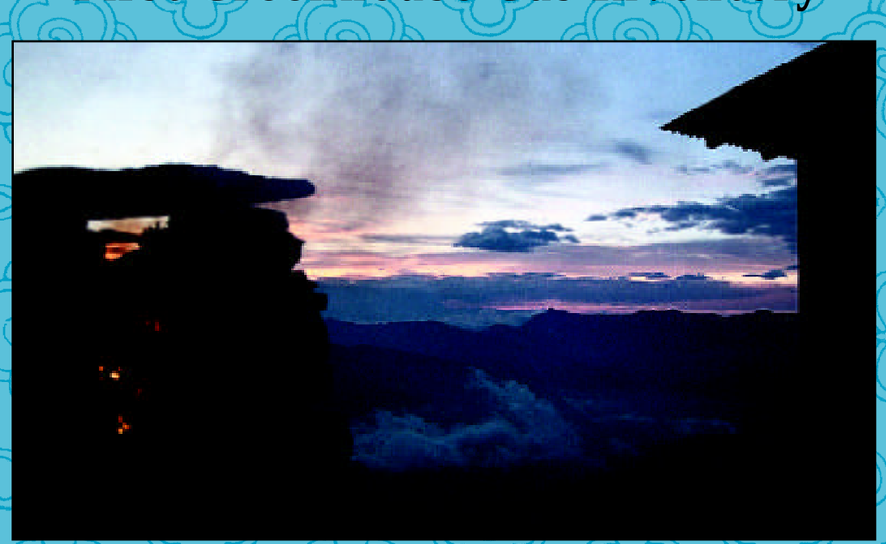
THE ROYAL GOVERNMENT OF BHUTAN
NATIONAL ENVIRONMENT COMMISSION

# First Greenhouse Gas Inventory



SEPTEMBER 2000

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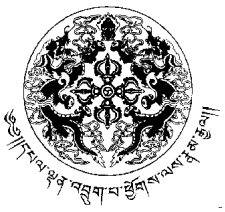

**THE ROYAL GOVERNMENT OF BHUTAN**
**NATIONAL ENVIRONMENT COMMISSION**

# INITIAL NATIONAL COMMUNICATION

## UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

SEPTEMBER 2000

## Members of the National Environment Commission and National Climate Change Committee

*Left to right: Mr. Pema Thinley, Dasho Nado Rinchhen, Lyonpo Kinzang Dorji, Lyonpo Khandu Wangchuk, Dasho Leki Dorji, Mr. Sither Namgyel, Mr. Daw Tenzin*

# NATIONAL ENVIRONMENT COMMISSION/CLIMATE CHANGE COMMITTEE MEMBERS

| | |
|---|---|
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| 2. H.E. (Lyonpo) Khandu Wangchuk, Minister for Trade and Industry | Member |
| 3. H.E. (Dasho) Leki Dorji, Deputy Minister for Communications | Member |
| 4. H.E. (Dasho) Nado Rinchhen, Deputy Minister for Environment | Member-Secretary |
| 5. Mr. Sithar Namgyel, Secretary, Survey of Bhutan | Member |
| 6. Mr. Daw Tenzin, Secretary, Planning Commission Secretariat | Member |
| 7. Mr. Pema Thinley, Director, Department of Education | Member |

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| | |
|---|---|
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| 2. Dr. Dechen Tsering, NEC Secretariat | Project Co-ordinator |
| 3. Mr. Nedup Tshering, NEC Secretariat | Project Facilitator |
| 4. Ms. Sangay Bida, CSO, Planning Commission Secretariat | Member |
| 5. Mr. Jigme Wangdi, Yusipang RNR-Research Center | Member |
| 6. Mr. Pasang Wangchen Norbu, Department of Forestry Services | Member |
| 7. Mr. Dungkar Drukpa, LUSS, PPD, Ministry of Agriculture | Member |
| 8. Mr. G Karma Chhopel, Meteorology Unit, Department of Power | Member |
| 9. Mr. Rinchhen Khandu, Ministry of Home Affairs | Member |
| 10. Mr. Tshering, Bhutan Chamber of Commerce and Industry | Member |

# FOREWORD

Climate change and its devastating consequences have become a global concern. The loss of thousands of human lives and insurmountable damage to property caused by El Niño, Hurricane Mitch, drought and floods in various parts of the world can be attributed to climate change. In our own country, we have experienced the worst ever monsoon rains which triggered off unprecedented number of floods and landslides causing the serious damage to life and property recorded in our recent history. There is thus no doubt that climate change warrants a global effort in finding a solution to its adverse effects.

It gives me great satisfaction that Bhutan has acknowledged the magnitude of the challenges posed by climate change and had ratified the United Nations Framework Convention on Climate Change (UNFCCC) during the 73rd Session of our National Assembly in 1995. As of now more than 170 countries have ratified this Convention which is truly encouraging. One of the primary issues the UNFCCC is addressing is the need to reduce the level of emission of greenhouse gases (GHG), which has been attributed as the primary cause of global warming. It was therefore made obligatory for all parties to the Convention to submit National Communications outlining the status of the GHG emissions by sources and sequestration by sinks and national priorities for vulnerability assessments and adaptation options.

The National Communication for Bhutan was prepared under the stewardshipof the National Environment Commission (NEC) which has been designated to host the National Climate Change Committee. It reflects Bhutan's unique position as one of the very few countries with GHG sequestration capacity. Our estimate of GHG emissions in 1994 was (-) 5.89 tons of $CO_2$ equivalent per capita. This is due largely to our development policy which embraces clean development mechanisms whereby we are deliberately foregoing economic opportunities through rapid industrialization and exploitation of our forest resources. We have not received due recognition from the international community for this responsible approach we are taking in managing our development nor have we been able to realize the value of our sequestration capacity. We hope that through the National Communications, we will be able to raise global awareness of our position on climate change issues.

In releasing this document, it gives us an opportunity to pay tribute to our beloved King, His Majesty Jigme Singye Wangchuck, for the farsighted and visionary leadership in guiding our environmental policy. We owe our rich forest cover and its high GHG sequestration potential to His Majesty's enlightened policy on forest conservation put in practice long before

environment itself became a buzzword. It is our hope that under His dynamic leadership, Bhutan will continue to prosper while maintaining its clean environment and be spared of the devastating consequences of climate change.

Finally, it gives me great pleasure to congratulate those involved in the preparation of The National Communication, particularly the Greenhouse Gas Project Management Team led by the NEC Secretariat. Despite the limitations in experience and knowledge on the issues being addressed, they have done a commendable job which of course would not have materialized without the financial support of the Global Environment Facility (GEF)/UNDP and the technical assistance from Tata Energy Research Institute (Teri), New Delhi, India.

Tashi Delek!

