Bhutan State of the Environment Report 2022

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Preface

The National Environment Commission Secretariat (NECS), among many others, is mandated by section 41 (i) of the National Environment Protection Act, 2007 to prepare and publish the State of Environment report periodically. Keeping in line with this provision, this is the fourth edition of the periodic reports, called, "Bhutan's State of the Environment Report," (BSER) 2022. BSER provides information on the current state and trends in Bhutan's environment, the underlying causes of environmental change and the responses to such changes.

This BSER has been prepared by the NECS with support from relevant stakeholders, through a consultative and review process. The report covers four thematic areas of land, water, air and biodiversity, while waste management and climate change have been considered as cross-cutting issues. Each of these themes is described using the framework of Drivers, Pressures, State, Impact and Response (DPSIR) and is based on published information and data collected from various organisations.

The information in the BSER aims to improve the understanding of environment and sustainable development issues and for informed decision-making. As a result, this report supports the government and citizens in their respective constitutional responsibilities in environmental conservation while pursuing justifiable socio-economic development and ultimately for the wellbeing of the Bhutanese people.

Sonam P. Wangdi
Secretary

Foreword

Bhutan is recognized at the international forums for its pristine and intact environment due to its strong conservation policies guided by the enlightened and visionary leadership of our beloved Monarchs. Similar to many other countries, Bhutan is also dependent on its natural environment for promotion of social well-being. As such, sustainable development is particularly important for a country like Bhutan, with its fragile mountain ecosystems, susceptible to the impacts of changing climate, and high level of biodiversity.

This report can be considered as part of the NEC's effort to further develop and strengthen the environmental reporting mechanisms. It presents information on the current status and trends related to land, water, air, biodiversity, waste Management and climate change. It takes stock, tracks the progress, highlights the challenges and provides some recommendations.

Bhutan's first State of the Environment report was prepared in 2001, followed by the second in 2008 and the third in 2016. This report is intended to inform citizens on the present state of the environment and also help planners to integrate environmental concerns in developing the 13th Five Year Plan. This report is a living document, updated every five years.

The implementation of the recommendations requires cooperation and participation of all relevant stakeholders, government and non-government, civil society organisations, academia, private sector and citizens. Therefore, I sincerely urge all to actively take part in the implementation of recommendations highlighted in this report for the benefit of present and future generations.

Lyonpo Tandi Dorji
Chair of NEC and
Minister for Foreign Affairs

Executive Summary

Today, 70.46% of the total land area remains under forest cover. More than half of the country's landscape (51.40%) is a protected area comprising five national parks, four wildlife sanctuaries, a strict nature reserve and biological corridors (MoAF, 2009; NSB, 2015). Nonetheless, the state of Bhutan's environment has been changing over time due to population growth and economic development. The pressures on the environment are directly proportional to the number of people dependent on natural resources. Bhutan's population is 681, 720 as per PHCB 2017.

This BSER covers four thematic areas: Land, Water, Air and Biodiversity. The Waste Management and Climate Change are reflected under the cross-cutting issues.

Land: The drivers and pressures on land resources are mainly from accelerated construction of farm roads, electricity transmission/distribution lines, industries and urbanisation. There are also emerging signs of forest degradations within the forest cover area. Forest Management Units (FMUs) are areas designated for scientific management of timber production. Some reports suggest FMUs are being overharvested. The supply of timber and fuel wood are much higher from forests falling outside of FMUs, indicating that there is overall, very high pressure on the forests and their resources. Pressures in critical watersheds and water sources are also likely to impact water supply. These impacts are compounded by rapid and poor road construction methods that are not only triggering numerous surface runoffs and landslides in geologically fragile areas but are also opening up previously inaccessible forest areas and watersheds to exploitation.

Land cover map of 2011 reported the operated agriculture land at 2.93%. This prime agricultural land (especially paddy fields) is under increasing pressure from growth in existing urban areas and creation of new urban settlements. In contrast, agricultural lands in rural areas are increasingly being left fallow due to rural urban migration. Such pressures and impacts on agricultural land have a huge implication on the food and nutrition security of the country.

The population of free grazing cattle and yaks are seen to be diminishing over the past decade. This trend suggests a decline in the pressure on land from grazing. While the per capita consumption of fuel wood (1.2 metric tons/year) is one of the highest in the world, it appears to be decreasing slowly, indicating signs of reducing pressure on forests from household energy needs.

Water: Although Bhutan has one of the highest per capita water availability in the world with 94,500 m^3/capita/annum, its imbalanced geographical and temporal distributions is leading to experience of shortages in local areas (NEC, 2016). Adverse impact of climate change is further aggravating the water problem for agriculture. Water quality is deteriorating in and around the urban areas.

The Bhutan Water Security Index (BWSI) developed in 2015 has five key dimensions, each with a set of indicators. The five key dimensions are 1) Rural drinking water supply, sanitation and hygiene, 2) Economic water supply for agriculture, industries and hydropower, 3) Urban water supply, sanitation and drainage, 4) Environmental water security, and 5) Disaster and climate change resilience.

BWSI should be adopted as a Key Result Area of successive Five Year Plans. This will help in mainstreaming water into sectoral policies, plans, programs and projects. River Basin Committees

(RBCs) should be established in all major river basins with the view to prepare the River Basin Management Plan (RBMP). RBMP should ensure coordinated development and management of water resources in the country to improve water security.

Air: Air pollution is becoming one of the emerging issues that has serious risks to human and environment health. Its quality is deteriorating, particularly in urban centres, industrial areas and along the southern border of the country. Emission of greenhouse gases, which contributes to climate change, seems to be increasing.

The air pollution from domestic sources may be controlled by enhancing appropriate existing air quality related standards to more stringent levels and strengthening its enforcement. Policies and incentives on the import of vehicles need to be harmonised. Trans-boundary air pollution and its impact can be controlled by strengthening regional cooperation.

Biodiversity: The total land area under Protected Areas is 16, 396.4 km^2, accounting to 51.40% of the country. There are 24 threatened mammal species of which one is critically endangered, 11 endangered, 12 vulnerable. In terms of avifauna, 18 threatened species are found of which 4 are critically endangered and 14 vulnerable. There are 182 species of butterflies categorised as rare and threatened species (IUCN, 2016). The total of 10, 231 ha land area are under high altitude wetland/marshes. However, engagement in illegal logging and poaching activities are increasing.

Biodiversity management can be improved by incorporating it in the environmental assessment process. Maintaining a certain percentage of water flow as environmental flow (e-flow) in the river system at all times will also help in sustaining aquatic life. In addition, the list of flora, fauna and IAS should be updated periodically. Protected areas should also be physically demarcated by the end of the 12FYP.

Waste Management: Waste management is the major emerging environmental issue for Bhutan. Poor waste management practices threaten public health and the natural environment such as pollution of water, air and emission of Greenhouse gases. According to the first National Solid Waste Survey in the urban areas in 2008 - organic waste constitutes more than half of municipal waste characteristics. Some hazardous wastes are from medical facilities, industrie and used electronics.

There is a need to provide adequate financial, technical and capacity building support to the implementing and collaborating agencies for effective implementation of Waste Prevention and Management Act, 2009 and its Regulation 2014. Implementing and collaborating agencies should prepare and implement an action plan towards attaining 'Zero Waste through maximising resource recovery for creating sustainable waste management systems and protecting the natural unique ecology of Bhutan" as reflected in the NISWM, 2014. The government should continue to encourage and incentivize private entities in carrying out waste management initiatives.

Climate Change*:* Bhutan is highly vulnerable to the adverse impacts of climate change. In addition to being a landlocked and least developed country with a fragile mountainous environment, high dependence of the population on agriculture and the significant role of hydropower for economic development increases the vulnerability. Bhutan also faces increasing threats from climate hazards and extreme events such as flash floods, glacial lake outburst floods (GLOF), windstorms, forest fires and landslides.

The Climate Change Policy 2020 addresses adaptation, mitigation and means of implementing climate actions. It also looks at ways to integrate climate change adaptation and disaster risk

reduction, mitigation with health, gender and cross cutting issues. Better coordination among institutions is essential to improve effectiveness of accessing climate finance. Information on climate finance sources should be made available by the various focal agencies to sectors and other implementers. Improving research capacity within institutions and empowering local experts, especially Royal University of Bhutan (RUB), would help by providing scientific basis for climate actions.

1. Background to the national environment report

1.1 Introduction

Environmental conservation has always played a central role in Bhutan's socio-economic development. Benefits of our conservation action extend beyond national boundaries and help to ensure inter-generational equity of Bhutanese and the global community. Bhutan's unwavering commitment to environmental conservation has been recognized globally and is widely regarded as a bastion for conservation in the 21st century.

Bhutan is one of the few countries in the world that enshrines environmental conservation in its Constitution. Article 5 of the Constitution of the Kingdom of Bhutan reflects commitment to secure ecologically balanced sustainable development while promoting justifiable socio-economic development.

Today, 70.46% of the total land area remains under forest cover. More than half of the country's landscape (51.40%) is a protected area network comprising five national parks, four wildlife sanctuaries, a strict nature reserve and biological corridors (MoAF, 2009; NSB, 2015).

Bhutan declared to remain carbon neutral at the 15th Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 2009 in Copenhagen, Denmark. In addition, the Intended Nationally Determined Contribution (INDC) submitted in September 2015 towards finalisation of the Paris Agreement further re-iterated Bhutan's pledge to remain carbon neutral.

The NEC published the first State of the Environment Report in 2001. The second report, renamed as Bhutan Environment Outlook (BEO) was published in 2008. The third report, again renamed as the Bhutan State of the Environment Report (BSER), was published in 2016. The NECS periodically publishes reports on the environmental condition in the country in accordance with the mandate under the National Environment Protection Act of Bhutan, 2007 (NEPA). This report is called the BSER 2022.

This BSER report is basically an update of the last BSER and it is intended to inform decision makers on environmental issues in relation to relevant socio-economic development activities.

1.2 State of the Environment Reporting

The BSER 2022 is part of the periodic assessment of the environmental conditions and trends. Following are the main objectives of the report:

- Provide information on the State of the Environment;
- Provide information to decision-makers for informed decision-making; and
- Make recommendations for strengthening enforcement and implementation of environmental policies, plans and programmes.

1.3 Process

The BSER was formulated in a participatory and consultative manner - involving various stakeholders from governmental and non-governmental organisations including Civil Society Organizations.

1.4 Methodology

This report is divided into three parts. Part one covers section one to three. These sections contain information on the national environmental reporting, physical features including geography and climate. These sections also contain information on demography and socio-economic development.

Sections four to nine cover thematic areas such as Land, Water, Air and Biodiversity. These thematic areas are written using the Driver-Pressure-State-Impact-Response framework. Further, the Waste Management and Climate Change are reflected under the cross-cutting issues. Each of this section contains recommendations at the end.

2. Physical features

2.1 Geography

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 150 to 7, 500 masl. The

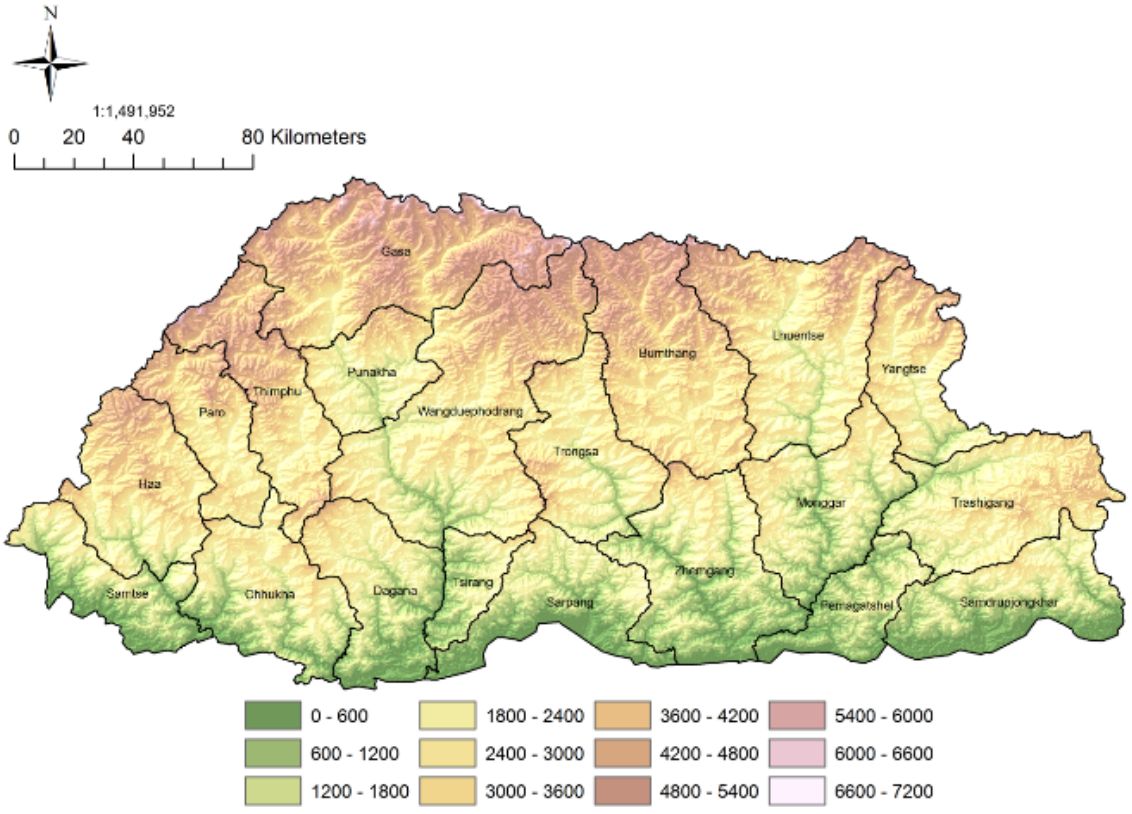


Figure 1: Altitude Zones of Bhutan

dominant topographic features are the high Himalayas in the north with snow-capped 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.

2.2 Climate

Bhutan has three climatic zones as shown below in Table 1:

Table 1: Climatic Zones of Bhutan (SNC, NEC, 2016)

Belt	Physical features	Altitude	Climatic characteristic	Temperature
Southern belt	Himalayan foothills	150 m - 2, 000 m	Subtropical climate High humidity and heavy rainfall	15°C - 30°C all year round
Central belt	River valleys	2, 000 m - 4, 000 m	Cool winters, hot summers and moderate rainfall	15°C - 26°C (June - September) and - 4°C - 15°C (winter season)
Northern belt	Snow Capped peaks and alpine meadows	above 4, 000 m	Cold winter and cool summer	

Bhutan receives about 70% of the precipitation during monsoons while pre-monsoon accounts about 20%. The annual precipitation ranges widely in various parts of the country. The northern region gets around 40 mm of annual precipitation, mostly in the form of snow. The temperate central valley gets a yearly average of about 1, 000 mm of rainfall while the southern region gets about 1, 500 mm of rainfall annually (NEC, 2016). The monsoons last from late June through late September.

3. Demography and socio-economic development

3.1 Demography

The 2017 PHCB shows that the total population of Bhutan is 735, 553 persons including both Bhutanese and non-Bhutanese. Out of the total population, 681, 720 persons are Bhutanese and 53, 833 persons are non-Bhutanese. The non-Bhutanese population includes 8, 408 tourists in hotels and on the move during the census reference day. Except for the total count, no detailed information was collected from the tourists, analyses are limited to 7, 27, 145 persons. The rural population is 62.2% of the total population of Bhutan. Thimphu *Dzongkhag* has the largest population (138, 736), constituting 19.1% of the total population in the country, while the least populated is Gasa *Dzongkhag* (0.5%) with 3, 952 persons.

In the last twelve years (2005 - 2017), Bhutan's total population has increased by 16% and the population density increased from 17 persons/km^2 to 19 persons/km^2. The population has increased at the rate of 1.3% per annum. The sex ratio of the population (number of males for every 100 females) at the national level is 110. The median age is 26.9 years, indicating that half of Bhutan's population is younger than 26.9 years. The total dependency ratio is 47.0 implying that for every 100 economically active persons, there are 47.0 dependents.

3.2 Poverty

Poverty is measured by two indicators of food and non-food consumption level (NSB, 2007). A single national food poverty line and single non-food allowance are computed based on monthly per capita levels. Table 2 shows the change in the poverty lines from 2012 to 2017. The

proportion of total population living below the poverty line has decreased from 12% to 8.2% during the period.

Table 2: Overall Poverty line. Source: NSB, 2012 & 2017

Poverty Parameter (in Nu. Per person per month)	2012	2017
Food poverty line	1154.74	1473.45
Non-food allowance	550.10	
Overall national poverty line	1704.84	2195.95

3.3 Socio Economic development

The country's economic sector is divided into three: primary - agriculture and mining; secondary - manufacturing, electricity, water and construction; and tertiary - services (NSB, 2015). In 2014/15, the tertiary sector recorded a sharp increase in real growth, from 0.3% in 2013 to 8.9% in 2014 (RMA, 2015).

The International Monetary Fund (IMF) in 2012 recognized Bhutan as the fourth fastest growing economy in the world (RGoB, 2013). Bhutan's GDP per capita in 2014 increased to USD 2, 611.7 from USD 2, 463.8 in 2013, and GDP growth rate at constant price dropped from 11.7% in 2010/11 to 5.5% in 2014/15 (RMA, 2015).

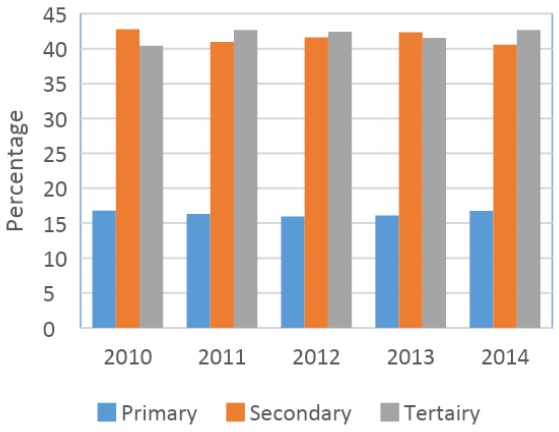


Figure 2: Share of major economic sectors to GDP. (Source: NSB, 2015)

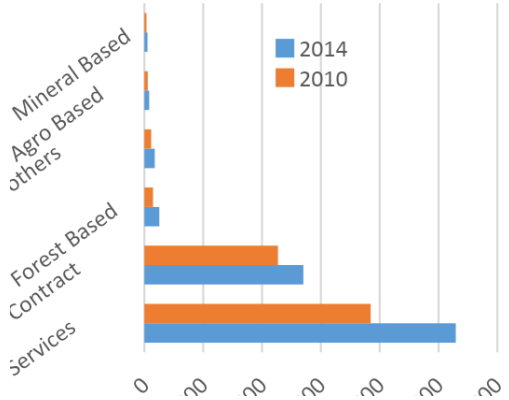


Figure 3: Types of Industries (2010 – 2014). Source: NSB, 2015

3.4 Industries

The major industrial activities include mining, manufacturing, wholesale and retail trade and other service industries. There were 69, 847 industrial establishments as of 2014 (NSB, 2015) Figure 3. The manufacturing sector consists of wood based, agro-based, and mineral-based industries and it accounted for 8.12% of GDP in 2014 while employing 7% of the total employed population. Mining and quarrying activities accounted 2.83% of the GDP, contributing to 0.9% employment in the same year (NSB, 2015)

Image 1: SEQ Image * ARABIC 1: Pasakha Industrial Area. Photo: Thinley Namgyel.

3.5 Energy

As per the record, stock of briquette decreased to 175.32 MT in 2021, constituting a decrease of about 515 compared to 2020. Further, disposal also decreased by almost 50% making a total of 167.82MT in the year 2021. The total timber supply in the economy decreased in 2021 compared to 2020. A total of 4.25 million Cu. ft. timbers were supplied in 2021, which was a decrease of about 47.7%. Of the total supply, 63.5% were supplied by DOFPS and 36.5% were supplied by NRDCL (Annual Environment Accounts Statistics 2022).

Bhutan imported oil at around 143, 169.0 KL in the year 2021 and most oil imports are for automobiles. It is reported that there is a decline of about 4.0% for petrol and an increase of about 9.0% for diesel import in the 2021. In terms of volume, the total supply of diesel increased from 100, 836.0 KL to 110, 330.0 KL and the supply of petrol decreased from 34, 291 KL to 32, 820.0 KL in the year 2021 (Annual Environment Accounts Statistics 2022).

In 2021, a total of about 85, 676.80 m^3 fuelwoods were supplied. Of the total, NRDCL supplied about 44, 477.19 m^3 which constitutes almost 52% and are supplied mostly to industries. The remaining 41, 199.61 m3 (about 48%) were supplied by the Department of Forest and Park Services mostly to the rural households (Annual Environment Accounts Statistics 2022).

The total supply of electricity decreased to 10, 920.33 Gwh in the year 2021 from 11, 471.09 Gwh in 2020, which decreased by about 5%. Almost 99.0% of total supply is internal generation, whereas imports account for barely 1.0% of total electricity supply. In monetary terms, the supply of electricity has decreased from Nu. 31, 653.02 million to Nu. 28, 452.52 million in the year 2021, which is a decrease of about 10% (Annual Environment Accounts Statistics 2022).

3.6 Urbanisation

Although 55% of Bhutan's population reside in rural areas, (DoL 2014), the pace of urbanisation is accelerating. Only 5% of the total population was estimated to live in urban areas in 1980. This increased to 15% in 1994 and 30.8% in 2005. The western region which includes the capital city (Thimphu) ranks the highest in terms of urban population (65.1%) and the central western ranks the lowest (7.1%).

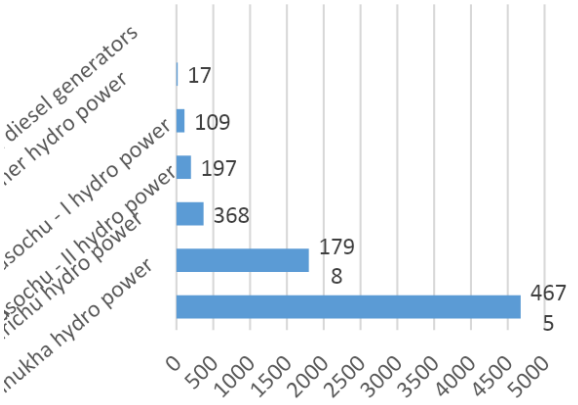


Figure 4: Electricity generation by hydropower stations, 2014 (Source: NSB, 2015)

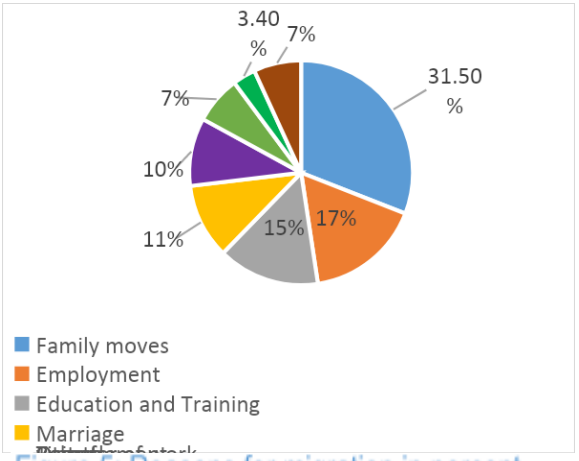


Figure 5: Reasons for migration in percent. Source: PHCB, 2005

3.7 Migration

Poverty, drudgery of rural life and the perception of better economic prospects in the urban areas have led to rural-urban migration as shown in Figure 5. Poverty Analysis Report (PAR) 2007 points out that incidences of poverty is less than 2% in the urban area vis-a-vis 23.2% in rural areas. The Rapid Impact Assessment of Rural Development (Planning Commission, 2007), also indicated that accessibility to services that could support income generation was only 16% in the rural areas.

Image 2: Traffic along Changlam in Thimphu. Photo: Thinley Namgyel, 2016

3.8 Tourism

Revenue generation from the tourism sector has decreased from USD 88.63 million in 2019 to USD 9.49 million in 2020. The number of tourists in 2019 was 315, 599 whereas in 2020 the number decreased to 29, 812 Bhutan at a Glance 2022).

3.9 Transport

Road is the main transport system. As of June 2022, based on Statistical Year Book 2022, the total number of vehicles in the country stands at 122, 865 which is a 61.41% increase from 2015. Light vehicles constitute 65.63%, 10.27% for heavy vehicles and 10.06% two wheelers which are mostly privately owned. Power tiller and tractor combines consist of 3.74% while Earthmoving equipment account for 3.30%. Electric vehicles represent only 0.29%.

Air transport was introduced in 1983 with links to neighbouring countries through the national airline (Druk Air). Private airline (Bhutan Airlines), joined the national carrier in November 2011. Domestic airline service was introduced in December 2011, operating on Paro - Bumthang, Yonphula – Gelephu route. A helicopter service has also been introduced.

3.10 Health services and infrastructure

The health system network comprises 58 hospitals, 179 primary health care centres, and 555 outreach clinics. There is now a widespread network of Health Facilities covering around 95% of the total population within three hours walking distance from the health facility (Statistical Yearbook of Bhutan 2022).

4. LAND

Pressure on the land is growing with economic development and population growth. The pressures are further compounded by the country's steep topography and mountainous environment. As a result of gradual increase in the population over the years, the population density of Bhutan increased from 17 persons per km^2 in 2005 to 19 persons per km^2 in 2017. While the population density of Bhutan at a gross level is quite low, the population density in arable and settlement areas has been significant with 85 persons per km^2 (NEC 2011).

4.1. Pressure

The drivers and pressures on the land resources are described in the National Action Program (NAP) to Combat land Degradation (MOAF 2014) and the National Biodiversity Strategy and Action Plan (NBSAP 2014). "Direct factors" are identified in the NBSAP and "Direct pressures" are identified in the NAP (table 3) and both can be classified as "pressures" in the DPSIR approach.

Table.3 Drivers and Pressures on land and resources as identified in the National Action Program to Combat Land Degradation and the National Biodiversity Strategies and Action Plan.

