseases risk	0.16	Ensuring nature-based solutions for

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
	because of **pests, or other similar climate induced disasters. Natural Disasters** flash floods, GLOFs, Heat and Cold Waves impacting crops and livestock both.	To reduce the occurrence of pests and diseases attack Reducing the climate disasters like Flash floods and GLOFs [Refer Water Sector 2 (a) and (b)]	RNR hazards (Promote e-pest surveillance system)		RNR hazards (Promote e-pest surveillance system)		reduction on RNR hazards (Promote e-pest surveillance system)		taking action against possible outburst of pests. The incidents of flash floods and GLOFs will be controlled ensuring no harm to nature and local indigenous environment friendly methodologies.
			(b) Strengthen plant and animal biosecurity and bio-safety level (Notifiable plant pests and diseases contained).	1.44	Strengthen plant and animal biosecurity and bio-safety level (Notifiable plant pests and diseases contained).	2.99	Strengthen plant and animal biosecurity and bio-safety level (Notifiable plant pests and diseases contained).	2.71	
			(c) Strengthen RNR Disaster management institution (SOPs for livestock and crop disease)	0.05	Strengthen RNR Disaster management institution (SOPs for livestock and crop disease)	0.10	Strengthen RNR Disaster management institution (SOPs for livestock and crop disease)	0.10	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(d) Enhance knowledge management, education and awareness in DM (Simulate and test SOPs and RNR DM arrangement and provide agro-met advisory services to farmers in pilot sites)	0.14	Enhance knowledge management, education and awareness in DM (Simulate and test SOPs and RNR DM arrangement and provide agro-met advisory services to farmers in pilot sites)	0.28	Enhance knowledge management, education and awareness in DM (Simulate and test SOPs and RNR DM arrangement and provide agro-met advisory services to farmers in pilot sites)	0.25	
			(e) Agricultural festivals and community group activities for enhancing local indigenous knowledge of agriculture	0.42	Agricultural festivals and community group activities for enhancing local indigenous knowledge of agriculture	1.14	Agricultural festivals and community group activities for enhancing local indigenous knowledge of agriculture	0.67	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(f) Conduct policy research (Agriculture and livestock policy research)	0.11	Conduct policy research (Agriculture and livestock policy research)	0.28	Conduct policy research (Agriculture and livestock policy research)	0.13	
			(g) Enhance generation of RNR technologies (Research on emerging and re-emerging infectious diseases (EIDs))	2.36	Enhance generation of RNR technologies (Research on emerging and re-emerging infectious diseases (EIDs))	2.36	Enhance generation of RNR technologies (Research on emerging and re-emerging infectious diseases (EIDs))	2.36	
			Weather and Climate Services for Building Climate Resilience (Agro-meteorological services developed, Education and Awareness)	0.96	Weather and Climate Services for Building Climate Resilience (Agro-meteorological services developed, Education and Awareness)	1.99	Weather and Climate Services for Building Climate Resilience (Agro-meteorological services developed, Education and Awareness)	1.81	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(h) Introducing crop/livestock insurance scheme.	6.10	Crop/livestock insurance scheme.	11.71	Crop/livestock insurance scheme.	7.43	
3	Loss of **soil fertility** due to **soil erosion** and top run-off.	Sustainable Land Management (SLM) techniques and practices needs to be applied as adaptation measures.	(a) Enhance adoption of RNR Technologies (Soil fertility, land and nutrient management technologies)	0.64	Enhance adoption of RNR Technologies (Soil fertility, land and nutrient management technologies)	1.31	Enhance adoption of RNR Technologies (Soil fertility, land and nutrient management technologies)	1.19	Environment friendly methodologies will be used to ensure least soil erosion and improved soil fertility.
			(b) Planning activities to improve crop diversification.	0.10	Agricultural festivals and community group activities for enhancing local indigenous knowledge of agriculture. [Refer 2 (e) for Agriculture Sector]				
			(c) Initiation of study on degraded agricultural lands.	0.03					

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(d) Improve land use planning in degraded water catchment areas to promote afforestation. (5000 Ha) [Refer Energy Sector Strategy 5 (c)]						
4	The farming **communities are vulnerable** to the impacts of climate change. Farmers are unable fetch good prices for crop and face **lack efficient storage techniques** and technologies.	To reduce vulnerability of farming communities to climate change.	(a) Enhance urban and agro forestry landscape management	0.03	Enhance urban and agro forestry landscape management	0.07	Funding for urban and agro forestry landscape management	0.26	Different methods ensuring to reduce the vulnerability of farmers to climate change so that they get proper and full benefit of the environment friendly developments.
			(b) Enhance livelihood choices for marginalized farmers AND Strengthen natural capital accounting system (Study and establish payment for ecosystem (PES) schemes)	0.24	Enhance livelihood choices for marginalized farmers AND Strengthen natural capital accounting system (Study and establish payment for ecosystem (PES) schemes)	0.50	Enhance livelihood choices for marginalized farmers AND Strengthen natural capital accounting system (Study and establish payment for ecosystem (PES) schemes)	0.45	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(c) Strengthen planning, monitoring and coordination (Develop agriculture subsidy policy, revise agriculture extension policy)	0.07	Strengthen planning, monitoring, and coordination (Develop agriculture subsidy policy, revise agriculture extension policy)	0.14	Strengthen planning, monitoring, and coordination (Develop agriculture subsidy policy, revise agriculture extension policy)	0.13	
			(d) Enhance agriculture infrastructure & farm mechanization (New farm machineries and area brought under farm mechanization)	6.29	Enhance agriculture infrastructure & farm mechanization (New farm machineries and area brought under farm mechanization)	13.00	Enhance agriculture infrastructure & farm mechanization (New farm machineries and area brought under farm mechanization)	11.79	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(e) Climate resilient technologies released and adopted (Development community seed bank, establish functional agromet advisory unit) [Refer Water Sector Strategy 3 (b)]						
			(f) School Agriculture Programme (Agriculture land developed)	0.43	School Agriculture Programme (Agriculture land developed)	0.89	School Agriculture Programme (Agriculture land developed)	0.81	
			(g) Increase domestic trade of RNR produce (Buy-back program by farmshop and market linkage)	0.51	Increase domestic trade of RNR produce (Buy-back program by farmshop and market linkage)	1.05	Increase domestic trade of RNR produce (Buy-back program by farmshop and market linkage)	0.95	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			Establish agro-based enterprises including agriculture, livestock, NWFPs and ecotourism (Heifer production farm, flower, mushroom exhibition)	3.14	Establish agro-based enterprises including agriculture, livestock, NWFPs and ecotourism (Heifer production farm, flower, mushroom exhibition)	6.50	Establish agro-based enterprises including agriculture, livestock, NWFPs and ecotourism (Heifer production farm, flower, mushroom exhibition)	5.90	
			(h) Promote viable farmer's groups and cooperatives AND Facilitate and support annual export of RNR products	0.83	Promote viable farmer's groups and cooperatives AND Facilitate and support annual export of RNR products	1.72	Promote viable farmer's groups and cooperatives AND Facilitate and support annual export of RNR products	1.56	
5	**Food security and self-sufficiency** of the	To ensure there is adequate food and self-	(a) Initiating research on wetlands.	0.98	Monitoring and surveillance of invasive weeds.	0.48	Monitoring and surveillance of invasive weeds.	0.48	The methodologies will ensure the food and self-

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
	country is at risk.	sufficiency is in place. Alternate Crop Production and Awareness is required.	(b) Enhance cereal production (Paddy, hybrid maize and wheat (storage facilities, community-based seed production))	0.51	Enhance cereal production (Paddy, hybrid maize and wheat (storage facilities, community-based seed production))	1.05	Enhance cereal production (Paddy, hybrid maize and wheat (storage facilities, community-based seed production))	0.95	sufficiency of the country by controlling invasive species, enhancing production of conventional and organic food items.
			(c) Enhance horticulture production (Vegetable, citrus, potato, MAPs, spawn production)	0.93	Enhance horticulture production (Vegetable, citrus, potato, MAPs, spawn production)	1.92	Enhance horticulture production (Vegetable, citrus, potato, MAPs, spawn production)	1.74	
			(d) Promote national organic & certification programme (Organic farming)	0.17	Promote national organic & certification programme (Organic farming)	0.35			
			(e) Capacity building/awareness sessions on	0.70	Capacity building/awareness sessions on	0.50			

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			reduction of food wastage.		reduction of food wastage.				
6	Decreased crop and livestock depredation by **wild animals** is a challenge in rural communities across the country	To ensure reduced HWC by nature-based solutions and highland habitat conservation and management.	(a) Highland habitat conservation and management		Highland habitat conservation and management	0.15	Highland habitat conservation and management	0.13	Even though the HWC is not a climate change concern the ways employed to reduce the same will ensure that nature-based solutions are opted which are best suited to country.
			Increasing (allocating land) farming away from forest land and raising proper awareness and land improvement for the same.	0.18					
			(b) Enhance research knowledge and information management (Knowledge on HWC and mitigation measures)	0.65					

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
7	Impact on **Livestock** due to changing climatic conditions	Climate resilient livestock for improving the conditions of farmers.	(a) Promote Climate Resilient Livestock Farming. Promote native cattle genetic utilization, pasture development	1.30	Promote Climate Resilient Livestock Farming. Promote native cattle genetic utilization, pasture development	2.69	Promote Climate Resilient Livestock Farming. Promote native cattle genetic utilization, pasture development	2.44	The objective is to ensure that Livestock management is carried out in such a way that impact of climate change is least on production and there is increase in the quality and quantity of livestock product.
			(b) Enhance animal health and nutrition services (Feed Quality Test Parameters and Disease outbreaks)	3.49	Enhance animal health and nutrition services (Feed Quality Test Parameters and Disease outbreaks)	7.22	Enhance animal health and nutrition services (Feed Quality Test Parameters and Disease outbreaks)	6.55	
			(c) Enhance meat production, egg production, dairy production, and livestock input supply (Pork, chicken, chevon, fish, Milk, butter, cheese, Cattle,	.	Enhance meat production, egg production, dairy production, and livestock input supply (Pork, chicken, chevon, fish, Milk, butter, cheese, Cattle, Broilers,	. 14.91	Enhance meat production, egg production, dairy production, and livestock input supply (Pork,	. 13.53	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			Broilers, piglets and fingerlings)		piglets and fingerlings)		chicken, chevon, fish, Milk, butter, cheese, Cattle, Broilers, piglets and fingerlings)		
			(d) Development of infrastructure and Establish commodity value chain for RNR produce (Honey, dairy and NWFP value chain)	0.54	Development of infrastructure and Establish commodity value chain for RNR produce (Honey, dairy and NWFP value chain)	1.12	Development of infrastructure and Establish commodity value chain for RNR produce (Honey, dairy and NWFP value chain)	1.01	
			(e) Promote Organic Livestock Farming	0.17	Promote Organic Livestock Farming	0.23			

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(f) Highland agriculture and livestock farming AND Promotion of highland enterprise (Develop capacity of highland livestock rearing households, and livestock input supplies)	0.89	Highland agriculture and livestock farming AND Promotion of highland enterprise (Develop capacity of highland livestock rearing households, and livestock input supplies)	1.83	Highland agriculture and livestock farming AND Promotion of highland enterprise (Develop capacity of highland livestock rearing households, and livestock input supplies)	1.66	
	TOTAL (Million USD)			**60.33**		**124.09**		**109.63**	
	TOTAL (Million BTN)			**4524.41**		**9306.91**		**8222.01**	

4.2.3 Forest and Biodiversity

Bhutan is the only country whose forests manage to keep the country carbon negative with a pledge made to remain carbon neutral for all times to come. Bhutan has a forest cover of 70.77%. Out of this 70.77%, 3.39% is alpine scrub forest and 9.74% comes under shrubs. 51.34% of the total area is under Protected Area.[4] Bhutan has pledged to keep at least 60% of its area as forests at all times.

A total of 11,248 species belonging to all the biodiversity groups have been recorded in Bhutan by the 2017 Biodiversity Statistics of Bhutan. 5,114 species are under Kingdom Animalia; 5,369 species under Kingdom Plantae; 690 fungal species; 55 species under Kingdom Chromista; 18 Eubacteria species and 2 protozoan species under Kingdom Protista.

The Agriculture, Forestry, and Other Land Use sector when excluding removals is the highest contributor to Bhutan's total GHG emissions accounting for 57.24% translating to 2183.25 Gg of CO_2e in 2015. Agriculture sector emission for the period is 552.87 Gg of CO2e translating to 14.49% of net emission while LULUCF (without considering removals) accounted for 42.74% of national emission with 1630.37 Gg CO_2e (NEC, 2021).