Lyonpo Kinzang Dorji
Chairman
National Environment Commission
And
Minister for Agriculture
Royal Government of Bhutan
Thimphu

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# Abbreviations

| | |
|---|---|
| BCCI | Bhutan Chamber of Commerce and Industry |
| C | Celsius |
| CBD | Convention on Biological Diversity |
| CoP | Conference of Parties |
| CSO | Central Statistical Organization |
| DANIDA | Danish International Development Agency |
| DFS | Department of Forestry Services |
| DoP | Department of Power |
| DRDS | Department of Research and Development Services |
| EA | Environmental Act |
| EIA | Environment Impact Assessment |
| ESPS | Environment Sector Program Support |
| FCCC | Framework Convention on Climate Change |
| FYP | Five Year Plan |
| GDP | Gross Domestic Product |
| GEF | Global Environment Facility |
| GHG | Greenhouse Gas |
| GIS | Geographic Information Systems |
| GLOFs | Glacial lake outburst floods |
| IPCC | Inter-Governmental Panel on Climate Change |
| JAFTA | Japan Forest Technical Association |
| LULUCF | Land use, land use change and forestry |
| LUPP | Land Use Planning Project |
| LUSS | Land Use and Statistics Section |
| MoA | Ministry of Agriculture |
| MoC | Ministry of Communications |
| MoHA | Ministry of Home Affairs |
| MPFD | Master Plan for Forestry Development |
| MTI | Ministry of Trade and Industry |
| NEC | National Environment Commission |
| NECS | National Environment Commission Secretariat |
| NEPA | National Environment Protection Act |
| NES | National Environment Strategy |
| NFE | Non-formal education |
| NGO | Non-government organization |
| PIS | Pre-investment survey |
| PMT | Project Management Team |
| RGoB | Royal Government of Bhutan |
| RMA | Royal Monetary Authority |
| SPAL | Soil and Plant Analytical Laboratory |
| SPOT | French Earth Observation Satellite |
| UNDP | United Nations Development Programme |

| | |
|---|---|
| UNFCCC | United Nations Framework Convention on Climate Change |
| WWF | World Wildlife Fund |

**Terminology**

| | |
|---|---|
| Ashi | Title for women of royal birth |
| Chhetrum | One-hundredth of Ngultrum |
| Dru-na-gu | Nine cereals grown in Bhutan[1] |
| Dzongkhag(s) | Administrative districts[2] |
| Kuensel | Bhutan's national newspaper |
| Lyonpo | Minister |
| Ngultrum | Bhutanís currency |
| Tseri | Shifting cultivation |

**Chemical Symbols**

| | |
|---|---|
| $CH_4$ | Methane |
| CO | Carbon monoxide |
| $CO_2$ | Carbon dioxide |
| $N_2O$ | Nitrous oxide |
| NMVOC | Non Methane Volatile Organic Compounds |
| NOX | Nitrogen oxides |
| $SO_2$ | Sulphur dioxide |

**Measures**

| | |
|---|---|
| Gg | gigagram ($10^9$g) |
| km | kilometers |
| kt | kilotons |
| m | meters |
| MW | megawatts |
| t | ton |

1 Rice, wheat, barley, maize, sweet buckwheat, bitter buckwheat and millets (finger, pearl and foxtail).
2 There are 20 administrative districts.

# Preface

***Need for a National Communication***

The ultimate objective of the UN Framework Convention on Climate Change (UNFCCC) is to reduce the atmospheric concentrations of GHG to a stable level, within a specific timeframe, to ensure no adverse human-induced interference with the climate system.

As part of its obligations and commitment under Articles 4 and 12 of the UN Framework Convention on Climate Change, the Royal Government of Bhutan (RGoB) needs to submit a National Communication to the UNFCCC Secretariat. As delineated in Article 12 of the Convention, each Party should communicate to the Conference of Parties (COP), through the Secretariat, information related to the national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases, and should provide a general description of steps taken to meet the objective of the Convention. Developing-country parties may also propose projects for financing.

The guidelines for preparing initial communications by parties not included in Annex I to the Convention furnish a structure that should include (a) the national circumstances and priorities; (b) the inventory using the methodology proposed by the Inter-Governmental Panel on Climate Change; (c) description of programs related to sustainable development, integration of climate change concerns in medium- and long-term planning, response strategies for abating emissions, mitigating impacts of climate change and adaptation measures; and (d) indication of the financial and technological needs associated with activities and measures envisaged under the Convention.

The National Communication also provides a mechanism through which the COP can assist member countries that cannot meet their obligations and commitments under the Convention. In the case of Bhutan, a Least Developed Country, the National Communication enables it:

- to organize and present the constraints specific to the ability of mountain ecosystems to deal with climate change;
- to define Bhutanís individual and joint activities specifically designed to achieve sustainable development and conservation of the natural environment, which are in consonance with measures to combat climate change;
- to attract external assistance, specifically finance and technology, for Bhutan in its endeavor to implement the UNFCCC; and
- to convince the developed world that Bhutan and all similar countries - geographically and economically ñ may have insignificant greenhouse gas emissions but are extremely vulnerable to adverse impacts of climate.

# Executive Summary

***National Circumstances***

The Kingdom of Bhutan covers about 40,077 square kilometers and is bordered by the Tibetan region of China in the north and India in the west, south and east. It is endowed with rich natural resources, important among which are forests and abundant water in the form of runoff rivers. The flora of Bhutan is exceptionally diverse. Forest covers an estimated 72.5% of the country. The magnitude of mineral resources is still unknown, since only 30% of the country has been mapped geologically.

**Table 1: National Circumstances**

| | | |
|---|---|---|
| Population | Numbers | 564,000 |
| Urban population | % | 14.5 |
| Country area | $Km^2$ | 40,077 |
| Forest cover | % of total area | 72.5 |
| Arable land area | % of total area | 7.7 |
| Others (land cover) | % of total area | 19.8 |
| GDP | In million US$ | 311 |
| GDP per capita | US$ | 551 |
| Share of primary sector in GDP | % | 40 |
| Share of secondary sector in GDP | % | 27 |
| Share of tertiary sector in GDP | % | 33 |
| Livestock population | '000 | 576 |
| Male life expectancy | Years | 66.0 |
| Female life expectancy | Years | 66.1 |
| Population in absolute poverty | | NA |
| Literacy rate | % | 54 |

Source: (CSO, 1995)

The population of Bhutan in 1998 was estimated at 637,777. Most of the population is concentrated in the broad river valleys and southern foothills, while large areas in the north are virtually uninhabited. Bhutan's urban population (14.5% in 1994) is expanding, thereby putting pressures on natural resources especially in and around urban areas. Waste disposal and its associated health hazards are other serious concerns linked to the growing urban population. The policy of the Royal Government is to maintain the present forest cover and restrict conversion to agricultural land for meeting higher food requirements.

Bhutan depends mainly on agriculture and other biophysical resources to maintain economic growth and sustain the livelihood of its people. The national economy also depends to a large extent on two other major sources, export of hydroelectric power and tourism.

As far as national priorities are concerned, the concept of environmental conservation runs through all aspects of Bhutan's tradition and development strategy. Bhutan has retained much of its natural vegetation intact, and forest conservation remains a top priority for the future as well.

While the Royal Government of Bhutan (RGoB) is strongly committed to environmental conservation, it also recognizes the need for economic development. NEC released Bhutan's National Environment Strategy (NES) on 17 December 1998 to "ensure the careful stewardship and sustained use of natural resources" in Bhutan. This strategy advocates "The Middle Path" of development and identifies three key cross-sectoral issues: effective natural resources management, integrated urban / rural planning and development planning that is sensitive to traditional Bhutanese values. The NES identifies three avenues for sustainable development:

1. hydropower development
2. food production
3. industrial development

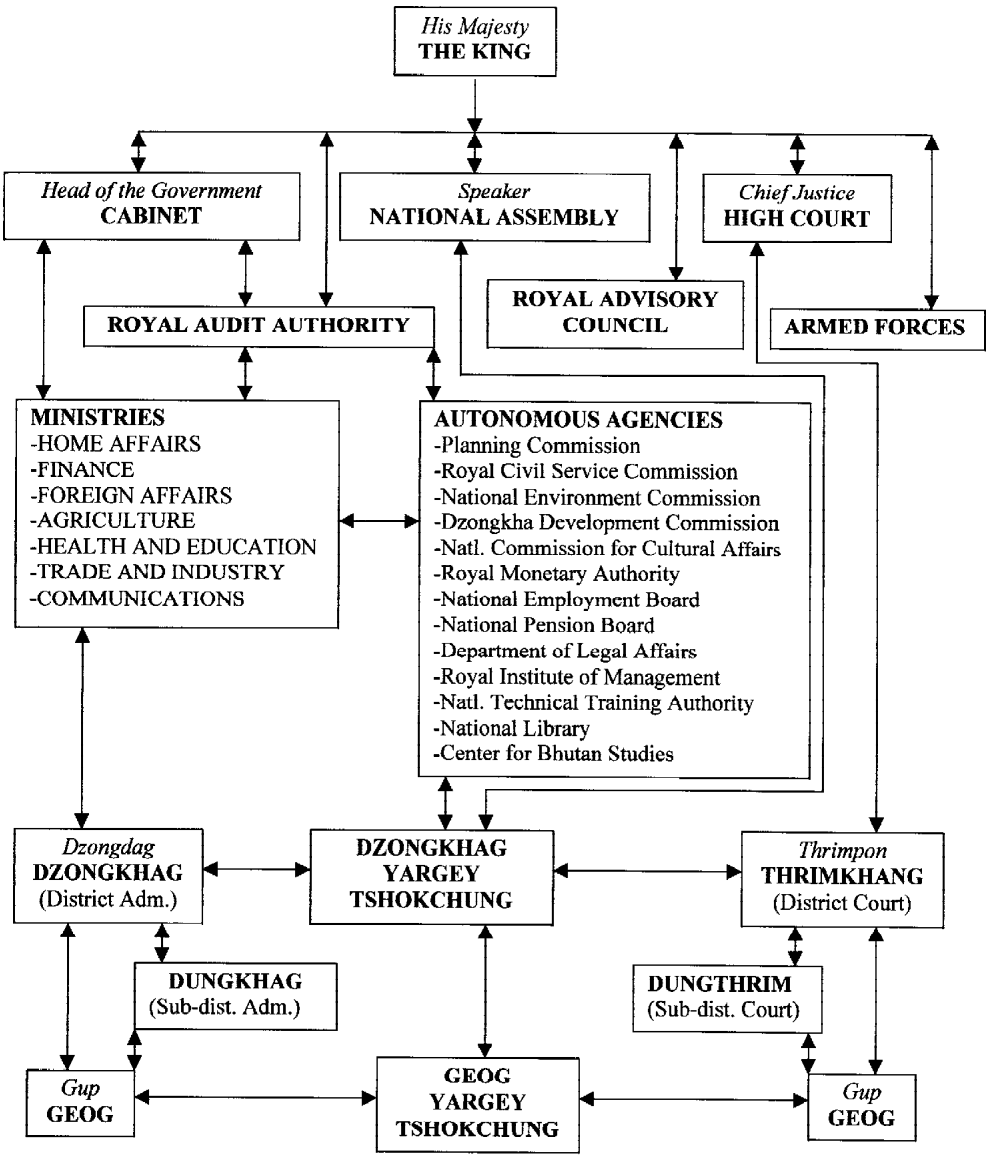



**Figure 1: The Bhutanese System of Governance**

***GHG Inventory***

Bhutanís decision to become a party to the UNFCCC is both wise and timely, and compiling a GHG inventory is an essential activity for the country. An understanding of the GHG sources and sinks is as vital as knowing the magnitude of GHG emissions and removals.

Bhutanís GHG emissions in 1994 were: $CO_2$ = 228.46 Gg, $CH_4$ = 19.22 Gg, $N_2O$ = 2.13 Gg, NOx = 0.71 Gg and CO = 2.29 Gg. By global standards, this is insignificant. However, GHG emissions in future will require continued study and monitoring.

Although such emissions are relatively small, an increasing trend is foreseen in some of the GHG sources examined, e.g., road transport. This increase is likely to continue if left unchecked.

A problem often encountered when undertaking the GHG Inventory was not only lack of data itself but also its low level of consistency. This problem must be addressed because it affects not only GHG inventories but also other research areas. Agencies involved in data collection and management require assistance in terms of physical facilities up-gradation and training human resources in effective data management procedures.

***Vulnerability and Adaptation***

Climate change is likely to have adverse impacts on Bhutan in its search for sustained, environmentally sound economic and social development. Such impacts would include significant declines in agricultural production, as well as harm to forests and water resources. Already frequent landslides and prolonged dry periods and unprecedented heavy monsoon rain affecting agriculture and biodiversity are visible in recent years because of climate change.

Moreover, Bhutan's vulnerability will increase with future global climate change, and thus the need to develop a national policy framework to raise awareness about vulnerability and adaptation is a priority.

Given the lack of climate change scenarios for Bhutan, this report assesses vulnerability and potential impacts on the basis of available information and the current state of knowledge under the IPCC. Six focus areas likely to be affected by climate change are: glacial lake outburst, landslides, health, water resources, agriculture and biodiversity.

A preliminary vulnerability assessment can be undertaken in light of the following:

- The increasingly frequent landslides affecting Bhutan are a major threat. Most of the population and infrastructure are located either in the valley bottoms or on the mountain slopes. This is a serious concern because nearly all settlement areas are prone to landslides and flooding, and hence likely to be very vulnerable to climate change. This vulnerability is particularly exacerbated during extreme weather events.

- The "best guess" scenario (IPCC) indicates that by the year 2100 temperature will have increased by $2^0$C and glaciers retreated by 49cm, with rainfall increased by 4.1%. This is the basis for environmental sensitivities described with regard to climate change and glacial retreats, because Bhutan's entire northern highlands are either covered with glaciers or snow. All the runoff rivers and other water resources are snow / glacier-fed, and 80% of the population, infrastructure and agricultural land are in the most vulnerable mountain valleys. Therefore, adaptation analysis must be stressed.

- Increased heat stress on organisms and altered water requirements for various species also are associated with climate change. This would severely affect Bhutan's uniquely adapted biodiversity.

The impacts of climate change are likely to be magnified by future economic and environmental changes in Bhutan. Increasing population, rural-urban migration and rapid urbanization pose a threat to future food security and water supply and increase the vulnerability to vector-borne diseases. It is essential to study the enhanced stress on physical and socio-economic systems as a result of climate change coupled with non-climatic changes.

Detailed information is needed in order to make better predictions of vulnerability and adaptation needs of Bhutan. The priority for the country, given the likely adverse impacts of climate change accentuated with the changes taking place currently, is to generate information on these impacts. Linkages between causative factors and impacts have to be analyzed and understood so that an appropriate adaptation strategy for each vulnerable sector can be developed and negative impacts minimized.

***Meeting Global Environmental Objectives***

After signing the Convention on Climate Change during the UNCED at Rio de Janeiro in June 1992, the 73rd session (1995) of Bhutan's National Assembly ratified the Convention, committing itself fully to the UNFCCC objectives.

Each international convention has many legal obligations, making it difficult for Bhutan to meet all obligations involved, implement activities and enforce provisions. Despite these constraints, however, the nation recognizes that it must play its part in ensuring that the global environment is protected.

To implement appropriate and effective responses to climate change, the following are priorities for Bhutan:

- Improved databases in all Ministries
- Devising of a robust policy for sustainable development that meets national imperatives as well as global environmental issues. For instance, mitigation options in the energy sector relevant to Bhutan are:

1. Renewable energy technology options
2. Improved technology to reduce fuelwood consumption
3. Introduction of fuel-efficient vehicles
4. Improvement of imported fossil fuel quality

These options, including their financial and economic implication, need to be examined carefully to establish the GHG abatement potential.