National Action Program (NAP) to Combat Land Degradation 2014	**National Biodiversity Strategies and Action Plan (NBSAP) 2014**
DIRECT FACTORS	**DIRECT PRESSURE**
Infrastructure development - Roads - Power transmission lines and distribution grids Urbanisation Industrial activities Mining	Land use conversion
Forest Fires Unregulated farming activities (burning of agriculture debris and pasture)	Forest fire
Excessive Forest Use	Over extraction of timber and fuelwood
Overgrazing	Overgrazing
	Forest offences and wildlife poaching
Unsustainable Agriculture - Imbalanced use of inorganic fertilisers - Steep slope agriculture - Use of plant protection chemicals - Irrigation management system	Unsustainable agricultural practices
Solid Waste	Pollution
INDIRECT FACTORS	**INDIRECT PRESSURES**
Climate Change	Climate change
Population Growth and Structure	Population
Poverty	Poverty
Policy and Institutional Issues	

4.1.1. Increasing pressure on State Reserved Forest Land[1]

Every year, thousands of hectares (ha) of State Reserved Forest Land (SRFL) are converted for various purposes and uses. The proportion of SRFL converted for different purposes varies from year to year (Figure 6). The pressure on SRFL comes mainly from the demand for infrastructure development such as construction of road, transmission infrastructures and other SRFL allotment i.e., allotment for various unspecified purposes. According to the statistics from Department of Forest and Park Services, a total of around 38, 000 ha of SRFL have been allotted for various purposes between 2015 and 2021, with road construction (16, 907 ha) being the highest followed by other SRFL allotment (9, 142.98 ha) and then construction of power transmission lines (6, 527.74 ha). However, there are no disaggregated statistics detailing how much of the SRFL allotted constituted forest cover and otherwise. SRFL is a broad term and although it largely constitutes forest, it may include water bodies and/or non-vegetated land cover.

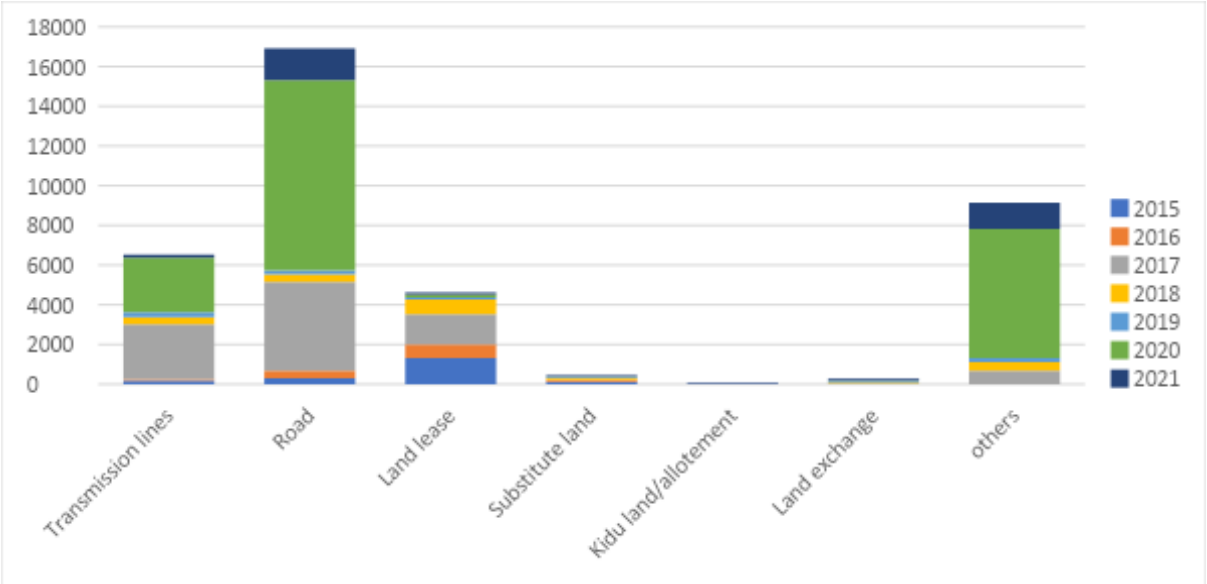


Figure 6: SRFL allotted for various purposes (in Ha) between 2015-2021 (Source: Forestry Facts and Figures, DoFPS)

As per NLCS 2021, the highest demand for lease of state land (Figure 7) was for commercial farming at 1, 228.94 acres followed by mining and business at 910.71 acres and 803.56 acres respectively. Further, a total of 533.466 acres of *kamzhing* and 77.513 acres of *Chhuzhing* were acquired in various districts and in turn, 569.713 acres of state land has been compensated for the acquisition.

[1] SRFL is referred in Forest and Nature Conservation Rules and Regulations of Bhutan, 2017

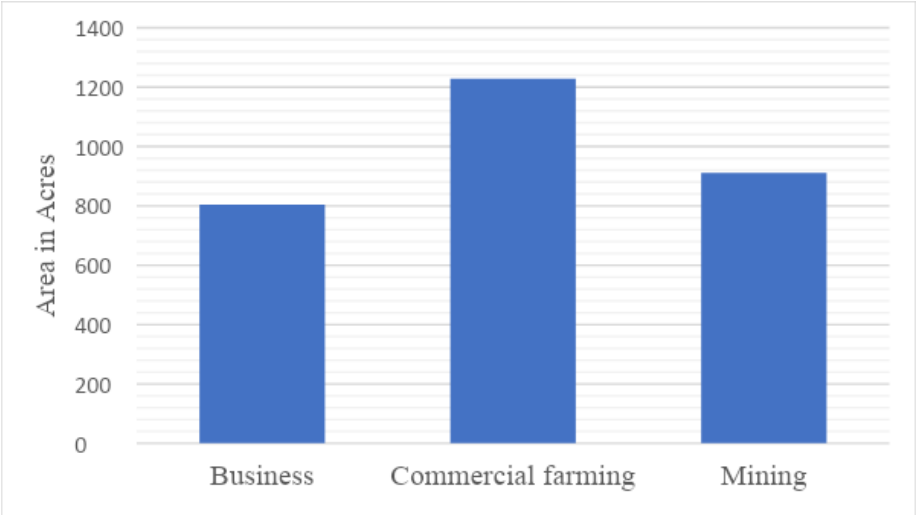


Figure 7: State Land leased between 2017-2021 (Source: NLCS, 2021)

4.1.2. Increasing demand for electricity and road services

Nearly 99.5% of electricity generation in Bhutan is from hydropower and roughly 75% of the total electricity generated each year is exported to India. The study carried out by DoFPS to understand the drivers of deforestation and degradation of forests underscored hydropower projects as one of the major drivers of deforestation. Forest loss due to construction of hydropower projects and transmission lines is evident across the landscape of Bhutan. The Ministry of Agriculture and Forest, 2017 estimated that around 2 ha of forest are lost for every MW of hydroelectricity generation capacity. Construction of PHPA-I, PHPA-II, and MHPA including their transmission infrastructures entailed clearing of approximately 1, 399.1 ha of forest cover (FRMD, 2019). On the other hand, the DoFPS has carried out compensatory plantation in around 991.1 ha of SRF land.

Similarly, about 16, 907.33 ha of SRFL was allotted for road construction between 2015 and 2021 (Figure 8). This is mainly due to accelerated construction of rural farm roads after 2008 (NEC, 2016). As per the statistical record of NSB, the total length of farm road increased from 1, 045 km in 2008 to 5, 128 km by 2013 to 11, 292 km by 2018. The changes in the length of "other roads" (i.e., PNH, SNH and access road[2]) is attributed to road reclassification carried out by the Department of Roads to fit proper definition. The *Dzongkhags* with the longest network of roads are Mongar, Trashigang and Samtse with total road length of 2, 041.7 km, 1, 285.06 km and 1, 256.57 km respectively. On the contrary, Gasa, Bumthang and Haa are the least connected *Dzongkhags* (Figure 9).

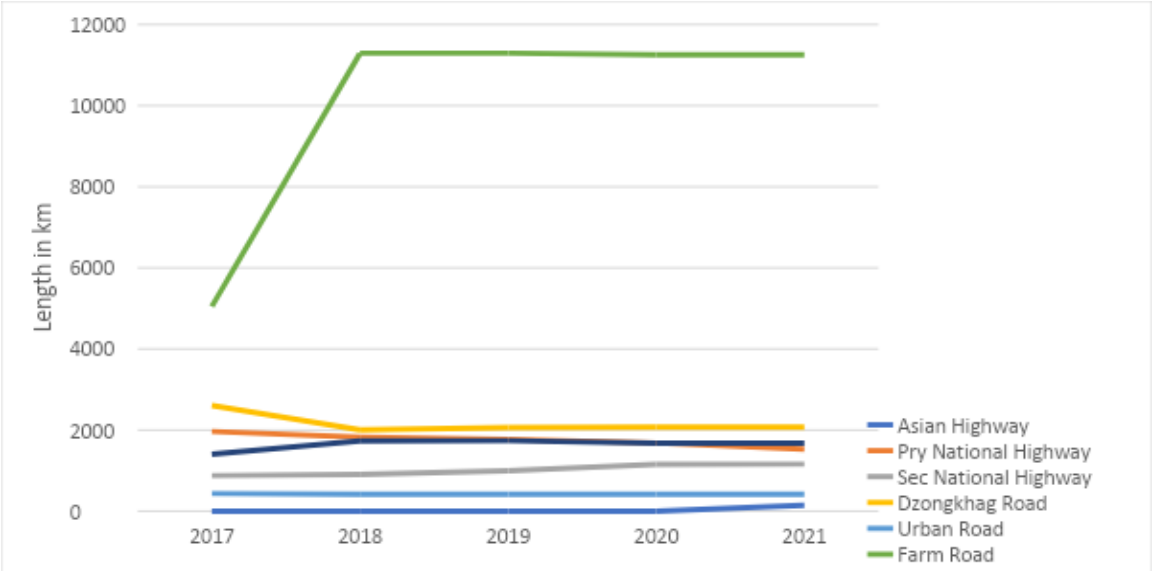


Figure 8: Types of roads and its length (km) in Bhutan (Source: SYB, NSB 2021)

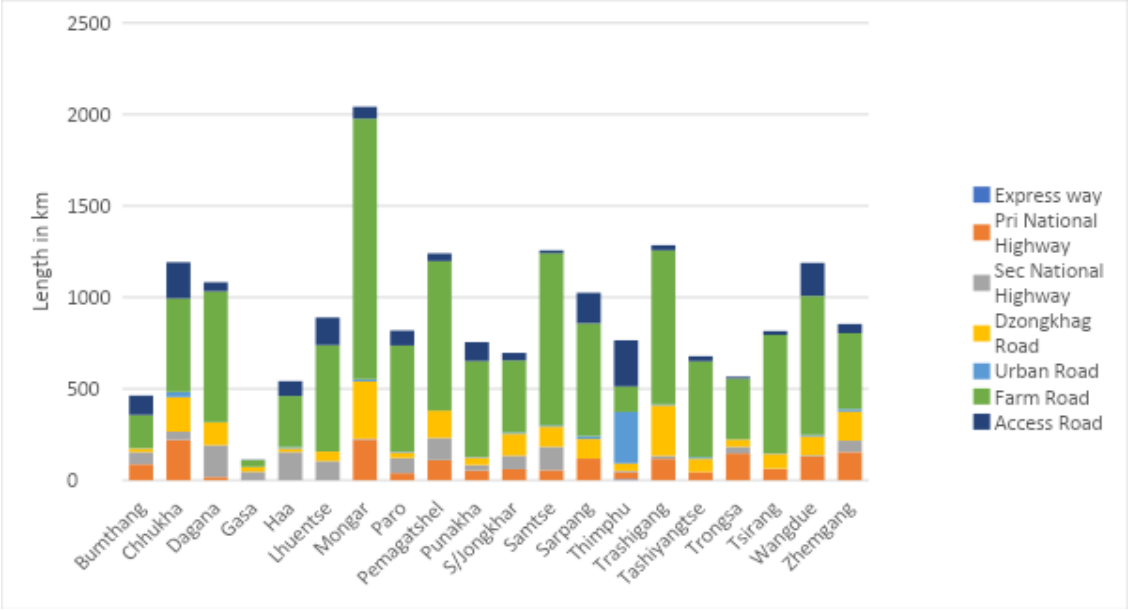


Figure 9: Length of road network by Dzongkhags as of 2021 (Source: SYB, NSB 2021)

4.1.3. Demand for timber and fuel wood

Bhutan has a relatively small percentage (14% including community forest) of forest area suitable for sustainable commercial timber production. According to national statistics, timber production between 2015 to 2021 was around 1.98 million m^3 and almost 72% of the total timber supply was subsidised.

The demand for timber is driven by the construction sector especially after events of natural or manmade disasters. There was high demand for timber from 2012 to 2013 for reconstruction of houses, monasteries and other infrastructures in western Bhutan after the earthquake of September 18, 2011 (NEC, 2016). Similarly, around 453, 570.11 m^3 of timber (Figure 10) was supplied in 2015 alone and this may be due to demand for construction of the Wangdue Phodrang Dzong, following the fire incident of 2012.

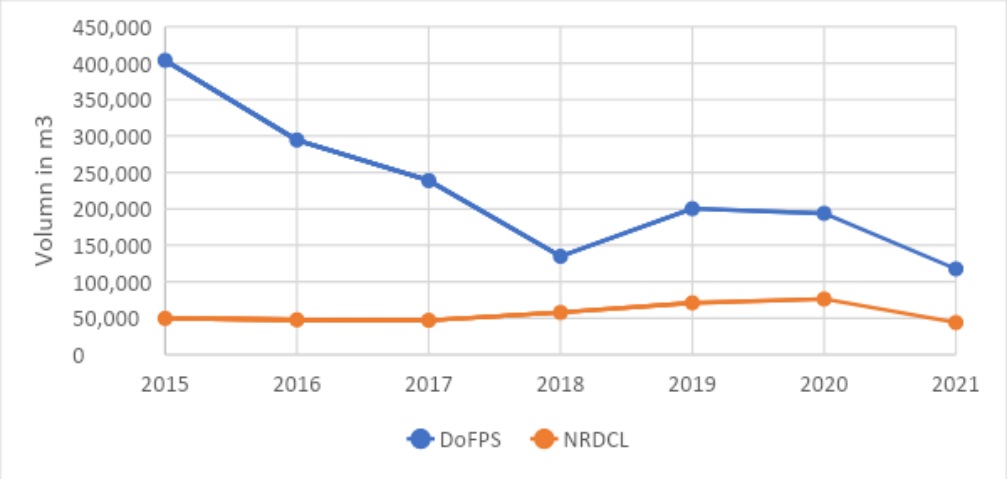


Figure 10: Timber produced and supplied by DoFPS and NRDCL (Source: Forestry Facts and Figures and Annual Reports, NRDCL)

Although the demand for fuelwood appears to be declining, Bhutan's per capita fuelwood consumption of 1.17 metric tons per annum is considered to be one of the highest in the world. 33.3% of rural households and 0.7% of urban households use fuelwood as a source of energy for cooking, while 59.8% of households in rural areas use wood for space heating, but only 14.5% of urban households use wood for space heating (UNESCAP, 2021). Around 786, 688.31 m^3 of fuelwood has been supplied (by DoFPS and NRDCL) from 2015 to 2021 (Figure 10). Pressure on forests outside of formally managed production areas is higher than in managed areas. It can also be observed from Figure 10 and Figure 11 that a substantial amount of timber and fuelwood have been supplied from outside of FMUs by the DoFPS compared to the timber and fuelwood supplied by NRDCL from FMUs and other managed concessions.

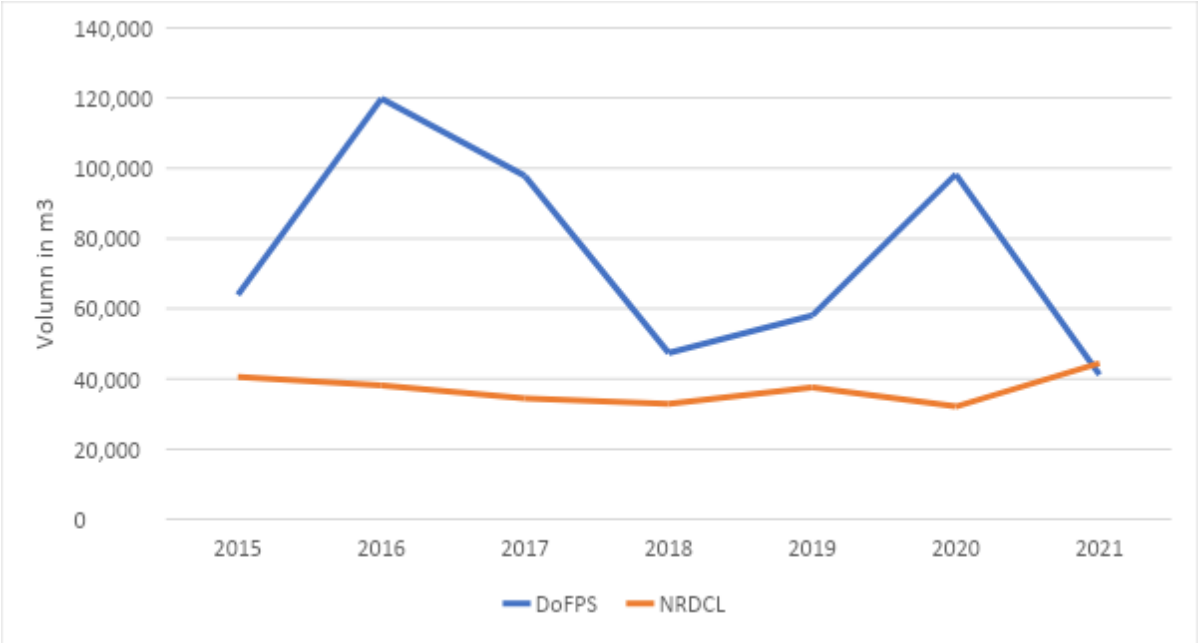


Figure 11: Fuelwood supplied by DoFPS and NRDCL (Source: Forestry Facts and Figures, DoFPS and Annual Reports, NRDCL)

4.1.4. Forest fire

Each year, Bhutan loses thousands of hectares of forest areas to fire. However, there was a decline in both incidence of forest fire and total forest burned from 2015 to 2020, which slightly

rose in 2021 (Figure 12). Between 2015 and 2021, 321 forest fire incidents were recorded in the country affecting about 45, 521.53 ha of forest areas, or an annual average of 6, 503.08 ha.

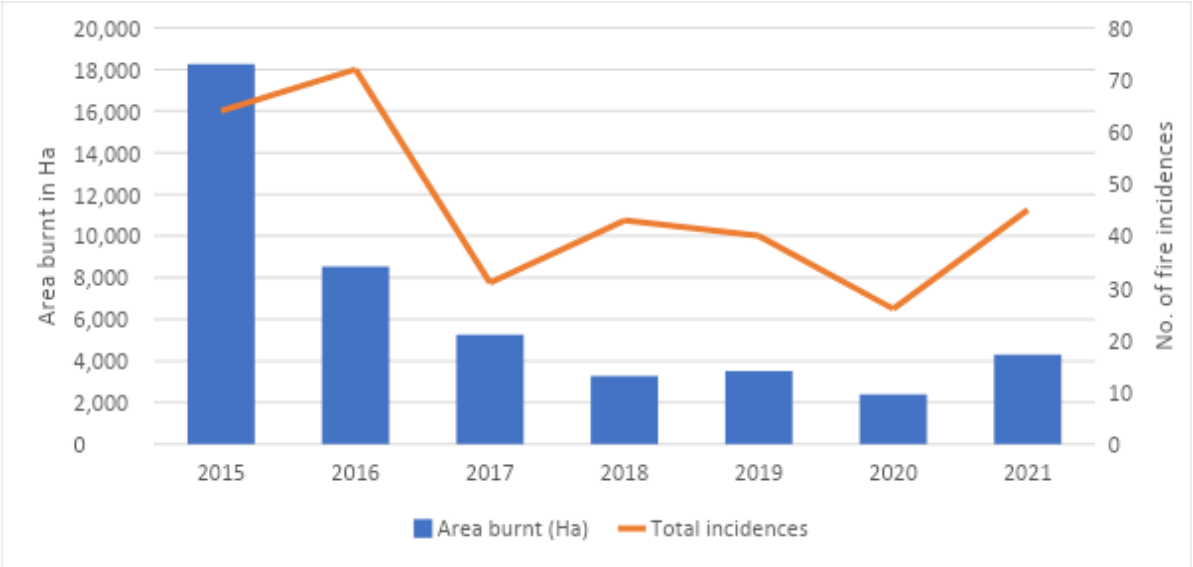


Figure 12: No. of forest fire incidences and area burnt from 2015-2021 (Source: Forestry Facts and Figures, DoFPS)

The *dzongkhag*-wise statistics of forest fire for the same time period indicates that Mongar and Wangdue Phodrang are the most affected *Dzongkhags* in terms of total area burnt (Figure 13). The *Dzongkhags* with highest incidences of forest fires are Wangdue Phodrang, Thimphu, Mongar, and Punakha. Although Thimphu has seen high incidences of forest fires, the total area affected is much lower than in the other affected *Dzongkhags*. This could be attributed to the population and human activity in Thimphu as both a cause of forest fire and also for response for firefighting.

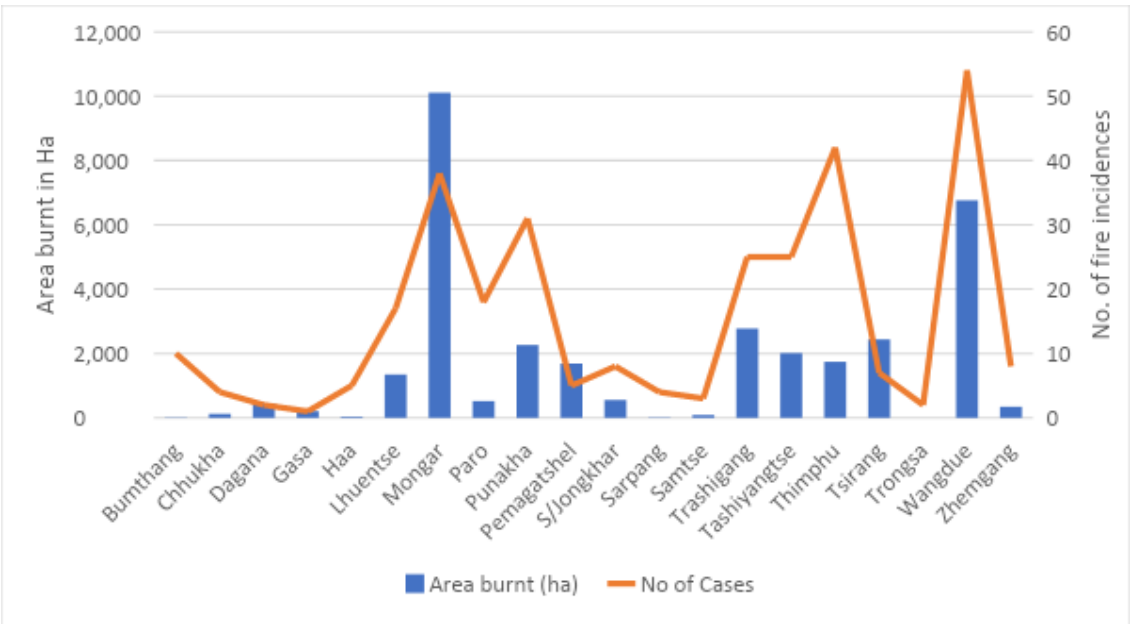


Figure 13: Dzongkhag wise distribution forest fire and area burnt from 2015-2021 (Source: Forestry Facts and Figures, DoFPS)

4.1.5. Mining and mineral extraction

Mining is one of the fastest growing sectors in the country and has historically been among the top four SRFL allotments. Currently, there are 31 active mines and 50 stone quarries accounting for 0.04% of Bhutan's area (DGM, 2021). In addition, there are 4 non-operational mines and 12 non-operational stone quarries, which are attributed to market issues. Further, there are 27 permit holders for collection of minerals (i.e., dolomite, limestone, red soil and stone) from the riverbeds and land surface (mostly land development).

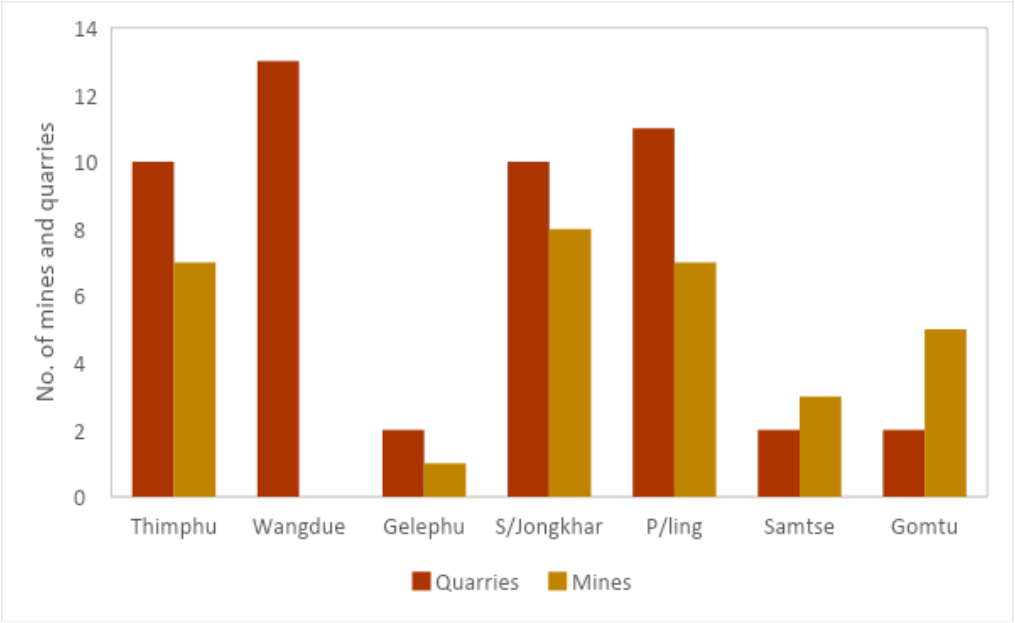


Figure 14: No of active mines and quarries based on regions (Source: DGM, 2021)

Some of the minerals mined in Bhutan are gypsum, dolomite, quartzite, talc, limestone, marble, coal, iron ore, calc tufa, phyllite and construction materials. On average, the total production of various minerals had increased steadily until 2020 (Figure 15). However, the widespread impact of COVID-19 pandemic caused supply chain disruptions and lack of manpower in the mining sector leading to a decline in production in 2020. However, with the restrictions easing and production rising, the mining sector has been recovering since then.

The mining sector is expected to continue exerting pressure on SRFL in the following years. In addition, mining activities have substantial impacts on the land environment, among others, through irreversible change of topography, land degradation, soil contamination and erosion.