The Royal Government of Bhutan has committed to remain carbon neutral in the 15th COP in 2009. To maintain the neutrality status, the government has set out various strategies and interventions. The strategies and policies are to maintain the biodiversity status in the country. The sustainable and effective management of resources will guarantee equitable sharing of benefits among all citizens. The promotion of a green economy will further ensure the effective conservation of biodiversity. All the interventions have been developed based on the central theme of biodiversity conservation and sustainable forestry practices to ensure a robust long-term strategy.

[4] https://www.un-redd.org/post/2019/08/22/understanding-forests-beyond-forest-cover-bhutan-s-redd-journey

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
1	**Drought** in combination with increased **lightning** (during rain) risks triggered **forest fires.** The increase in the incidence of **natural hazards** such as glacier lake outburst floods (GLOFs), flash floods, droughts, and forest fires have made the impact of climate change more evident.	Reduced risk of natural disasters (such as catastrophic impacts of GLOFs) and forest fires. Strengthen Forest fire management in Bhutan through participatory and consultative approach	(a) Develop fire management plans and strategy. Upscale Dzongkhag level fire management interventions and infrastructure. A national fire cache should be developed at strategic locations to ensure coverage of all Bhutan and effectively manage and control large fires. Fuel load management in both chir pine and blue pine forests	1.48	Evaluating and assessing plans and strategies. Upscale Dzongkhag level fire management interventions and infrastructure. Fuel load management in both chir pine and blue pine forests	1.48	Strengthening the existing strategies. Upscale Dzongkhag level fire management interventions and infrastructure. Fuel load management in both chir pine and blue pine forests	1.48	The forest and biodiversity will encounter a smaller number of natural disasters then expected leading to better ecosystems and higher value of natural capital.
			(b) Capacity Development at Dzongkhag level fire management services. Capacity building content to be developed for	0.11	Capacity Development at Dzongkhag level fire management services. (PUBLIC)	0.04	Capacity Development at Dzongkhag level fire management services. (PUBLIC)	0.04	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			sensitization about forest fires. (PUBLIC)						
			(c) Spreading awareness on forest fires Awareness sessions should be conducted during fire seasons.	0.28	Spreading awareness on forest fires Awareness sessions should be conducted during fire seasons.	0.14	Spreading awareness on forest fires Awareness sessions should be conducted during fire seasons.	0.14	
			Integrate basic fire related studies in general education system and in the curriculum of Royal University of Bhutan.	0.12	Upgrading the fire related studies in general education system and in the curriculum of Royal University of Bhutan.	0.06	Upgrading the fire related studies in general education system and in the curriculum of Royal University of Bhutan.	0.06	
			(d) Conduct Capacity Need Assessment Capacity building to manage and fight forest fire. Formulate HR plan and implement capacity building.	6.07	Conduct Capacity Need Assessment Capacity building to manage and fight forest fire. Formulate HR plan and implement capacity building. (FIRE SERVICE DEPARTMENT)	6.07	Conduct Capacity Need Assessment Capacity building to manage and fight forest fire. Formulate HR plan and implement capacity building.	6.07	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(FIRE SERVICE DEPARTMENT)				(FIRE SERVICE DEPARTMENT)		
			(e) Carrying out applied research on forest fire. Research and study should be conducted on fire ecology under different ecosystems. Tree species (indigenous), that are fast growing and fire resistant should be studied. Research into optimal burning cycles, seedling recruitment, burn intensity, mortality, and recovery rates.	56.00	Carrying out applied research on forest fire. Research and study should be conducted on fire ecology under different ecosystems. Tree species (indigenous), that are fast growing and fire resistant should be studied. Research into optimal burning cycles, seedling recruitment, burn intensity, mortality, and recovery rates.	10.00	Carrying out applied research on forest fire. Research and study should be conducted on fire ecology under different ecosystems. Tree species (indigenous), that are fast growing and fire resistant should be studied. Research into optimal burning cycles, seedling recruitment, burn intensity, mortality, and recovery rates.	10.00	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(e) Reduce forest fire incidences	0.61	Reduce forest fire incidences	1.26	Reduce forest fire incidences	1.14	
			(f) Lowering level of dangerous lakes upstream, mapping of hazard zones, and integrated watershed and wetland management in critical areas. [Refer Water Sector Strategy 2 (a)]		Lowering level of dangerous lakes upstream, mapping of hazard zones, and integrated watershed and wetland management in critical areas. [Refer Water Sector Strategy 2 (a)]		Lowering level of dangerous lakes upstream, mapping of hazard zones, and integrated watershed and wetland management in critical areas. [Refer Water Sector Strategy 2 (a)]		
			(g) Upgrade rehabilitate existing GLOF/rainstorm EWS installed. Maintenance of existing Hydro-met observation network and GLOF EWS facilities. Glaciers and snow (Hydrological modelling) and forecasting. [Refer		Upgrade rehabilitate existing GLOF/rainstorm EWS installed. Maintenance of existing Hydro-met observation network and GLOF EWS facilities. Glaciers and snow (Hydrological modelling) and forecasting. [Refer Water Sector Strategy 2 (b)]		Upgrade rehabilitate existing GLOF/rainstorm EWS installed. Maintenance of existing Hydro-met observation network and GLOF EWS facilities. Glaciers and snow (Hydrological modelling) and forecasting. [Refer		

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			Water Sector Strategy 2 (b)]				Water Sector Strategy 2 (b)]		
2	**Change in phenological characters** of plants/ loss of endemic species. The impact of climate change is high at the **boundaries between different ecosystems.**	Effective conservation and protection of forest and biodiversity.	(a) National REDD+ readiness phase for mitigation of climate change impacts (Develop Forest type map, develop REDD+ and Forest reference level)	0.90	National REDD+ Project	1.39	National REDD+ Project	2.08	There will be reduced losses of species and interaction between different ecosystems will result in better environment and protection of forest and biodiversity
			(b) Establishment and operation of forest management units (FMUs) for different forests such as heritage forests, community forest,	1.50	Establishment and operation of forest management units (FMUs) for different forests such as heritage forests, community forest, local forest	2.00	Establishment and operation of forest management units (FMUs) for different forests such as heritage forests, community forest, local forest	2.00	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			local forest management plans, and private forests.		management plans, and private forests.		management plans, and private forests.		
			Bhutan For Life (WWF): APPROVED (26.6 MUSD) Ecotourism products and activities for Protected Areas (PA)s Strengthening enforcement and management of protected areas Protecting and monitoring wildlife and biodiversity						

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(c) Strengthening REDD+ and watershed management in Bhutan: APPROVED (0.595 MUSD) Sustainable Forest management, the forest management code of Bhutan, and forest law enforcement.						
			(d) Enhance urban and agro forestry landscape management [Refer Agriculture Sector Strategy 4 (a)]						
3	**Change in migratory pattern** of the transboundary wildlife and increase in the **human wildlife conflicts**	Protection of wildlife, reducing the human wildlife conflicts and protecting the vintage forests and	(a) Enhance conservation and sustainable utilization of biodiversity	0.42	Enhance conservation and sustainable utilization of biodiversity	0.87	Enhance conservation and sustainable utilization of biodiversity	0.79	There will be increased forest cover due to plantation, increased carbon sink, reduced human
			(b) Sustainable management and utilization of timber (Establish	1.00	Sustainable management and utilization of timber (Establish Forest	2.06	Sustainable management and utilization of timber (Establish	1.87	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
	(HWC) in farming.	corridors of migration of the respective fauna.	Forest Management Unit, Local Forest Management plans).		Management Unit, Local Forest Management plans).		Forest Management Unit, Local Forest Management plans).		wildlife conflicts due to safe corridors and effective management of wetlands and watersheds.
			(c) Effective management of wetlands and watersheds (Habitat enrichment plantations, watershed assessment, water source management)	4.90	Effective management of wetlands and watersheds (Habitat enrichment plantations, watershed assessment, water source management)	10.13	Effective management of wetlands and watersheds (Habitat enrichment plantations, watershed assessment, water source management)	9.19	
			(d) Habitat management, improvement and enrichment (Management of degraded wildlife habitats (saltlicks, grassland) both inside and outside the protected areas.	5.00	Habitat management, improvement and enrichment (Management of degraded wildlife habitats (saltlicks, grassland) both inside and outside the protected areas.	10.00	Habitat management, improvement and enrichment (Management of degraded wildlife habitats (saltlicks, grassland) both inside and outside the protected areas.	10.00	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(e) Restoring the habitats of animals and the corridors they use. Carry out plantation in collaboration with Social Forest and Extension Division (SFED)	0.98	Identify plantation sites and carry out plantation in collaboration with SFED.	2.03	Identify plantation sites and carry out plantation in collaboration with SFED.	1.84	
			(f) Enhance community-based forest management and conservation (Develop and revise CF and NWFP management plans)	0.25	Enhance community-based forest management and conservation (Develop and revise CF and NWFP management plans)	0.52	Enhance community-based forest management and conservation (Develop and revise CF and NWFP management plans)	0.48	
			(g) Strengthen protected and conservation area management (Implement PA management plan)	1.66	Strengthen protected and conservation area management (Implement PA management plan)	3.42	Strengthen protected and conservation area management (Implement PA management plan)	3.11	
			(h) Reduce forestry and wildlife offences / conflicts (Zero	0.69	Reduce forestry and wildlife offences / conflicts (Zero	1.43	Reduce forestry and wildlife offences / conflicts (Zero	1.30	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			Poaching and SMART patrolling)		Poaching and SMART patrolling)		Poaching and SMART patrolling)		
			(i) Improve professional capacity (Conduct arms training for forestry staffs)	0.93	Improve professional capacity (Conduct arms training for forestry staffs)	1.92	Improve professional capacity (Conduct arms training for forestry staffs)	1.74	
			(j) Enhance conservation and sustainable utilization of biodiversity (innovative technologies that would minimize the use of fuel wood for heating and cooking) AND Strengthen nature based eco-tourism [Refer Energy Sector Strategy 3 (f)]	1.01	Enhance conservation and sustainable utilization of biodiversity (innovative technologies that would minimize the use of fuel wood for heating and cooking) AND Strengthen nature based eco-tourism. [Refer Energy Sector Strategy 3 (f)]	2.09	Enhance conservation and sustainable utilization of bio-diversity (innovative technologies that would minimize the use of fuel wood for heating and cooking) AND Strengthen nature based eco-tourism. [Refer Energy Sector Strategy 3 (f)]	1.90	
			(k) Effective management of wetlands and watersheds (Habitat	4.90	Effective management of wetlands and watersheds (Habitat enrichment	10.13	Effective management of wetlands and watersheds (Habitat	9.19	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			enrichment plantations, watershed assessment, water source management)		plantations, watershed assessment, water source management)		enrichment plantations, watershed assessment, water source management)		
4	Affected by the **invasion of new diseases, pests, and parasites** due to change in long term average temperature and rainfall pattern.	Reduced impact of the invasive pests, parasites, fungal and other climate born diseases.	(a) Strengthen plant and animal biosecurity and bio-safety level (Notifiable plant pests and diseases contained)	1.44	Strengthen plant and animal biosecurity and bio-safety level (Notifiable plant pests and diseases contained)	2.99	Strengthen plant and animal biosecurity and bio-safety level (Notifiable plant pests and diseases contained)	2.71	As a result of the identified actions the impact of local and alien invasive species and pest will reduce over time. These actions will also reduce the impact of invasive pests, parasites, fungal and other climate born diseases.
			(b) Consistently monitor and maintain inventories of biodiversity. Strengthen natural capital accounting system (Study and establish payment for ecosystem (PES) schemes)	4.90	Consistently monitor and maintain inventories of biodiversity. Strengthen natural capital accounting system (Study and establish payment for ecosystem (PES) schemes)	10.13	Consistently monitor and maintain inventories of biodiversity. Strengthen natural capital accounting system (Study and establish payment for ecosystem (PES) schemes)	9.19	
			(c) Control and manage the establishment of invasive species. Engage communities in the	1.07	Control and manage the establishment of invasive species. Engage communities in the management of IAS.	1.37	Control and manage the establishment of invasive species. Engage communities in	1.37	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			management of IAS. Promote Capacity building and Research.		Promote Capacity building and Research.		the management of IAS. Promote Capacity building and Research.		
			(d) Identify areas that are prone to pest and diseases.	0.18	Promote Capacity building, Research and Development in Pest and diseases management plan. Develop Pest and Diseases Strategy Plan	0.27	Strengthen Sustainable Forest Management	0.37	
			(e) Promote Capacity building and Research. Develop a Pest and diseases management plan.	0.39	Promote Capacity building and Research. Develop a Pest and diseases management plan.	0.52	Promote Capacity building and Research. Develop a Pest and diseases management plan.	0.48	
			(f) Strengthen Pest and diseases risk reduction on RNR hazards (Promote e-pest surveillance system) [Refer Water Sector Strategy 2 (a)]		Strengthen Pest and diseases risk reduction on RNR hazards (Promote e-pest surveillance system) [Refer Water Sector Strategy 2 (a)]		Strengthen Pest and diseases risk reduction on RNR hazards (Promote e-pest surveillance system) [Refer Water Sector Strategy 2 (a)]		

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(g) National REDD+ Strategy and Action Plan Implementation Project: SEEKING SUPPORT (49.13 MUSD). National Forest Monitoring and Information on Safeguards, National Forest Reference Emission Level, forest management, and forest law enforcement.	49.13					
	TOTAL (Million USD)			**145.92**		**82.33**		**78.52**	
	TOTAL (Million BTN)			**10944.18**		**6175.09**		**5888.89**	

4.2.4 Water

Water is one of Bhutan's most abundant resources and is critical in supporting agriculture, hydroelectric energy production, and tourism. Water is also one of the country's most vulnerable sectors which consist of glaciers, glacial and high-altitude wetlands, rivers and river basins, and ground water reservoirs. The fragility of the Himalayan landscape makes GLOFs a significant threat. Groundwater and reservoirs are limited to flat valleys, particularly in regions close to the Indian border. Bhutan has four major river systems which are the country's primary water resource: The Amo Chhu (Toorsa), the Wang Chhu (Raidak), the Punatsang Chhu (Sunkosh), and the Drangme Chhu (Manas). The Punatsangchhu is one of the largest rivers in the country. All rivers depend principally on glacier melt, snow, and seasonal rainfall. While the country has an annual water availability of 94,500 m3 per capita, most rivers are in deep gorges, limiting the main sources of irrigation and drinking water to small springs and tributaries.