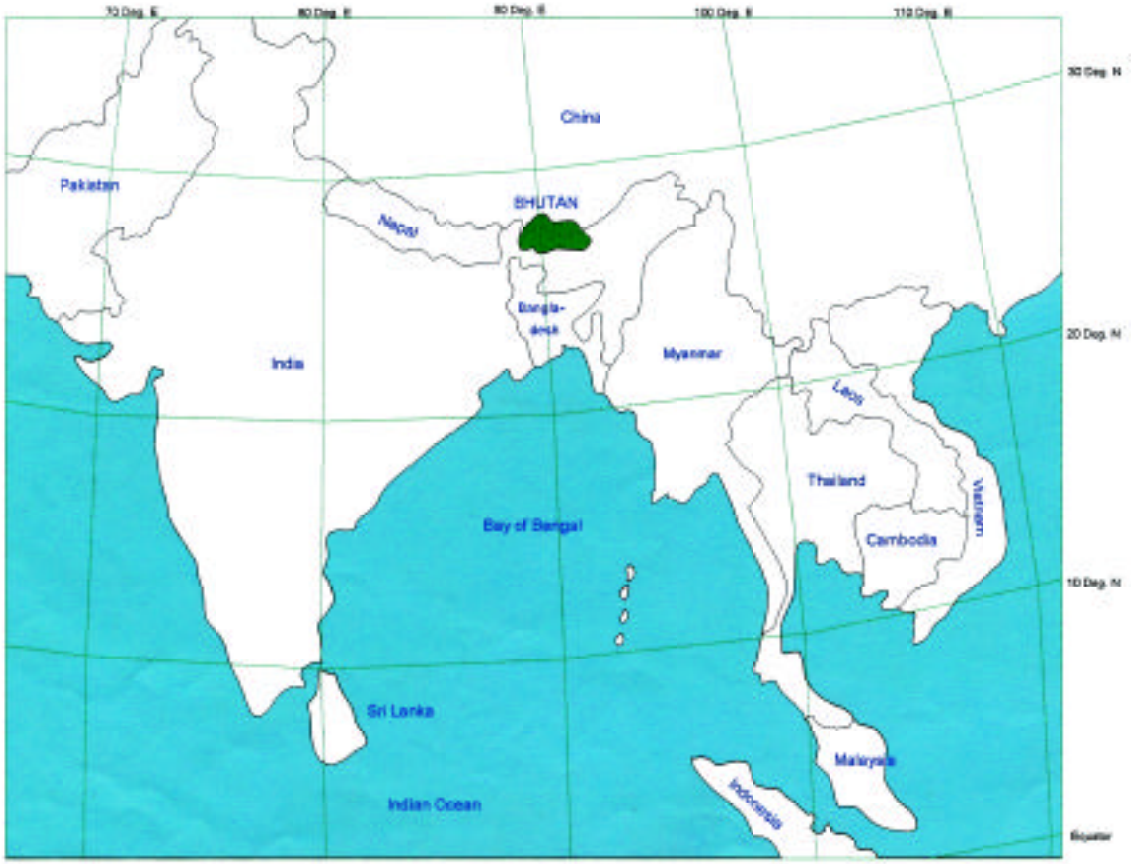
*Fuelwood is the traditional source of cooking and heating energy in Bhutan*

- Studies on impacts of climate change: The vulnerability of Bhutan to likely change in climate can be better defined only after analysis of the impacts on the country's mountain ecosystem. Projects to analyze the likely impact on water resources, forests, agriculture and livestock are extremely relevant not only in the context of the livelihood of a majority of Bhutanese, but also in terms of earnings from export of hydropower.

Enhanced capability to predict extreme events such as glacial lake outbursts is needed to ensure preparedness, thereby reducing socio-economic impacts.

Development of a national policy framework to facilitate implementation of appropriate and effective mitigation measures and adaptation strategies is important. This will require institutional strengthening, community participation, development of national capacity and local and regional expertise. It also will include developing locally appropriate methodologies for analyzing these effects and increasing understanding of current interactions of climate and environmental and socio-economic effects and changes.

## Map showing the location of Bhutan



# Chapter 1:
# National Circumstances

## 1.1 History

Bhutan remained under self imposed isolation from the outside world until 1960. The third King, His Majesty Jigme Dorji Wangchuck (1952-1972), opened the nation's doors to the outside world with the initiation of planned economic development and launching of the First Five Year Plan in 1961. Barely a decade later, Bhutan joined the United Nations and became a permanent member in 1972. Today, it is a member of many international organizations and an active party to the two environment-related conventions: the Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC).

## 1.2 Location and Geography

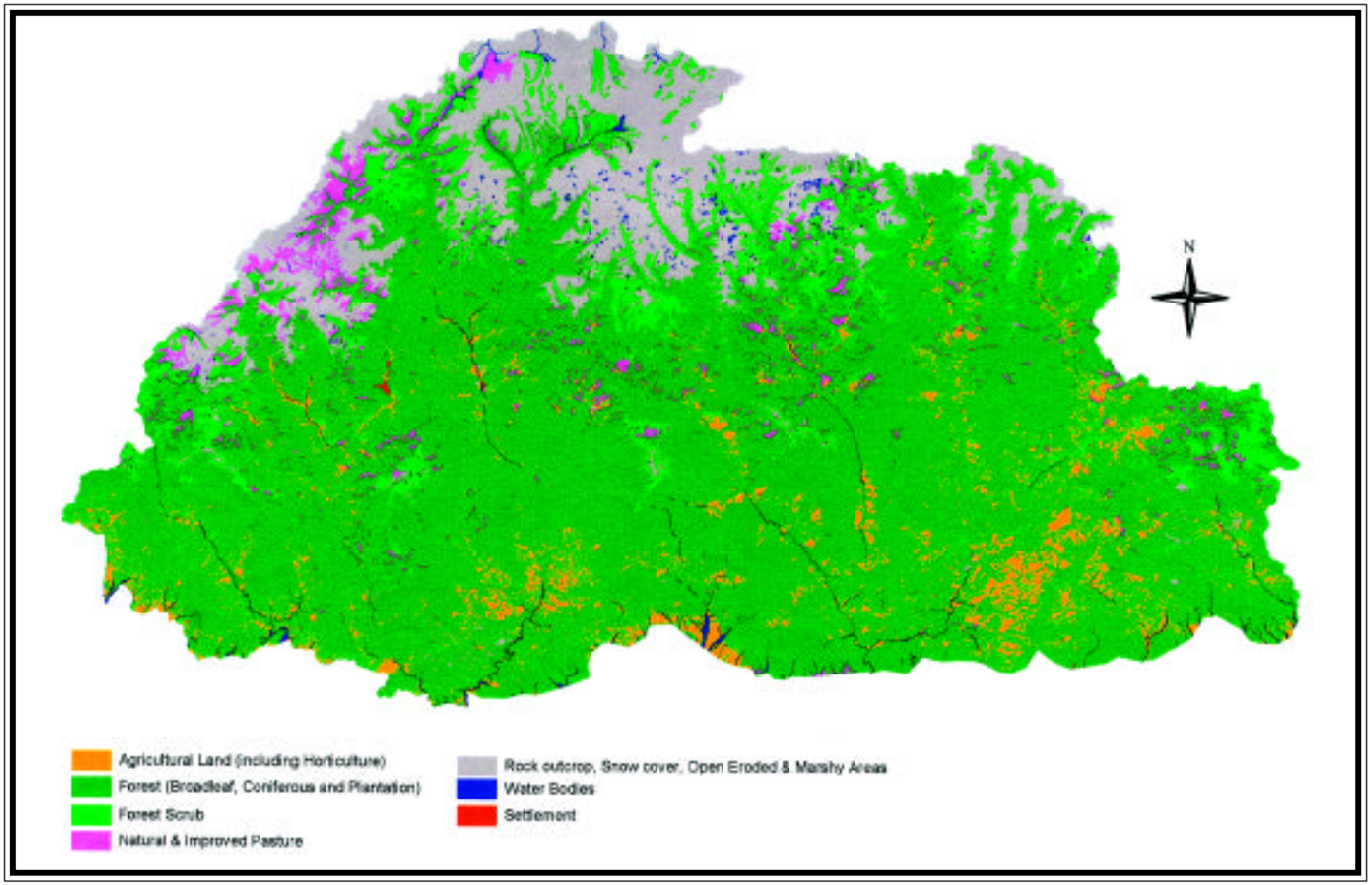
Bhutan is a landlocked country in the Himalayas with a land area of about 40,077 square kilometers. The country lies between $26^0$45' N and $28^0$10' N latitudes and $88^0$45' E and $92^0$10' E longitudes. It has a maximum longitudinal distance of 330 kilometers and a latitudinal distance of 180 kilometers. Bhutan is bordered by the Tibetan region of China on the north and by India on the west, south and east. The terrain is highly rugged; rising from an elevation of 100 meters above sea level in the south, it reaches over 7,550 meters in the north.