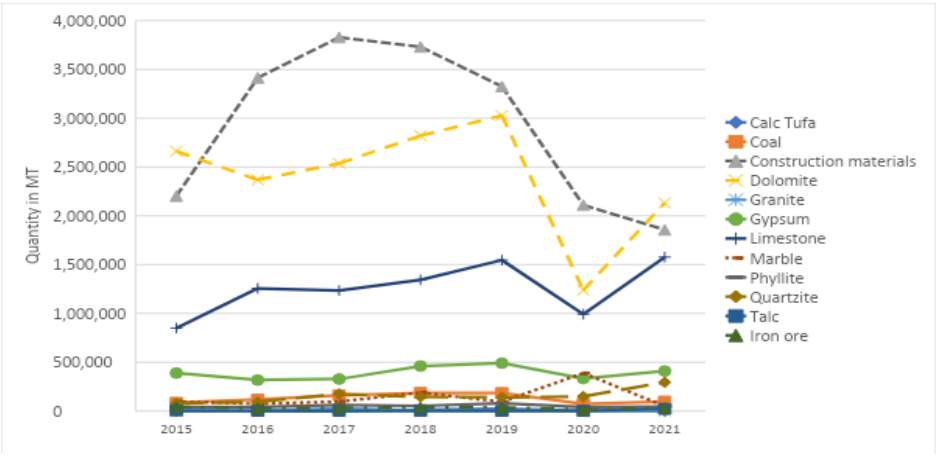


Figure 15: Mineral production by type from 2015-2021 (Source: DGM, 2021)

Further, NRDCL reported increasing production of stone and sand from 2015 to 2011-2019 followed by a decline in production in 2020 as shown in Figure 16. This decline in production coincides with the covid-19 pandemic.

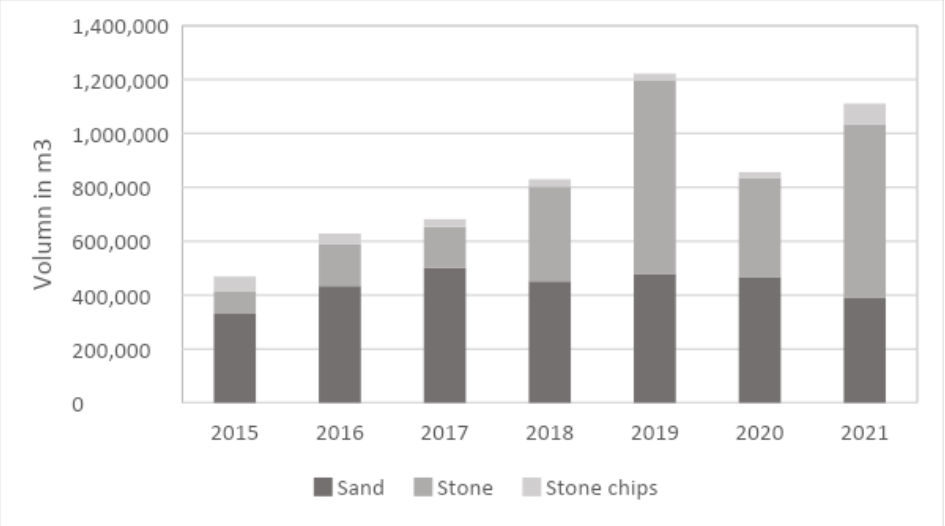


Figure 16: Sand and Stone supplied from 2015 to 2021 (Source: Annual Reports, NRDCL)

4.1.6. Urbanisation

Despite being a small developing country, Bhutan is urbanising at an accelerated rate. Urban population has increased from 196, 111 persons (30.9%) in 2005 to 274, 967 persons (37.8%) in 2017 (PHCB, 2017). The Bhutan National Urbanization Strategy 2008 estimated annual urban population growth rate at a significant 7.3% against the overall population growth of 1.3%. The strategy also projects that additional land will be required nationally to accommodate urban areas and recognizes that agricultural lands would bear the most pressure from urban development.

Further, the NAP to combat land degradation 2014 has identified urbanisation as a direct factor leading to land degradation in Bhutan primarily due to direct utilisation of agricultural land and increased requirements for construction materials such as sand and stones and timber along with requirements for waste dumpsites and impacts from pollution.

4.1.7. Grazing by livestock

Grazing of livestock inside forests is an integral part of the farm production system in Bhutan. Both the NAP 2014 and NBSAP 2014 identified overgrazing as a contributor to land degradation in Bhutan. Livestock grazing, when unregulated, can adversely affect forests. The impact of grazing is usually localised, and varies from place to place depending on the forest types and grazing intensities. There is also anecdotal evidence that grazing can adversely impact regeneration in localised areas particularly following forest harvesting in FMUs.

Majority of the cattle grazing takes place in forests, open pastures and grasslands on a free-range basis. Due to migratory practices, most grazing areas in temperate zones are subject to grazing throughout the year by cattle in summer and yaks in winter (MOAF, 2014). NBSAP notes that the issue of overgrazing is still not clear due to lack of detailed studies and notes that other factors may also affect grazing areas. However, the population of free grazing cattle and yaks are seen to be diminishing gradually (Figure 17) over the past decade and this trend suggests a decline in the pressure on land from grazing (MoAF, 2017).

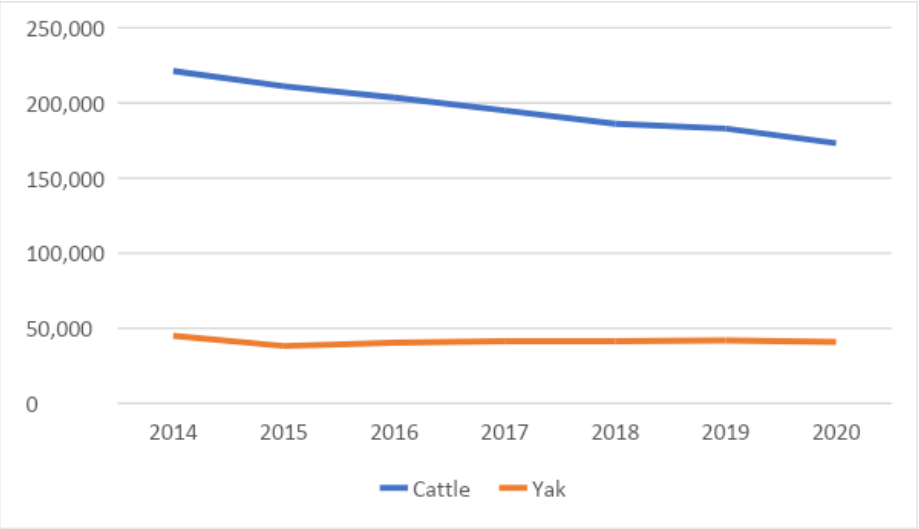


Figure 17: Trends in population of cattle and yak in Bhutan from 2014 to 2020 (Source: Annual Reports, DoL and SYB)

4.2. State

4.2.1. Land Cover

The land use and land cover (LULC) assessment of Bhutan, 2016 reports that the forests (excluding shrubs) remain the dominant land cover in Bhutan covering 70.77% of the total area. This is followed by shrubs (9.74%), snow cover (5.35%) and alpine scrub (3.39%). Rocky outcrops (3.12%), agriculture (2.75%), meadows (2.51%), scree (1.03%), water bodies (0.65%), moraines (0.37%), built up area (0.19%), landslide (0.10%) and non-built up area (0.02%) constitute the remaining land.

There was no significant difference between LULC assessment carried out in 2010 and 2016 (Figure 18). The total forest coverage in the Land Cover Map Project (LCMP) 2010 was 70.46% while the assessment in 2016 shows 70.77%. And cultivated agricultural land was 2.93% in LCMP 2010, while LULC showed 2.75%. The only significant difference was observed in snow and glaciers, which decreased from 7.46% (LCMP 2010) to 5.35% (LULC 2016).

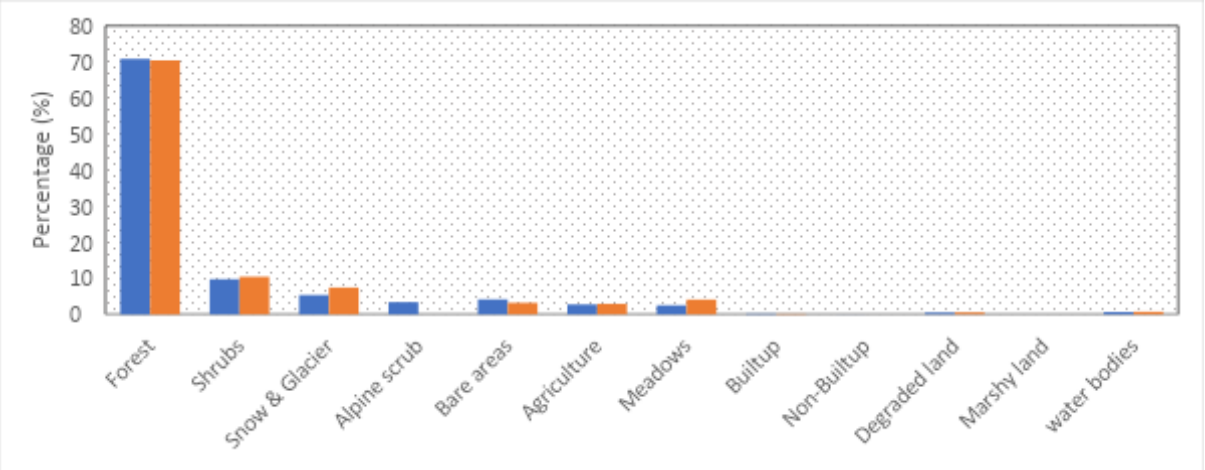


Figure 18: Comparison of LCMP 2010 and LULC 2016 (Source: FRMD, 2017)

4.2.2. Forested land

The forest cover of Bhutan marginally increased from 70.46% in 2010 to 70.77% in 2016 (FRMD, 2017). As per the National Forest Inventory (NFI) 2016, which spanned from 2012 till 2015, 2, 730, 889 ha of Bhutan's total area is under forest cover. The dominant forest type is broadleaf forest with 45.99% followed by mixed conifer with 13.53%. Fir forest, which dominates high altitude areas comprises 6.02% while blue pine and chir pine constitutes 2.64% and 2.59% respectively.

The NFI also estimated the biomass and carbon stock of forests. The total biomass of forests is estimated to be about 1, 109 million tonnes, which translates to 521 million tonnes of carbon, while the total forest carbon stock is estimated to be 709 million tonnes including 188 million tonnes of carbon stored in forest soils as soil organic carbon. It was found that the total biomass stock is greater in broadleaf forest with 726 million tonnes than conifer forest of 329 million tonnes of biomass. This corresponds to 341 million tonnes of carbon in broadleaf forest and 155 million tonnes of carbon in conifer forest.

4.2.3. Agriculture land

The traditional subsistence oriented mixed farming system that includes cropping, livestock rearing and use of non-wood forest products for sustenance is still practised in Bhutan. Due to the terrain of the country, agriculture is predominantly practised around human settlements which are located on mountain slopes. Around 31% of agriculture occurred on lands more than 50% slope (NSSC, 2014). Steep slope agriculture is inherently risky and such cultivation requires proper water and soil conservation measures to sustainably manage and maintain the integrity of the agricultural lands.

As per LULC, 2016, cultivated agricultural land stands at 2.75% (equivalent to 105, 682.43 ha) and is dominated by *Kamzhing* (arable dryland) constituting 1.78% (68, 260.64 ha). This is followed by *Chhuzhing* (paddy cultivation) with 0.83% (31, 891.87 ha) and lastly orchards comprising 0.14%. In comparison to the LULC 2016, the RNR Census 2019 indicates higher area of *kamzhing* under cultivation while area under *chhuzhing* cultivation was lower. The differences in the area statistics of agricultural type can be attributed to the different data types of land ownership which may differ from actual use (NEC, 2016).

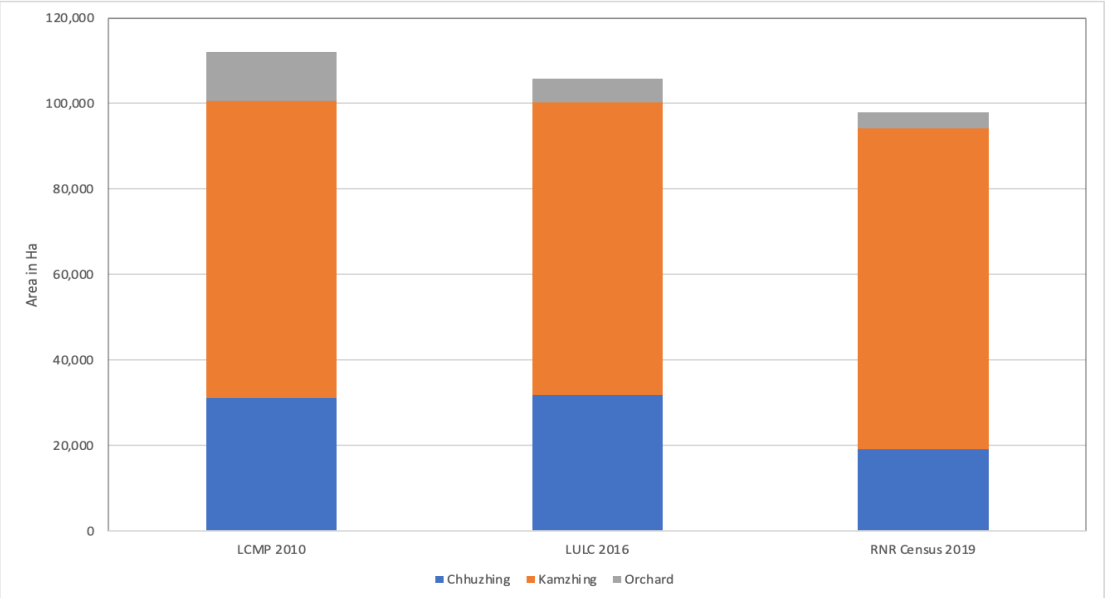


Figure 19: Area of land use under different agricultural land use (Source: SYB, 2021)

The trend in agricultural land use has been driven by conversion of agricultural land to other uses, particularly for developmental activities. From 2016 to 2021, a total of 533.47 acres of *kamzhing* and 77.51 acres of *chhuzhing* were lost to various developmental activities (Figure 20). The highest conversion was seen in 2021 after the commencement of the *Gyalsung* Project, in which 142.245 acres of *kamzhing* and 34.783 acres of *chhuzhing* were acquired.

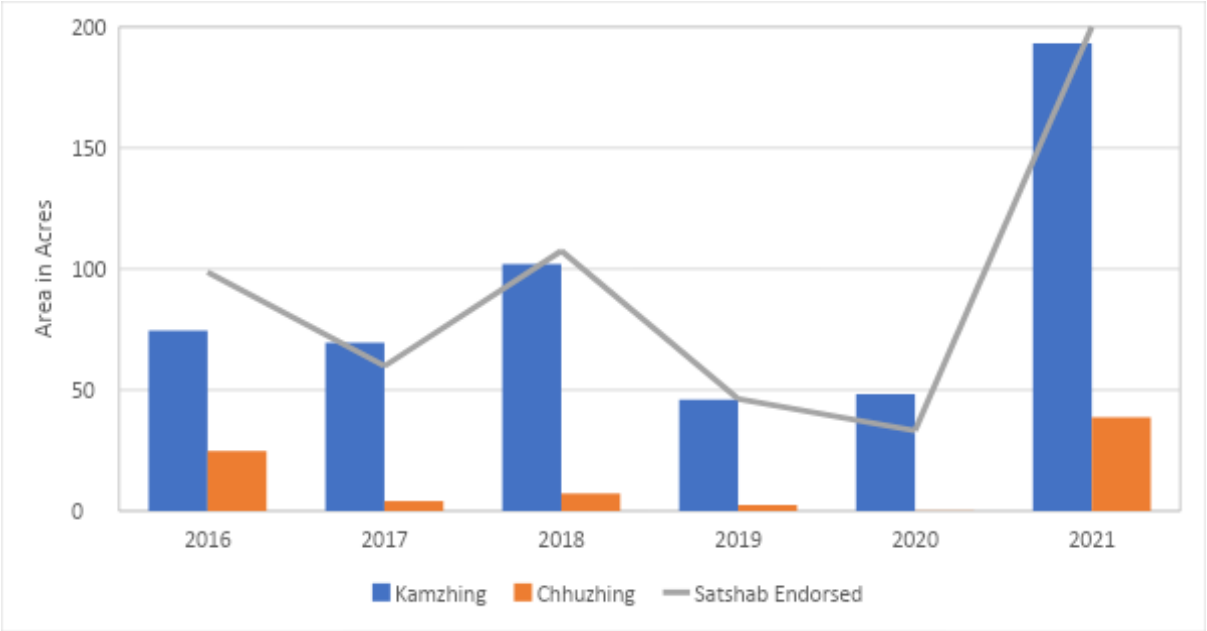


Figure 20: Total dry and wet land converted for various purposes from 2016-2021 (Source: NLC, 2021)

4.2.4. Degraded land

Degraded land includes areas that are permanently or semi-permanently degraded either due to natural processes or human interventions and can be landslide areas, gullies, ravine and moraines. The LULC assessment reports 0.47% of Bhutan's total area as degraded areas with 0.10% classified as landslide areas and 0.37% as moraines.

Information on areas of landslides and natural erosion areas, state of the degraded lands is limited. While many causes and pressures of land degradation are often identified in the NAP to Combat Land Degradation 2014 and the NBSAP 2014, it is not known to what extent and state the different categories of land such as forests, grasslands and agricultural land are degraded.

4.2.5. Built-up land

Built up areas include artificial constructions covering the land with an impervious surface. It includes settlements, urban areas, schools and institutes, industrial areas, hospitals, transport and other infrastructures. The built-up area in 2016 was 7, 457.03 ha or 0.19% of total land area. Between the LCMP in 2010 and LULC assessment in 2016, the area of built-up land increased from 6, 150.87 ha (0.16% of total land area) to 7, 457.03 ha (0.19% of total land area).

4.2.6. Non-built-up areas

Non-built-up areas include waste dump sites, mines, stone quarries and other extraction sites, which comprised 330.1 ha (0.01% of total land area) in 2010 and increased to 595.89 ha (0.02% of total land area) in 2016.

As per Geosciences and Mining Journal 2021, there were 31 active mines and 50 stone quarries covering an area of 1, 713.19 ha. 4 mines and 12 stone quarries were reported non-operational due to market issues, however the area of these non-operational mining activities are not

mentioned. Samtse, Chhukha and Wangdue *Dzongkhags* have the highest number of mines and quarries (Figure 21), which is mainly due to a combination of presence of mineral deposit, high demand and their proximity to industries and market.

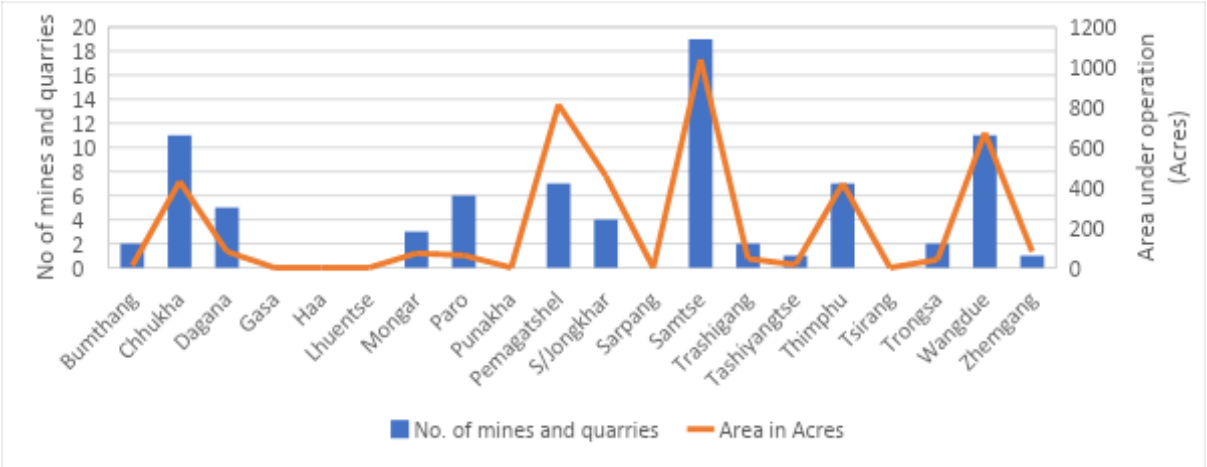


Figure 21: No. of mines and quarries and area under operation (Source: DGM, 2021)

4.3. Impact

4.3.1. Biodiversity

Both natural and anthropogenic pressures on land have major impacts on the rich biodiversity of Bhutan. The impacts from pressures on land include direct loss of forest cover due to anthropogenic activities such as timber harvesting, logging, fodder and fuel wood collection, agriculture clearing, RoW clearing and so on. These activities contribute to habitat fragmentation and loss of biodiversity. Further, increased road development in remote and previously inaccessible areas may increase access for illegal resource extraction.

4.3.2. Air quality

Vegetation plays an important role in atmospheric purification and air pollutant reduction. The loss of vegetation cover due to forest fire, timber harvesting, mining, agriculture clearing, RoW clearing, urbanisation and so on has potential to impact air quality through increased suspended particulate matter and other pollutants.

4.3.3. Water resources

The loss of vegetation, riparian buffers, wetlands and other natural lands increases sediment load and other pollutants in water, alters stream flows, erodes river or stream banks, and affects aquatic life as covered in the chapter on water, and also potentially increases the operating costs of hydropower generation.

Land and forest degradation in watershed areas may contribute to decrease in water availability. According to an assessment on drinking water sources conducted by the Public Health Engineering Division in 2012, drying up of drinking water sources has been reported in various *Dzongkhags*.

4.3.4. Landslides

Due to the steep terrain and fragile geology, most landslides in Bhutan are found on cut slopes and the embankments of roads and highways. Landslide related risk to lives, livelihoods, infrastructures, properties and environment is on rise in the last decade due to increasing intensity of rainfall induced by climate change and interactions of human activities with nature.

4.3.5. Food production

The loss of agricultural land has the potential to reduce food availability and contribute to food insecurity. The area cultivated for many cereal crops has been declining in the last few years (Figure 22). As a result, the production of the same cereal crops has been decreasing (Figure 23) despite improvements in technology and management techniques.

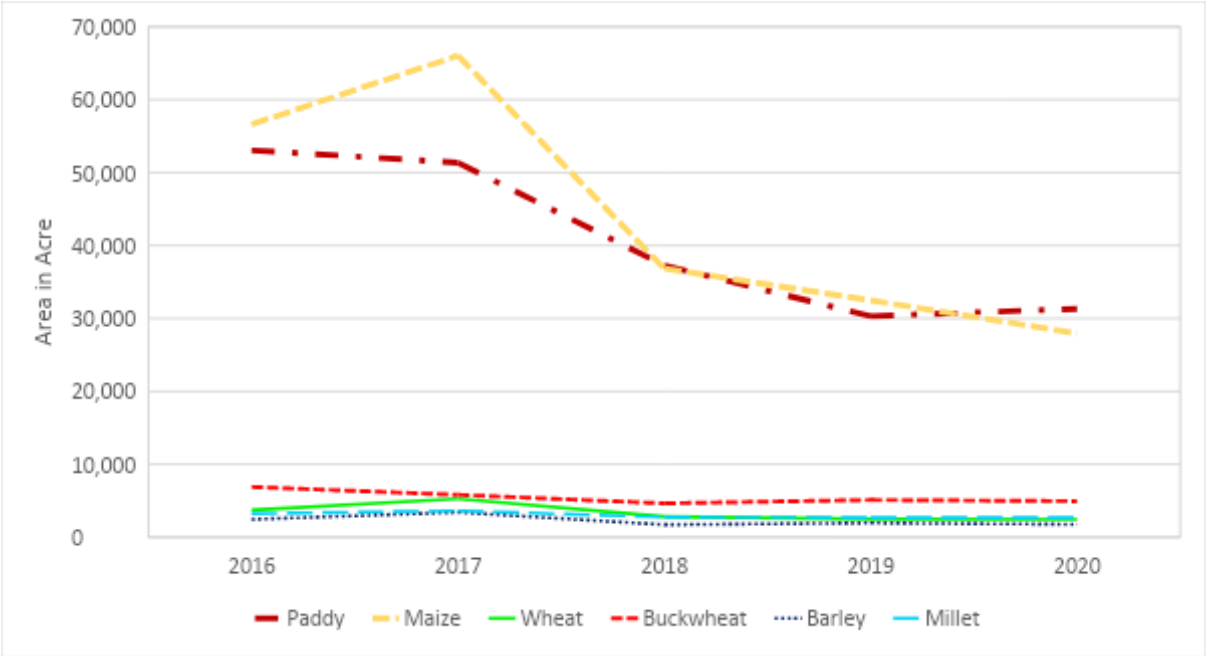


Figure 22: Harvested area for cereal crops from 2016 to 2020 (Source: SYB, 2021)

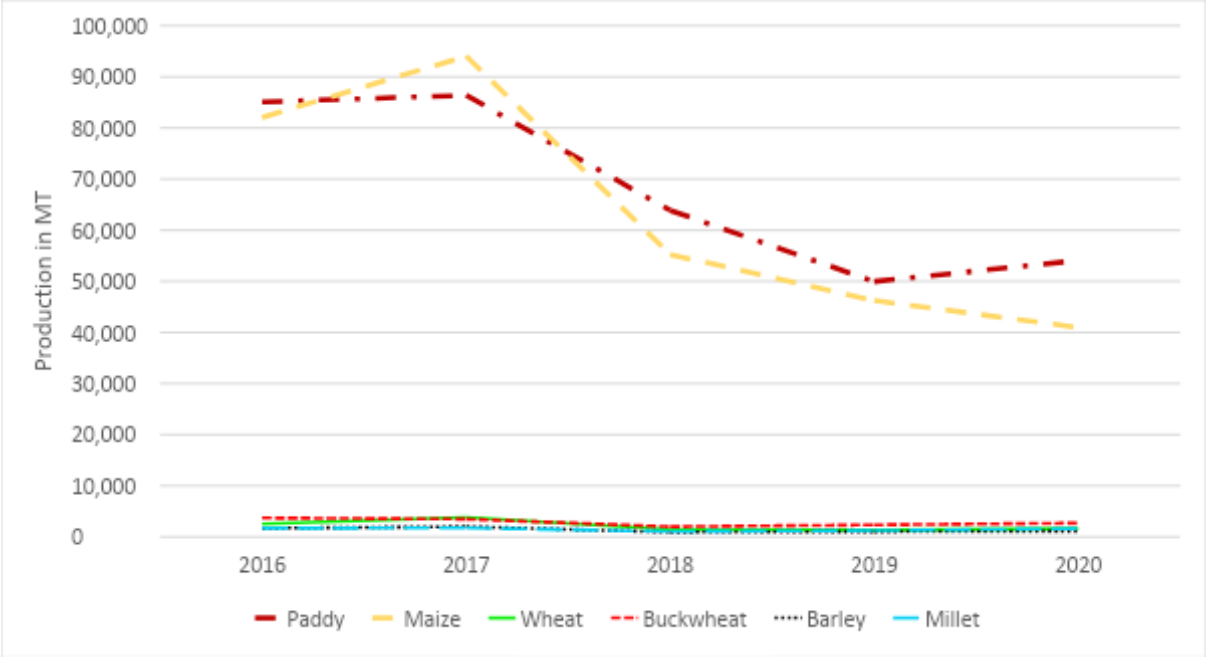


Figure 23: Production of cereal crops from 2016 to 2020 (Source: SYB, 2021)

4.4. Response

4.4.1. Legislation

A number of legislation and policies have been put in place for the sustainable management of land and its resources. The Constitution of the Kingdom of Bhutan 2008 mandates environmentally sustainable and justifiable sustainable development and mandates the

government to ensure 60% forest cover for all time and also identifies the roles and responsibilities of both citizens and government in this regard. Several legislations such as the National Environment Protection Act 2007; The Land Act of Bhutan 2007; Environment Assessment Act, 2000; Forest and Nature Conservation Act of Bhutan, 1995; Mines and Minerals Management Act of the Kingdom of Bhutan, 1995; Waste Management and Prevention Act of Bhutan, 2009; The Water Act of Bhutan 2011; and contain mandates for sustainable management of land. Details of the provisions of these legislations are further elaborated in Annexure II.