Projections for future river flows due to climate change impact on glacial and river systems show mixed results, with some showing increases and others decreasing (Xu, 2019). Projected changes in precipitation are highly variable. However, models suggest there could be an overall increase in precipitation at the national level. Precipitation is expected to rise especially in the southern border with India during the monsoon season, when water resources are particularly abundant (Paltan, 2018). Projected increases in the number of days with very heavy precipitation could further increase the risk of flooding and impact runoff, erosion, and rates of river discharge.

The CCKP model ensemble projects a 10%–15% increase in the volume of water falling during a 5-day extreme rainfall episode by the 2050s (World Bank, 2021). The seasonal precipitation regime is also expected to change before the end of the century, with the projected number of days of consecutive dry spells set to increase by seven days in January and December (NEC, 2021). Rising temperatures can also impact water resources by accelerating the rate of snowmelt. As temperatures increase, snow will likely become rain and snowmelt will likely begin earlier, thus peak river discharge may also occur earlier (World Bank, 2021). These conditions could increase the potential for riverine flooding and GLOFs, which can impact populations and infrastructure near rivers.

The following strategy therefore, addresses the vulnerabilities in the water sector:

a. S/N	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
1	Water **shortages** occurring due to, 1. Dry periods are expected to get drier, wet periods are expected to get wetter, making the overall system more vulnerable to the impacts of climate change. 2. The snow cover decline over the recent decade could result in a decrease in water resources availability in the long run.	Combat water shortages under Climate Change	(a) Water resources monitoring and mapping. Monitor infiltration, water buffers, and erosion	0.40	Adoption and diffusion of appropriate technologies for water harvesting and efficient use.	39.00	Mandating the procedures and methodologies for water efficiency at municipal, agriculture and industry level.	0.12	Enhanced water resource utilization efficiency will reduce dependence on ground water, and other unsustainable sources. Improve water utilization and efficiency. Increase the use of rainwater harvesting at household level.
			(b) Research and Development on hydrology, cryosphere, and water resource. Spreading awareness and Promotion for Water Efficiency. Conduct awareness program on water related hazards at the community level (Enabling action).	0.14	Study the feasibility of multipurpose storage reservoirs for seasonal storage (Drinking and Irrigation), build multi-purpose storage reservoirs. [Refer Energy Sector 2 (c)]		Construction of storage reservoirs for seasonal multipurpose storage in and near areas of acute water shortage (cities and agriculture). [Refer Energy Sector 2 (c)]		

a. S/N	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(c) Develop water safety plans and implement proper water supply systems with an adequate design, and study ground water use and its risks and potentials across Bhutan.	0.39	Construction of storage reservoirs for seasonal multipurpose storage in and near areas of acute water shortage (cities and agriculture). [Refer Energy Sector 2]		Explore technologies for rainwater harvesting and efficient water usage and management.	3.64	
			(d) Explore technologies for rainwater harvesting and efficient water usage and management.	2.55	Promotion for water efficiency, procedures and methodologies for water efficiency at municipal, agriculture and industry level.	3.64			
			(e) Assessing the efficiency of existing water treatment facilities and water supply network systems	0.11					

a. S/N	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
2	Frequent occurrence of GLOFs due to Heavy rainfall/snowmelt, hilly terrain	Reducing the impact of climate disasters like GLOFs	(f) Lowering level of dangerous lakes upstream, mapping of hazard zones, and integrated watershed and wetland management in critical areas. Ensure operation and maintenance of infrastructure (aimed at fast recovery).	1.83	Detailed monitoring of Glacial lakes and implementation of measures like lowering, siphoning, storage and barriers to reduce risk of GLOF	1.30	Upgrade/rehabilitate existing GLOF/rainstorm EWS installed. Maintenance of existing Hydro-met observation network and GLOF EWS facilities. Glaciers and snow (Hydrological modelling) and forecasting.	5.28	Reduction of GLOF and other water resource related climate disasters
			(g) Upgrade, rehabilitate existing GLOF/rainstorm EWS installed. Maintenance of existing Hydro-met observation network and GLOF EWS facilities.	3.43	Upgrade/rehabilitate existing GLOF/rainstorm EWS installed. Maintenance of existing Hydro-met observation network and GLOF EWS facilities. Glaciers and snow (Hydrological modelling) and	5.28			

a. S/N	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			Glaciers and snow (Hydrological modelling) and forecasting. Ensure operation and maintenance of infrastructure (aimed at fast recovery).		forecasting. Ensure operation and maintenance of infrastructure (aimed at fast recovery).				
3	Limited sources of irrigation for agriculture due to limited accessibility (major rivers basins are in remote areas).	Increase access to improved irrigation systems	(h) Adopt Climate Smart irrigation and water efficient technologies (Install sprinkle (climate smart) irrigation system)	4.56	Increasing the use of pressurized systems including drip irrigation, etc	3.51	Introduce water harvest technologies to make water available for off-season vegetables	8.52	Enhanced water resource utilization efficiency will reduce dependence on ground water, and other un-sustainable sources in Irrigation
			(i) Climate resilient technologies released and adopted (Development community seed bank, establish functional	1.23	Strengthening Water Security and Enhancing Management. National Integrated Water Resource Management Plan	0.57	Increasing the use of pressurized systems including drip irrigation, etc	3.51	

a. S/N	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			agromet advisory unit)						
			(j) Increasing the use of pressurized systems including drip irrigation, etc	3.51	Introduce water harvest technologies to make water available for off-season vegetables	8.52			
			(k) Strengthening Water Security and Enhancing Management. National Integrated Water Resource Management Plan	0.37					
	TOTAL (Million USD)			**18.52**		**61.82**		**21.07**	
	TOTAL (Million BTN)			**1388.83**		**4636.50**		**1580.10**	

4.2.5 Transport

As a land-locked least developed country located in a fragile mountainous environment, Bhutan remains highly vulnerable to the impacts of climate change and will disproportionately bear the impacts of climate change. Therefore, an adaptation component is also included in the INDC from Bhutan.

The national road network has expanded rapidly since the construction of the Phuentsholing - Thimphu Highway, the country's first road. As of 2017, there are over 18,181.3 km of motorable roads, including national highways, district roads, feeder roads, farm roads, urban roads, expressways, power tiller tracks, access roads, and forest roads. As of June 2018, there were 96,307 registered vehicles in Bhutan, and this is increasing at an average of 9.2% annually (NEC, 2021).

An expected increase in mean annual temperature by 3.5ºC (1980-2069) will lead to an accelerated melting of **Bhutan's high mountain glaciers, triggering Glacial Lake Outburst Floods (GLOFs) impacting downstream rural and urban infrastructure** and energy supplies, drinking and irrigation water, farmlands, transportation and communications, and loss of human life. Infrastructure and services include urban buildings and spaces, energy, transportation, water, wastewater and drainage, communication, healthcare, and industries. These **infrastructures that have been designed and built in the past cannot cope with the extremes of climate and weather events** such as floods, flash floods, windstorms, and cyclones, posing a greater risk to infrastructure and services.

Further, climate-induced extreme **precipitation during the monsoon causes flashfloods**, damaging the farmlands, **farm roads, and national highways cutting off vital transport routes** between the highlands, inner central valleys, and southern townships. This adversely impacts food supplies and the population's access to vital health and energy services.

Adaptation measures in surface transport can be divided into two groups of actions. The first includes measures focused on the **reduction of risk and hazard on roads** caused by extreme weather events. The second group includes measures **improving the traffic infrastructure** in what would be the most affected localities.

The first issue which is of traffic safety, in relation to expected impacts of climate change, is closely related to the implementation of the Intelligent Transport Systems. Implementation of Intelligent Transport Systems can help reduce the impact of extreme weather phenomena on accidents. Another measure in this area could be more pronounced educative activities (media, schools including driving schools) focused on risk awareness of extreme weather conditions in relation to transport.

The second group of measures are adaptation measures focused on the **rebuilding of transport infrastructure** in relation to the increased risk of intense thunderstorms and flood situations.

The interventions in the transport sector are presented below:

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
1	Climate and weather extremes damaging transport infrastructure	(a) Capacity Building to carry out vulnerability assessment and design of climate resilient transport infrastructure	Engineers and designers from DOR and municipal authorities	0.50	Engineers and designers from Dzongkhag authorities	1.20	Engineers and designers nationwide	3.00	Capacity built for designing and implementing climate resilient transport infrastructure.
3	Risk through flashfloods, GLOFs and thunderstorms.	(b) Redesigning and mitigating climate risks to transport infrastructure	Critical stretches of national highways and urban roads	30.00	Dzongkhag roads	50.00	All roads	100.00	Climate and disaster resilient infrastructure
	TOTAL (Million USD)			**30.50**		**52.20**		**103.00**	
	TOTAL (Million BTN)			**2287.50**		**3915.00**		**7725.00**	

4.2.6 Human Health

The health of the Bhutanese has improved tremendously since the introduction of planned socio-economic development. Life expectancy increased to 69.5 years in 2014 from a mere 32.4 years in 1960. Leprosy and iodine deficiency disorders have been eliminated and malaria is targeted to be eliminated soon. Universal childhood immunization was achieved in 1990 and immunization levels have been maintained over 95% since 2010. Due to a very successful immunization programme, polio and neonatal tetanus have been eliminated and the programme is targeting the elimination of measles. Hepatitis B birth dose and human papillomavirus (HPV) vaccine for girls are new strategies to reduce the incidences of hepatitis B and cervical cancer, respectively. However, climate change presents new challenges in the health sector, particularly outbreaks of waterborne and vector-borne diseases and hindered access to services. It is also expected that health losses due to climate change-induced undernutrition will occur mainly in areas that are already food insecure.

The goal is to achieve healthy lives for all ages of Bhutanese people and a climate-resilient healthcare facility to protect and improve the health of their target communities in an unstable and changing climate. The strategy is drafted by taking inputs from (i) Five Years Plans of Bhutan, (ii) Third National Communication to the UNFCCC, 2020 (iii) Assessment of climate risks on Health for National Adaptation Plan (NAP), Bhutan, and (iv) Climate Change Vulnerability Analyses and Mapping for National Adaptation Plan (NAP) formulation process in Bhutan.