Geographically, Bhutan can be divided into three major areas: the southern foothills, inner Himalayas and higher Himalayas. The southern foothills rise from the plains to a height of 1,500 meters but are only about 20 kilometers wide. The inner Himalayas, meanwhile, gradually rise to about 3,000 meters and contain the broad river valleys of central Bhutan, the economic and cultural heartland of the country. The northern region comprises the main Himalayan range of the high mountains; population in this zone is sparse.

## 1.3 Climate

The country can be divided into three distinct climatic zones corresponding broadly to the three main geographical divisions. The southern belt has a hot, humid climate, with temperatures remaining fairly even throughout the year—between $15^0$C and $30^0$C-and rainfall ranging between 2,500 and 5,000 millimeters. The central inner Himalayas have a cool, temperate climate, with annual average rainfall of about 1,000 millimeters, while the higher and more northern region has an alpine climate, with annual rainfall of around 400 millimeters. Much of this rainfall is concentrated in the summer, with the southwest monsoon accounting for 60 to 90% of total rainfall.

There is substantial variation within these broad ranges, and the climate and rainfall characteristics change dramatically from one valley to another, with consequent sharp changes in the composition of agricultural production.


N
Agricultural Land (including Horticulture)
Forest (Broadleaf, Coniferous and Plantation)
Forest Scrub
Natural & Improved Pasture
Rock outcrop, Snow cover, Open Eroded & Marshy Areas
Water Bodies
Settlement

## 1.4 Natural Resources

### 1.4.1 Flora

The flora of Bhutan is exceptionally diverse as a result of the great range of altitudinal zones and varied climatic conditions. Forests of alpine scrub, fir, mixed coniferous species, temperate scrub and broadleaf species, many of which are unique to Bhutan, cover an estimated 72 % of the country. About 47 indigenous species have been listed, and it is thought that many more are not identified (Grierson and Long, 1984). The vast wealth of flora is highly appreciated by both Bhutanese and the world outside.

### 1.4.2 Forest Types

The total forest area of the country is estimated at 2.9 million hectares (LUPP, 1995). Forests of Bhutan are divided into three major types, namely; broadleaf forest of 50%, conifer forest of 38% and scrub forest of 12% (DFS). The detailed stratification of the forest types in Bhutan is given in the Inventory Data Table described in Chapter 2.

The Master Plan for Forestry Development (1991) has classified the forests of Bhutan into the following broad categories:

***Fir forest-***The upper forest zone in the higher ridges between 2,700 meters and the tree line at 3,600-3,800 meters is dominated by almost pure stands of fir. Some hemlocks and birches also are present. Beard-like lichens and mosses generally decorate the fir forests, an indication of the pollution-free atmosphere.

***Mixed Conifers -***This forest type occupies the largest portion of the sub-alpine zone of the country, between 2,000 and 2,700 meters of elevation. Spruce, hemlock or larch, or a mixture of these, are the dominant species. Hemlock generally tends to occupy wetter slopes than spruce. Beard-like lichens and mosses also decorate these forests.

***Chir Pine -***This subtropical tree of dry, sandy soils predominates in the deep, dry valleys between 900 and 1,800 m. These forests are characterized by the highly seasonal monsoon climate, with annual burning of the understory grass. Chir pine usually occurs in pure forms and is extensively tapped for resin.

***Blue Pine-***This forest type is found in the temperate valleys between 1,800 and 3,000 meters. Blue pine is a dominant, fast-growing and colonizing species, especially in burnt and disturbed areas. It is found in a close canopy with almost no understory growth. Although blue pine forests are subjected to heavy biotic interference, grazing and forest fires, they regenerate with relative ease.

***Broadleaf mixed with Conifer-*** In some parts of Bhutan the transition between broadleaf forest and conifer forest is very gradual, and there are extensive areas of mixtures of these types. These forests are generally of oak mixed with blue pine or upper hill forest mixing with hemlock or spruce.

***Broadleaf forest (divided into three groups)***
Temperate broadleaf forests dominate the temperate hillsides between 2,000 and 2,900 meters. This group is further divided into 2 subgroups, namely, evergreen oak forest and cool broadleaf forest.

Subtropical hill forests occupy the subtropical hills between 1,000 and 2,000 meters. They are rich mixed forests with a wide variety of both subtropical and temperate genera.

Tropical lowland forests occupy the low hills below 700 meters. They are broadly classified as semi-evergreen but vary from almost totally deciduous on dry exposed slopes to almost totally evergreen in moist sheltered valleys. Species diversity is very rich, and the forests are multi-storied.

### 1.4.3 Fauna

Because Bhutan's forests have remained largely undisturbed, a number of rare animals can still be found in the country, including wide distributions of golden langur, takin and blue sheep. The exact number of rare species is not known, but more than 160 species of mammals alone have been reported. Tiger, leopard, snow leopard, red panda, gaur, serow, Himalayan black bear, wild boar, musk deer and other types of deer are commonly found in many parts of Bhutan. Notably, the Phobjikha valley in western Bhutan is one of the global wintering grounds for the rare black-necked crane. One-quarter of the country thus has been declared as protected reserves / sanctuaries / nature parks.

### 1.4.4 Water Resources

With the high precipitation and altitudinal variation, water resources—mainly in the form of rivers—are abundant in Bhutan. While the wide altitudinal difference provides many possibilities for hydropower generation, the main rivers are generally deeply incised and irrigated agriculture is limited to areas served by gravity from small perennial streams. The Power Master Plan estimates that rivers could provide 30,000 MW of electricity (1990-93). Because local requirements are still modest, the majority of energy produced will be exported, representing a large part of Bhutan's total export revenue.

### 1.4.5 Minerals

The exact magnitude of Bhutan's mineral resources is unknown, given that only 30% of the country has been mapped geologically. This mapping nonetheless indicated the occurrence of coal, limestone, dolomite, talc, marble, gypsum, slate, zinc, lead, copper, tungsten and quartzite deposits. Out of these, coal, limestone, dolomite, gypsum and quartzite are mined for domestic use and export purposes.

**Table 2: National Circumstances**

| | | |
|---|---|---|
| Population | Numbers | 564,000 |
| Urban population | % | 14.5 |
| Country area | $Km^2$ | 40,077 |
| Forest cover | % of total area | 72.5 |
| Arable land area | % of total area | 7.7 |
| Others (land cover) | % of total area | 19.8 |
| GDP | In million US$ | 311 |
| GDP per capita | US$ | 551 |
| Share of primary sector in GDP | % | 40 |
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| Share of tertiary sector in GDP | % | 33 |
| Livestock population | '000 | 576 |
| Male life expectancy | Years | 66.0 |
| Female life expectancy | Years | 66.1 |
| Population in absolute poverty | | NA |
| Literacy rate | % | 54 |

Sources: (CSO, 1995; Bhutan 2020, 1999)