Some of the relevant processes arising from the above legislation include safeguard measures such as Environmental Assessment including EIA for major development activities. For example, Strategic Environmental Assessments have been conducted for Dhamdum Industrial Estate and Punatsangchhu basin.

4.4.2. Policies and strategies

Several policies also guide land management such as National Forest Policy 2011, Food and Nutrition Security Policy 2014, Economic Development Policy 2016, Climate Change Policy of the Kingdom of Bhutan 2020.

4.4.3. Sustainable land management

Sustainable Land Management is now implemented as a regular program through the Land Management Unit at NSSC. Implementation of SLM to combat land degradation in the country is also to fulfil the requirements/obligations as a member country to United Nations Convention to Combat Desertification (UNCCD). SLM technologies and approaches are being promoted and implemented in the field in collaboration with farmers, D*zongkhag* and *Gewog* extension and regional research centres. In addition to the RGoB budget additional funding supports are explored in order to implement SLM activities.

4.5. R*ecommendations*

There are adequate legislative tools and policies for sustainable land and forest management. However strategic assessments and planning and application of existing measures and tools are required to ensure integrated and holistic management across sectors. Some of the specific recommendations include:

4.5.1. SEA for new *Thromde* plans

Implement Strategic Environment Assessment (SEA) for urban (new *Thromde* plans) and infrastructure planning, including impacts beyond urban or project boundary.

4.5.2. Integration of food and nutrition security into development planning

The food and nutrition security policy must be integrated in overall decisions on land conversion planning for development activities.

4.5.3. Identification and prioritisation of critical forests, habitats, and watersheds

Identification and prioritisation of critical forests, habitats, and watersheds needs to be completed for sustainable management of land and water resources.

4.5.4. Land capability mapping

Land capability mapping should be carried out in order to identify areas that can sustainably support various uses such as agriculture or other development activities.

4.5.5. Studies on ecological footprint and local ecological carrying capacity

Studies on ecological footprint and local ecological carrying capacity should be carried out to support policy makers, planners, decision makers and managers in development planning and land management as per Constitutional mandates on "ecological degradation".

5. WATER

Water in Bhutan is a strategic resource that not only sustains human livelihood and ecosystems but also forms the basis of socio-economic development through its contribution to agriculture, hydropower, water based-industries, and tourism. Bhutan is known to have the highest per capita water availability in the world. Bhutan's freshwater ecosystems comprises snow, glaciers, lakes, rivers, streams, springs, wetlands, peatlands and marshes. Rivers, the primary source of water in Bhutan are mostly fed by rainfall and supplemented by glacial and snow melt.

Bhutan has five major and five minor river systems that drain through separate basins. The river systems (22,684.66 ha) and their hydrological basins (38, 39, 400 ha) are shown in Figure 24.

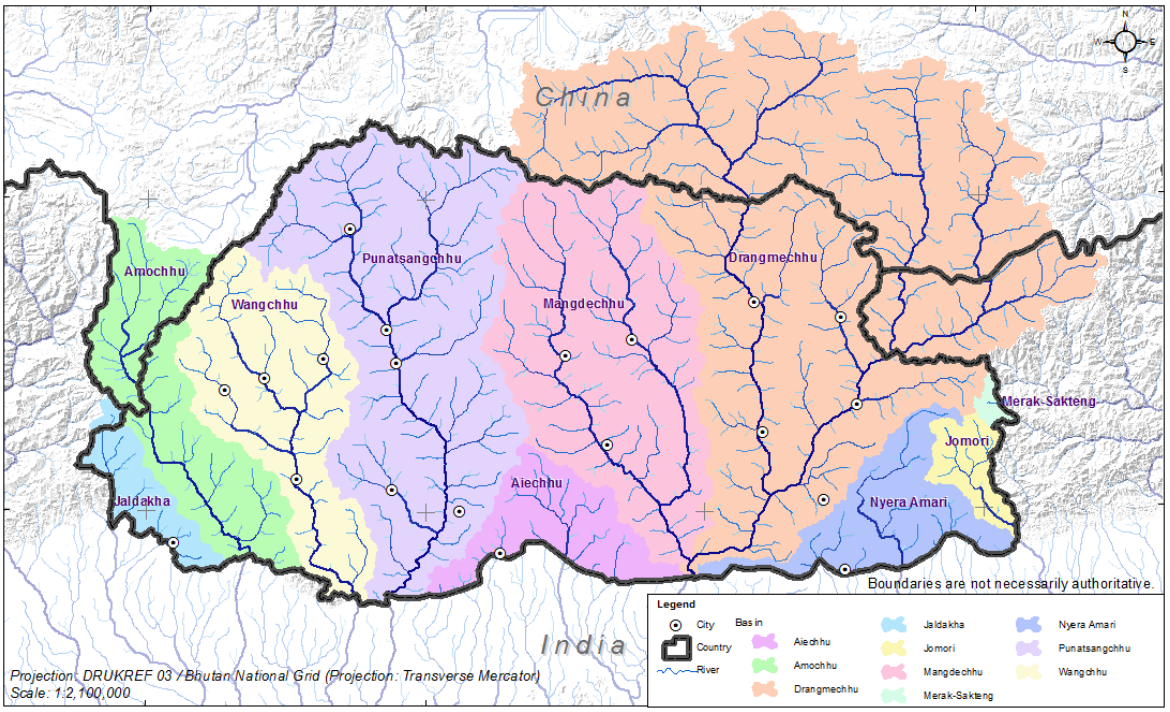


Figure 24: River systems and hydrological basins.

5.1 Pressure

5.1.1 Increased water demand

The United Nations Water Development Report 2022 indicates that the global water use is likely to increase over 20 to 30% of the current water use by 2050, largely due to increasing demand in the industry and energy sectors, and increasing domestic uses to enhance water and sanitation service coverages. In Bhutan, agriculture accounts for nearly 94.08% of water use, 5.03% for domestic consumption and 0.89% for industrial purposes (Bhutan Water Facts, 2018). About 99.5% of households in Bhutan have access to improved water sources with a majority of them being piped water. However, only 63% of the population has 24 hours access to drinking water, indicating that some population still does not have a continual supply of water.

The water demand in Bhutan has increased over the years due to urbanisation, population growth, change in lifestyle and economic advancement thus increasing pressure on water dependent sectors. The climate and hydrological projections further suggest an increase in frequency and duration of dry spells resulting in reduced flows and recharge of aquifers thereby limiting the available water sources and enhancing water shortages (Assessment of climate risk on water resources of Bhutan, NAP). The table 4 below projects the water demand for the drinking, industrial and irrigation water until the year 2030-2050.

Table 4: Current and future water demand for the water sectors in Bhutan

Sectors	Population/total irrigated area (Ha)	Drinking water demand	Water required 2017 (MCM/Yr)	Population in 2050	Water Demand LPCD	Water Required 2030/2050 (MCM/Yr)
Drinking water	727,145	150	39.81	1,039,090	300	113.78
Industry & others	-	-	74.39	-	-	218.35
Irrigation water	25011	-	666.9	-	-	911.8

5.1.2 Increased waste generation

The water quality monitoring conducted by the NECS indicates that Bhutan's water resources are healthy at the macro level. However, at localised level, the quality and aesthetics of water bodies has deteriorated due to illegal dumping of solid waste, agricultural run-off, and discharge of untreated or inadequately treated wastewater including domestic and industrial effluents. The release of solid waste and wastewater into the water bodies without adequate treatment reduces the ability of water resources to support its ecosystem services thereby affecting human health and ecosystem.

With the increasing number of vehicles in Bhutan, water pollution due to automobile wastewater is also increasing, especially in the areas where automobile workshops are located along streams and rivers. Zangmo (2016), reported that as per the study carried out by Asian Development Bank, Bhutan approximately generates 6.5 million litres of automobile wastewater every year with around 21.2 million litres of automobile wastewater predicted to be generated by 2018.

5.2 State

5.2.1 Water resources and availability

Bhutan has one of the highest per capita water resource availability in the world with 94,500 m^3/capita/annum (NEC, 2016). Most of the river discharge is fed by rainfall, with the monsoon and pre-monsoon forming 88% of the annual precipitation, followed by an estimated 2-12% glacial melt and another 2% from snow melt. The total drainage basin of the river is at an area of 580, 000 km^2 (MDPI Journal, 2021). Glacial and glacial lakes serve as freshwater storage and also

forms the water sources for some major rivers in Bhutan. There are 110 supra-snow lakes mostly in the head water sources of Mangde Chhu watershed and 495 floating supraglacial lakes with most of it in Punatsangchhu basin (Mapping wetland in Bhutan). The Glacial Lake Inventory, 2021 states that there are 567 glacial lakes with an area 55.04 ± 0.055 km^2, accounting for 19.03% of the total water bodies and 0.14% of the total land area of Bhutan (Glacier Lake Inventory 2021, NCHM).

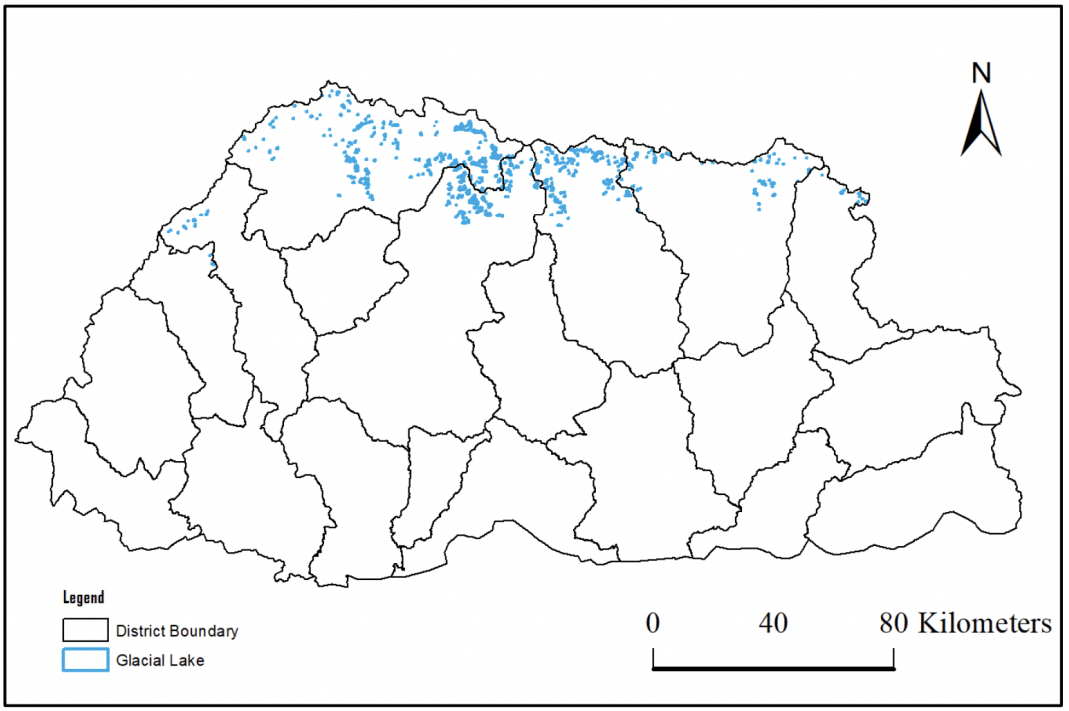


Figure 25: Distribution of glacial lakes in Bhutan

Bhutan is divided into 186 watersheds. 20 sub-basins with a total area of 5, 18, 882 ha have been identified as critical watersheds, of which the largest area (1, 32, 083 ha) is located in Kurichhu sub-basin. Wetlands are an important water resource in Bhutan and consist of water bodies such as high altitude wetlands, marshes, bogs, lakes and swamps. A total of 3, 027 high-altitude (above 3000 masl.) wetlands, including supra-snow lakes, supra-glacial lakes, glacial lakes, lakes in alpine meadows, sub-alpine habitats and marshes, (Bhutan Water Facts, 2018) have been mapped. The high altitude wetland covers about an area of 102 square kilometres contributing to 0.6% of the high altitude land area and 0.26% of the total land cover of the country (Mapping wetland in Bhutan). Bhutan has designated three Ramsar sites (about 1, 225 ha of wetlands) which are of international importance.

Although Bhutan water balance does not show any water scarcity at the national, basin, or even *Dzongkhag* level, imbalance in geographical and temporal distributions of water leads to experience of shortages in local areas. Water is largely available in the form of major rivers and tributaries flowing in valley bottoms, while most communities depend on smaller streams, springs and lakes for domestic and agricultural use. Table 5 below shows the area of the river basins and their annual flow.

Table 5 Basins and Flow Calculations. (Source: NEC, 2016)

Management Basin	**Area (km^2)**	**River Basins**	**Area (km2)**	**Annual flow (MCM)**
Amochhu	3252	Jaldakha	942	9, 375.07
		Amochhu	2310	
Wangchhu	4596	Wangchhu	4596	5, 209.06
Punatsangchhu	11582	Punatsangchhu	9645	19, 129.79
		Aiechhu	1937	6, 989.14
Mangdechhu	7380	Mangdechhu	7380	11, 797.24
Drangmechhu	11584	Drangmechhu	8457	13, 569.14
		Nyera amachhu	2348	4, 50 6.57
		Jomori	642	
		Merak - Sakteng	137	
Total	38394	Total	38394	70, 576.01
		Population		746, 773
		Per Capita Water Available		94, 508.04 m3/Annum
		Flow		2, 238.0 m3/s

The streams, springs and lakes which are key for drinking and irrigation water supply in Bhutan are threatened both in quality and quantity due to human interventions exacerbated by the impact of climate change. The changing rainfall pattern and increasing temperature resulting from climate change has reduced water flows especially during winter and drying up of springs and rivulets leading to water shortages across Bhutan. Assessment conducted by the Watershed Management Division (WMD) recorded about 0.9% of water sources as dried up, 25.1% in drying state and 73.8% as the sources remaining the same of the total 7, 399 water sources that were mapped.

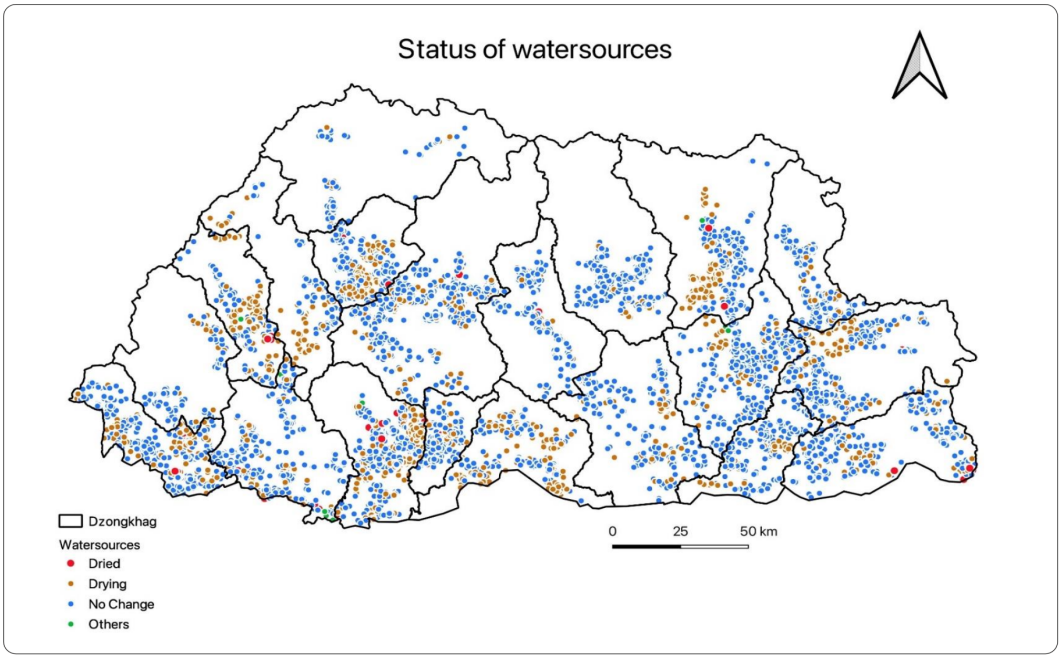


Figure 26: Status of water sources in the country (WMD, 2021)

5.2.2 Water quality

The NECS has been conducting ambient monitoring of rivers, streams/tributaries and effluent outlets to assess the existing water quality, record the situational changes and to map the trend over time to support appropriate interventions and evidence-based decision making. The Water Quality Monitoring (WQM) programme was initially carried out in Thimphu *Dzongkhag*, where the *Thimchhu* starting from the upper reach of Dodena until Chuzom was monitored along with its tributaries and effluent points. In line with the 12th Five Year Plan, the WQM programme was extended to 11 additional *Dzongkhags*, namely Bumthang, Chukha, Gasa, Haa, Paro, Punakha, Samdrup Jongkhar, Sarpang, Trongsa, Tsirang and Wangdue Phodrang from 2019 for which physico-chemical are primarily monitored. Overall, the water quality was found to be within the environmental standards except in some areas. In most cases, the water quality was found to be deteriorating along the stretches where there were human settlements or activities that resulted in discharge of domestic/industrial effluents, wastewater and solid waste into the water bodies. For instance, in Thimphu, the water quality in the areas where there was discharge of effluent from the drain water, automobile effluents and Sewerage Treatment Plants were found to be inadequate.

A total of 3, 091 drinking water samples (1, 289 from urban and 1, 802 from rural) were tested for E.Coli by the Royal Center for Disease Control in 2020 of which 46.6% for urban and 74.6% for rural was found to be safe for consumption. Of the 443 treated water samples that were tested for free residual chlorine, more than 50% of the total samples were found to be inadequately chlorinated. 1, 094 samples were monitored for turbidity during which the maximum number of turbid samples were found during the rainy season (May-September).

5.2.3 Vulnerability to Glacial Lake Outburst Flood

Glaciers are retreating at an accelerated rate due to increase in extreme weather events such as rainfall and temperature thereby enhancing the risk of Glacial Lake Outburst Flood (GLOF). Bhutan experienced a total of 21 GLOFs of which only 6 cases were reported in the literature. After the country's major GLOF event in 1994, the Government of Bhutan undertook various measures to monitor, mitigate and create awareness on risks associated with GLOF hazard.

The NCHM carried out a re-assessment of the Potentially Dangerous Glacial Lakes (PDGL) of Bhutan in 2019. As per the assessment, 17 PDGLs are recorded with a major of 9 lakes in the Pho Chhu sub basin, 3 in Mangde Chhu sub basin, 2 in Mo Chhu sub basin, 2 in Chamkhar Chhu sub basin and 1 in Kuri Chhu sub basin.

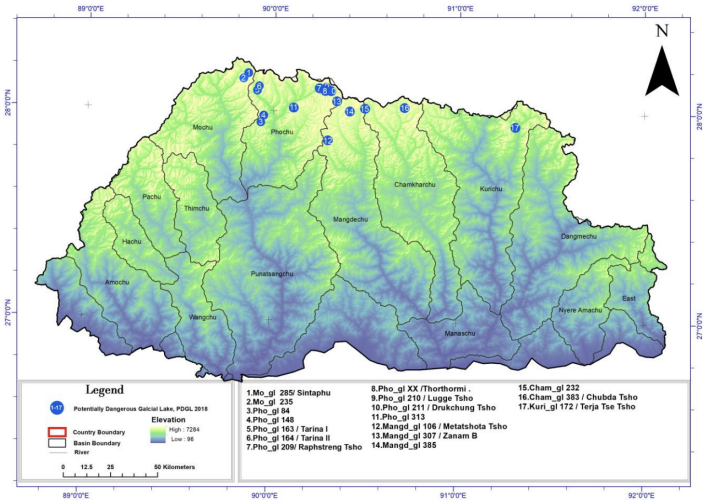


Figure 27: Location of PDGL of Bhutan

5.3 Impact

5.3.1 Water scarcity

Water availability and demand have been calculated in order to establish monthly water balances at the level of basins, sub-basins and *Dzongkhags* (NEC, 2016). The results are summarised ranked in decreasing order of potential water scarcity as shown in Table 6:

Table 6: Summary of Dzongkhags with potential water shortage by 2030. Source: (NEC, 2016)

Method	Basin	*Dzongkhag*	JANUARY	MAY	JUNE
Falkenmark	Punatsangchhu	Thimphu	Scarcity	-	-
Water balance	Wangchhu	Haa	Stress	-	-
	Punatsangchhu	Thimphu	Absolute scarcity	Scarcity	Stress
	Aiechhu	Zhemgang	Scarcity	Stress	-
Demand ratio	Amochhu	Samtse	Ok**	--	

The assessment was based on 80% dependable water generated within the *Dzongkhags*. If inflow from upstream areas is taken into account, all *Dzongkhags* have adequate water supply to meet additional water demand for domestic, irrigation and industrial use until the year 2030.

5.3.2 Water user conflict

The NECS received around 10 water related disputes since 2017. Most of the disputes were related to drinking and irrigation for which the issues either relate to water sharing or disturbances/disruption of the water supply system.

5.3.3 Water and Vector borne diseases

Bhutan experiences a series of climate-sensitive health burdens. Projected temperature rise is

likely to increase the incidence of vector-borne diseases, particularly malaria and dengue; and water borne diseases such as dysentery and cholera. 54 cases of malaria were detected in 2020 as compared to 42 cases in 2019, and the active malaria transmission foci are confined mainly to southern Dzongkhag.

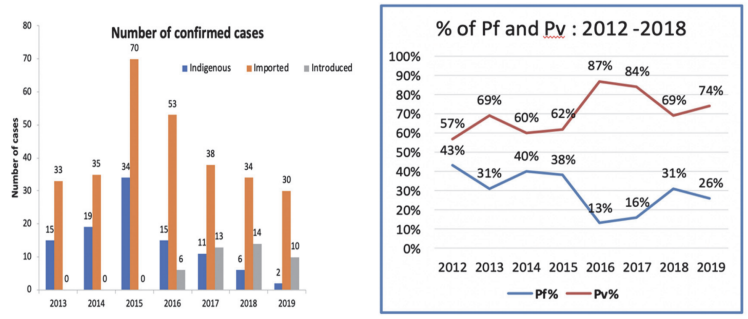


Figure 28: Trend of malaria cases over the years (VDCP, MoH)

Dengue was first documented in Bhutan in 2004 and since then seasonal outbreaks have occurred between 2010 and 2017 with the reported cases ranging from 500 to 1, 000. However, the country witnessed a major outbreak in 2019 with total cases of 5, 480, reported from 18 *Dzongkhags* and 64% of the total cases from Phuentsholing Hospital. The dengue cases dropped to 238 cases in 2020, a 95% decrease as compared to 2019 following the preventive and control measures by the Ministry of Health.

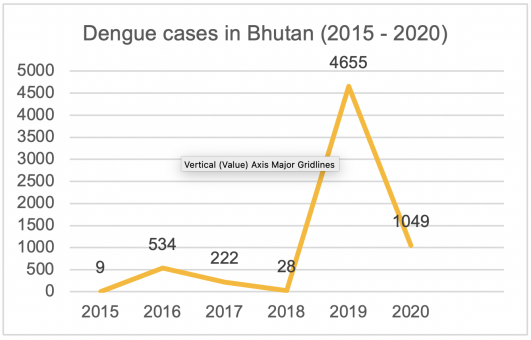


Figure 29: Dengue cases in Bhutan (2015-2020)

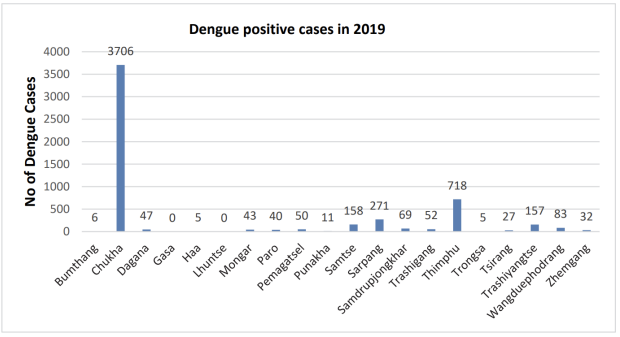


Figure 30: Dengue positive cases by Dzongkhags, 2019

IPCC states an increased risk of water-borne diseases such as diarrhoea and dysentery under the current climate change projections. Diarrhoea has remained one of the top three causes of morbidity in Bhutan for the last one decade until 2019 and has contributed to about 10-15 % of the morbidity cases. However, the cases of diarrhoea have been declining gradually over the years from 65, 495 cases in 2009 to 42, 472 in 2019 and 25, 262 in 2020 mainly due to access to improved drinking water and sanitation facilities, and increased number of ODF *Gewogs*.

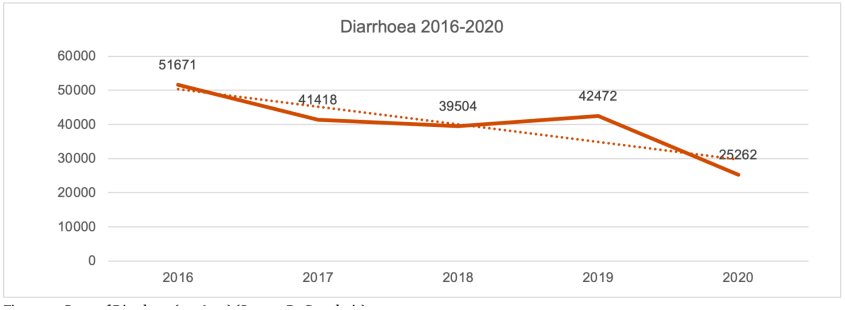


Figure *31: Cases of diarrhoea: 2016-2020 (NAP assessment)*

5.3.4 Increased run-off and landslides

The extreme weather event due to climate change has led to increased water related disasters such as flash floods, landslides and GLOF event. NCHM recorded about 20 major flash floods and landslides between 2016-2022 with the most recent event in June 2022 that resulted in casualties and damage to infrastructures. Further, the erratic rainfall pattern has resulted in loss of agricultural products. The continuous rainfall in October, 2021 damaged harvested paddies in many parts of the country.