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
1	Due to climate change, impact to human health will be serious. It could increase the demand on health sector. Hence it creates a demand for to increase institutional capacity of the country.	Upgrading Health Infrastructure, Medicines and healthcare technologies. Improved capacity in handling climate sensitive diseases and their early signs.	(a) Capacity building of health workers, awareness. Long Term Trainings and Research to aid in forecasting diseases and early treatment/ containment. (Strengthen Patient Safety and Quality of Healthcare Services).	0.25	Capacity building of health workers, awareness. Long Term Trainings and Research to aid in forecasting diseases and early treatment/ containment.	0.52	Capacity building of health workers, awareness. Long Term Trainings and Research. Strengthen Patient Safety and Quality of Healthcare Services.	0.48	There will be an improved outcome in terms of health infrastructure to manage the climate sensitive diseases with climate resilient infrastructure.
			(b) Health workforce development (short term) and institutional linkages. Policy studies/evaluation/research /development of legislations. Implementation of e-health strategy including strengthening of health information and technology system.	1.49	Policy studies/evaluation/research /development of legislations. Implementation of e-health strategy including strengthening of health information and technology system.	3.07	Implementation of e-health strategy including strengthening of health information and technology system.	2.29	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(c) Climate risk and vulnerability study for all health care facility to identify measures in terms of Infrastructure, Technologies, Products, and process.	0.37	Climate risk and vulnerability study for all health care facility to identify measures in terms of Infrastructure, Technologies, Products, and process.	0.37			
			(d) Health infrastructure upgradation: Setting up a standard and requirement for each health establishment such as hospitals, satellite clinics, and public health units (Medicine, Healthcare Technologies and Infrastructure)	42.44	Health infrastructure upgradation- Setting up a standard and requirement for each health establishments such as hospitals, satellite clinics, and public health units (Medicine, Healthcare Technologies, and Infrastructure)	87.74	Health infrastructure upgradation- Setting up a standard and requirement for each health establishment such as hospitals, satellite clinics, and public health units (Medicine, Healthcare Technologies, and Infrastructure)	79.58	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(e) Capacity building of engineers on disaster resilient construction practices (Local artisans). Strategy for continuous utility service of health care institution during climate risks (Water supply, climate friendly construction features, mosquito free environment, waste management, supply chain management).	0.14	Capacity building of engineers on disaster resilient construction practices (Local artisans). Strategy for continuous utility service of health care institution during climate risks (Water supply, climate friendly construction features, mosquito free environment, waste management, supply chain management).	0.14	Capacity building of engineers on disaster resilient construction practices (Local artisans). Strategy for continuous utility service of health care institution during climate risks (Water supply, climate friendly construction features, mosquito free environment, waste management, supply chain management).	0.14	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
2	Climate Change will impact maternal and child health. The maternal mortality ratio was 89 in 2017. For the same time, the under-five mortality rate (U5MR) was 34 per 1000 live births.	Reduce the maternal mortality ratio to less than 70 per 100,000 live births by 2030. Reduce the maternal mortality ratio to less than 30 per 100,000 live births by 2040. Reduce the maternal mortality ratio to less than 5 per 100,000 live births by 2050.	(a) Strengthen maternal, reproductive, adolescent and child health services and prevention of vaccine preventable diseases Implement pre-pregnancy intervention program for woman.	1.69	Strengthen maternal, reproductive, adolescent and child health services and prevention of vaccine preventable diseases Implement pre-pregnancy intervention program for woman.	3.49	Strengthen maternal, reproductive, adolescent and child health services and prevention of vaccine preventable diseases Implement pre-pregnancy intervention program for woman.	3.17	There will be improved maternal and child health services with better health indices.
3	Currently health facilities across the country monitor and	Improved capacity in handling of climate induced diseases	(a) Implement integrated disease surveillance program (IDSP) to strengthen disease surveillance for infectious diseases to	1.69	Implement IDSP to strengthen disease surveillance for infectious diseases to detect and respond to outbreaks immediately.	3.49	Implement IDSP to strengthen disease surveillance for infectious diseases to detect	3.17	The outcome will be reduced impact of diseases like

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
	report 29 Notifiable diseases. With increasing impact of climate change, water and vector borne diseases and safety plans needs an upgrade. Compared to 2019, there was a decrease in the number of cases reported in almost all Notifiable diseases in 2020 except for TB and Malaria. Tuberculosis (TB) still	including respiratory, Water and Vector borne diseases. Attain WHO malaria elimination Certification by 2022. Tuberculosis incidence per 1,000 population. Reduce the Tuberculosis prevalence rate (per 10,000) to 5 by 2030. Reduce the Tuberculosis prevalence rate (per 10,000) to 2.5 by 2040. Reduce the Tuberculosi	detect and respond to outbreaks immediately. Strengthen surveillance, laboratory capacity for prevention and control of emerging and re-emerging infectious diseases / Zoonoses. (Integrate Disease specific safeguards in urban planning)		Strengthen surveillance, laboratory capacity for prevention and control of emerging and re-emerging infectious diseases / Zoonoses (Integrate Disease specific safeguards in urban planning)		and respond to outbreaks immediately. Strengthen surveillance, laboratory capacity for prevention and control of emerging and re-emerging infectious diseases / Zoonoses (Integrate Disease specific safeguards in urban planning)		tuberculosis, water and vector borne diseases which leads to high mortality due to unsafe infrastructure.
			(b) Create Awareness on VBDs and WBDs Monitoring of vector borne disease Implementation of Water safety plans. WASH programme – Develop, monitor and evaluate water safety plans. Integrate relevant non-health data in the health	0.51	Create Awareness on VBDs and WBDs Monitoring of vector borne disease Implementation of Water safety plans. WASH programme – Develop, monitor and evaluate water safety plans. Integrate relevant non-health data in the health	1.05	Create Awareness on VBDs and WBDs Monitoring of vector borne disease Implementation of Water safety plans. WASH programme – Develop, monitor	0.95	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
	poses a major public health concern for Bhutan with rising multi drug resistant-TB cases. In 2020, there were 919 cases of all forms of TB reported in the country among which 65 were RR/MDR-TB. There were only 54 new cases in 2020.	s prevalence rate (per 10,000) to 1 by 2050.	surveillance system - Initiate Sentinel & real-time surveillance for WBD and VBD (Strengthen WASH interventions in urban zones)		surveillance system - Initiate Sentinel & real-time surveillance for WBD and VBD (Strengthen WASH interventions in urban zones)		and evaluate water safety plans. Integrate relevant non-health data in the health surveillance system - Initiate Sentinel & real-time surveillance for WBD and VBD (Strengthen WASH interventions in urban zones)		
			(c) Strengthen early diagnosis treatment and prevent outbreak of vector borne diseases and (Neglected Tropical Diseases) NTDs. Research and monitoring on VBDs and WBDs and its risk due to Climate Change. Early Warning System for Disease Surveillance and warning (Cross	0.76	Strengthen early diagnosis treatment and prevent outbreak of vector borne diseases and (Neglected Tropical Diseases) NTDs. Research and monitoring on VBDs and WBDs and its risk due to Climate Change. Early Warning System for Disease Surveillance and warning (Cross	1.57	Strengthen early diagnosis treatment and prevent outbreak of vector borne diseases and (Neglected Tropical Diseases) NTDs. Research and monitoring on VBDs and WBDs and its risk due to	1.43	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			cutting) Review and proper design of Water supply infrastructure. Strengthen Disease Monitoring and Surveillance		cutting). Review and proper design of Water supply infrastructure.		Climate Change. Early Warning System for Disease Surveillance and warning (Cross cutting). Review and proper design of Water supply infrastructure.		
			(d) Enhance and sustain the Tuberculosis control program to detect, treat, prevent, and build TB cases and multidrug resistant TB cases. (Prevention and treatment of TB, MDR-TB and sustain leprosy elimination status)	0.81	Enhance and sustain the Tuberculosis control program to detect, treat, prevent, and build TB cases and multidrug resistant TB cases. (Prevention and treatment of TB, MDR-TB and sustain leprosy elimination status)	1.68	Enhance and sustain the Tuberculosis control program to detect, treat, prevent, and build TB cases and multidrug resistant TB cases. (Prevention and treatment of TB, MDR-TB and sustain leprosy elimination status)	1.52	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(e) Strengthen RSHP and promote safety in workplace and adaptation measures to reduce health impact of climate change. (WASH (NU. 20m) transferred to MoWHS)	0.29	Strengthen RSHP and promote safety in workplace and adaptation measures to reduce health impact of climate change.	0.59	Strengthen RSHP and promote safety in workplace and adaptation measures to reduce health impact of climate change.	0.54	
4	With the increase in impact of climate change there will be requirement of "One health approach" with the improved "Tertiary Health care systems".	Promote One health approach with the improved Tertiary Health care systems and improve health Infrastructure, equipment to handle climate sensitive diseases	(a) Improve health literacy and healthy behavior through health promotion, multi-sectoral collaboration, and community participation (Increase Inter-sectoral and international collaboration)	0.34	Upgrade health literacy and healthy behavior through health promotion, multi-sectoral collaboration, and community participation (Increase Inter-sectoral and international collaboration)	0.70	Advanced health literacy and healthy behavior through health promotion, multi-sectoral collaboration, and community participation (Increase Inter-sectoral and international collaboration)	0.70	The outcome will be improved and advanced tertiary health services with requisite infrastructure.
			(b) Institutional strengthening. Labs and equipment to deal with climate sensitive diseases.	0.68	Upgrading labs and equipment to deal with climate sensitive diseases.	1.40	Advanced labs and equipment to deal with climate sensitive diseases.	1.27	

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
			(c) Service expansion (establishment of Emergency Obstetrics & Emergency Medical and Trauma Centers; blood centers in hospitals, ED/ER Units, quarantine/isolation rooms, and expansion of Microbiology Laboratories in 7 hospitals). Strengthen emergency medical services and IHR	1.35	Upgrade in health services (establishment of Emergency Obstetrics & Emergency Medical and Trauma Centers; blood centers in hospitals, ED/ER Units, quarantine/isolation rooms, and expansion of Microbiology Laboratories in 12 hospitals).	2.80	Advancement in health services (establishment of Emergency Obstetrics & Emergency Medical and Trauma Centers; blood centers in hospitals, ED/ER Units, quarantine/isolation rooms, and expansion of Microbiology Laboratories in 12 hospitals).	2.54	
			Tertiary health care system and promote traditional health care. (Improve Access to Quality Tertiary Healthcare Services).	15.21	Tertiary health care system and promote traditional health care. (Improve Access to Quality Tertiary Healthcare Services).	15.21			
5	Climate change will bring an acute toll worldwide for higher rates of	Due to environmental toxins to ultraviolet radiation, air pollution, infectious	(a) Development of innovative and integrated palliative care (Allopathic and traditional medicine) for National Cancer Institute	0.08	Upgrade of integrated palliative care (Allopathic and traditional medicine) for National Cancer Institute	0.17	Advancement of integrated palliative care (Allopathic and traditional medicine) for	0.16	With the improved energy efficiency and more usage of conventiona

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
	cancer, especially lung, skin, and gastrointestinal cancers. [University of California San Francisco (UCSF) Study Focuses on Global Impact for Major Cancers and Steps Needed to Lessen Risks]	agents and disruptions in the food and water supply.					National Cancer Institute		l energy sources there will be reduced air pollution or environmental degradation. This coupled with advanced and upgraded infrastructure will provide better results.
			(b) Traditional Medicine Services, strengthen Spiritual services and local healing practices	3.21	Upgrading traditional medicine services, strengthen spiritual services and local healing practices.	6.64	Advanced Medicine Services, strengthen Spiritual services and local healing practices.	6.02	
			(c) Reduced pollution due to improved (efficiency and use of conventional energy sources) transport and energy sector services. [Refer Transport Sector Strategy 2 and Energy Sector Strategies 1, 2, 3 and 5]		Reduced pollution due to improved (efficiency and use of conventional energy sources) transport and energy sector services. [Refer Transport Sector Strategy 2 and Energy Sector Strategies 1, 2, 3 and 5]		Reduced pollution due to improved (efficiency and use of conventional energy sources) transport and energy sector services. [Refer Transport Sector Strategy 2 and Energy Sector Strategies 1, 2, 3 and 5]		

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
6	Climate change will bring an acute toll worldwide for higher rates of Livestock (animal health) related diseases.	Improved capacity and results in animal health giving better outputs of livestock.	(a) Research on impact of climate change on animal health (Livestock). Research on impact of climate change on animal health zoonotic diseases. [Refer Agriculture Sector Strategy 7 (a)]		Research on impact of climate change on animal health (Livestock). Research on impact of climate change on animal health zoonotic diseases. [Refer Agriculture Sector Strategy 7 (a)]		Research on impact of climate change on animal health (Livestock). Research on impact of climate change on animal health zoonotic diseases. [Refer Agriculture Sector Strategy 7 (a)]		Improved Livestock health management will have reduced impact of climate change and better production and productivity.
			(b) Continuous capacity development and awareness on animal health. (Enhance animal health and nutrition services, Feed Quality Test Parameters and Disease outbreaks) [Refer Agriculture Sector Strategy 7 (b)]		Continuous capacity development and awareness on animal health. (Enhance animal health and nutrition services, Feed Quality Test Parameters and Disease outbreaks) [Refer Agriculture Sector Strategy 7 (b)]		Continuous capacity development and awareness on animal health. (Enhance animal health and nutrition services, Feed Quality Test Parameters and Disease outbreaks) [Refer Agriculture Sector Strategy 7 (b)]		

Sr No	Vulnerability	Objective / Action Plans	Short Term (5-10 Years)	Amount (Million USD)	Medium Term (15-20 Years)	Amount (Million USD)	Long Term (25-30 Years)	Amount (Million USD)	Expected Environment Impact
	TOTAL (Million USD)			**71.30**		**130.64**		**103.95**	
	TOTAL (Million BTN)			**5347.45**		**9797.92**		**7795.89**	

5. Social and Economic Impact of LTS

The magnitude of the challenge assumed by the world by bringing into force the Paris Agreement calls for a structural transformation of economic activities. This transformation is also a great opportunity for boosting the economy and generating prosperity under green growth approaches. Today, the great imperative in Bhutan would be to transform the emissions pattern of the economy into a net-zero emissions, or negative emissions (i.e., removals) society, in sectors where it is possible - and very low emissions where it is not possible to reach zero. In practice, this means that each sector will be transformed toward zero emissions, yet at different speeds.