## 1.5 Socio-economic Features of Bhutan

### 1.5.1 Population Growth and Trends

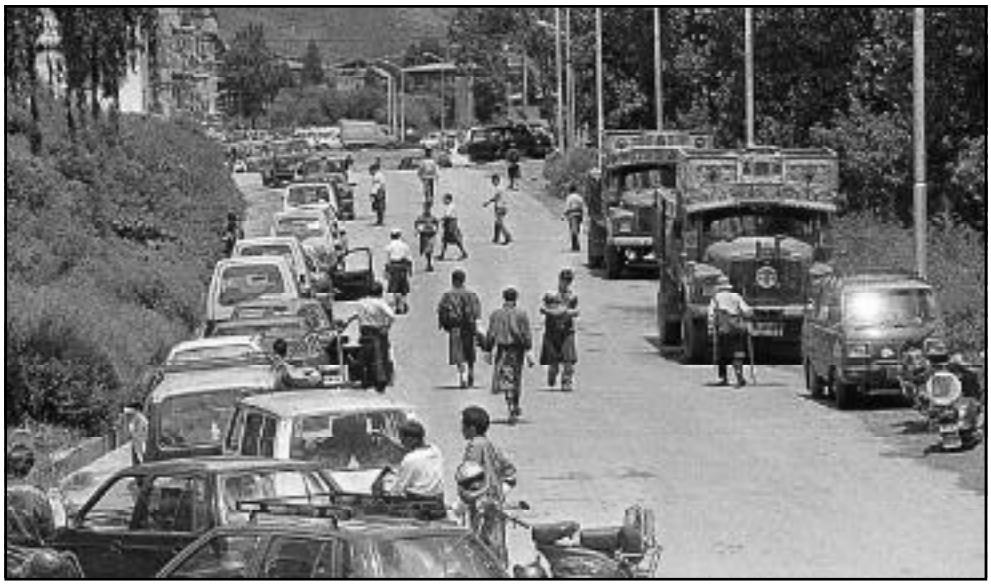
Bhutan is the least populated country in South Asia, with the current (1998) population estimated at 637,777. Most of the population is concentrated in the broad river valleys and southern foothills, while large areas in the north are virtually uninhabited. The average family size is estimated to be 6.5, with 2 to 100 households per village.

The proportion of the population younger than 15 years is very high (43%). As this group enters the reproductive period, the population growth rate is likely to rise above the current 3.1% unless the use of contraceptives and child spacing is encouraged. The improved quality of medical services and improved health infrastructures are some of the main factors underlying the rapidly expanding population.

### 1.5.2 Urbanization and Internal Migration

Bhutan's capital, Thimphu, has a population of about 45,000 and Phuentsholing, the second-largest town, has about 23,000 inhabitants. The urban population in 1994 was 14.5% of the total. Due to rural-urban migration, Bhutan's expanding urban population is increasing pressure on the natural resources base in and around urban centers. The land available for urban growth is limited by both topography and government policies to maintain the present forest cover and restrictions to land conversion.

Growing urbanization has resulted in problems related to traffic management and sewage disposal. In 1995, there were about 6,000 vehicles in the Thimphu valley. This unanticipated growth is leading to traffic congestion and increasing vehicular emissions. Vehicle emission-testing programs have been devised recently and planned for setting standards. The country's waste management system is in initial development. In Thimphu, eight truckloads of solid waste are collected each day and transported to a landfill located on the edge of a ravine. The City Corporation has already begun the process of developing a second landfill site.



*The traffic and vehicular emission is becoming an emerging concern in Thimphu*

### 1.5.3 The Economy

Bhutanís economy is estimated to have expanded by roughly 6.5% in 1994. The traditional sector comprising agriculture, animal husbandry and forestry continued to predominate, accounting for roughly 40% of GDP. However, the share of the modern sector, comprising manufacturing, mining, electricity and construction, grew to about 30% of GDP. In 1994-95 the manufacturing sector received a major boost with the commissioning of a joint-sector ferro-silicon plant (RMA).

***Sales of Major Industries***

During 1994-95, sales by the six largest manufacturing industries increased 20%. A total of 78% of sales went to the Indian market, with domestic sales accounting for only 21%. Sales to third-country markets were negligible and amounted to only 1%. Of the total sales, Bhutan Carbide and Chemicals accounted for 34%, followed by Bhutan Board Products with 24% and Penden Cement with 19% (RMA).

***Power***

Gross revenue from electricity sales by the Chhukha Hydro Power Corporation amounted to Nu. 608.9 million in 1994-95. Although 86% of the revenue still came from sales to India, revenue from domestic sale also increased quite substantially. The increase resulted mainly from the commissioning of the Bhutan Ferro Alloys plant and the increase of domestic tariff by 10 chhetrums per unit (RMA).

***Tourism***

The number of tourists visiting Bhutan has gradually increased since the sector was privatized in 1991-92. During 1994-95, 4,324 tourists visited Bhutan, representing an increase of 25% over the previous fiscal year. With the increase in tourist inflows, tourism revenue also increased to US$ 4.63 million, compared to US$ 3.55 million in the year earlier.

**Table 3: GDP at factor cost by kind of activity in 1980 prices**

| Sectors | 1980 | 1990 | 1991 | 1992 | 1993 | 1994 | Compound growth 1980-1994 in % |
|---|---|---|---|---|---|---|---|
| 1. Agriculture, livestock, forestry and fishing | 621.4 | 992.8 | 1,024.6 | 1,006.4 | 1,045.3 | 1,066.2 | 3.9 |
| 1.1 Agriculture proper | 309.9 | 530.9 | 544.8 | 555.6 | 563.9 | 575.2 | 4.5 |
| 1.2 Livestock | 139.2 | 212.0 | 229.4 | 201.6 | 227.2 | 231.7 | 3.7 |
| 1.3 Forestry and logging | 172.3 | 249.9 | 250.4 | 249.2 | 254.2 | 259.3 | 3.0 |
| 1.4 Fishing | Neg | Neg | Neg | Neg | Neg | Neg | Neg |
| 2. Mining and quarrying | 6.8 | 19.3 | 27.4 | 23.5 | 26.2 | 29.8 | 11.1 |
| 3. Manufacturing | 35.8 | 158.1 | 186.7 | 208.8 | 217.3 | 223.6 | 14.0 |
| 4. Electricity and gas | 2.5 | 204.1 | 200.4 | 210.0 | 232.0 | 229.8 | 38.1 |
| 5. Construction | 88.5 | 136.8 | 116.2 | 156.6 | 181.8 | 279.8 | 8.6 |
| 6. Wholesale and retail trade, restaurants and hotels | 121.5 | 134.7 | 145.1 | 160.7 | 163.8 | 170.2 | 2.4 |
| 7. Transport, storage and communication | 47.9 | 172.1 | 182.0 | 192.3 | 223.4 | 231.0 | 11.9 |
| 8. Finance, insurance and real estate | 70.2 | 212.2 | 208.8 | 215.4 | 238.1 | 245.4 | 9.4 |
| 9. Community, social and personal services (Government) | 120.4 | 223.3 | 233.2 | 251.6 | 266.5 | 295.6 | 6.6 |
| Less: Imputed bank service charges | -20.0 | -28.8 | -21.0 | -28.1 | -45.0 | -55.0 | 7.5 |
| **Gross Domestic Product** | 1,095.0 | 2,224.6 | 2,303.4 | 2,397.2 | 2,549.4 | 2,716.3 | 6.7 |
| **Less: Consumption of fixed capital** | 61.2 | 218.0 | 233.4 | 236.3 | 249.9 | 268.2 | |
| **Net Domestic Product** | 1,033.8 | 2,006.6 | 2,070.0 | 2,160.9 | 2,299.5 | 2,448.1 | |

Source: (CSO, 1995)

## 1.6 National Priorities

The RGoB is strongly committed to environmental protection, with forest conservation continuing to have top priority. His Majesty the King, Jigme Singye Wangchuck, has stated that:

"Throughout the centuries, the Bhutanese have treasured their natural environment and have looked upon it as the source of all life. This traditional reverence for nature has delivered us into the 20th Century with our environment still richly intact. We wish to continue living in harmony with nature and to pass on this rich heritage to our future generations."