5.4 Response

5.4.1 Policies and legal instruments

Policies and legal instruments governing water resources and related issues are discussed under Policy response in Annexure II.

5.4.2 National Integrated Water Resource Management Plan

The National Integrated Water Resource Management Plan (NIWRMP), 2016, was developed to ensure that the water resources are protected, conserved and/or managed in an economically efficient, socially equitable and environmentally sustainable manner. The plan seeks holistic management of water resources through adoption of water security concepts and recognizing river basins as an effective platform for local level management and development of water resources.

In line with NIWRMP, the Bhutan Water Security Index (BWSI) was developed based on five key dimensions; 1) Rural drinking water supply, sanitation and hygiene, 2) Economic water supply for agriculture, industries and hydropower, 3) Urban water supply, sanitation and drainage, 4) Environmental water security, and 5) Disaster and climate change resilience, all with a set of indicators. The BWSI is a tool to assess the status of water security of the country using a score measured on a scale of 1-5, whereby 5 means water security of the basin is in model stage and 1 in hazardous stage.

The NIWRMP is currently implemented in the Wangchhu Basin through establishment of the Wangchhu Basin Committee, development and implementation of the Wangchhu Basin Management Plan using the Wangchhu Water Security Index (WWSI) system. The NECS will gradually institutionalise NIWRMP in the remaining management basins through establishment and operationalization of the River Basin Committee and development and implementation of the River Basin Management Plan.

5.4.3 Water resources inventory

NECS carried out a preliminary national water resources inventory in 2013 - 2014 followed by the community level water resources assessment in Mongar, Pema Gatshel, Tsirang and Samtse. In 2019, the Department of Forest and Park Services carried out assessment and mapping of 7, 399 water sources. As per the assessment findings, 0.9% have been recorded as dried up, 25.1% are in drying state while 73.8% of the water sources are recorded as not changed over the years.

Further, the NECS is coordinating and implementing the project on "Comprehensive assessment of water resources including both quality and quantity" in collaboration with the relevant agencies. The assessment includes the assessment of both surface and groundwater in the selected *Dzongkhags*. The groundwater assessment has been conducted in Gelephu gewog under Sarpang *Dzongkhag* and the findings point out the prospect of groundwater in two sites of

the total three sites that were assessed. To further build upon the water sources mapping of the DoFPS, surface water assessment in critical areas within Thimphu and Wangdue Phodrang Dzongkhags is to be conducted.

5.4.4 Watershed management plans

The Watershed Management Division, under the Department of Forests and Park Services has assessed the watersheds in Bhutan and identified critical watersheds that need immediate attention. The wetlands management program was also created to strategize wetlands conservation or management as a strategic area for overall watershed management and water resources management.

5.4.5 Civil society initiatives

CSOs are taking initiatives to address water pollution. Clean Bhutan Initiative has one of its main strategies as, "clean rivers and tributaries" where the activities are focussed in removing solid waste that are illegally dumped in the river and stream channels.

The Bhutan Water Partnership, established in 2001, addresses some elements of the governance and the management of water resources. The Partnership supports financing community initiatives on water source protection and exploring alternative water sources.

5.4.6 Maintaining water quality and quantity

- The NECS is envisaging to cover the entire *Dzongkhags* in terms of ambient water quality monitoring to establish the baseline formation and trends of water quality. The guideline for water quality monitoring is also being developed to establish a uniform protocol and procedures for monitoring of the water quality.

- Alternative financing of watershed management through Payment for Ecosystem Services (PES) has been explored in Bhutan. There are currently three pilot schemes initiated by the DoFPS and Local Governments (LG). All the PES schemes in the country are set up to link the upstream and downstream communities to enhance the maintenance of the water quality and to manage water resources through a watershed lens.

5.4.7 Climate change adaptation and disaster risk reduction

- Bhutan launched its National Adaptation Plan process in 2015 to build on Bhutan's Nationally Determined Contribution (NDC) by accelerating the NDC vision to scale up adaptation in the medium- to long-term and by focusing on priority sectors such as water resources. NAP readiness project builds on existing capacities and enhancing institutions already in place for adaptation planning: i) Enhanced coordination, learning and knowledge management for an iterative NAP process; ii). Technical capacity enhanced for the generation of climate scenarios and impact assessment; iii). Vulnerability assessments undertaken and adaptation options appraised and prioritized; and iv). NAP formulated and capacity for implementation and monitoring established. The climate risk assessment on agriculture, forest and biodiversity, health, water and climate change vulnerability assessment was carried out through this project. Based upon the findings of the assessment, the adaptation priorities for those sectors were prioritized and utilized in formulation of the NAP.

5.5 Recommendations

5.5.1 Institutionalisation of NIWRMP, 2016

The NIWRMP is currently implemented in the Wangchhu Basin for which the Wangchhu Basin Committee is established, Wangchhu Basin Management Plan and WWSI system developed and

implemented. The WWSI system assesses the status of water security in the Wangchhu Basin through input of data in terms of the key dimensions and generation of system score.

Implementation of NIWRP in the remaining management basins will support assessment and understanding of the status of water resources of the entire country thereby allowing for proper interventions to enhance the water security of the country.

Institutionalisation of the NIWRP in the remaining management basins will result in:

- Establishment and operationalization of the River Basin Committee.
- Development of the Water Security Index ultimately leading to the Bhutan Water Security Index.
- Assessment of the water resources on an annual basis and producing the water security report in terms of the five key dimensions, thereby providing updated information on the status of water security.

5.5.2 Expand and establish real time water monitoring stations

Expansion of the existing water quality monitoring stations to include the small streams and tributaries and installation of real-time monitoring systems is critical for proper management of water quality and quantity, timely dissemination of water related information including early warning for water disasters, and detection of any sources of pollution or disturbances of the water bodies.

5.5.3 Ground water resources assessment

Groundwater assessment in selected sites of Sarpang and Samdrup Jongkhar is being undertaken as part of the Water Resources Assessment Project in order to assess the prospect of groundwater for abstraction. The site has been prioritised based on the needs of the WFP and its findings will be utilised for implementation of the WFP.

As the surface water sources are limited due to pollution and impacts of climate change, groundwater resources have to be explored as the alternative source to cater to the increasing demand for water. Therefore, the assessment for potential groundwater resources has to be expanded in the prospective areas for in depth understanding of the groundwater hydrology and study its feasibility for abstraction and use.

6. AIR

Air quality in Bhutan has long been regarded as pristine. However, recent rapid development is placing pressure on air quality in the major urban centres and at several industrial areas with relatively heavy industries. Today, air pollution is becoming one of the emerging issues that has a serious risk to human and environment health.

6.1 Pressure

6.1.1 Increasing vehicle numbers

Increasing number of motor vehicles contributes to local air pollution. Besides tailpipe emissions, other related emissions include particulate matter from tire and brake wear-out, and re-suspended road dust. As of June 2022, based on Statistical Year Book 2022, the total number of vehicles in the country stands at 122, 865 which is a 61.41% increase from 2015. Light vehicles constitute 65.63%, 10.27% for heavy vehicles and 10.06% two wheelers which are mostly privately owned. Power tiller and tractor combines consist of 3.74% while Earthmoving equipment account for 3.30%. Electric vehicles represent only 0.29%.

6.1.2 Trans-boundary air pollution

There is a significant issue of trans-boundary air pollution in the South Asian region (UNEP 2013) and this issue also affects Bhutan. The image above shows air pollution levels from the Indo-Gangetic plains moving into Himalayan range. Visual observation of hazy pollution levels along the southern belt of the country now moving to northern parts, especially during winter months**,** confirms the presence of this phenomenon.

6.1.3 Road resurfacing and re-suspended road dust

Dust generated from re-suspended road dust from unpaved roads in the country contributes to air pollution. The total length of road network in the country as of June 2022 is 18, 270.15 kilometres of which only 4, 863.78 kilometres are paved (blacktopped with bitumen). From the total unpaved road network of 13, 406.20 kilometres, 12,333,30 kilometres belong to farm road and access road and rest falls under secondary national highway, *Dzongkha* and Urban Road.

Activities such as burning of bitumen and asphalt for road resurfacing also contribute to air pollution.

6.1.4 Industrial and mining/quarrying activities

Manufacturing industries and mining activities are also a source of local air pollution. The number of manufacturing and production industries has increased by 19.55% from 2, 823 in 2014 to 3, 375 in June 2022. Industries also contribute to GHG emissions. The emissions from the industries are primarily from metal, chemical and mineral based (cement) industries and GHG emission in 2015 from industrial process and product use was 796.42 Gg of CO2 equivalent.

Mining and quarrying activities generate significant dust pollution within the local area due to excavation and loss of vegetation.

6.1.5 Construction activities

Windblown dust particles from the construction sites are a source of dust pollution. Rapid urbanisation has fuelled a boom in the construction industry. Exposed ground area due to removal of vegetation for construction purposes makes it susceptible to wind.

Similarly, the construction phase of the hydropower plants generates dust and other air pollution due to vegetation removal and other related activities such as increased traffic flow and fuel combustions.

6.1.6 Forest fires and fire hazards

Forest fires contribute to local air pollution. From 2016 - 2022, 257 incidences of forest fires damaged about 54, 460.2 acres of forest area. Most forest fires are human induced, commonly from burning of agricultural debris, careless smokers, road workers, electricity short-circuits, lemon grass harvesters and children playing with matchsticks).

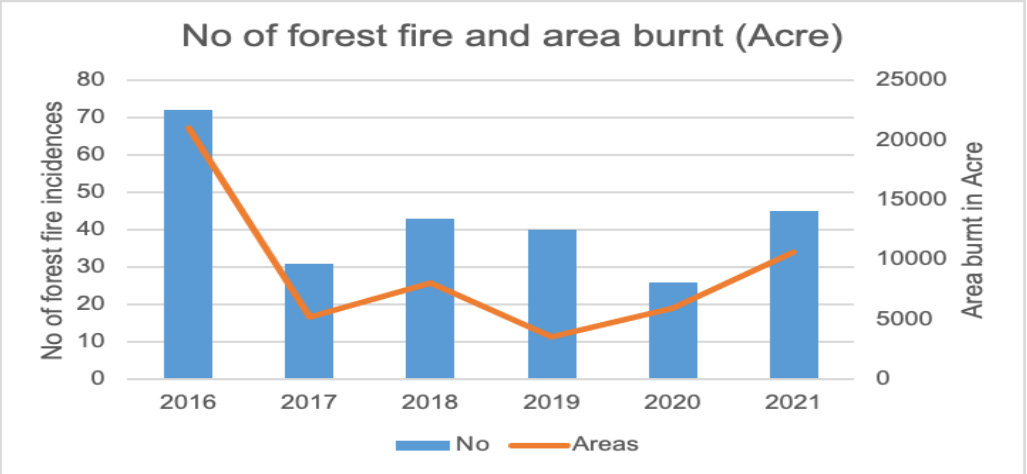


Figure 32: No of forest fire and area burnt.

6.1.7 Burning of fuel wood and kerosene for heating and cooking

Use of fuel wood and Kerosene for household heating and cooking contributes to air pollution. Household space heating, in the higher region, coupled with thermal inversion is making air pollution worse during the winter months. Fuelwood is a primary source of household energy and Bhutan has the highest per capita consumption of fuelwood at 1.2 metric tons per year.

6.2 State

6.2.1 State and trend in particulate matter (PM) levels

Air pollution in Bhutan has been monitored with varying degrees of reliability since the early 2000. The longest data available is for measurement of particulate matter of less than 10 micrometres in diameter (PM10) in Thimphu and particulate matter of less than 2.5 micrometres in diameter (PM2.5) was monitored recently after installation of automated air quality monitoring stations in Thimphu and Rinchending. PM10 is generally understood as "repairable dust" that is inhaled by humans.

Figure 33 shows the trend in level of PM 10 in Thimphu is improving over the period compared from 2015 and the trend in level of PM2.5 remains more or less the same. The levels are still within the national permissible limits for mixed areas.

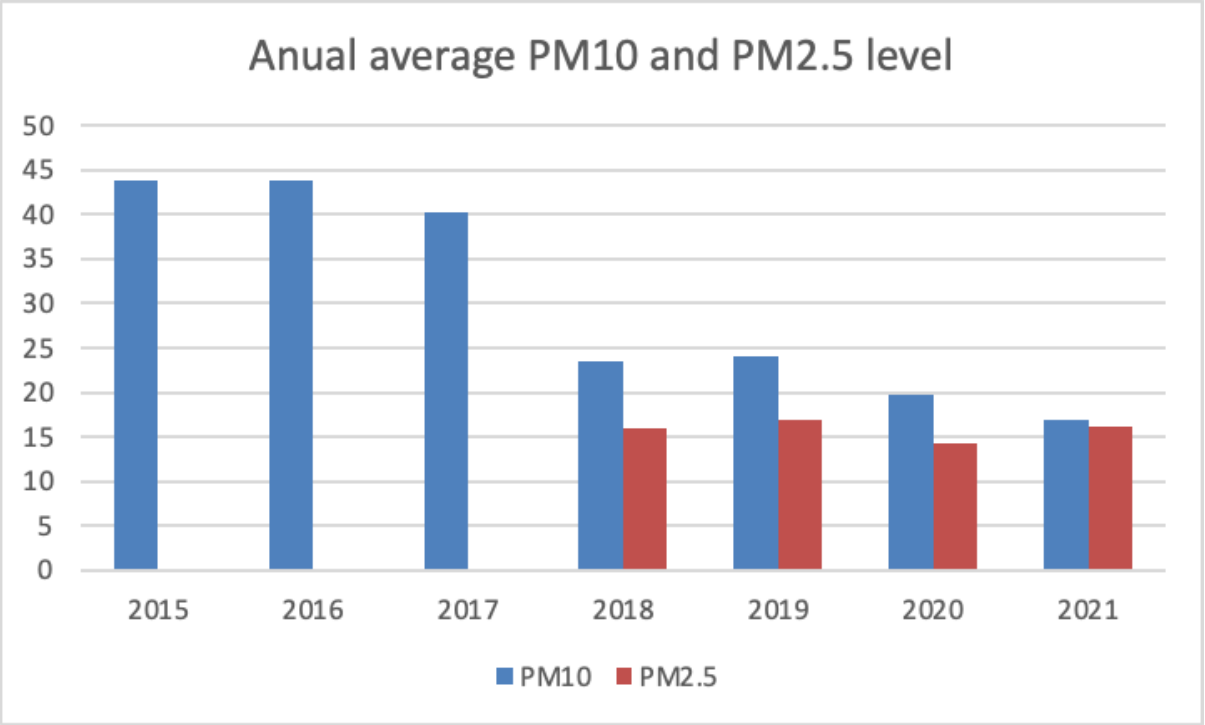


Figure 33: Annual average PM10 and PM2.5 level

The levels of PM10 at the Pasakha industrial estate could exceed the national permissible annual average PM 10 limits for industrial areas if corrective measures are not undertaken (Figure 33). Deteriorating air quality in Pasakha was a factor in the relocation of a local school.

Annual average PM10 levels for Rinchending is 60 µg/m^3 for all the years for which data is available.

Similarly, for Bajothang, is currently within the annual average national permissible limits for all the years for which data is available.

Annual average PM10 levels at Kanglung is within the permissible annual average national limits (50 µg/m^3) for sensitive areas. However, the levels have exceeded the permissible limits in 2013. The increased incidences of exceeding the permissible national limits indicate deterioration of overall air quality over the years.

6.2.2 Trends in greenhouse gas emissions

As shown in the Figure 37, the estimated total national GHG emissions have increased by 45% from 1,549.64 Gigagrams of Carbon dioxide Equivalent ($GgCO_2e$) in 2000 to 2,253.33[2] $GgCO_2e$ in 2010. The emissions are highest from the agriculture sector due to relatively lower levels of emissions from the other sectors. The emissions from agriculture are predominantly from subsistence farming and therefore termed "survival emissions". Moreover, the emissions from the sector have remained fairly constant over the years.

On the contrary, emissions from the other sectors have been increasing rapidly over the years. The emissions from the industrial processes have increased by 118.29% from 237.76 $GgCO_2e$ in 2000 to 519.00 $GgCO_2e$ in 2010. Emissions from the energy sector have increased by 139.50 % from 260.31 $GgCO_2e$ in 2000 to 623.44 $GgCO_2e$ in 2010. Since 2009, the combined emissions

[2] The estimated total emissions for 2010 are preliminary. The Figures will be updated through the 3rd GHG inventory.

from Energy and industrial processes have already exceeded the emissions from agriculture. The emissions from waste increased from 46.27 $GgCO_2e$ in 2000 to 118.60 $GgCO_2e$ in 2010

6.3 Impact

6.3.1 Human health

According to WHO, air pollution has a direct impact both on the health of humans and the environment. PM 2.5, particulate matter of less than 2.5 micrometres in diameter, is among one of the most harmful air pollutants. Although particulate matter can cause health problems for everyone, certain groups of people are especially vulnerable. These sensitive groups include children, the elderly, exercising adults, and those suffering from asthma or bronchitis. There has been no study conducted for assessing the impact of air pollution in Bhutan to date.

6.3.2 Crop productivity

Air pollution affects crop productivity. A pilot study conducted by Sherubtse College through support from Male Declaration indicated that ground level ozone impact on the biomass of the Spinach in Kanglung.

Several media reports claim decreasing yield of fruits and vegetables to the increasing particulate matter concentration in the local area due to mining and industrial activities. A proper scientific study has to be conducted to ascertain the reports.

6.4 Response

6.4.1 Policies and strategies

There are a number of existing Policies, Strategies, Standard and Legislations to promote cleaner modes of transport and industrial growth as detailed under Annexure II.

6.4.2 Fiscal measures and import restriction on vehicles

As per the "Sales Tax, Customs and Excise Act of the Kingdom of Bhutan, 2000," import of used or second hand vehicles, machinery and equipment are restricted in the country. Import of two-stroke engine vehicles have also been banned. The minimum permissible engine standards are Euro III and Bharat III.

The revised customs duty and sales tax of June 2011, imposes differentiated duties and taxes on the import of vehicles based on the engine capacities. Higher cylinder capacity vehicles are liable for higher duties and taxes. Since June 2012, vehicle imports have also been subject to a "green tax". Electric vehicles and bicycles are exempted from all forms of taxes while hybrid vehicles are liable for green tax only. This is also to enhance energy security with improved air quality as a co-benefit.

However, at the same time, the system of providing vehicle quotas which exempts import duty and other tax exemptions to those entitled to such quotas negates the efficacy of fiscal measures to manage congestion and pollution, in addition to balance of trade issues arising from increasing vehicle numbers.

6.4.3 Air pollution monitoring

The NECS and competent authorities conduct periodic compliance monitoring of development activities in accordance with relevant provisions of Environment Assessment Act 2000 and

NEPA 2007. Monitoring of air pollution levels at the workplace constitute a core component of the environmental monitoring activities.

To monitor ambient air quality, automated monitoring stations have been established at Thimphu and Pasakha. An additional station is being constructed in Darla *gewog*, Chukha *dzongkhag*. All these stations will have capabilities to monitor other parameters in addition to particulate matter. In future, a station to monitor air quality in remote sites will be established in Chelela, between Haa and Paro.

6.4.4 Promotion of mass transit

The government provides subsidies for operating the city bus services in Phuentsholing and Thimphu. Proposals are being developed to improve the efficiency and reliability of urban transport systems for Thimphu. The focus of the proposals are to increase fleet size of the city bus frequency and to improve the bus stops and incorporate Intelligent Transport System measures to promote modal shift to public transport.

6.4.5 Electrification

As of December 2015, almost the entire country has connected to the on-grid electricity supply scheme (BPC, 2015). This was achieved through an accelerated rural electrification program. Since mid-2013, 100 units of electricity has been provided free of cost in the rural area. The aim is to reduce the high fuel wood consumption in the rural homes.

6.4.6 Promotion of improved cook stoves and alternate source of energy

The erstwhile Department of Renewable Energy (DRE), with financial support from Global Environment Facility (GEF), Bhutan Trust Fund for Environmental Conservation (BTFEC) and United Nations Development Program (UNDP) has distributed about 8,000 numbers of improved efficient cooking heating stoves. Efficient cooking and heating stoves will reduce consumption of firewood and kerosene. In addition, the department has distributed more than 2,000 solar water heating systems and solar home lighting systems. A 300-kW wind power plant is also installed at Wangdue Phodrang.

6.4.7 Regional cooperation on trans-boundary air pollution

Recognizing the concerns of trans-boundary air pollution in the region, the seventh meeting of the Governing Council of South Asia Cooperative Environment Programme (SACEP) in Male, Republic of Maldives on 22 April 1998; the Male Declaration on Control and Prevention of Air Pollution and its Likely Trans-boundary Effects for South Asia was signed by the Environment Ministers of Bangladesh, Bhutan, India, Iran, Pakistan, Maldives, Nepal and Sri Lanka.

UNEP has also started a Joint Forum that brings together all the trans-boundary air quality management networks in Asia. Bhutan has regularly participated in the forum since 2010.

6.5 Recommendations

6.5.1 Revise air quality standard, strengthen its implementation and improve data management system

Revise appropriate existing air quality related standards, reflecting changing socio-economic conditions and strengthen its implementation.

6.5.2 **Strengthening regional cooperation to curb trans-boundary air pollution**

Strengthen regional cooperation under the Male declaration and other regional environmental initiatives to help curb impact of trans-boundary air pollution.

6.5.3 **Increase coverage and parameters for air quality monitoring**

Install additional automated air quality monitoring stations to ensure adequate geographical representation of air quality status in the country. The parameters for air quality monitoring should be increased to accommodate at least primary air pollutants.

6.5.4 **Promotion of vehicle emission control measures**

Measures such as eco-driving techniques and maintenance for efficient vehicle operation must be introduced within the curriculum of the vocational training institutes. Awareness campaigns and capacity building on eco-driving should be provided to general public and private driving training schools as well.

7. BIODIVERSITY

Biological diversity - or biodiversity is the "variability among living organisms from all sources including diversity within species, between species and of ecosystems". It helps regulate climate through carbon sequestration, filters air and water, and mitigates the impact of natural disasters such as landslides and storms. Direct benefits include food and fibres from natural vegetation, wood and non-wood products from forests, fish from freshwater systems, pollination of crops, medicines from plants, and psychological health. It forms the web of life of which we are an integral part and upon which we so fully depend. Bhutan has always recognized and upheld the significance and role of biodiversity conservation in human wellbeing and the country's diverse ecosystems and eco-floristic zones harbour a rich array of species. Bhutan has a wide range of ecological zones ranging from sub-tropical forests to alpine meadows and permanent snow and ice and has one of the highest species density (richness per km^2) in the world.

7.1 Pressure

7.1.1 Wood and Non-wood forest products

There are engagements in the collection of wood and non-wood forest products for the purpose of own consumption or for sales in Bhutan. The NWFPs products mainly include cane and bamboo, cordyceps, daphne, incense, medicinal and aromatic plants, medicinal fruits, mushrooms, spices, wild vegetables, etc. There is also a collection of woods for timber and other materials. A total of 3.8 million cft of timber allotted for different purposes and 1.8 million cft for firewood according to RNR Annual Report 2022 and Annual Forestry Statistics 2021. There are 21 FMUs designated in the country covering 5.17 % of geographical area corresponding to a total area of 198,406.84 ha.

7.1.2 Forest fire

Forest fires in Bhutan continue to take a substantial toll on biodiversity with annual fire incidences averaging about 57 events (Figure) and scarring an average of about 200 ha annually. Forest fires have many implications for biological diversity. At the regional and local level, they lead to change in biomass stocks, air pollution, and alter the hydrological cycle with subsequent impact on plant and animal species. Current fires in Bhutan are mostly concentrated in the chirpine and bluepine zones forests, with occasional fires within sub-tropical broadleaved forests.

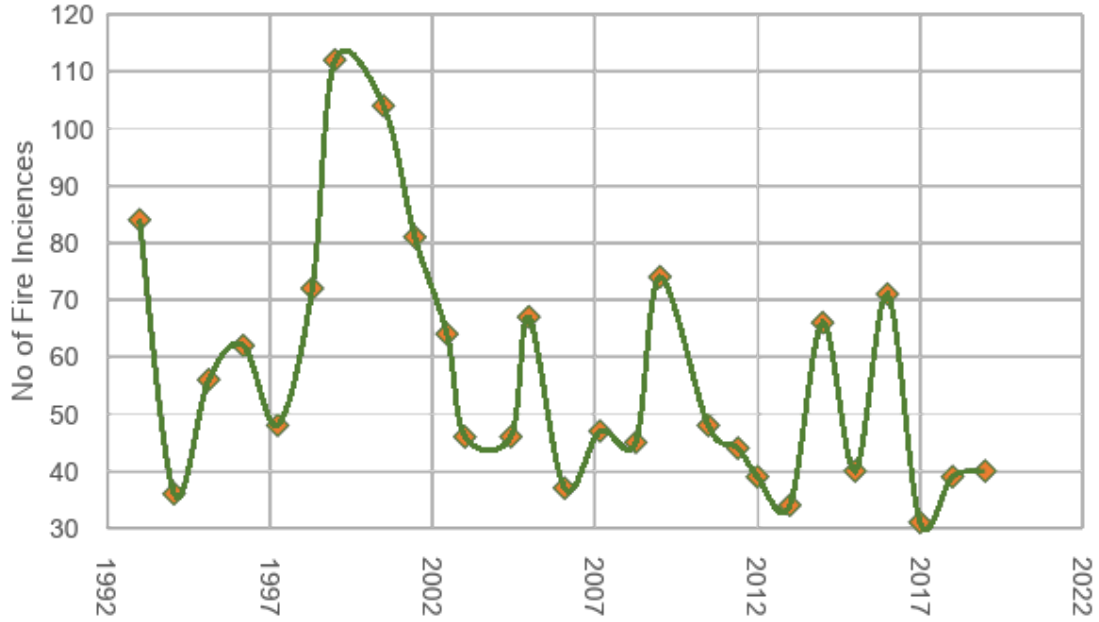


Figure 34: Number of fire incidences from 1992 till 2019

7.1.3 **Habitat fragmentation**

In 2021 alone, about 3375ha of State Reserve Forest Land (SRFL) are allotted for various development activities resulting in habitat fragmentation.

In between 2011-2012, 152.7 ha of State land was allotted from protected areas and 2,561.40 ha of land from other State land areas for development purposes (FRMD, DoFPS, MoAF, 2013). Trends, Figures and indicators on increasing developmental activities are discussed under Land Section.

7.1.4 **Infrastructure development**

Infrastructural development is a major threat to biodiversity. As socio-economic activities progress to meet the demand of rapidly increasing population and urbanisation, farmlands and forests are lost to infrastructure development every year. Many hydropower projects, construction of transmission (high, medium and low voltage) lines, road construction and minerals and quarrying pose a serious threat to both flora and fauna of the country. Trends, Figures and indicators related to infrastructure development are described under the Land Section.