To design effective policy packages to support the planning and achievement of climate targets, policymakers need to identify policies that can reduce GHG emissions in a timely and cost-effective manner, while meeting development-related and other national objectives. Bhutan will aim to make a successful transition to the so-called "Fourth Industrial Revolution" - and the decarbonization that it entails - which is socially fair. A first step toward "transition management" would be to identify the main impacts, for instance, on the labor market. The identification of these impacts should consider the recognition that they can show differently in different sectors. To do so, the Long-Term Strategy for low-emission growth must be complemented with several detailed impact analyses.

Some level of quantification is vital in addressing the bias found in public debates that tends to focus narrowly on a single piece of data: the incremental cost of clean technology (for example, the higher price of an electric bus versus a diesel one). To overcome this bias, it is important to count on the quantification of the economic benefits that come from reducing oil consumption or the diseases associated with polluted air.

5.1 Socio-Economic modeling of Bhutan's economy

A socio-economic model was developed to quantify the effects of different policies and interventions on Bhutan's key socio-economic parameters. This model can enable an integrated quantitative assessment of different cross-sectoral climate policy packages for Bhutan through 2050 and their implications for key variables of interest such as Balance of Trade, GDP, and jobs. The model assesses the impact of key decarbonization-oriented interventions in the following sectors:

- Transport
- Energy
- Agriculture
- Industry

Each of these sectors has a comprehensive list of policy interventions, as described in sectoral Low Emissions Development Strategy (LEDS) documents. A key input into the model is the amount of funds disbursed against each policy intervention, and the extent to which a policy's goals are expected to be achieved. The model uses these inputs to

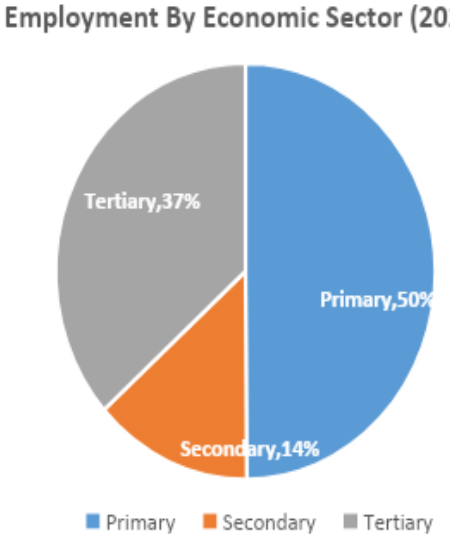
calculate impacts on jobs, GDP, and Balance of Trade in Bhutan, over a period of 30 years spanning from 2020 to 2050. This model can be updated from time to time, to integrate newly gained knowledge about Bhutan's economy and associated data.

5.2 *Findings and Conclusion*

As stated above, the socio-economic impact of Bhutan's long-term low-emission development strategy has been captured by its effect on Jobs, GDP, and Exports.

Jobs

In 2020, of the total employed persons, the highest was employed in the agriculture sector (49.9%), and the lowest was in the industry sector (13.5%). The share of employment in



the service sector stood at 36.6%. (NSB, 2020)

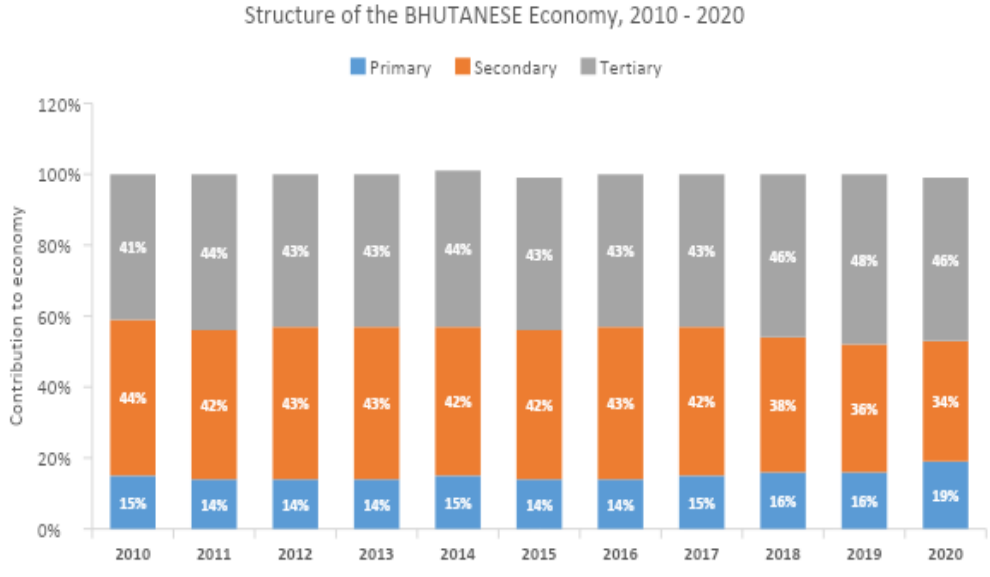
A relatively high percentage of Bhutan's labor force is engaged in the primary sector (agriculture, mining, quarrying, etc.). This trend is generally observed across most LDCs. As Bhutan aims to gradually transition to a developing economy, greater productivity and mechanization in the primary sector will accompany an economy wide transition of the labor force towards the secondary (manufacturing etc), and tertiary sectors (services etc).

Bhutan's long-term low emissions development strategy will be key to its economic ambitions. Implementation of its constituent policies will encourage a sustainable transition for Bhutan's economy. Our model projects that low emission policy interventions emerging from sectoral low emission development strategies (LEDS), will add over 6000 jobs in the secondary sector, and nearly 30,000 jobs in the tertiary sector, by 2040. The sectors who are set to witness the highest job growths are listed below:

Additional jobs created across major industries			
Industry / Sector	**upto 2030**	**upto 2040**	**upto 2050**
Sale, maintenance, and repair of motor vehicles and motorcycles; retail sale of fuel	14,787.70	29,575.39	73,938.48
Manufacturing, recycling	1,288.34	2,576.67	6,441.68
Electricity, gas, and water supply	1,234.95	2,469.91	6,174.77
Agriculture, hunting, forestry, and fishing	746.97	1,493.93	3,734.83
Wholesale trade and commission trade, except of motor vehicles and motorcycles	660.63	1,321.26	3,303.14
Rubber and plastics	462.37	924.73	2,311.83
Inland transport	210.23	420.45	1,051.13
Hotels and restaurants	208.48	416.97	1,042.41

GDP

The broad structure of the economy i.e., primary sector, secondary sector, and tertiary sector have by and large remained same over the past several years. However, from 2017 secondary sector's share of the economy started to decline (NSB, 2020).



In 2020, among the three broad sectors, the tertiary sector had the highest share of the economy with 46.36 percent followed by the secondary sector with 34.41 percent and primary sectors with 19.23 percent. While the primary sector had increased in share by 3.45 percentage points, the tertiary sector and secondary sector recorded a decline in their shares by 1.80 percentage points and 1.65 percentage points respectively.

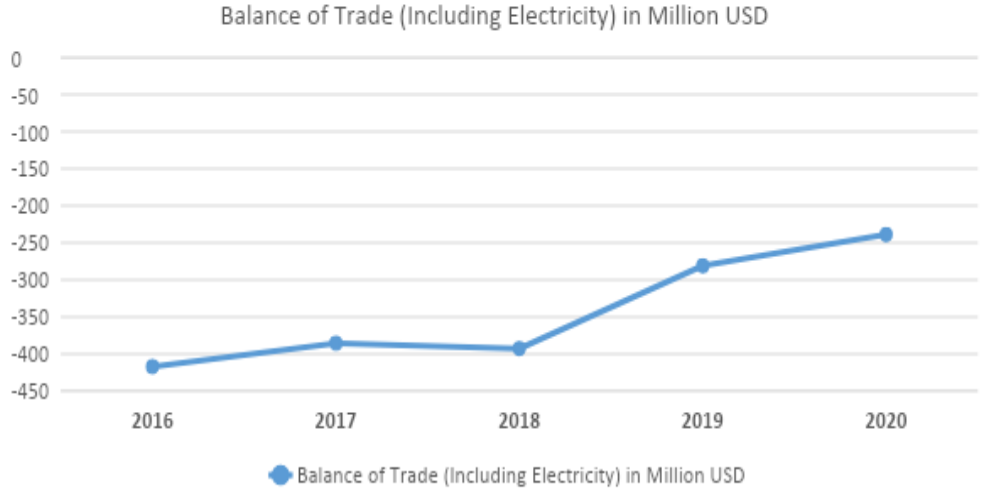
Bhutan's transition from an LDC to a Developing Economy will require structural changes, wherein the secondary and tertiary sectors will contribute a greater share to the national economy. Bhutan's long-term low emissions strategy will provide a boost to the declining secondary and tertiary sectors of the economy. Our model projects that the implementation of LEDS policy interventions will add more than 260 million USD to the secondary sector, and nearly 80 million USD to the tertiary sector, by 2040. The macroeconomic impact of such structural change will mean that a greater number of Bhutanese people will have access to jobs with higher wages. Industries with the highest projected gains are presented below:

Additional GDP Generated in USD Million			
Industry / Sector	**upto 2030**	**upto 2040**	**upto 2050**
Electricity, gas, and water supply	103.05	206.10	515.25
Chemicals and chemical products	9.04	18.08	45.21
Manufacturing, recycling	7.91	15.82	39.55
Renting of M&Eq and other business activities	6.23	12.46	31.15
Inland transport	6.06	12.13	30.32
Sale, maintenance, and repair of motor vehicles and motorcycles; retail sale of fuel	6.03	12.06	30.16
Other supporting and auxiliary transport activities; activities of travel agencies	4.05	8.09	20.23
Rubber and plastics	3.93	7.85	19.64
Real estate activities	3.66	7.32	18.29
Basic metals and fabricated metal	3.24	6.48	16.20
Wood and products of wood and cork	2.81	5.63	14.07
Financial intermediation	2.49	4.98	12.45
Pulp, paper, paper products, printing, and publishing	2.27	4.54	11.35
Retail trade, except of motor vehicles and motorcycles; repair of household goods	2.23	4.46	11.15
Wholesale trade and commission trade, except of motor vehicles and motorcycles	2.19	4.38	10.94

Balance of Trade

With limited domestic production capacity, the overall economy has largely been driven by the usual sectors and is contingent on imports. Exports, excluding electricity, fell drastically, while the decline in imports has not been uniform in all goods with induced demand for a few commodities including essential edible items and electronic items. Considering both the import and export of electricity, trade in electricity alone accounted for 24% of the overall trade. The trade deficit including trade in electricity, in

2020, was recorded at Nu. 18.38 billion which translates to 9.8% of nominal GDP, and without trade in electricity, the figure touched Nu. 45.72 billion which translates to 24% of nominal GDP. The increasing trade imbalance remains a concern in mitigating the current account deficit in the economy.



Bhutan's long-term low-emission development strategy is projected to have a positive impact on its Balance of Trade. Estimates suggest that the implementation of LEDS will generate 300 million USD in exports for the Bhutanese economy. Improved trade will allow the government to provide a better standard of living for its citizens. The industries projected to see the highest number of exports by 2040 are presented below:

Net Exports in Million USD	
Industry	**Net Exports**
Electricity, gas, and water supply	124.90
Basic metals and fabricated metal	2.95
Sale, maintenance, and repair of motor vehicles and motorcycles; retail sale of fuel	2.23
Hotels and restaurants	2.09
Chemicals and chemical products	1.58
Mining and quarrying	1.51

To summarize the results of our model's projections, the table below lists the short, medium, and long-term socio-economic impacts of various components of Bhutan's long term low emissions strategy:

Socio-Economic Parameter	up to 2025	up to 2030	up to 2050
Total Additional Jobs Created	20,438.22	40,876.43	102,191.08
Total Additional GDP Generated in USD Million	178.86	357.72	894.30
Total Import Requirements in implementing policy levers in USD Million	23.92	47.84	119.61
Total Exports in implementing policy levers in USD Million	88.19	176.38	440.95
Balance of Trade in USD Million[5]	64.27	128.54	321.35

5.3 Decoupling GHG emissions with socio-economic growth

As explained in the preceding chapters, several climate change mitigation actions, that form a part of the overall long-term strategy, promise reduction in GHG emissions. They are aligned with Bhutan's commitment to remain carbon neutral throughout its socio-economic evolution. With the implementation of the measures outlined in this LTS, there is evidence of the increase in GDP through enhanced economic activities with GHG emissions. For instance, through the implementation of the LTS interventions, in 2025 the reduction of GHG as compared to a BAU scenario is 1261.26 GgCO2e (24% decrease) while there is an increase of USD 89.43 Million in Bhutan's GDP. Similarly, in the long-term scenario, there is strong evidence of the decoupling with a GDP increase of 25% and a GHG decrease of 20% from the BAU scenario. Table 7 and Figure 17 below show the decoupling of GDP and GHG emissions in Bhutan for the short, medium, and long term.