### 1.6.1 Forest

Forest policies were developed stating that a minimum of 60% of the land area must be under forest cover in perpetuity.

- RGoB has set aside 26.23% of the country's total area as protected area. The protected areas consist of four national parks, four wildlife sanctuaries and one strict nature reserve. Management of the protected areas has been entrusted to the Nature Conservation Division under the Department of Forestry Services.

- The Royal Government of Bhutan created the Department of Forests in 1952. The Forest Act of 1969 (now superseded by Forest and Nature Conservation Act, 1995) declared all forestland as Government Reserved Forest.

- The National Forest Policy promulgated in 1974 clearly states that for a mountainous country with a very fragile ecosystem and an expanding agricultural economy, forestry operations should accord the highest priority to indirect benefits and the conservation role, giving only secondary importance to direct revenue from the sale of timber.

- All forestry operations were nationalized in 1979 with the main objective of protecting forests from over-exploitation. In the same year, the Social Forestry Program was launched with the main aim of promoting people's participation in the management of forests.

- The Forest and Nature Conservation Act, 1995, states that no Government Reserved Forest will be operated unless there is an approved Forest Management Plan.

- In July 1999, 14 forestry management units and three working schemes, covering an area of 143,966 hectares, have approved management plans. Inventory for another 11 forest management units, covering an area of 141,642 hectares, has been completed and management plans are being prepared.

- Tseri (shifting cultivation) remains one of the prominent land use systems in many parts of Bhutan, representing nearly 30% of the total area of cultivation. It is, however, to be phased out on agricultural and environmental grounds. Tseri remains a major challenge to be addressed.

- Afforestation / reforestation programs of degraded forestland and clear-felled areas were initiated to improve the sustainable capacity of the forestland. By the end of 1997, the DFS had achieved some 17,123.37 hectares of plantation.

There are four main goals set in the forest policy to ensure that forest resources are used according to sustainable principles, contributing to social justice and equity:

1. Protection of the land, its forest, soil, water resources and biodiversity against degradation, such as loss of soil fertility, soil erosion, landslides, floods and other ecological devastation, and the improvement of all degraded forest land areas, through proper management systems and practices;

2. Contribution to the production of food, water, energy and other commodities by effectively coordinating the interaction between forestry and farming systems;

3. Meeting of long-term needs of the Bhutanese for wood and other forest products by placing all the country's production of forest resources under sustainable management;

4. Contribution to the growth of national and local economies, including exploitation of export opportunities, through fully developed forest-based industries, and contribution to balanced human resources development through training and creation of employment opportunities.

Recognizing the need for economic development, the NEC released a National Environment Strategy (NES) on 17 December 1998 to "ensure the careful stewardship and sustained use of natural resources" in Bhutan[3]. This strategy advocates "The Middle Path" of development and identifies three key cross-sectoral issues: effective natural resources management, integrated urban / rural planning and development planning that is sensitive to traditional Bhutanese values. The NES identifies three avenues for sustainable development, hydropower development, self-sufficiency in food production, and industrial development.

### 1.6.2 Hydropower Development

The first mini-hydel project was established with assistance from the Government of India in 1967. The first major hydel scheme, the 336 MW Chhukha Hydropower Corporation, on the Wangchhu River was commissioned in 1986. By 1996, there were 23 hydroelectric power stations in the country including mini-micro hydels.

Further development of hydropower will help in meeting the growing demand of electricity for Bhutan, and at the same time will generate additional revenue from its exports. With electricity now generally available in major urban areas, the Royal Government is aiming to expand the grid to the countryside through rural electrification projects. However, given the nation's

*Chhukha hydropower dam: Hydroelectric generation in Bhutan is based on runoff of the river schemes.*

3 Senior officials of the RGoB met in Paro, Bhutan, at the Workshop on Environment and Sustainable Development in May 1990. The Paro Resolution, adopted at the workshop, called for "The Middle Path" of development to ensure sustainability. The Resolution also urged the development of a National Environment Strategy (NES) to "ensure the careful stewardship and sustained use of natural resources" in Bhutan. As a consequence, a major focus of the RGoB in recent years has been toward efforts to develop the NES through the NEC; this was completed and declared on 17 December 1998.

terrain, transmission systems are prohibitively expensive. Consequently, micro-hydel and mini-hydel projects and alternative sources of energy will play a key role for rural electrification. This will have a direct impact in replacing fuelwood for lighting, cooking and heating. Other anticipated benefits include

development of a network of small-scale industries, with economic ramifications for rural areas. In addition, hydropower projects would have tangible benefits for the land itself, by helping reduce floods and encouraging forest growth in watershed areas.

### 1.6.3 Self-sufficiency in Food Production

Agriculture has always played a critical role in the subsistence livelihood of the Bhutanese people and, more recently, in agro-based export production. More than 85% of the population is still involved in various agriculture-related activities (MoA, 1996).

Development plans have always promoted agriculture production to boost the national economy. A basic factor in these plans was the acknowledgment that most lands are still managed by farmers. Current government economic strategies promote community participation to undertake a partnership in agricultural projects.

Traditional land use and cultivation have not been developed in isolation. Forestry, agriculture, livestock, buildings, medicines, handicrafts and the production of other goods were all components of an integrated system designed to sustain the environment and meet community needs.

However, the transformation from subsistence to a cash-oriented economy, combined with the growing population, has forced a change from the environment-friendly traditional systems into an intensive and extensive cultivation of agricultural crops at the expense of forests. With limits to expansion of arable land and increasing productivity, the first step in moving toward self-sufficiency is to know the nature, extent and state of current agricultural practices. In recognition of this critical cropping pattern and ecosystem-specific information, the Ministry of Agriculture has initiated specific policy initiatives. It is reiterated in the National Environment Strategy that the primary objectives of a high degree of food self-sufficiency, household income and rural employment can only be achieved through intensive agriculture, diversification of commodities and promotion of agro-based industries.

### 1.6.4 Industrial Development

Bhutan has limited industrial resources and agricultural potential and hence must devise alternative ways to generate revenue. The goal of industrial

development aims to increase productivity in the sector to finance public expenditures, meet costs of social and basic infrastructure as well as the trade deficit, and diversify employment opportunities.

Currently, industrial activity in Bhutan can be classified into four categories:

1. Forest / wood-based
2. Agro-based
3. Mineral-based
4. Service-based

As a result of the strong conservation standards promulgated in the Forest Act of 1969 and the Forest and Nature Conservation Act of 1995, extraction of timber for sale or commercial use has declined sharply. Most of the growth in the industrial sector has thus come from mineral-based activities. To maintain a regional balance, the RGoB is encouraging industries in other areas.

Until now the impacts of Bhutan's industrial activities on the local environment have been minimal, but further industrial growth will have repercussions on the country's fragile mountain environment. Consequently, the RGoB is allowing mining on a highly selective basis and is also keen to regulate and monitor future industrial development.

### 1.6.5 Infrastructure

The RGoB has become conscious of the need to ensure that its assets, both infrastructural and natural, are safely protected from the impacts of natural calamities and climate change. The feasibility studies of remedial measures for natural calamities are ongoing, including monitoring of glacial lakes in the northern part of the country. Environmental awareness campaigns are held nationwide by various governmental units and NGOs under the assistance of international organizations such as GEF, UNDP, WWF and the Government of Denmark.

In development activities, the Ministry of Communications has touched almost all 20 *Dzongkhags* with a motorable road network, built numerous feeder roads linking to the highways, constructed bridges, developed housing schemes, introduced waste management and urban planning systems, developed information infrastructures and introduced international air travel links with the assistance of major development partners, led by India. The Ministry of Trade and Industry has developed numerous hydropower stations, industrial infrastructures, geological survey and mining activities and a tourism system.