7.1.5 **Human wildlife conflicts**

Human-wildlife conflicts such as crop damage, livestock **depredation, and retaliatory killing** pose serious threats to livelihood and agro-biodiversity. Annual Forestry Statistics 2021 reported crop damage of 8.65 acre and livestock kills of 27 affecting about 66 household Forestry offences

Forestry offences constitute extraction, conversion, possession, utilisation, transportation, trade and disposal of forest resources. In 2019, a total of 1,911 offences related to timber, poaching, fishing, NWFPs and land encroachments were reported. Amongst these, offences related to

illegal timber was highest with 795 incidences, followed by fishing and aquatic offences with 504 incidences. Poaching was the least with 49 cases.

7.2 State

7.2.1 Annual average change in forest area

Forest area is largely stable in Bhutan with minor local level changes. For details, refer to the Land Section.

7.2.2 Export of forestry products

The main export of NWFPs in terms of revenue are *Cordyceps* and *matsutake* mushrooms. In 2021, exports of NWFP fetched Nu. 325 million.

7.2.3 Protected forest area

The total land area under protected areas is 19,750.57 km^2, accounting to 51.40 % of the country. It is made up of protected areas (43.48 %), biological corridors (7.73%) and the royal botanical parks (0.24 %). There are eight biological corridors, five national parks, four wildlife sanctuaries and one strict nature reserve (DoFPS 2021).

7.2.4 Threatened animal species

Due to the high forest cover located in the eastern Himalayas, pristine environment, strong conservation efforts and 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 animal species, 5,369 plant species, 690 species of fungi. 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 are also found in Bhutan. These include: 15 vulnerable, 20 endangered and 13 critically endangered seed plants; 13 vulnerable, 11 endangered and two critically endangered mammal species; 22 vulnerable, four endangered and four critically endangered bird species; eight vulnerable and three endangered fish species, 11 vulnerable, five endangered and two critically endangered amphibians; and one vulnerable butterfly. The detailed listings are provided in the following table 7.

Table 7: Detail listing of species and status.

Sl. No	Species	Status
Fishes		
1	*Aborichthys garoensis*	Vulnerable
2	*Cirrhinus cirrhosis*	Vulnerable
3	*Cyprinion semiplotum*	Vulnerable
4	*Cyprinus carpio*	Vulnerable
5	*Devario assamensis*	Vulnerable
6	*Pseudecheneis sirenica*	Vulnerable
7	*Schistura inglisi*	Vulnerable
8	*Schizothorax richardsonii*	Vulnerable
9	*Tor putitora*	Endangered
10	*Pterocryptis barakensis*	Endangered
11	*Clarias magur*	Endangered

Birds		
1	Chestnut-breasted Partridge	Vulnerable
2	Blyth's Tragopan	Vulnerable
3	Common Pochard	Vulnerable
4	Long-tailed Duck	Vulnerable
5	Woolly-necked Stork	Vulnerable
6	Lesser Adjutant	Vulnerable
7	Indian Spotted Eagle	Vulnerable
8	Greater Spotted Eagle	Vulnerable
9	Eastern Imperial Eagle	Vulnerable
10	Black-necked Crane	Vulnerable
11	Wood Snipe	Vulnerable
12	Dark-rumped Swift	Vulnerable
13	Great Hornbill	Vulnerable
14	Rufous-necked Hornbill	Vulnerable
15	Wreathed Hornbill	Vulnerable
16	Great Slaty Woodpecker	Vulnerable
17	Grey-crowned Prinia	Vulnerable
18	Beautiful Nuthatch	Vulnerable
19	Grey-sided Thrush	Vulnerable
20	Hodgson's Bushchat	Vulnerable
21	Kashmir Flycatcher	Vulnerable
22	Rustic Bunting	Vulnerable
23	White-winged Duck	Endangered
24	Pallas's Fish Eagle	Endangered
25	Egyptian Vulture	Endangered
26	Steppe Eagle	Endangered
27	Baer's Pochard	Critically Endangered
28	White-bellied Heron	Critically Endangered
29	White-rumped Vulture	Critically Endangered
30	Red-headed Vulture	Critically Endangered
Mammals		
1	Alpine Musk Deer	Endangered
2	Arunachal Macaque	Endangered
3	Asian Elephant	Endangered
4	Asian small-clawed Otter	Vulnerable
5	Asiatic Black Bear	Vulnerable
6	Bengal Slow Loris	Vulnerable
7	Binturong or Bearcat	Vulnerable

8	Capped Langur	Vulnerable
9	Chinese Pangolin	Critically Endangered
10	Clouded Leopard	Vulnerable
11	Common Leopard	Vulnerable
12	Dhole	Endangered
13	Gaur	Vulnerable
14	Golden Langur	Endangered
15	Himalayan Musk Deer	Endangered
16	Hispid Hare	Endangered
17	Hog Deer	Endangered
18	Indian Rhinoceros	Vulnerable
19	Pygmy Hog	Critically Endangered
20	Red Panda	Endangered
21	Sambar	Vulnerable
22	Smooth-coated Otter	Vulnerable
23	Snow Leopard	Vulnerable
24	Takin	Vulnerable
25	Tiger	Endangered
26	Wild Water Buffalo	Endangered
Amphibians and Reptiles		
1	*Kachuga kachuga*	Critically Endangered
2	*Gavialis gangeticus*	Critically Endangered
3	*Indotestudo elongate*	Endangered
4	*Cuora mouhotii*	Endangered
5	*Kachuga dhongoka*	Endangered
6	*Pangshura sylhetensis*	Endangered
7	*Chitra indica*	Endangered
8	*Xenophrys cf. nankiangensis*	Vulnerable
9	*Python molurus*	Vulnerable
10	*Oligodon juglandifer*	Vulnerable
11	*Ophiophagus hannah*	Vulnerable
12	*Melanochelys tricarinata*	Vulnerable
13	*Morenia petersi*	Vulnerable
14	*Python bivittatus*	Vulnerable
15	*Geoclemys hamiltonii*	Vulnerable
16	*Cuora amboinensis*	Vulnerable
17	*Hardella thurjii*	Vulnerable
18	*Nilssonia hurum*	Vulnerable
Butterfly		
1	*Bhutanitis ludlowi*	Vulnerable
Plants		
1	*Eulophia stenopetala*	Extinct
2	*Brugmansia suaveolens*	Extinct in the Wild
3	*Aquilaria malaccensis*	Critically Endangered

4	*Astragalus paroensis*	Critically Endangered
5	*Bulbophyllum leopardinum var. tuberculatum*	Critically Endangered
6	*Ceropegia dorjei*	Critically Endangered
7	*Cheirostylis sherriffii*	Critically Endangered
8	*Meconopsis bhutanica*	Critically Endangered
9	*Nardostachys jatamansi*	Critically Endangered
10	*Onosma griersonii*	Critically Endangered
11	*Ophiorrhiza longii*	Critically Endangered
12	*Oreorchis sanguinea*	Critically Endangered
13	*Paphiopedilum fairrieanum*	Critically Endangered
14	*Saurauia punduana*	Critically Endangered
15	*Sorbus lingshiensis*	Critically Endangered
16	*Androsace hemisphaerica*	Endangered
17	*Bistorta griersonii*	Endangered
18	*Bulleyia yunnanensis*	Endangered
19	*Carex nigra subsp. drukyulensis*	Endangered
20	*Ceropegia bhutanica*	Endangered
21	*Cypripedium elegans*	Endangered
22	*Cypripedium himalaicum*	Endangered
23	*Hoya bhutanica*	Endangered
24	*Hypericum sherriffii*	Endangered
25	*Ilex venulosa*	Endangered
26	*Illicium griffithii*	Endangered
27	*Isodon atroruber*	Endangered
28	*Meconopsis superba*	Endangered
29	*Neopicrorhiza minima*	Endangered
30	*Paphiopedilum spicerianum*	Endangered
31	*Paphiopedilum venustum*	Endangered
32	*Pedicularis sanguilimbata*	Endangered
33	*Strobilanthes accrescens subsp. accrescens*	Endangered
34	*Taxus wallichiana*	Endangered
35	*Sorbus rinzenii*	Endangered
36	*Aglaia perviridis*	Vulnerable
37	*Bambusa clavata*	Vulnerable
38	*Buddleja bhutanica*	Vulnerable
39	*Corallodiscus cooperi*	Vulnerable
40	*Cupressus macrocarpa*	Vulnerable
41	*Cycas pectinata*	Vulnerable
42	*Cymbopogon bhutanicus*	Vulnerable

43	*Cypripedium cordigerum*	Vulnerable
44	*Drepanostachyum annulatum*	Vulnerable
45	*Jacaranda mimosifolia*	Vulnerable
46	*Malaxis muscifera*	Vulnerable
47	*Pedicularis griniformis*	Vulnerable
48	*Picea brachytyla*	Vulnerable
49	*Rhododendron dalhousiae var. rhabdotum*	Vulnerable
50	*Saxifraga vacillans*	Vulnerable

7.2.5 **Wetlands/marshes**

According to Bhutan Water Facts by UWICE, there are a total of 3027 high altitude wetlands, including supra-snow lakes, glacial lakes and supra glacial lakes and marshes covering 0.26 % of total land area.

7.2.6 **Net trade in wildlife and captive bred species**

The net trade in the form of revenue collected as fines for engagement in illegal forestry activities have increased from Nu.8.57 million in 2008-2009, Nu. 8.88 million in 2009-2010 to 10.19 million in 2010-2011 (DoFPS, MoAF 2011). Based on the wildlife products that were seized by the DoFPS from 2008-2012, the estimated value of these products were around Nu. 1.02 million and Nu. 29.3 million and Nu. 45.03 million in 2014 and 2015 respectively (DoFPS, 2015).

7.3 Impact

7.3.1 **Extraction and exploitation of resources**

According to the report by UWICE, collection of *cordyceps* also results in environmental degradation through degrading shrub lands, littered landscapes, changing grasslands and associated forest degradation. Due to the increasing number of *cordycep* collectors, sustainability of the resource is also becoming an issue of great concern.

7.3.2 **Loss of habitat**

Hydropower poses the greatest threat to the conservation of the White Bellied Heron. Roads and infrastructure facilities are concentrated along the river, increasing human settlements and related economic activities that threaten the habitat of this endangered bird. The report also mentions that the herons were abandoning their habitat along Punatsangchhu in Wangdue Phodrang after it had been mined (RSPN, 2011).

Overall Black Necked Cranes' arrival in Bhutan has remained consistent. However, Phobjikha saw an increasing trend, while arrival in Bumdeling has been declining steadily (RSPN, 2011).

7.3.3 **Deteriorating quality of forest**

The Forest Management Units (FMUs) located near the urban centres of Thimphu, Paro and Haa are under heavy pressure to meet the demand of timber and firewood for the population of these *Dzongkhags*.

Observations made as per the report of Dhital and Tashi (2010), indicate that most of the hardwood stands have been removed for meeting the demand of firewood and were substituted by conifers. This has resulted in change in species composition of the areas. The report also states that interlines that are supposed to be operated in the subsequent pass periods are disappearing as it is harvested for meeting rural timber demand. This has resulted in poor quality, sparsely populated stands for future passes.

7.3.4 **Fragmentation of habitat**

Habitat fragmentation from installation of transmission lines, construction of hydropower plants and roads impacts the wildlife and aquatic habitat.

For instance, construction of 10,000 MW hydropower plants by 2020 would entail additional transmission lines of 1,416 KM of 400kV lines; 120 Km of 220kV lines; 110 km of 132kV lines; 10 km of 66kV lines.

Increasing demand for electricity and road services are discussed under the Land Section.

Image 4: Installation of power transmission lines entails clearing large corridor of forests. Photo: Thinley Namgyel.

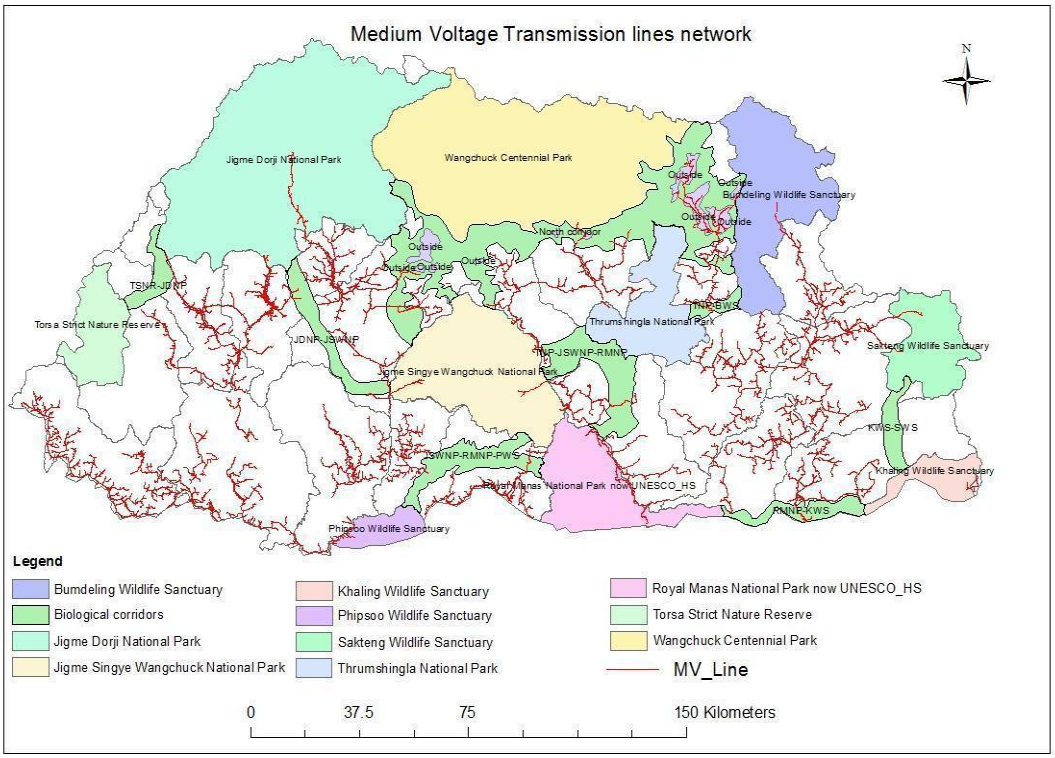


Figure 35: Map of medium voltage power transmission lines passing through protected areas and biological corridors. Data Source: BPC, 2016

7.3.5 **Ecological imbalance**

Invasive plant, animal, bird and fish species are of concern for ecological imbalance. *Tithoniadiversifolia* (tree marigold), *Ageratina adenophora*, *Chromolaenaodorata* and *Eupotorium* spp., climber *Michenia* sp., whitetop weed (*Parthenuim* sp.), Spanish Flag or LAVA (*Lantana camara)* and climbers like Bitter Vine (*Mikania micarantha)* causes damage to the favored plant species by suppressing their growth in plantations. Frequent weeding and removal entails heavy expenditure for the Government (Climate Summit 2011, Dhital 2009). Bark beetles (*Ips scmuzinhoferin*) attack spruce and blue pine trees. According to NBSAP, 2014, Bhutan has a record of 46 global invasive species of which 11 are alien invasive.

7.4 Response

7.4.1 **Implementation of policies and legal instruments**

Environmental Policy and legal instruments governing biodiversity are attached as Annexure: II.

7.4.2 **Education and awareness**

Many government agencies, civil society organisations, schools and institutes carry out education and awareness activities on the environment. Events like International Day for World Wildlife Day, March 3, Biological Diversity on May 22, World Environment Day, June 4 & 5, International Tiger Day, July 29, International Snow Leopard Day, October 23, and national events like Rhododendron festival, Social Forestry Day, June 2, Matsutake festival in third week of August are observed in the country. Most schools in the country have nature clubs and school agriculture programs.

7.4.3 **Exploring alternatives to timber usage in construction**

A two year Common Fund for Commodities (CFC) funded pilot project on bamboo value chain development for construction products was signed between International Network for Bamboo and Rattan (INBAR) and MoAF. The project aims to develop a bamboo sector that will provide a sustainable source of timber and promote as a suitable alternative for wood-based construction materials products. A number of residential and office spaces in the south are constructed of Bamboos by the Department of Forest and Park Services.

7.4.4 **Regeneration/afforestation**

As of December 2015, 17,485.66 Ha of plantation were created. The Department of Forest and Park Services has created 632.44 Ha of plantation throughout the country in 2015. Bhutan also entered Genius World record by planting 49,672 tree seedlings in one hour by 100 people on June 2, 2015 during the commemoration ceremony of His Majesty 4th King (DoFPS, 2015)

7.4.5 **Increased surveillance**

As of June 2012, DoFPS has 1475 personnel of which 733 work in territorial/regional areas, 269 in Park, 241 in *Dzongkhag* and the remaining 232 work at the head office (Bhutan RNR Stats 2012).

7.4.6 **Human wildlife conflict**

In order to address the human-wildlife conflict, the DoFPS has developed the "Bhutan National Human Wildlife Conflict Management Strategy 2008". An endowment fund is also established that provides some compensation to the farmers for the loss of their properties to wildlife and prevent retaliatory killing. The total fund generated as of December 2011 is Nu. 1,960,179.

Community based sustainable funding mechanism for wildlife depredation of crops and livestock is initiated. An endowment fund was established on eighth April 2011. As of 2015, a total of 56 *gewog*s have a Trust Fund established with an amount between Nu. 300,000 to 500, 000 each.

Image 5: Chendibji village in Trongsa. Most settlements in Bhutan occur inside the forest, where human-wildlife conflict are the main issues. Photo: Chencho Norbu

7.5 Recommendations

7.5.1 Incorporate biodiversity concerns into the EIA and SEA

Incorporate biodiversity concerns in the environmental assessment process through incorporation of biodiversity into Environmental Assessment Act 2000 amendment. The terms of reference for carrying out the Environmental Impact Assessment must reflect the need to consider biodiversity aspects.

7.5.2 Maintain minimum e-flows for aquatic life

Strengthen implementation of relevant provision Water Ac of Bhutan, 2011 reflects legal requirement of to maintain minimum environmental flows in the rivers, mainly for hydropower projects.

7.5.3 Update list of flora and fauna and invasive alien species (IAS)

DoFPS should periodically update the list of flora and fauna databases. Currently used data are from the 1990s. Carryout comprehensive inventory of IAS and its ecological value and update the list accordingly.

7.5.4 Baseline information for aquatic species

Baseline information on aquatic species should be collected for the main river system in the country with particular focus on the river that has been planned for hydropower plants.

7.5.5 Demarcation boundaries for all protected areas

All protected areas should have demarcation boundaries on the ground.

8. CROSS-CUTTING ISSUES: WASTE MANAGEMENT

Waste management is a major emerging and cross-cutting environmental issue for Bhutan. Poor waste management practices threaten public health, liveable human settlement and the natural environment through pollution of water, air and the emission of greenhouse gas.

8.1 Pressure

8.1.1 Increasing waste generation

With rapid urbanisation, increasing affluence, and population growth including increased urban population, the total amount of waste generated has increased over the past decade. In a survey conducted by the Ministry of Works and Human Settlement in 2008, a total of 30 tons of solid waste were collected from 10 municipal towns. However, in 2019, as per the National Waste Inventory Survey conducted by the National Statistics Bureau in collaboration with the National Environment Commission Secretariat, the total solid waste generation in the country has increased to 172.161 tons/day. The per capita solid waste generation in 2019 was 0.23 kg/day.

The increasing availability of convenient, affordable, and packaged products with disposable bags and containers also lead to increased non-degradable wastes along with the change in consumption lifestyle.

Image 6: Open landfill at Memelakha. Photo: Chencho Norbu, 2016

8.2 State

8.2.1 Municipal Solid waste

According to the first National Solid Waste Survey in the urban areas (MOWHS, 2008), the bulk of municipal solid waste is composed of organic matter (58%), followed by paper waste (17.21%) and plastic materials (12.73%). As per the National Waste Inventory Survey of 2019, solid waste constitutes food waste (46 %) followed by plastics (17.08%) and paper (15.76 %). There is an increase in the generation of plastic waste in 2019 compared to 2008 due to increasing consumption patterns for packaged foods, easily affordable and convenient usages of plastics.

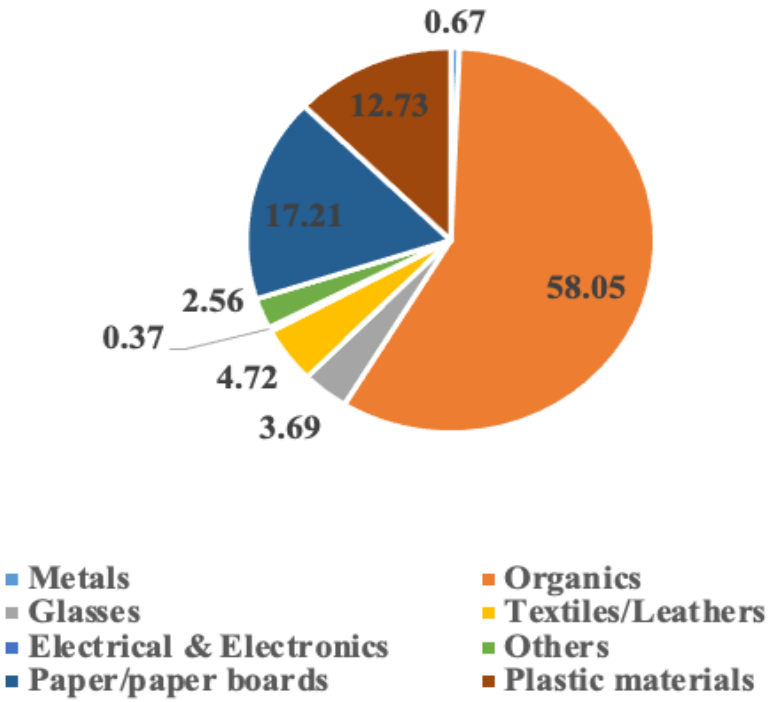


Figure 36: Average composition of MSW from all sources. Source: MOWHS, 2008

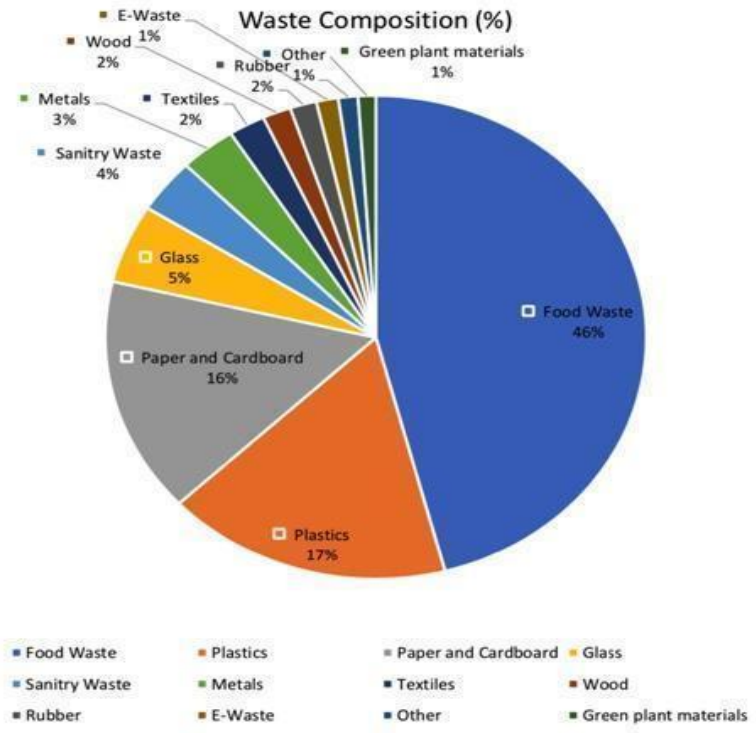


Figure 37: Average composition of MSW from all sources. Source: NSB,, 2019

In most urban areas particularly for commercial units, the most waste disposal method is municipal collection service with 72.12 %; however, more than 85.1 % of households in rural areas are without access to waste collection services (NSB, 2019). Availability of waste collection vehicles, waste storage facilities, frequencies of waste collections, inappropriate timing and location of waste collection points being far were some of the reasons for not using available

waste collection services by the households in urban and rural areas (NSB, 2019). The current common practice of waste segregation at households is categorised into dry and wet waste. As per NWIS 2019, two categories of waste segregation is a successful practice with most of the households in urban and rural areas practising waste segregation with 88.54 % and 78.44 % respectively. However, for the management of household wastes in rural areas, approximately 62.6 % are disposed of in the pits and 54.6 % are openly burnt in comparison to 13.2 % of disposal in pits and 9.8% of open burning (NSB, 2019). Similarly, as per the perception survey report of NWIS 2019, both urban and rural households have good knowledge and practices of 3Rs (reduce, reuse and recycle). However, the recycling practices is at a minimum percentage of 26.79 % in urban and 29.83 % in rural areas of Bhutan due to the presence of low recycling facilities in the country.

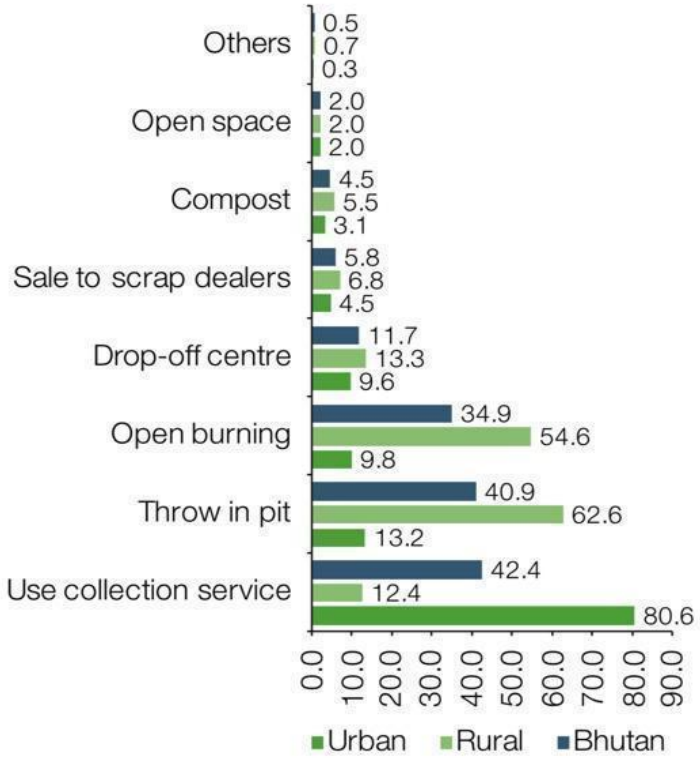


Figure 38: Household waste disposal practices. Source: NSB, 2019

8.2.2 **Sewage management**

Septic tanks are the most prominent sewer management system for houses and buildings which are cleaned and emptied when it reaches its maximum capacity. Recently, there has been an introduction of eco-friendly wastewater treatment plants across many of the Dzongkhags. The Eco-line bio film technology has been installed in the following places (Table 10). In addition, there are 7 Sewage Treatment Plants (STPs) in Thimphu Municipality.