Table 9. GDP and GHG projections under BAU and LTS scenario

	BAU		LTS		Comparison (BAU-LTS)	
Year	GHG (GgCo2e)	GDP (USD) Millions)	GHG (GgCo2e)	GDP (USD) Millions)	GDP USD Millions)	GHG (GgCO2e)
2025	5230.95	3521.46	3969.67	3610.89	-89.43	1261.29
2030	5702.62	3521.46	4209.90	3879.18	-357.72	1492.72
2050	7526.03	3521.46	5975.39	4415.76	-894.30	1550.64

[5] This BoT reflects the net imports as a result of economic activities generated through the implementation of policy levers

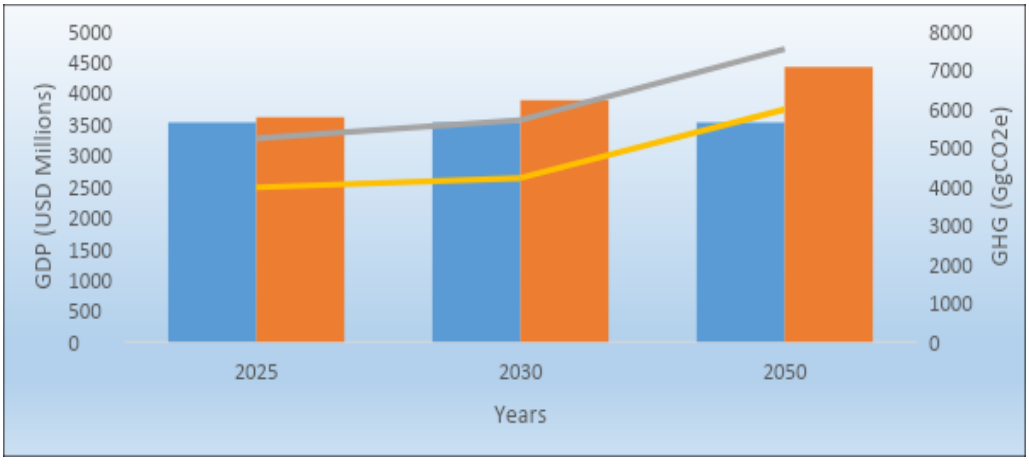


Figure 15. GDP and GHG Comparison between BAU and LTS Scenario

6. Implementation arrangements and means of finance

Three components of implementation arrangements are considered including:

i) Governance and policy, i.e., questions that relate to the concrete implementation of policy measures and programmes to support the mitigation activities identified, as well as the definition of institutional responsibilities.

ii) Opportunities for mobilizing international climate finance, the potential of attracting revenues from international carbon market mechanisms and bilateral donors, and the domestic finance and investment potential.

iii) Addressing technology and capacity barriers.

6.1. Integration into development plans and processes

The sectoral agencies will lead the implementation of interventions under this long-term strategy in collaboration with relevant central and local government agencies. It is proposed that the lead agencies institute a coordination group with members from relevant agencies, including GNHC, NEC, MoWHS, MoEA, Ministry of Finance, and representatives from the local governments. This group will act as the central node to prioritize activities and sources of international or bilateral climate finance, and partners for urban carbon market projects. After the prioritization, activities may be selected for further development into proposals for international climate finance or carbon market projects and develop concrete proposals.

At the local level, local government will be the main implementing agencies, and a campaign to build awareness and capacity within municipal administrations and relevant staff should be undertaken. Following this local governments will be enabled to suggest activities that may be taken forward at the central level for financing proposals. In addition, upon guidance from the lead agency, local governments shall work towards

improving data collection systems in the first three years of the strategy to ensure monitoring and reporting of emission reductions as well as adaptation interventions.

In terms of coordination between the central and local governments, there should be a clear delineation of roles and responsibilities. While central-level government institutions have better access to international financing, local governments have access to a larger share of the planned budget as seen in the 12th Five Year Plan while also serving as attractive destinations for some development aid.

Many different institutions and agencies are involved in the implementation of measures under this LTS. It is to be noted that for clarity of roles and accountability, only one lead agency is identified. Further, only the agencies directly involved in the implementation are included. Those agencies responsible for general coordination and cross-cutting issues such as the GNHC and Ministry of Finance and the implementing partners who can support the actual implementation of the plans and programmes are not listed. However, the lead agency shall identify all such relevant partners and take them on board during the implementation process.

One of the key measures in creating an enabling environment is the need to provide both fiscal and non-fiscal incentives to discourage carbon-intensive activities while promoting low carbon activities and technologies. It is therefore important to include a separate section on climate change in the next revision of the Economic Development Policy and ensure that the required incentives and disincentives are adequately covered both in the policy document and the updated regulations on fiscal incentives.

6.2. Ensuring Means of Implementation

Low-emission development strategies and initiatives have the potential to attract implementation support from international and bilateral development partners, but the funding is neither assured nor predictable. Therefore, the proposal for funding must be robust for its consideration and innovative for its long-term sustainability. It must present both the benefits and costs of interventions and highlight the consequences of inaction. A robust and sustainable approach to mobilizing implementation finance is to develop a business case and present it as an opportunity for investment, not just as a donor support possibility. It must also assess and target the most relevant sources, be they international, bilateral, or domestic.

6.2.1 Mobilizing international climate finance and revenues from international carbon market mechanisms

Bhutan successfully met the LDC graduation criteria in two United Nations triennial reviews of 2015 and 2018 (ESCAP 2020). It is set to graduate from the group of LDCs in 2023. According to the Royal Government of Bhutan, COVID-19-induced economic disruptions will not affect Bhutan's plans to graduate from the LDC (SAM, 2020). The Official Development Assistance (ODA) is expected to fall, but graduation should not significantly affect the development financing because LDC status is not a critical factor when deciding about aid allocation (UNESCAP 2020). Nevertheless, in light of its graduation, the Bhutanese government strives to establish a clearer focus of its policies on priority sectors and seeks to explore alternative sources of financing and investments by development partners as well as private investments.

Additional investment costs for the low GHG emitting technology options and climate-resilient activities are a key barrier to adoption and implementation in all sectors covered by this LTS. These additional investment costs accrue either to the citizens (private and corporate sectors) or to administrations (public agencies, CSOs, and SOEs). There are many ways of addressing the financing barrier, including direct grants, concessional loans, or loans at market rates but backed with government guarantees. In an ideal case, the NEC, GNHC, and MoF can mobilize international climate finance or revenues from carbon markets.

International climate finance can be mobilized ex-ante through avenues such as the GCF and GEF and therefore cover the upfront investment costs. Bhutan already has several projects under GCF and GEF financing and has sufficient experience in developing proposals from these international financing windows. Bhutan also sits on the GCF board representing the LDC group and this may provide the required support to mobilize finances for LTS interventions.

In addition, Bhutan may seek opportunities from bilateral climate finance, either through bilateral climate finance or the development of carbon market pilots under Article 6 of the Paris Agreement (for market and non-market approaches). Several countries have specific programmes for bilateral climate finance, such as Germany's International Climate Initiative (IKI) which aims at financing climate protection and biodiversity projects to implement countries' Nationally Determined Contribution. Other countries such as Austria and Norway have similar programmes that may provide more easily accessible ex-ante finance.

Since January 2018, the Ministry of Finance (MOF), the NEC Secretariat, the MEA, and the Gross National Happiness Commission (GNHC) of RGOB have been discussing the possibility of developing and piloting a Bhutan Climate Fund (BCF) with the World Bank, to help monetize mitigation outcomes from hydropower exports (World Bank, 2018). Interventions with mitigation outcomes

in the other sectors could also be considered under the activities of the Bhutan Climate Fund.

6.2.2 Mobilizing finance from bilateral donors

In addition, several of Bhutan's key development partners are engaging in Article 6 pilot programmes:

- The Joint Crediting Mechanism, Japan

The Joint Crediting Mechanism (JCM) was established in 2010 to promote market-based cooperation on mitigation activities in multiple sectors with developing countries. The main goal of the JCM is to allow cooperation between Japan and developing countries that can deliver mitigation results to be accounted for toward the NDC achievement of both Japan and host countries. JCM activities cover energy efficiency, power generation, and waste.

- KliK Foundation, Switzerland

The foundation aims to purchase certificates from international mitigation activities. Before ITMOs can be purchased by KliK, a bilateral agreement will need to be signed between the Swiss Government and the respective host country. Such agreements have already been sealed between Switzerland and Peru, and Ghana. Sectors of registered projects cover among others household energy (biodigesters) and solar PV/solar home systems.

- Swedish Energy Agency

The Swedish Energy Agency (SEA) wants to acquire emissions reduction credits for their 2030, 2040, and 2045 climate targets. Until now SEA has commissioned nine virtual pilots in seven counties in South America, Asia, and Africa in mainly energy and waste-related activities (SP 2020). Previously, SEA participated in the Dagachhu Hydro Power Project CDM project.

- Standardized Crediting Framework (SCF), the World Bank

The Standardized Crediting Framework (SCF) of the World Bank (WB) is a country-led approach to emission reduction crediting aiming at simplifying and streamlining processes as well as lower transaction costs. It has been successfully piloted in Senegal and Rwanda in energy-related projects providing significant time and cost savings compared to traditional CDM processes (WB 2020). WB's Carbon Initiative for Development (Ci-Dev) donors have agreed to offer the SCF to countries and regions where the Ci-Dev portfolio is active.

6.2.3 Mobilizing domestic finance and investment potential

As much as there is an opportunity to apply for international and bilateral sources of implementation finance, Bhutan's economic growth and development status present possibilities for mobilizing, at least some of the finances, domestically. However, for this to happen successfully, there has to be a change of attitude, perception, and approach to development and services financing.

Firstly, climate financing must be seen as a business investment opportunity rather than as a window for international aid. This paradigm shift in itself will enable stakeholders to treat the projects in terms of their profits and long-term sustainability. Secondly, innovative finance approaches must be explored. This does not necessarily mean identifying new or additional sources of finance but making more efficient and effective use of the existing fund streams. Thirdly, the mitigation activities must be mainstreamed as a part of the respective agencies' regular programmes so that the interventions are sustained and not discarded as a one-time, project-based investment. Fourthly, fiscal decentralization as promoted by the 12 FYP must be vigorously pursued as most of the activities will happen at the local government levels. This will ensure project ownership and more efficient use of resources.

Regarding the implementation of the LTS, there are a number of domestic finance mechanisms that could be pursued, some immediately and others with minor adjustments to policy and legal frameworks:

Payment for ecosystems services

This mechanism, where the users of a resource pay the people who are responsible for the management and sustainability of the same resources, is already in practice in Bhutan in drinking water supply schemes and a watershed management group for hydropower generation. This system could be strengthened and expanded to include other areas such as urban agriculture, urban forest, open and green spaces, and municipal waste management.

User fees and charges

A few municipal services in Bhutan, e.g. water supply and sanitation, roads, etc. charge user fees and service charges but they are nominal and hardly cover even the operation and maintenance costs. Consequently, municipal services are unreliable and of poor quality. It is possible to raise the fees and charges and therefore, the quality and reliability of services to the benefit of both the service providers and users. In Thimphu, for example, many building owners maintain private water lines in addition to the municipal supply, because the city services are not reliable. This has adverse cost implications to the building owners, municipal revenue and public health owing to uncertain water quality, all of which can be addressed through consolidation of both the resources and services.

Carbon Taxes

Bhutan levies green taxes on ICE & and hybrid vehicles, petrol, and diesel ranging from 5% to 30% and is levied on Free on Board (fob) value of imported goods (DRC, 2017). These taxes are imposed with the objective of internalizing the pollution cost of these imports. While these taxes commonly go to the national

exchequer to finance development works, they could be used dedicatedly for climate and environmental investments.