Table 8: Wastewater treatment plants installed and under construction

	Areas	Capacity (No. of people)
1.	Trashigang	800
2.	Wamrong	800
3.	Gyalposhing	1,500
4.	Samdrupjongkhar (LAP 1)	3,000
5.	Sarpang (VTI)	1,000
6.	Damphu	1,500
7.	Trongsa (MHPA dam colony)	1,000
8.	Trongsa (MHPA Residential)	1,000
9.	Trongsa (MHPA Office colony)	400
10.	Bajo town	3,000
11.	Ministers Enclave	500
12.	Khuru town (under construction)	3,000
13.	Samdrup Jongkhar (LAP 2) under construction	4,000

Source: Sangsel Ecotrade, 2016

Table 9: Detail of STPs, Capacities, Location and the Technology of Treatment Plant

No	Type of Treatment Plant system	Capacity of Treatment plant	Location of Treatment of plant	Year of Com-missio n	Name of areas Served	Daily Average Waste (m3)
1	Moving bed Biofilm Reactor	0.75 MLD	Dechencholing	2013	Dangrina, Dechencholing	300 m^3
2	Oxidation Pond (Natural Process)	1.75 MLD	Babesa	1996	Core Area (Lower Changangkha,RBP,Changedaphu,Lower Changzamtog,Zilukha Sunay Market,JDWNRH,Old PWD colony),Olakha LAP,Lungtenphu LAP,Changdelo	1640 m^3
3	Eco line	1 MLD	Lower Taba	2019	Upper Taba,Lower Taba	696 m^3
4	Mokan Joka System	0.1 MLD	Hejo	2019	Hejo	56 m^3
5	Activated Sludge Process	0.6 MLD	Langjopkha	2017	Langjophaka	120 m^3

6	Activated Sludge Process	2 MLD	Near RSTA	2018	Yhss Area,Lower Motithang area,Kawajangsa	320 m^3
7	Sequential Batch Reactor	12 MLD	Babesa	Under Constr uction	Lungtenphu LAP,Simtokha LAP,Babesa Lap, Network towards Old Babesa STP will be diverted to the new STP once completed.	Recently commissio ned

Source: Thimphu Thromde, 2021

8.2.3 Medical waste

Medical waste refers to all categories of waste generated from health facilities, clinics, home based treatment of patients (MoH, 2021). Medical wastes are categorised into infectious, pathological, pharmaceutical wastes including sharps, chemicals, pressurised and radioactive wastes.

A total of 241 health facilities including hospitals and BHUs collectively generated a total of 1.984 tons of medical wastes per day in 2019 (NSB, 2019). Currently, there are 49 hospitals, 186 PHCs, 53 sub posts, 542 ORCs, 3 *Thromde* Health Center, 6 Health Information and Services Center (HISC) in the country (MoH, 2020). As per Annual Medical Waste report 2021, a total of 690 tons of medical wastes was generated by the medical facilities (MoH, 2021). From the total, general waste constitutes 421.57 tons and infectious waste at 268.21 tons (MoH, 2021) as below Figure 39.

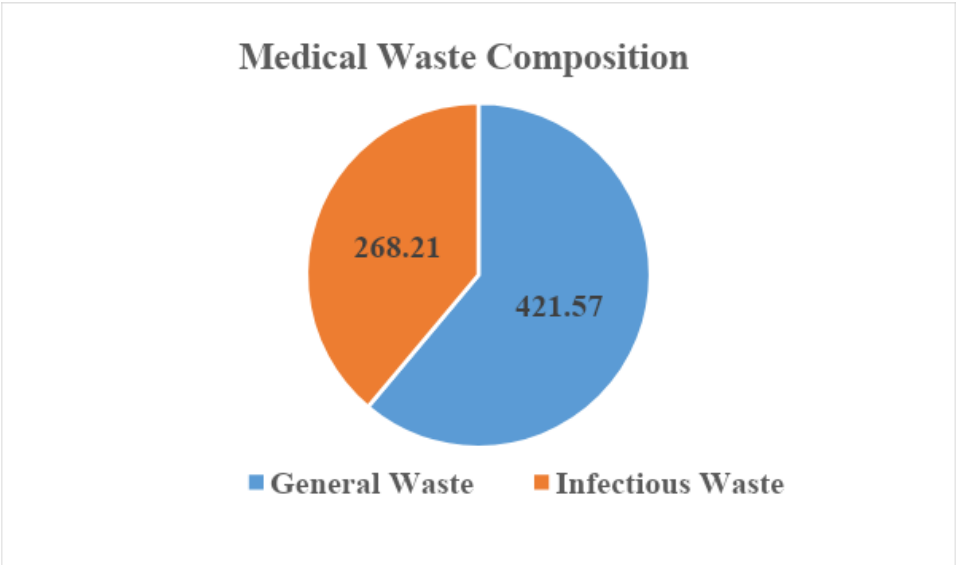


Figure 39: Composition of Medical Wastes. Source: MoH, 2021

Medical waste is segregated at the source by using colour coding bins, for instance, for general waste (green bin), food waste (blue bin), hazardous waste (red bin), and for sharps (yellow or

white bin). Deep pit burial is the predominant method of disposal of health care wastes throughout the country. All hazardous waste except pathological wastes is autoclaved. Pathological waste including sharps are disposed of in deep burial bits. Other medical wastes are segregated, treated with bleaching powder and dumped into deep pit burial. Currently, a total of 26 tons of infectious wastes including COVID-19 generated from Jigme Dorji Wangchuck National Referral Hospital were incinerated at Memeylakha (MoH, 2021). All hospitals in the country have autoclaves and waste shredders (MoH, 2021).

8.2.4 **E-waste**

E-waste refers to all discarded, obsolete or recyclable electrical or electronic equipment including all components in 2007, electrical and electronic wastes formed only 0.37% of the total 30 tons of municipal wastes collected and it consisted mostly of printer cartridges from the offices (MOWHS, 2008). In 2019, as per the National Waste Inventory Survey, e-waste has increased to 1.37 % of the total 172.161 tons generated per day (NSB, 2019). Potential recovery of precious metal such as gold, silver, copper, platinum, lead, cadmium and mercury can be extracted from electronic equipment such as the CRTs, printer circuit boards, printer wire boards, semiconductors, transistors contain at the End-of-life (Teri, 2009) as illustrated in Figure 40 below. The current practice of managing e-waste from government offices is by surrendering non-functional electronics/appliances to the Department of National Properties, while the e-waste generated by the private sector is usually repaired and reused and those beyond repair are sold to scrap dealers (Kuensel, January 2, 2016).

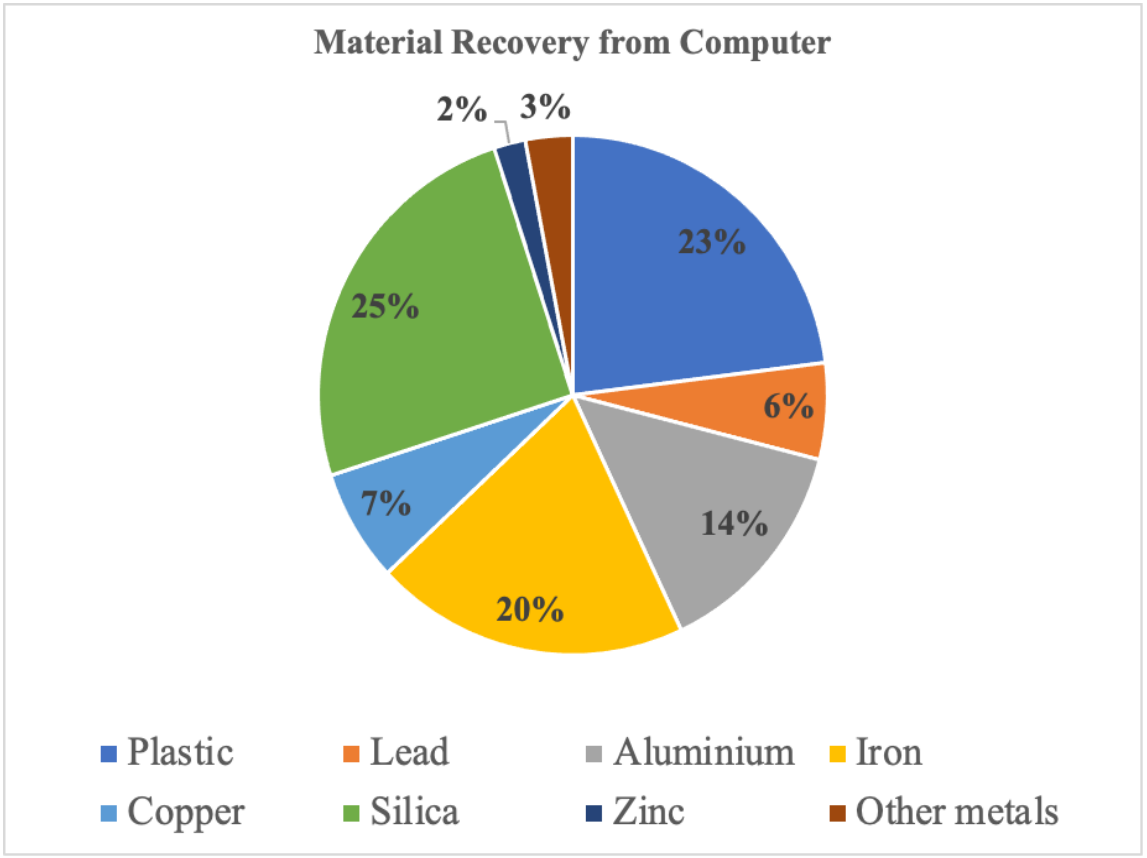


Figure 40: Material recovery from computer. Source: TERI, 2009

8.2.5 **Industrial waste**

Pasakha Industrial Area (PIA) was established in 2003 and by 2010 there were 37 registered industries of which 11 are not operational (NTNU 2010). These industries manufacture TMT bars, ingots, billets, ferro alloys, calcium carbide, marble slabs, liquid oxygen, nitrogen, bitumen, beer, soap, and carbonated drinks.

There are 5 ferro alloys industries located in PIA which generate slag and micro silica as waste. The marble processing unit generates marble slurry and some marble chips as waste. Earlier the marble slurry was bought for brick and idol making in India but due to unfavourable market conditions this has discontinued and now the waste slurry is accumulated in the factory premises (NTNU 2010).

The common practice of industries had been to stockpile the waste in their premises and the Pasakha industrial landfill has been under operation only since July 2015. As per the report from the Compliance Monitoring Division (CMD), NECS, 1,476.37 tons of waste has been collected from July 2015 - March 2016.

8.3 Impact

Poor waste management and low civic responsibility towards waste management have led to increased littering of road sides, trails, public and other open areas leading to visual eyesore and lowering of the image of "Brand Bhutan ". Open littering and illegal dumping of wastes into the environment has become a pressing issue. The NWIS report of 2019 does not include the waste data of non-domestic waste dumped in open areas, river banks, roads/drains, etc.

The difficult and steep terrain makes identification of waste management sites such as landfills and dumping areas very difficult. This means that land fill sites are often not in the ideal locations in terms of geology or proximity to communities.

The non-biodegradable waste and other waste including hazardous materials from households, institutions, medical facilities and industrial areas has the potential to contaminate and pollute the surrounding environment including water bodies and soil. Leachate management from the Thimphu municipal dump has been a challenge. Wastewater Treatment Plants (WWTPs) currently receive both gray and black waters together from households and buildings, and effluents are discharged into the water bodies like rivers. Hence, with the low removal efficiencies of WWTPs, it can contaminate the water quality including the presence of microplastics and deteriorate the health of the freshwater ecosystem. In terms of e-waste, after the end of electronic equipment's life, the process of recovering precious metals involves use of acids and other hazardous chemicals that can deter environmental health as illustrated in table 10. Concurrently, as per Teri, the absence of an effective method for collection and reporting of e-waste will lead to exposure to hazardous elements like lead, cadmium, mercury, arsenic, barium, beryllium and brominated flame-retardants (Teri, 2009).

Table 10: Harmful effects of handling e-waste

Components	Toxic Constituents	Potential Occupational Hazard
Printed circuit boards	Lead and cadmium	• Tin and lead inhalation • Possible brominated dioxin, beryllium, cadmium, mercury inhalation
Cathode ray tubes	Lead oxide and Cadmium	• Silicosis • Injuries from CRT glass in case of implosion • Inhalation or contact with phosphor containing • cadmium or other metals
Switches, Flat screen monitors	Mercury	• Affecting the central nervous system as well as kidneys in human being
Computer batteries	Cadmium	• Very toxic for inhalation • Carcinogenic
Capacitors and transformers	PCB	• Very toxic to aquatic organisms thereby enters human being through food chain
Printed circuit boards, plastic casings cable	Brominated flame retardant (brominated dioxin, and heavy metal)	• Inhalation of brominated dioxin, and heavy metal
Cable insulation/coating	PVC (Contain chlorine which form dioxins and furans)	• Inhalation of dioxins and furans

8.4 Response

8.4.1 Policies and legislation

Policy and legislation on waste management is detailed as Annexure II.

The recommendation from the National Conference on Sustainable Solid Waste Management (MoWHS, 2014) has identified the requirement of strict enforcement of existing rules and regulations on waste management followed by adequate monitoring. The conference also noted that cleaning campaigns were not an effective and sustainable solution for waste management and it should only be used as an awareness initiative.

8.4.2 Waste Management Flagship Program

Under the 12th Five Year Plan of Bhutan, the Royal Government of Bhutan has prioritised addressing the pertinent issue of solid waste as one of the national flagship programs. The Royal Government of Bhutan endorsed 'Waste Management and Stray Dog Population Control' as a flagship program on January 23, 2020 during the 46th Lhengye Zhungtshog. Prior to the government endorsement, Her Majesty the Gyaltsuen most graciously launched the Waste Management Flagship Programme on June 2, 2019.

As per the blueprint of the Waste Management Flagship Program, the program intends to embark on a multi-pronged approach. On the waste management front, the overall goal is to achieve Zero Waste Bhutan whereby the current trend of disposing over 80% to the landfill is reversed to less than 20 % based on the principles of circular economy. This can be achieved through the propagation of 100% source segregation and provision of adequate downstream facilities such as provision of segregation bins to all household, adequate number of waste collection facilities & drop-off centres at convenient locations, efficient collection, storage and transportation systems, functional material recovery facilities and final disposal facilities such as sanitary landfills and incineration plants. These facilities will be complemented by education and awareness on the consequences of unmanaged waste to both human health and the environment;

policy interventions, particularly on the establishment of a sustainable financial mechanism to realise a self-sustaining model for effective and efficient management of all streams of waste; and private sector involvement in provision of waste management services. The program module includes all aspects of waste management from waste generation and separation/segregation; collection, transfer and transport; sorting, treatment and recovery; and final disposal with an emphasis on maximising resource efficiency (NECS, 2020).

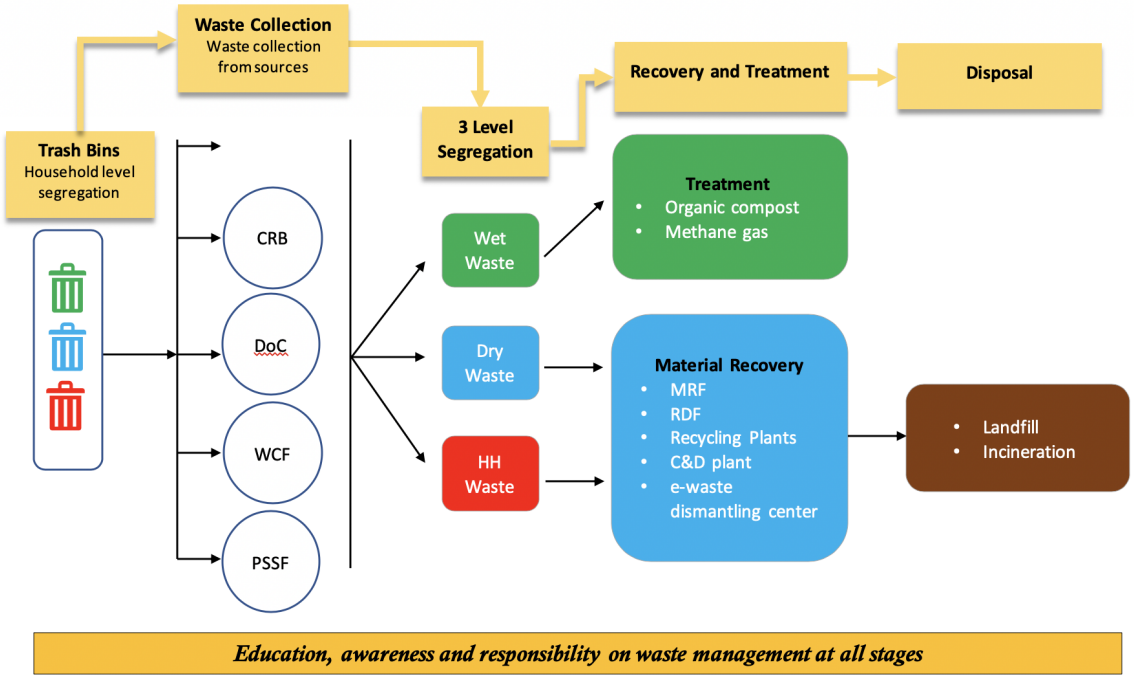


Figure 41. Flow chart of the program module

The Waste Management Flagship Program has rolled out in Thimphu as a pilot for the last two years from 2020 by the Program Management Unit housed by the Waste Management Division under the National Environment Commission Secretariat.

The PMU has successfully implemented and achieved the following activities:

- Development of Waste Management Flagship Blueprint;
- Construction and operation of 25 Waste Collection Facilities (WCF-I, II & III) under Thimphu Dzongkhag;
- Distribution of 9 electric waste collection vehicles to Thimphu Thromde;
- Launched Zero Waste Bhutan website;
- Initiated construction of a 40 TPD Material Recovery Facility (MRF) as Taba;
- Developed Education Awareness and Behavioral Change Strategy;
- Developed Ecology Note of Bhutan and successfully integrated into the revised science curriculum of class 4-8;
- Developed 12 Standard Operating Procedures (SOPs) for institutional waste management across the country;
- Installed and operation of 300 kg/cycle biomedical and hazardous waste incinerators in Thimphu, Phuentsholing, and Mongar;
- Distribution of 300 numbers of Street Litter Bins to Thimphu Thromde;

- Published a social experiment report on three-colour coded bin source segregation in Thimphu;
- Enhanced capacity of participants from Self-Help Women Group and Special Educational Needs (SEN) on plastic waste upcycling;
- Development of Zero Waste Bhutan APP to enforce and monitor Waste Prevention and Management Act 2009; and
- Construction of Integrated Waste Management Facility at Memelakha, Thimphu is under progress.

Include waste prevention and management act 2009 (Zero Waste Bhutan APP)

8.4.3 **Civil society and community mobilisation**

Clean Bhutan is a relatively new civil society organisation that has been working to advocate and sensitise the citizens about behaviour and habits to manage waste and to help reduce waste generation. Clean Bhutan works on mobilising volunteers and focuses on clean rivers and tributaries, clean trekking routes and highways, and zero waste communities, villages and towns.

The Samdrup Jongkhar Initiative (SJI) under the Lhomon Society is working to develop a potential model to raise living standards in Samdrup Jongkhar dzongkhag. As part of its key focus areas, SJI is actively promoting zero waste strategies that are significantly reducing waste, building awareness and empowering communities.

The NECS in collaboration with schools under Thimphu Thromde, launched a program on Youth Action for 4Rs. The program aims to build a lasting and sustainable partnership in waste management with the schools; establish a conducive environment for fostering environmentally friendly thinking in our youth; and instil civic responsibility and good ethics in waste management in families and society by making our youth goodwill ambassadors in waste management. The Youth Action for 4Rs program has 10 schools from Thimphu Thromde, one monastic school from Thimphu, six schools from outside Thimphu and Bhutan Archery Federation as a partner. Furthermore, the National Environment Commission Secretariat developed an environmental education material for the school children to bring in behavioural change towards waste management and instil a sense of civic ownership on "my waste, my responsibility". This Ecology Note of Bhutan was later successfully integrated in the revised science curriculum of class 4-8 across the country.

Furthermore, to eliminate illegal dumping of wastes and inculcate a sense of social responsibility towards "My waste, my responsibility", the National Environment Commission Secretariat launched the Zero Waste Hour on June 2, 2019 by Her Majesty The Gyaltsuen coinciding with the Coronation Day of His Majesty The Fourth Druk Gyalpo. At least an hour on the second day of every month as "Zero Waste Hour" was observed by all offices, institutions and every citizen across the country by cleaning their own surrounding areas to make it a waste free backyards and to manage our own waste in an environmentally sound manner.

8.5 Recommendations

8.5.1 Provision of support in the implementation of Waste Prevention and Management Act of Bhutan and its Regulation.

Provide adequate financial, technical and capacity building support to the implementing and collaborating agencies to effective implementation of Waste Prevention and Management Act, 2009 and its Regulation 2014.Operationalization of the National Integrated Solid Waste Management Strategy, 2014

Implementing and collaborating agencies should prepare and implement an action plan towards attaining "Zero Waste through maximising resource recovery for creating sustainable waste management systems and protecting the natural unique ecology of Bhutan" as reflected in the NISWM, 2014.

8.5.2 Strengthen stakeholder coordination, engagement and support

Waste management is a pertinent and cross cutting issue that needs support from all implementing agencies and related stakeholders across the country to achieve Zero Waste Bhutan vision.

8.5.3 Promote public-private partnership

Continue to encourage and incentivize private entities in carrying out waste management initiatives.

9. CROSS-CUTTING ISSUES: CLIMATE CHANGE

Bhutan is highly vulnerable to the adverse impacts of climate change. In addition to being a landlocked and least developed country with a fragile mountainous environment, high dependence of the population on agriculture and the significant role of hydropower for economic development increases the vulnerability. Bhutan also faces increasing threats from climate hazards and extreme events such as flash floods, glacial lake outburst floods (GLOF), windstorms, forest fires and landslides.

9.1 Pressure

Global warming and climate change is a global phenomenon that has been attributed to human activities since the start of the industrial revolution (IPCC 2014). In Bhutan climate change is viewed as largely driven by global level activities but is affecting all sectors in Bhutan.

The emission of greenhouse gases from Bhutan is largely negligible at a global level and in fact Bhutan's vast forests absorb more CO2 than total GHG emissions indicating that the country is a net sink of greenhouse gases (NEC 2011).

9.2 State

In terms of GHG emissions, the emission of greenhouse gases from Bhutan are increasing with increasing socio-economic development but are still within the sink capacity of the forests and is further discussed under the Air Section.

The current vulnerabilities to climate change are highlighted in the National Adaptation Programme of Action (NEC 2005) and the Second National Communication to the UNFCCC (NEC 2011). Bhutan is vulnerable in all key sectors of water, agriculture, human health, energy (hydropower), forests and biodiversity and natural disasters. Some of the observed vulnerabilities and possible impacts are seen in dwindling water sources, increasing pests, increasing incidences of forest fires and changing monsoon patterns as described in the other sections in this report.

The rapid melting of glaciers and increasing risk of GLOF is of particular concern in Bhutan. Glaciers are reported to be melting at rates of 30-40m per year for debris-covered glaciers and 8-10 metres per year for debris-free glaciers (NEC 2011).

9.3 Impact

9.3.1 **Biodiversity**

It is anticipated that there will be a general northward/upslope migration of Bhutan's forests in the future under rising average temperatures (NECS 2011). There have already been observations of Blue pine (*Pinus wallichiana*) encroachment into spruce/maple/birch forests and decline of *Abies densa* forests on the mountain tops in the 1980s due to moisture stress (Gratzer et al., 1997).

The Montane cloud forests of Bhutan which occur around 2,500 masl located in the inner deep valley slopes of Dochula-Bajo series are also vulnerable to increased incidence of moisture stress from rising temperature (Wangda and Ohsawa, 2010). This could lead to habitat loss for some important relict plant species like *Taxus*, *Magnolia*, *Tetracentron* and endangered bird species such as hornbills (MoAF 2014).

A study by Wangchuck Centennial Park (2011) on the vulnerability in Wangchuck Centennial Park indicates considerable loss of habitats for the snow leopard and other endangered and globally significant birds under future climate. Habitats of Black Necked Crane and White Bellied Heron are likely to be at additional risk. Intensity and incidences of pests and diseases is also likely to increase.

9.3.2 **Water resources**

Climate change causes glacial retreat, glacial lake outburst floods and reduction of water resources. The fifth Assessment Report of IPCC states with high confidence that glaciers are continuing to shrink almost worldwide. Projections from the SNC 2011 also indicate glacier retreat rates of 78.2 m to 168 m for the period 2010-2039 for debris covered glaciers and of 20.1 m to 43.2 m for the period 2040-2069 for debris free glaciers. As a result of its impact on water, climate change threatens hydropower for clean energy and other socio economic activities (NEC 2011).

The climate scenarios in the SNC (2011) project a moderate increase in mean total annual rainfall for the 2040-2069 period, with the wet monsoon season getting wetter and the dry winter season getting warmer and drier. There may be more incidences of water shortages especially during the dry winter season. More specifically, rainfall is expected to particularly increase in the south of the country especially during the monsoon period when water is already abundant (NEC 2016).

9.3.3 **Air quality**

Projected climate change could exacerbate respiratory disorders associated with reduced air quality in urban and rural areas. Studies have indicated that high temperatures are an enabling condition for high ozone concentrations at ground level (IPCC 2007), which causes adverse public health and ecosystem impact.

Higher temperatures, decreased soil moisture, extended periods of drought due to climate change enhances risk of wildfires, leading to air pollution. Climate change will also affect aeroallergens which are pollen of specific seasonal plants. Studies have indicated that there will

Image 7: High altitude glacial lakes of Lunana. (Left to right: Bechung, Raphstreng and Thorthormi lake). Thorthormi lake was identified as one of the most dangerous glacial lakes in Bhutan and was the subject of the first NAPA project to reduce risk of GLOF. Photo: Chencho Norbu, 2010

be earlier onset of pollen season, possibly enhanced seasonal pollen loads in response to higher temperature and longer growing season (Kinney 2008).

9.3.4 Land use and land use change

Climate change is likely to exacerbate soil erosion, cause floods and landslides leading to further reduction in biomass, physical and chemical degradation of land (UNCCD 2015).For example, extreme precipitation can reduce productivity of land by washing off topsoil. Climate change and land degradation has the potential to disrupt ecological and land use systems which in turn affect food and water supplies leading to negative impacts on livelihoods and adaptive capacity.

9.4 Response

9.4.1 Institutional arrangements

The National Environment Commission is the highest-level climate change committee. A Multi-Sectoral Technical Committee on Climate Change (MSTCCC) was established by the NEC in 2010 with members from line agencies including representatives from private and civil society organisations and serves as the technical level body for coordinating climate change activities. A Climate Change Division was established within the NECS in 2009.