Public-private partnerships

Public-private partnership projects can provide alternative sources of finance for the provision of municipal services such as water supply, waste management, urban agriculture, management of recreational facilities, etc. Project proposals must be developed as a business case first, with the public sector or the government stepping in to support only if the user fees, charges, and other receivables such as material recovery from waste management or produce from urban farming fall below the agreed financial returns.

Corporate social responsibilities

Corporate social responsibility (CSR) activities also provide opportunities for partnership with the private sector for low-emission and climate-sensitive development. The focus here too should be to shift from the current perception of CSR as a charity to it being a business opportunity. The scope of securing finance through CSR would be enhanced if it is linked to tax reporting and investments in emission and mitigation reduction projects through policy interventions or statutory requirements.

Dedicated Funds

With investments from development partners, philanthropy organizations, and contributions from beneficiaries, dedicated funds to invest in climate-smart interventions could be one way of ensuring the sustainability of climate investments. The LEDS for manufacturing industries recommends setting up a Cleaner Production Fund to finance investments in the manufacturing sector. To market carbon credits generated by the hydropower projects, a proposal to set up a Bhutan Climate Fund was also developed with support from the World Bank. A consolidated sovereign fund could be established with diverse mandates including but not limited to inventory national carbon assets, market these assets to international carbon markets, use the revenue from these carbon markets, and support from development partners to finance both mitigation and adaptation activities.

6.3. Addressing technology and capacity barriers

Overall, state-of-the-art building, transport, and waste management-related technologies face long-term implementation challenges in Bhutan. Therefore, it is highly relevant for both the central and local governments to acquaint themselves with the necessary technical expertise that allows them to understand the technology that is being implemented, provide proper technological maintenance, and adjust the technology to secure its long-term operability. This

can be achieved by having qualified experts both in the MoWHS and the Thromdes but also, and most importantly, by continually enhancing staff members' capacities through hands-on training in real-life settings. In addition, efforts should be made to secure financial resources to cover all these future technology-related needs.

The Climate Technology Network Centre (CTCN) could be the starting point for technology transfer and the government, through the NECS as the National Designated Entity (NDE) under the Technology Mechanism of the UNFCCC, could request support in updating a technology needs assessment for updating a Technology Needs Assessment to detail out technology related mitigation assessments.

In the case of public-private partnerships for public services, such as waste management in Thimphu, it is critical to enhance the monitoring capacity of the municipal staff members.

7. Enhancing Partnerships

To ensure sustainable implementation, existing partnerships must be strengthened and new partnerships developed. This chapter looks at the current partnerships and proposes new ones to ensure that meaningful partnerships are sustained to deliver climate action. Partnerships can focus on resource mobilization, experience sharing as well and capacity building not just at the government level but also extended to society at large.

At a national level, partnerships will mean developing implementation mechanisms involving central government and local government agencies, the private sector, civil society organizations, and special interest groups, particularly youth and women groups. Currently, climate action is seen as the responsibility of government, and the society at large is mostly involved in being idle stakeholders, consulted during the formulation of plans and programs. There is a need to move away from this and adopt a whole of society approach towards climate action, particularly when faced with ever increasing climate-induced disasters and calamities. Climate action is currently dependent on the resources provided by development partners and actions are no longer sustainable once the support phase is completed. To ensure sustainability and continuity of climate action, a national-level funding mechanism similar to the concept of the Bhutan Climate Fund (The World Bank, 2018) with coverage extended to all sectors of the economy. The current interventions through the Bhutan Trust Fund for Environment Conservation and the Bhutan for Life are more focused on conservation and pilot activities and there is an urgent need to upscale the interventions and also explore interventions in other sectors, primarily energy

including transport, waste management, and manufacturing industries. The World Bank estimates a capital requirement of over USD 55 million for the establishment of the Bhutan Climate Fund (BCF) and this resource could be mobilized through the multilateral financing windows including the development banks. The resource mobilization and revenue generated by the BCF could be operated independently from the government budgeting system with a certain percentage of the revenue being given to the central exchequer as royalty as is currently practiced for the export of electricity from hydropower companies under the auspices of the Druk Holding and Investment (DHI).

Enhanced partnership at the national level would also mean expanding the composition of the Climate Change Coordination Committee (C4) to include members from academia, civil society, and the private sector. The C4 as originally intended would be the policy coordination body on climate action and would also have the additional role of vetting and validating proposals for climate action to ensure that climate action is not carried out in a silo and haphazard manner but is mainstreamed into national plans and programs.

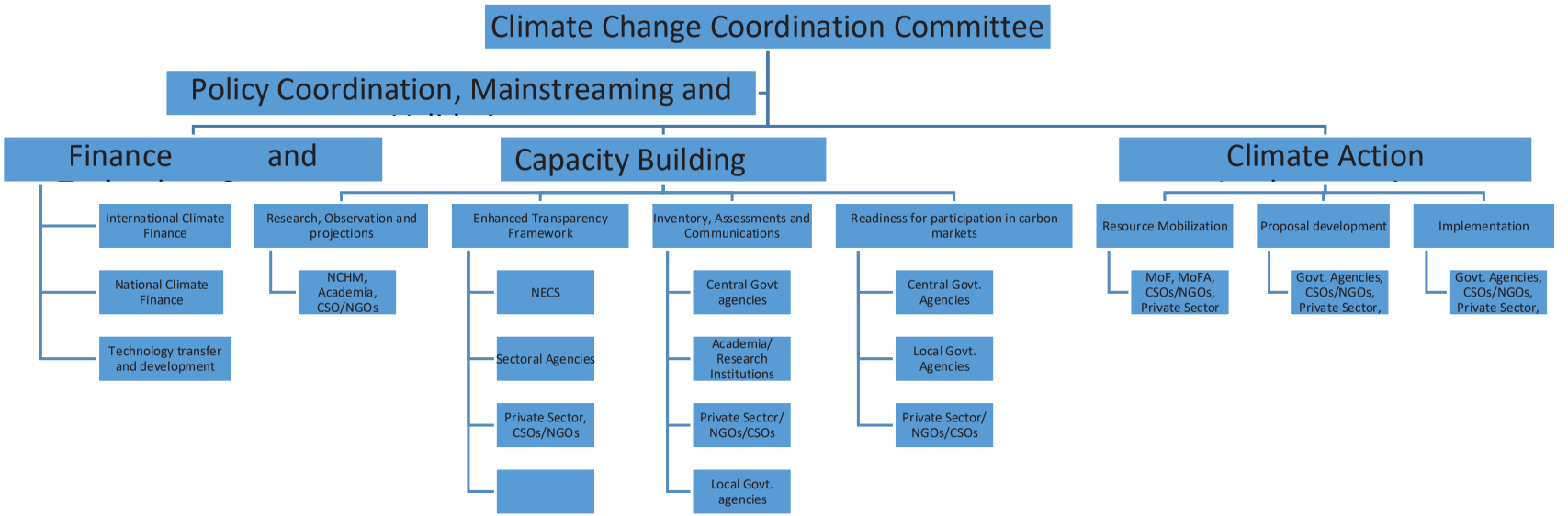


Figure 16. Illustration on domestic partnerships

At the international level, existing partnerships with multilateral mechanisms, multilateral banks, and development partners must be further strengthened and new partnerships developed, particularly in the areas of climate finance focusing on capacity development, mitigation, and adaptation.

While current climate finance has mostly been based on grant financing from multilateral financing windows, expecting Bhutan to graduate from the LDC group by 2023, it is important to explore the concessional loans from development banks as well as to actively participate in the carbon markets, both regulated and voluntary ones.

The government has to take the lead in exploring the potential for projects in Bhutan to participate in the carbon markets both in the developed world and the regional markets and get into bilateral and multilateral agreements to enable Bhutanese entities to trade carbon credits in the feasible markets.

Considering the vulnerability of Bhutan to climate change impacts, both climate-induced disasters as well impact on the economic activities, national agencies involved in systemic observation such as the National Center for Hydro-Meteorology and the Royal University of Bhutan develop partnerships with international organizations and research institutions for additional capacity building, technology transfer and knowledge sharing.

8. Annexures

Annexure I: Socio-economic Model Methodology

This model is based on Input-Output Analysis pioneered by Wassily Leontief[6]. Input-output tables (IOTs) provide a detailed picture of an economy through which mutual interrelationships among the producers and consumers in that economy can be systematically quantified. IOTs have become a widely used tool for national accounting, economic planning, and policy analysis.

The I/O model breaks the economy down into International Standard Industrial Classification (ISIC) codes (Rev. 4), a classification system for economic activity developed and maintained by the United Nations Statistics Division. Input-output tables specify which ISIC codes (e.g., industries) supply the inputs for each other industry, and which entities buy the outputs of each industry. Other tables, also divided up by ISIC code, specify the total jobs, value-added, employee compensation, and economic output of each ISIC code.

In this model, the effects of the policy package on key economic metrics (e.g., jobs, GDP, employee compensation) are sometimes described as "direct," "indirect," and "induced" impacts. The model captures all three types of impacts. It can be helpful to understand the differences between these types of impact. Consider a hypothetical policy whose effect is to cause the auto manufacturing industry to grow (to increase its output)

- **Direct** economic impacts are those within the affected business itself, caused by the policy or project. For example, if the policy causes the auto manufacturing industry to hire more workers, those added jobs are a direct impact of the policy
- **Indirect** economic impacts are those within suppliers of the affected industry. For example, if the growth of the auto industry causes the auto manufacturers to buy more steel, and steel-making companies hire more workers in response, the added jobs at steel-making companies are an indirect impact of the policy
- **Induced** economic impacts are those caused by the re-spending of money paid to workers or the government as a result of the growth of the affected industry. For example, the new workers at the auto and steel-making companies will spend their wages on various items, such as restaurants and leisure travel. The resulting job growth in the restaurant industry or in the leisure travel industry is an induced impact. Similarly, if the growth of the auto industry increases government tax revenue (for instance, from workers' income taxes or sales taxes on the additional vehicles sold), and the government spends the money on building new highways, added jobs at highway construction companies are an induced impact

[6] https://www.econlib.org/library/Enc/bios/Leontief.html

The final output of the model gives projections of the additional jobs created, impact on GDP, Balance of Trade etc., under varying scenarios of policy implementation. Policy goals and sub-goals are drawn from the sector-specific LEDS documents. Sub-goals were then prioritized based on estimated relevance in 2050. The Supply and Use tables were used from “Economic Indicators for South and Central Asia: INPUT-OUTPUT TABLES” published by the Asian Development Bank.

Annexure II: Socio Economic Data

Input Data

Policy Lever / Intervention	Economic Sector	Implementation % in 2050
BRT/ Enhanced Public Transport System	Surface Transport	Medium - 80%
Rail System (LRT and Passenger train)	Surface Transport	Nil - 0%
Improved bicycle systems (PBS)	Surface Transport	Nil - 0%
Improved sidewalks, crosswalks	Surface Transport	Medium - 80%
Carpooling, Ride sharing and rental services	Surface Transport	Medium - 80%
Gradual Phase Out of ICE Vehicles	Surface Transport	Medium - 80%
Annual vehicle capping	Surface Transport	Medium - 80%
On-Street Policy (parking charges, etc.)	Surface Transport	Medium - 80%
Vehicle and fuel standards	Surface Transport	Medium - 80%
Electric vehicles	Surface Transport	Medium - 80%
Hydrogen powered vehicles	Surface Transport	BAU - 20%
Advance traffic management system (CCTV, auto-signaling, etc.)	Surface Transport	Medium - 80%
Advance public information system (bus info displays, e-ticketing and GPS tracking)	Surface Transport	Medium - 80%
Advance parking information system	Surface Transport	Medium - 80%
Transport Integration	Surface Transport	Medium - 80%
Freight Train	Surface Transport	Nil - 0%
Demand Aggregation and Integrated Transport Hub	Surface Transport	BAU - 20%
Replacement of fossil reductant use in the ferro alloys sector	Industry	Medium - 80%

Cement Blending	Industry	Medium - 80%
Waste Heat Recovery for pre-heating raw materials	Industry	Medium - 80%
RDF in Cement Plants (Alternative Fuel)	Industry	Medium - 80%
Energy Efficiency increase in production processes	Industry	Medium - 80%
Direct Hot Charge in the Steel Industry	Industry	Medium - 80%
Energy Efficiency of electric motor systems	Industry	Medium - 80%
Conversion of Diesel boilers to electric boilers	Industry	Medium - 80%
Diversification	Industry	Medium - 80%
Uptake of farm based and composting industry meeting 30% of national demand by 2030 and 45% of national demand by 2050	Agriculture	Medium - 80%
Promoting perennial cropping in identified barren and suitable land with additional carbon sequestration benefits with the target of 23654 Ha by 2030 an 28528 Ha by 2050	Agriculture	Medium - 80%
Biogas development - 50,000 m3 capacity by 2030 and 83,000 m3 by 2050	Agriculture	Low - 50%
Stall feeding - 8333 heads of improved breed by 2030 and 25000 by 2050	Agriculture	Low - 50%
Rollout of rooftop Solar and Solar Water Heating: Implementing the prosumer concept with adequate feed-in tariff policy	Energy	Medium - 80%
Switching LPG cooking to electricity: 100% switch from LPG based cooking to electricity-based cooking	Energy	Medium - 80%
Utility Scale PV - Enhancing National Energy Security through diversified energy source	Energy	Medium - 80%

Please Note:

1. Default start date of all policies / interventions is 2020

2. Please select an implementation scenario for each policy

3. Default implementation % will be set as 0%

Socio-Economic Parameter	upto 2030	upto 2040	upto 2050
Total Additional Jobs Created	20,438.22	40,876.43	102,191.08
Total Additional GDP Generated in USD Million	178.86	357.72	894.30
Total Import Requirements in implementing policy levers in USD Million	23.92	47.84	119.61
Total Exports in implementing policy levers in USD Million	88.19	176.38	440.95
Balance of Trade* in USD Million	64.27	128.54	321.35

**This BoT reflects the net imports as a result of economic activities generated through the implementation of policy levers*

Additional jobs created across major industries			
Industry / Sector	**upto 2030**	**upto 2040**	**upto 2050**
Sale, maintenance, and repair of motor vehicles and motorcycles; retail sale of fuel	14,787.70	29,575.39	73,938.48
Manufacturing, recycling	1,288.34	2,576.67	6,441.68
Electricity, gas, and water supply	1,234.95	2,469.91	6,174.77
Agriculture, hunting, forestry, and fishing	746.97	1,493.93	3,734.83
Wholesale trade and commission trade, except of motor vehicles and motorcycles	660.63	1,321.26	3,303.14
Rubber and plastics	462.37	924.73	2,311.83
Inland transport	210.23	420.45	1,051.13
Hotels and restaurants	208.48	416.97	1,042.41

Additional GDP Generated in USD Million			
Industry / Sector	**upto 2030**	**upto 2040**	**upto 2050**
Electricity, gas, and water supply	103.05	206.10	515.25
Chemicals and chemical products	9.04	18.08	45.21
Manufacturing, recycling	7.91	15.82	39.55
Renting of M&Eq and other business activities	6.23	12.46	31.15
Inland transport	6.06	12.13	30.32
Sale, maintenance, and repair of motor vehicles and motorcycles; retail sale of fuel	6.03	12.06	30.16
Other supporting and auxiliary transport activities; activities of travel agencies	4.05	8.09	20.23
Rubber and plastics	3.93	7.85	19.64
Real estate activities	3.66	7.32	18.29
Basic metals and fabricated metal	3.24	6.48	16.20
Wood and products of wood and cork	2.81	5.63	14.07
Financial intermediation	2.49	4.98	12.45
Pulp, paper, paper products, printing, and publishing	2.27	4.54	11.35
Retail trade, except of motor vehicles and motorcycles; repair of household goods	2.23	4.46	11.15
Wholesale trade and commission trade, except of motor vehicles and motorcycles	2.19	4.38	10.94
Mining and quarrying	1.88	3.76	9.39
Agriculture, hunting, forestry, and fishing	1.64	3.28	8.21
Electrical and optical equipment	1.56	3.11	7.79
Post and telecommunications	1.53	3.05	7.64
Construction	1.44	2.88	7.19
Hotels and restaurants	1.38	2.75	6.89
Water transport	1.15	2.30	5.74
Other nonmetallic minerals	1.11	2.23	5.57
Air transport	0.91	1.81	4.54
Other community, social, and personal services	0.57	1.14	2.84
Public administration and defense; compulsory social security	0.14	0.28	0.71
Leather, leather products, and footwear	0.09	0.19	0.46

Textiles and textile products	0.09	0.18	0.46
Machinery	0.08	0.17	0.42
Food, beverages, and tobacco	0.07	0.14	0.34
Education	0.03	0.07	0.17

Balance of Trade in USD Million									
Industry / Sector	**upto 2030**			**upto 2040**			**upto 2050**		
	Socio-Economic Parameter	**upto 2030**	**upto 2040**	**upto 2050**	**Socio-Economic Parameter**	**upto 2030**	**upto 2040**	**upto 2050**	**Socio-Economic Parameter**
Agriculture, hunting, forestry, and fishing	0.05	0.20	0.15	0.09	0.39	0.30	0.23	0.98	0.75
Mining and quarrying	0.18	0.93	0.76	0.36	1.87	1.51	0.89	4.67	3.78
Food, beverages, and tobacco	0.02	0.01	-0.01	0.04	0.02	-0.03	0.11	0.04	-0.07
Textiles and textile products	0.02	0.00	-0.02	0.04	0.00	-0.04	0.11	0.01	-0.10

Leather, leather products, and footwear	0.02	0.00	-0.02	0.04	0.00	-0.04	0.11	0.00	-0.10
Wood and products of wood and cork	0.65	0.35	-0.30	1.31	0.71	-0.60	3.26	1.77	-1.49
Pulp, paper, paper products, printing, and publishing	1.12	0.36	-0.76	2.24	0.71	-1.53	5.60	1.78	-3.82
Chemicals and chemical products	1.69	2.47	0.79	3.37	4.95	1.58	8.43	12.36	3.94
Rubber and plastics	2.67	1.37	-1.29	5.34	2.75	-2.59	13.34	6.87	-6.47
Other nonmetallic minerals	0.11	0.35	0.24	0.22	0.69	0.47	0.55	1.73	1.18
Basic metals and fabricated metal	1.43	2.90	1.47	2.86	5.80	2.95	7.14	14.50	7.36
Machinery	0.04	0.00	-0.04	0.07	0.00	-0.07	0.18	0.00	-0.18
Electrical and optical equipment	0.68	0.01	-0.67	1.36	0.02	-1.34	3.40	0.05	-3.35

Transport equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufacturing, recycling	2.04	1.84	-0.21	4.08	3.67	-0.41	10.21	9.18	-1.03
Electricity, gas, and water supply	5.22	67.68	62.45	10.45	135.35	124.90	26.12	338.38	312.26
Construction	0.70	0.04	-0.66	1.39	0.08	-1.31	3.48	0.20	-3.28
Sale, maintenance, and repair of motor vehicles and motorcycles; retail sale of fuel	0.44	1.55	1.12	0.87	3.11	2.23	2.18	7.77	5.59
Wholesale trade and commission trade, except of motor vehicles and motorcycles	0.18	0.55	0.37	0.35	1.09	0.74	0.88	2.73	1.85
Retail trade, except of motor vehicles and motorcycles; repair of	0.16	0.53	0.36	0.33	1.06	0.73	0.82	2.64	1.82

household goods									
Hotels and restaurants	0.13	1.18	1.04	0.27	2.36	2.09	0.67	5.89	5.22
Inland transport	2.48	1.87	-0.61	4.96	3.74	-1.22	12.40	9.35	-3.05
Water transport	0.47	0.91	0.44	0.94	1.82	0.88	2.35	4.54	2.19
Air transport	1.18	1.21	0.03	2.36	2.42	0.06	5.91	6.05	0.14
Other supporting and auxiliary transport activities; activities of travel agencies	0.21	0.61	0.40	0.42	1.23	0.80	1.05	3.06	2.01
Post and telecommunications	0.26	0.48	0.22	0.52	0.96	0.44	1.30	2.40	1.11
Financial intermediation	0.10	0.09	-0.01	0.19	0.17	-0.02	0.48	0.43	-0.05
Real estate activities	0.07	0.05	-0.02	0.15	0.10	-0.05	0.37	0.26	-0.11

Renting of M&Eq and other business activities	1.47	0.42	-1.05	2.93	0.83	-2.10	7.33	2.08	-5.24
Public administration and defense; compulsory social security	0.02	0.01	-0.01	0.05	0.02	-0.03	0.11	0.05	-0.07
Education	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.01	-0.01
Health and social work	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other community, social, and personal services	0.12	0.23	0.11	0.24	0.47	0.23	0.60	1.17	0.57

Annexure III. GHG Projections

Years	BAU GHG Emission Estimates in Gg CO2e per annum		
	Total Emission	Sink Capacity	Net emission / Removal
2000	3162.01	-9031.00	-5868.98
2001	2501.27	-9065.87	-6564.60
2002	1919.94	-9100.75	-7180.81
2003	1341.31	-9135.46	-7794.15
2004	1713.89	-9170.43	-7456.54
2005	2186.36	-9205.56	-7019.19
2006	3023.56	-9240.48	-6216.92
2007	5910.50	-9275.44	-3364.94
2008	2601.91	-9310.66	-6708.75
2009	2181.50	-9346.59	-7165.09
2010	2740.36	-9382.21	-6641.85
2011	2882.09	-9391.27	-6509.18
2012	2963.09	-9398.98	-6435.89

2013	3164.94	-9406.67	-6241.72
2014	5717.11	-9413.32	-3696.21
2015	3750.56	-9421.01	-5670.45
2016	4143.14	9421.00	-5277.86
2017	4262.97	9421.00	-5158.03
2018	4382.80	9421.00	-5038.20
2019	4502.63	9421.00	-4918.37
2020	4622.47	9421.00	-4798.53
2021	4742.30	9421.00	-4678.70
2022	4862.13	9421.00	-4558.87
2023	4981.96	9421.00	-4439.04
2024	5101.79	9421.00	-4319.21
2025	5221.63	9326.79	-4105.16
2026	5341.46	9233.52	-3892.06
2027	5461.29	9141.19	-3679.90
2028	5581.12	9049.78	-3468.65
2029	5700.95	8959.28	-3258.32
2030	5820.79	8869.68	-3048.90
2031	5940.62	8780.99	-2840.37
2032	6060.45	8693.18	-2632.73
2033	6180.28	8606.25	-2425.97
2034	6300.11	8520.18	-2220.07
2035	6419.94	8434.98	-2015.04
2036	6539.78	8350.63	-1810.86
2037	6659.61	8267.13	-1607.52
2038	6779.44	8184.45	-1405.01
2039	6899.27	8102.61	-1203.34
2040	7019.10	8021.58	-1002.48
2041	7138.94	7941.37	-802.43
2042	7258.77	7861.95	-603.19
2043	7378.60	7783.33	-404.73
2044	7498.43	7705.50	-207.07
2045	7618.26	7628.45	-10.18
2046	7738.10	7552.16	185.93
2047	7857.93	7476.64	381.29
2048	7977.76	7401.87	575.89
2049	8097.59	7327.86	769.74
2050	8217.42	7254.58	962.85

Annexure IV: Forest Fire Emission Estimates

Timeline	Values	Forecast	Lower Confidence Bound	Upper Confidence Bound	Column
2000	23314.20				
2001	14644.16				
2002	5425.99				
2003	2711.21				
2004	7965.51				
2005	19580.68				
2006	56280.75				
2007	9599.17				
2008	4211.30				
2009	9314.31				
2010	10897.20				
2011	10903.73				
2012	12175.20				
2013	46694.81				
2014	15375.00				
2015	21280.00				
2016	8521.00				
2017	5249.00				
2018	5249.00	5249.00	5249.00	5249.00	cumulative
2019		12681.26	-1158.43	26520.94	
2020		50917.09	33609.17	68225.00	
2021		9109.19	-11086.82	29305.20	
2022		3491.63	-19234.61	26217.87	
2023		-1436.10	-26443.58	23571.37	
2024		-62.43	-27165.10	27040.24	
2025		2959.33	-26092.78	32011.44	
2026		10387.55	-21828.40	42603.49	
2027		48623.38	14742.45	82504.31	
2028		6815.48	-28656.45	42287.42	
2029		1197.92	-35800.59	38196.43	
2030		-3729.81	-42198.15	34738.53	
2031		-2356.14	-42243.83	37531.55	
2032		665.62	-40596.16	41927.40	
2033		8093.84	-35484.64	51672.32	
2034		46329.67	1483.53	91175.81	
2035		4521.77	-41560.34	50603.89	
2036		-1095.79	-48384.69	46193.12	
2037		-6023.52	-54492.21	42445.17	
2038		-4649.85	-54273.24	44973.54	
2039		-1628.09	-52382.83	49126.65	
2040		5800.13	-46881.16	58481.42	
2041		44035.96	-9717.84	97789.76	
2042		2228.06	-52579.97	57036.09	
2043		-3389.50	-59234.51	52455.51	
2044		-8317.23	-65182.92	48548.47	
2045		-6943.56	-64814.50	50927.38	
2046		-3921.80	-62783.35	54939.76	
2047		3506.42	-57046.88	64059.72	
2048		41742.25	-19763.31	103247.82	
2049		-65.65	-62511.35	62380.06	
2050		-5683.21	-69057.46	57691.05	

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