9.4.2 Carbon neutral declaration

The Constitution of the Kingdom of Bhutan mandates a minimum of 60% of Bhutan's total land mass to be kept under forest cover for all times. This mandate forms the cornerstone of Bhutan's commitment to remain carbon neutral, where emissions from Bhutan will be kept below the sink capacity of the forests. The carbon neutral commitment was initially declared in 2009 at the 15th Conference of Parties to UNFCCC, and again included in Bhutan's Intended Nationally Determined Contribution towards the finalisation of the Paris Agreement in 2015.

9.4.3 Low emission development strategies and action plans

Efforts are underway to build capacity towards achieving the carbon neutral commitment under various projects, and two Low Emission Development Strategies (LEDS) and three Nationally Appropriate Mitigation Actions (NAMAs) are being developed. These strategies are action plans geared towards reducing emission from industrial, transport, waste and building sectors.

Other national initiatives that contribute to mitigation of climate change include sustainable land management, livestock improvement, reforestation programmes and alternative renewable energy sources wherever feasible.

9.4.4 Implementing adaptation action

Adaptation to climate change in Bhutan is being undertaken under several projects and programs, through implementation of the National Adaptation Program of Action (NAPA). The first NAPA project successfully reduced risks and vulnerabilities from glacial lake outburst floods in the Punakha and Wangdi and Chamkhar valleys" (NECS, 2012). The second NAPA project currently under implementation will enhance national, local and community capacity to prepare for and respond to climate induced multi hazards to reduce potential lessees of human lives, national economic infrastructure, livelihood and livelihood asset (NEC, 2016).

Other adaptation action is being taken by the Ministry of Agriculture and Forests through a Sectoral Adaptation Program of Action (SAPA) to enhance the resilience of Bhutan's rural households to the effects of climate change. The Ministry of Health also implemented a pilot project on health adaptation to climate change to assess risk and develop an integrated surveillance to enhance effective management of climate sensitive health risks, improve capacity

to respond to climate-sensitive health risks and emergency preparedness and disease prevention measures.

An Ecosystem Based Adaptation (EbA) project for Thimphu is being developed to strengthen the adaptive capacity by raising public awareness of the impacts of climate change and the benefits in urban areas through EbA interventions.

9.4.5 National Adaptation Plans

Adaptation in the medium to long run will be addressed through the planning and implementation of National Adaptation Plan (NAP). The NAP process was established at COP16 of UNFCCC and the primary objectives of NAPs are to reduce vulnerability to the impacts of climate change and to integrate climate change adaptation into policies, programmes and plans. A proposal has been drafted to develop Bhutan's first NAPs and the NAP process in Bhutan will be synchronised with the five-year development planning cycles and also the reporting cycles of the Paris Agreement.

9.4.6 REDD+

Bhutan is preparing to participate in the REDD+ program under the United Nations Framework Convention on Climate Change (UNFCCC). REDD+ mechanism is designed to reduce emission from deforestation and forest degradation and enhance carbon sequestration through sustainable management of forest resources, using market and financial incentives. The Department of Forest and Park Services is leading the readiness program. REDD+ mechanism has potential to generate carbon revenues as well as non-carbon co-benefits and contributes to Bhutan's sustainable development through improved management of forest resources, forest law enforcement and governance.

Image 8: Climate smart agriculture practice. Photo Chencho Norbu

9.5 Recommendations

9.5.1 **Increased coordination for access to climate finance**

Improve coordination mechanisms to access climate finance. The financing options and strategy should align with the national priorities as set out by the various national documents that reflect local needs and priorities. Information on such sources should be made available by the various focal agencies of the different climate funds and donors to sectors and other implementers.

9.5.2 **Enhance knowledge generation on the impact of climate change**

Improve knowledge generation process, which will provide the scientific basis for climate actions. Research capacity of the national institutions, especially within Royal University of Bhutan, should be enhanced through systematic transfer of knowledge to empower local experts.

10. RECOMMENDATIONS

#	Land: Recommendation	Responsible Lead Agency
1	Implement Strategic Environment Assessment for urban (new Thromde plans) and infrastructure planning including impacts beyond urban or project boundary.	Ministry of Infrastructure and Transport (MOIT).
2	Integrate Food and Nutrition Security Policy into overall decisions on land conversion planning for development activities.	Ministry of Agriculture and Livestock (MOAL).
3	Identify and prioritise critical forests, habitats and watersheds for sustainable management of land and water resources.	Department of Forest and Park Services (DOFPS).
4	Carry out land capability mapping to identify areas that can be sustainably support various uses such as agriculture and other development activities.	Ministry of Energy and Natural Resources (MOENR).
5	Studies on ecological footprint and local ecological carrying capacity should be carried out to support policy makers, planners, decision makers and managers in development planning and land management as per Constitutional mandates on "ecological degradation".	MOENR
Sl No	**Water: Recommendation**	**Responsible Lead Agency**
1	Institutionalise NIWRMP.	Department of Water (DOW).
2	Expand and establish real time water monitoring stations.	DOW
3	Carry out groundwater assessment in selected sites.	DOW
Sl No	**Air: Recommendation**	**Responsible Lead Agency**
1	Revise air quality standards, strengthen its implementation and improve data management system.	Department of Environment and Climate Change (DECC).
2	Strengthen regional cooperation to curb trans-boundary air pollution	Ministry of Foreign Affairs and External Trade (MOFAET).
3	Increase coverage and parameters for air quality monitoring	DECC
4	Promotion of vehicle emission control measures.	MOIT
5	**Full enforcement of vehicular emission standards.** Production of vehicle emission test certificates should be made mandatory during annual vehicle roadworthiness inspections. Furthermore, traffic police should be required to check vehicle emission test	MOIT

	certificate when checking driving licence, vehicle registration certificate and insurance certificate.	
Sl No	**Biodiversity: Recommendation**	**Responsible Lead Agency**
1	Incorporate biodiversity concerns into the EIA and SEA	National Environment Commission (NEC).
2	Maintain minimum e-flows for aquatic life.	DECC
3	Update list of flora and fauna and invasive alien species.	National Biodiversity Centre (NBC)
4	Baseline information for aquatic species.	DOFPS
5	Demarcate boundaries for all protected area networks.	DOFPS
Sl No	**Waste Management: Recommendation**	**Responsible Lead Agency**
1	Provision of support in the implementation of Waste Prevention and Management Act of Bhutan and its Regulation.	Ministry of Finance (MOF).
2	Strengthen stakeholder coordination, engagement and support.	DECC
3	**Promote public - private partnership**	DECC
Sl No	**Climate Change: Recommendation**	**Responsible Lead Agency**
1	Increase coordination for access to climate finance.	DECC
2	Enhance knowledge generation on the impact of climate change.	DECC

Annexure I: DPSIR Framework

Drivers

In general, the **Drivers,** or indirect forces, are defined as fundamental processes in society (which include demographic changes and economic and social processes) that cause more concrete **Pressures** on the environment (such as changes in land use, resource extraction, pollution and waste production, and the modification and movement of organisms). Key drivers include: demographics; consumption and production patterns; scientific and technological innovation; economic demand, markets and trade; distribution patterns; institutional and social-political frameworks and value systems. The characteristics and importance of each driver differ substantially from one region to another, within regions and within and between nations. For example, in the area of population dynamics, most developing countries are still facing population growth while developed countries are faced with a stagnant and ageing population. The resource demands of people influence environmental change.

Pressures

Key pressures include: emissions of substances which may take the form of pollutants or waste; external inputs such as fertilisers, chemicals and irrigation; land use; and resource extraction. Human interventions may be directed towards causing a desired environmental change such as land use, or they may be intentional or unintentional by-products of other human activities, for example, pollution. The characteristics and importance of each pressure may vary from one region to another, but it is often a combination of pressures that leads to environmental change. For example, climate change is the combined result of emissions of different greenhouse gases, deforestation and land-use practices. Furthermore, the ability to create and transfer environmental pressures onto the environment of other societies varies from one region to another. Affluent societies with high levels of production, consumption and trade tend to contribute more towards global and transboundary environmental pressures than the less affluent societies which interact in more direct fashion with the environment in which they live.

State and Trends

Environmental state also includes trends, which often refers to environmental change. Environmental change may be natural, human-induced or both. Examples of natural processes include solar radiation, extreme natural events, pollination, and background levels of erosion. Key forms of human induced environmental change include, for example, climate change, desertification and land degradation, biodiversity loss, and air and water pollution. Different forms of natural or human-induced changes interact. One form of change, for example, climate change, will inevitably lead to ecosystem change, which may result in desertification and/or biodiversity loss. Different forms of environmental change can reinforce or neutralise each other. For example, a temperature increase due to climate change can, in Europe, partly be offset by changes in ocean currents triggered by climate change. The complexity of the physical, chemical and biological systems constituting the environment makes it hard to predict environmental change, especially when it is subject to multiple pressures. The state of the environment and its resilience to change varies greatly within and among regions due to different climatic and ecological conditions.

Impacts

The environment is directly or indirectly affected by activities in the social and economic sectors, contributing to change (either negative or positive) in human well-being and in the capacity/ability to cope with environmental changes. Impacts, be they on human well-being, the

social and economic sectors or environmental services, are highly dependent on the characteristics of the drivers and, therefore, vary markedly between developing and developed regions.

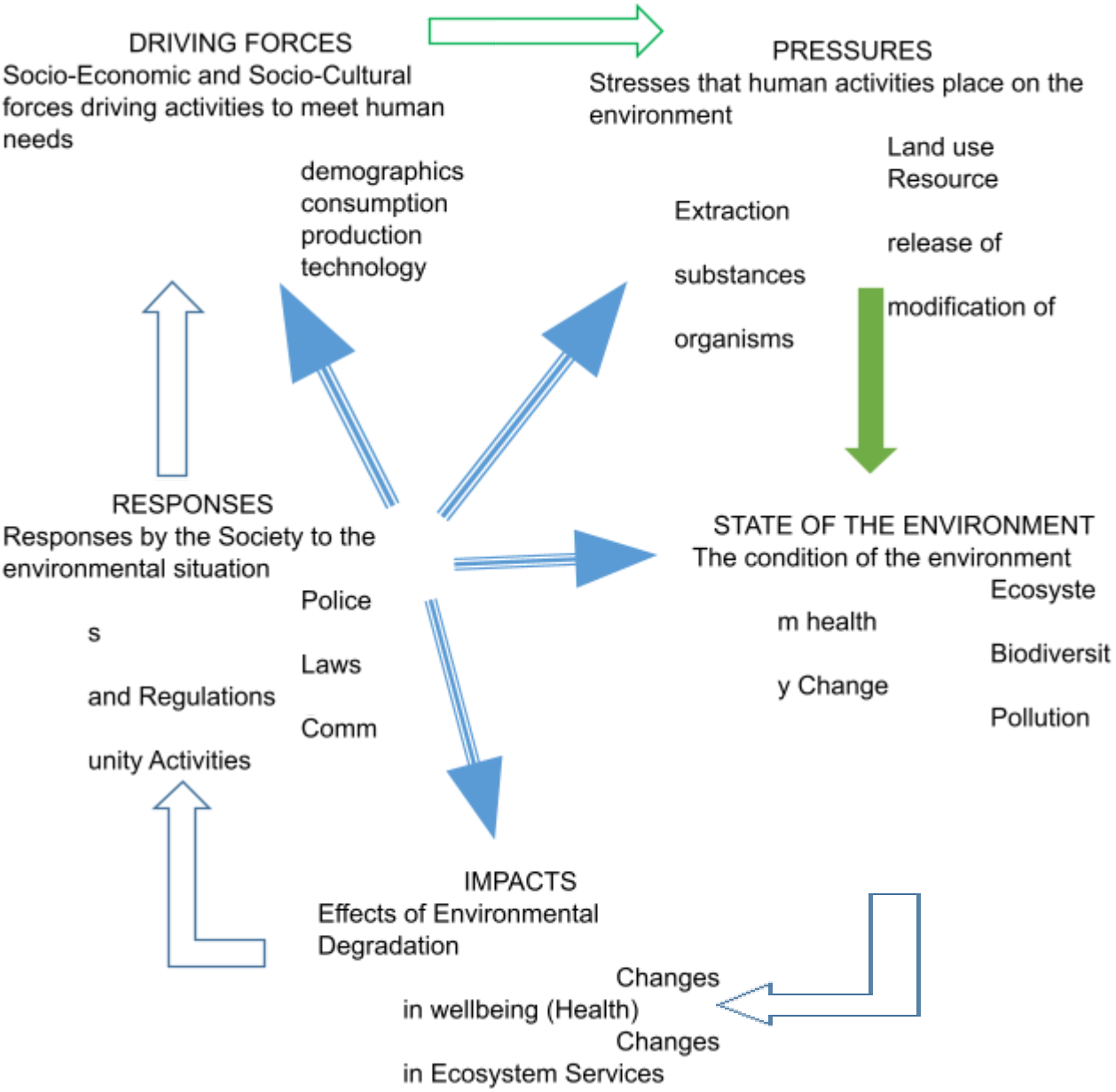
Responses

Responses address issues of vulnerability of both people and the environment, and provide opportunities for reducing human vulnerability and enhancing human well-being. Responses take place at various levels: for example, environmental laws and institutions at the national level, and multilateral environmental agreements and institutions at the regional and global levels. The capacity to mitigate and/or adapt to environmental change differs among and within regions, and capacity building is, therefore, a major and overarching component of the response options.

The *GEO* framework has been used in the analyses of issues in all the chapters, both explicitly and implicitly. Its utility is in integrating the analyses to better reflect the cause-and-effect relationships, and ultimately society's response in addressing the environmental challenges it faces**.**

The DPSIR Framework

(Driver-Pressure-State-Impact-Response)



Annexure II: Policy Responses

Water

Water Act and Regulation

The Water Act of Bhutan 2011 and Water Regulation of Bhutan 2014 is an important milestone in the development of the legal framework regarding the water resources management in the country. The scope of the Act and regulation covers water management in all its aspects: surface water and groundwater, both in quantitative and in qualitative terms. It also concerns the infrastructure dimension: river basins, irrigation systems, dams, water supply systems, etc.

Bhutan Drinking Water Quality Standards

The Bhutan Drinking Water Quality Standard 2016 describes the quality parameters set for drinking water and the maximum permissible limit for each of the set parameters. Such primary standards protect public health by limiting the levels of contaminants in the drinking water.

Environmental Standards

An environmental standard 2020 was developed for maintaining a clean, healthy environment. An environmental standard specifies the maximum permissible concentration and it seeks to regulate and reduce the amounts and/or complexity of wastes discharged and pollution to the environment and to keep emission levels below the set standard.

Wetland Regulation

The Wetlands regulation under DoFPS restricts any significant conversion of wetlands areas and has provided the required standards and guidelines for the protection of our water resources.

Air

Policies and Strategies

There are a number of existing Policies and strategies that are geared towards promoting low emission and efficient development in the transport sector. The key strategies include promotion of mass transport, non-motorised transport and cleaner modes of transport such as alternative fuels, electric cars and hybrid cars. Some of the key policies and strategies are listed below.

- National Transport Policy, 2006
- Road Sector Master Plan (2007-2027)
- Surface Transport Development Plan 2007
- Economic Development Policy (2010)
- Bhutan's Second National Communication to the UNFCCC (2011)
- Transport 2040: Integrated Strategic Vision (2011)
- National strategy and action plan for low carbon development, 2012
- Bhutan's Intended Nationally Determined Contribution (2015)
- Bhutan's National Environment Strategy for Sustainable Development (2015)

Emission Standards & Road worthiness certificate

The national standards for vehicle emissions were set in 2004 for improving the efficiency of the vehicle fleet in the country. Environmental standards covering industrial emissions, ambient air quality, and workplace emission have been set by the National Environment Commission in 2020. Roadworthiness certificates for the vehicles are required to be renewed on an annual basis.

Biodiversity

Implementation of Policies and legal instruments

Following are some of the Policies and Acts supporting biodiversity conservation and use:

The Forest Act of 1969 was the first legislation related to the conservation of biodiversity. Later, the National Forest Policy was formulated in 1974 which highlighted biodiversity conservation in Bhutan. Subsequently, the Plant Quarantine Act 1993 was enacted to prevent the introduction of pests not already present or widespread in the country; control those pests already present by restricting their spread and by endeavouring to eradicate them; provide facilities for services for import of plant products; and extend cooperation in the prevention of movement of pests in international trade and traffic.

The Forest and Nature Conservation Act of Bhutan, 1995 lists a total of 30 species of wild animals and plants in Schedule I as totally protected species. These include 17 species of mammals, 1 species of fish, 5 species of birds and 7 species of trees. The list was further revised and approved by the Cabinet in February 2012 whereby 6 species of birds were included under Schedule I as totally protected. The Plant Quarantine Act 1993 and Seed Act of Bhutan 2000 were enacted to regulate import and export of plants and seeds and to prevent invasive species.

The Environmental Assessment Act 2000 directs the government to ensure that environmental concerns are taken into account when formulating, renewing, modifying and implementing any policy, plan or program. It requires the issuance of environmental clearance as a prerequisite to the approval of any development activity.

The Seed Act of Bhutan 2000 regulates the import and export of agricultural seeds and prevents introduction of unwanted plants and diseases. It also promotes the seed industry with the aim to enhance rural income and livelihood.

The Pesticide Act of Bhutan 2000 encourages the practice of organic agriculture and integrated pest management with a centralised system that controls and limits the import, sale and use of pesticides.

The Biodiversity Act of Bhutan 2003 ensures regulating access to genetic resources in the country and promoting sustainable and use of biodiversity resources through benefit sharing and protecting local knowledge and interests related to biodiversity. The National Environment Protection Act of Bhutan 2007 has an entire chapter dedicated to the protection of forest, biodiversity and ecosystem integrity.

The National Environment Protection Act 2007 calls for conservation of natural resources to be based on a participatory approach aimed at achieving an equitable sharing of the costs and benefits of conservation among resource users. It also promotes the use of clean energy and alternative technologies in order to reduce use of fuel wood/timber from primary forests. It also calls for conservation and protection of wetlands, alpine regions, watersheds, and other vulnerable ecosystems in addition to the existing protected areas.

The Constitution of the Kingdom of Bhutan 2008 decrees that the country maintain a minimum of 60 percent of the total land under forest cover for all times to come. The government is tasked to conserve and improve the environment and safeguard the country's biodiversity.

The National Forest Policy 2011 ensures that Bhutan's forest resources and biodiversity are managed sustainably to provide a wide range of social, economic and environmental benefits

while maintaining the constitutional requirement of a minimum of 60% of the country's total area under forest cover.
The Water Act of Bhutan 2011 establishes water resources as a state property and ensures that it is protected, conserved and/or managed in an economically efficient, socially equitable and environmentally sustainable manner.

Cross Cutting (Waste Management and Climate Change)
The Waste Prevention and Management Act 2009 extends to all forms of waste whether solid, liquid, or gaseous, hazardous or non-hazardous, organic or inorganic, from residential, agricultural, commercial, medical or industrial sources, produced by any person, including materials being stored for recycling or in the process of recycling, including the transportation of waste in any form, and import and export of waste in Bhutan.

The Waste Prevention and Management Regulations 2012 identifies roles and areas of implementation of the implementing agencies for the purpose of establishing a sound waste management system including monitoring procedures at every organisation level, through efficient collection, segregation, treatment, storage, transportation, reduction, reuse, recycling and safe disposal of solid, liquid and gaseous wastes.

In keeping with the requirements of the legislation and regulation of waste management, an Integrated Solid Waste Management Strategy was developed in 2014 to operationalize and institutionalise a comprehensive set of planning approach and practices for integrated solid waste management.

Annexure III: Waste Management in Thimphu City

Thimphu Thromde has the highest population among urban centres in Bhutan at around 116,012 of the total 757,042 population in 2015.

Till December 2014 Thimphu Thromde was responsible to collect and dispose waste at the landfill without any segregation done at source and site. In 2010, Greener Way, a private firm started collection of recyclable waste like plastic bottles and paper. Only as recently as 2015, Thimphu Thromde has outsourced collection and segregation of waste to Greener Way and with privatisation the main focus has been on waste segregation at source. Other than this formal entity, there are several non-formal scrap collectors/dealers in Thimphu and other Urban Centers. Greenerway handles, on average, 20–22 tonnes of PET bottles, 40–45 tonnes of waste paper and 18–20 tonnes of HDPE (mixed waste) per month (UNDP 2012).

The Thimphu Thromde inaugurated a composting plant in October 2010 at a cost of Nu. 8.1 million. The Ministry of Economic Affairs, Ministry of Agriculture and NEC coordinated efforts in establishing this plant. The compost plant in Serbithang receives about four tones (4,000kgs) of organic waste daily, except on Sundays. This is a threefold increase compared with previous years. The plant received 226 truckloads (141,259kgs per month) of wet organic waste from Greener Way (contracted to collect and segregate waste within Thimphu) within the last 4 months (Kuensel, 6 May 2015).

The landfill of Thimphu was built in 1994 within an area of 3.41 acres, with a capacity for 10 years but the landfill reached its capacity in 6 years. It is used more as a dumping ground because it does not fulfil the requirements of a landfill as it lacks concreting and plastic lining to prevent leakage of leachate and ducts to collect methane. Due to leakage of leachate and waste overflow, Thimphu Thromde now has plans to build a semi-aerobic landfill in Memelhakha which will also include a leachate collection facility.

The national waste survey 2008 has indicated a per capita waste generated of 0.53 kg/day and is estimated to generate 61486 kg/day (61.48 tonnes/day) by the total population of Thimphu in 2015. The graph below shows the municipal waste generation projections of Thimphu till 2030. The population growth rate of Thimphu is 2.2% and solid waste management facilities will need to cater to the growing waste.

An interview with Clean Bhutan, a local Non-governmental Organization with a vision of zero waste Bhutan by 2030 stated that on an average; people living in Thimphu generate 0.3kg of waste per person per day. In particular, the dumping ground located between Taba and Lanjophakha saw a waste collection of approximately 8MT (8000 kgs) per day in 2016. This is due to people living in Dechencholing, Taba and Thimphu Thromde bringing their waste to this dumping ground when they miss the collection truck and over weekends to throw waste collected over the week (Clean Bhutan May 2016 interview). Subsequently; 4-5 truckloads (approximately 20 MT) of recycling waste of cardboards and PET bottles are collected from Paro and Thimphu (Clean Bhutan May 2016 interview).

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Acronyms and Glossary of Bhutanese Terms

Acronyms

AAC	Annual Allowable Cut
BEO	Bhutan Environment Outlook
BHU	Basic Health Unit
BLLS	Bhutan Living Standard Survey
BSER	Bhutan State of the Environment Report
BTEFC	Bhutan Trust Fund for Environmental Conservation
BWP	Bhutan Water Partnership
CBD	Convention on Biological Diversity
CCD	Climate Change Division
CFT	Cubic Feet
CITES	Convention on International Trade in Endangered Species of Fauna and Flora
CMD	Compliance Monitoring Division
CO2	Carbon dioxide
CTEM	Clean Technology and Environmental Management
DHMS	Department of Hydromet Services
DITT	Department of Information Technology and Telecom
DoE	Department of Energy
DoFPS	Department of Forest and Park Services
DoR	Department of Roads
DPSIR	Driver-Pressure-State-Impact-Response
DRC	Department of Revenue and Customs
DRE	Department of Renewable Energy
EC	Environmental Clearance
ECHAM	European Center Hamburg Model
EFRC	Environment Friendly Road Construction
EIMS	Environmental Information Management System
EU	European Union
FDI	Foreign Direct Investment
FFF	Forest, Facts and Figures
FMU	Forest Management Unit
FRMD	Forest Resource Management Division
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse gas
GIS	Geographic Information System
GLOF	Glacial Lake Outburst Flood
GNH	Gross National Happiness
GNHC	Gross National Happiness Commission
HadCM	Hadley Centre Coupled Model
ICIMOD	International Center for Integrated Mountain Development
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
JDNP	Jigme Dorji National Park
JDWNRH;	Jigme Dorji Wangchuck National Referral Hospital
JICA	Japan International Cooperation Agency

LDC	Least Developed Country
LCMP	Land Cover Assessment Project
MCM	Million Cubic Meter
MDG	Millennium Development Goal
MoAF	Ministry of Agriculture and Forests
MoEA	Ministry of Economic Affairs
MoIC	Ministry of Information and Communication
MSTCCC	Multi Sectoral Committee on Climate Change
MT	Metric ton
MW	Megawatt
NAP	National Action Program to Combat Land Degradation
NAP	National Adaptation Plan
NAPA	National Adaptation Program of Action
NBC	National Biodiversity Center
NBSAP	National Biodiversity Strategic Action Plan
NCD	Nature Conservation Division
NEC	National Environment Commission
NECS	National Environment Commission Secretariat
NEPA	National Environment Protection Act of Bhutan, 2007
NFI	National Forest Inventory
NIIT	National Institute for Information and Technology
NIWRMP	National Integrated Water Resource Management Plan, 2016
NSB	National Statistical Bureau
NSSD	National Strategy for Sustainable Development
Nu	Ngultrum (Bhutanese currency)
OECD	Organization of Economic Cooperation and Development
ORC	Outreach Clinic
PES	Payment for Ecosystem Services
PHCB	Population and Housing Census of Bhutan
PHPA	Punatsangchhu Hydropower Project Authority
PIE	Pasakha Industrial Estate
PM	Particulate Matter
PM10	Particulate matter of 10 μm or less
PSR	Pressure-State-Response
RCDC	Royal Center for Disease Control
RGoB	Royal Government of Bhutan
RNR	Renewable Natural Resources
RSPN	Royal Society for the Protection of Nature
RSTA	Road Safety and Transport Authority
SEA	Strategic Environment Assessment
SFD	Social Forestry Division
SLMP	Sustainable Land Management Project
SNC	Second National Communication
SoE	State of the Environment
SPM	Suspended Particulate Matter
SYB	Statistical Year Book
TOE	Tonnes of Oil Equivalent

TMT	Thermo Mechanically Treated
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Program
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
US-EPA	United States Environmental Protection Agency
UWICE	Ugyen Wangchuck Institute of Environment and Conservation
WCD	Wildlife Conservation Division
WHO	World Health Organization
WMD	Watershed Management Division
WRCD	Water Resource Coordination Division
WWF	World Wildlife Fund

Glossary of Bhutanese Terms

Cham	Timber for sawing post/pillar
Chhuzhing	Irrigated land
Drashing	Standing tree for sawing
Dzongkhag	*Dzongkhag*
Gewog	Administrative block made up of few to several villages
Kamzhing	Non-irrigated agricultural land
Lag thram	Land ownership certificate
Sokshing	Woodlot for production of leaf litter
Thromde	City
Tsamdo	Registered grazing land
Tseri	Slash-and-burn cultivation