For its part, the Ministry of Agriculture has developed national and regional agricultural farms, research and extension centers, and agro-mechanical and forestry management units.

### 1.6.6 Projects and Survey

A vision into the future prompted the RGoB to take the initiative in providing a mechanism to control unsustainable land-use practices and watersheds. The rising frequency of harsh climate patterns particularly heavy rains and anomalously long drought periods necessitates the Watershed Management Program. The project would provide a lead role in promoting better and more suitable land use practices, such as agro-forestry, as well as integrated development activities.

The Land Use and Statistics Section (LUSS), under the Policy and Planning Division of the Ministry of Agriculture, is expected to start an agricultural census by the beginning of 2001. This census will provide the latest information and help to update the present document. The scope of LUSS also includes improvement in collection and analysis of data through the application of GIS and remote sensing.

The limited capacity of government agencies has hindered the development of a national climate change strategy and projects in this area. However, the RGoB signed the Bhutan National Greenhouse Gas (GHG) Project with the UNDP in Thimphu on August 15, 1996, with funding from the GEF. A Project Management Team (PMT) comprising 10 members from NECS, DFS, Department of Research and Development Services (DRDS), LUSS, Central Statistical Organization (CSO), Meteorology Unit (Department of Power), Ministry of Home Affairs (MoHA) and Bhutan Chamber of Commerce and Industry (BCCI) was formed to implement the project activities.

## 1.7 Regulations

All rules and regulations related to development activities in Bhutan explicitly highlight the concern for environmental conservation. As part of this, the NEC Secretariat has developed a specific Environmental Assessment Act (EA) 2000, and an umbrella National Environmental Protection Act (NEPA), will be initiated within the Eighth Five Year Plan with assistance from the Government of Denmark under the Environmental Sector Programme Support (ESPS).

The RGoB's commitment to global environmental concerns in general, and climate change in particular, is reflected in the ratification of the UNFCCC on August 25, 1995, by the 73rd Session of the National Assembly. The NEC was designated as the focal point for climate change activities in Bhutan and its commission members as the National Climate Change Committee.

Furthermore, specific environmental concerns are included in the development plans and the Paro Resolution, which led to the formulation of "The Middle Path", the National Environment Strategy (NES).

### 1.8 Education — School Curriculum

To achieve the target of 100% literacy in the country, the RGoB also has introduced non-formal education (NFE) systems nationwide. In 1994, the adult literacy rate was 54% (CSO). The NFE focuses on domestic and basic social aspects, with environmental issues being introduced right at the initial stages of the education system.

### 1.9 Vision 2020

The Royal Government of Bhutan, through the Planning Commission, has developed a Vision Statement in the form of a strategy document giving its 20-year perspective. This visionary strategy, known as "Bhutan 2020: A Vision for Peace, Prosperity and Happiness", as well as the NES will be incorporated into future Five Year Plans.

It is evident that the development objectives of the country and its priority areas accord high recognition to sustainable development. The emphasis on maintaining forest area, developing environmentally friendly power-generating sources, increasing food self- sufficiency within the confines of a policy of non-conversion of forest land to agricultural land, and balancing regional and industrial development also will serve to check deleterious environmental impacts associated with development.

To conclude, the Bhutanese vision for 2020 encompasses the concept of "Gross National Happiness". This will aim at undertaking balanced and equitable social and economic development, pursuing environmentally sustainable tenets, and developing appropriate governance structures within the context of Bhutan's culture and heritage.

# Chapter 2:
# The Bhutan National GHG Inventory

## 2.1 Introduction

The inventory chapter highlights only the main features of Bhutan's Greenhouse Gas (GHG) Inventory, which identifies the potential GHG sources and sinks and provides estimates of major GHGs in Bhutan for 1994. The GHG Inventory constitutes a major part of Bhutan's National Communication to the Conference of Parties (COP) to the UN Framework Convention on Climate Change.

Following closely the IPCC 1996 Revised Guidelines methodology provided for National GHG Inventories (IPCC, 1996, Vol. 1-3), the first GHG Inventory of Bhutan has been prepared. The data collection phase of the inventory process was particularly difficult because of either non-availability or poor quality data. Consequently, it took longer than scheduled, and estimates were made for those data not locally available using default values provided by the IPCC guidelines. This was inevitable eventhough it raised concern regarding the level of confidence. This simply means that the more the inventory relies upon international / regional default values, the less its level of confidence becomes; the Project Management Team tried its best to minimize the situation.

However, the constraint is obvious given the fact of Bhutan's status as a least developed country, and the wide scope and unique requirements of the inventory. It is the first of its kind to be undertaken by the Royal Government of Bhutan. Despite numerous adverse circumstances, some positive aspects emanated during the tenure of the project. Bhutan is bestowed with His Majesty's far-sighted policy of commitment in conserving the natural

*His Majesty the King with School children.*

*His Majesty with public in one of the Dzongkhag plan meetings.*

*His Majesty's visionary and far-sighted policies have ensured that the people of Bhutan enjoy a richly intact environment that can be passed onto future generations.*

environment, and has always stated that “Gross National Happiness is more important than Gross National Product.” To save ourselves from undesirable consequences of environmental ignorance, there is always a need for wisdom and vision.

Because the National Assembly ratified the UNFCCC, and because the government and the public have a compact of integrity, no community indifferences were faced in implementation of the GHG project. Nationwide awareness on climate change and the “greenhouse effect” has been launched through three regional workshops and demonstrations on the use of alternative fuels (sawdust) for heating stoves. The enthusiastic participation from the communities and support to the issue was accelerated when Her Royal Highness Ashi Chimi Yangzom Wangchuck graced the western regional workshop as Chief Guest at the opening ceremony, accompanied by Their Royal Highnesses Ashi Kesang Choden Wangchuck and Ashi Dechen Yangzom Wangchuck. Members of the public expressed increased appreciation for the fact that they also could be responsible for the alteration of the natural course of climate patterns / mitigation.

**Table 4: Initial national GHG inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol 1994**

| Greenhouse Gas Sources and Sink Categories | CO2 | CH4 | N2O |
|---|---|---|---|
| **Total (Net) National Emissions (Gigagram/year)** | **-3,321.05** | **19.22** | **2.13** |
| **1. All Energy** | **94.77** | **0.05** | **0.00** |
| A Fuel Combustion | **94.77** | **0.05** | **0.00** |
| Energy and transformation industries | 8.42 | 0 | 0 |
| Manufacturing industries and construction | 16.18 | 0.01 | 0.00 |
| Transport-road | 42.99 | 0.01 | 0 |
| Commercial-institutional and residential | 27.18 | 0.04 | 0.00 |
| Others | N.A. | N.A. | N.A. |
| B Fugitive fuel emission | **0** | **0** | **0** |
| Solid fuels-coal mining | 0 | 0 | 0 |
| Oil and natural gas | N.A*. | N.A. | N.A. |
| **2. Industrial Processes** | **133.69** | **0** | **0** |
| A Mineral products-cement | 86.75 | 0 | 0 |
| B Chemical Industry-calcium carbide | 28.67 | 0 | 0 |
| C Metal Production-ferro alloys | 18.27 | 0 | 0 |
| D Other production-alcoholic beverages | 0 | 0 | 0 |
| **3. Agriculture** | **0** | **19.17** | **2.13** |
| A Enteric fermentation | 0 | 16.89 | 0 |
| B Manure management | 0 | 2.28 | 0.01 |
| C Rice cultivation | 0 | 0 | 0 |
| D Agriculture soils | 0 | 0 | 2.12 |
| E Prescribed burning of savannas | N.A. | N.A. | N.A. |
| F Field burning of agricultural residues | N.A. | N.A. | N.A. |
| G Others | N.A. | N.A. | N.A. |
| **4. Land use, land use change and forestry** | **-3,549.52** | **0** | **0** |
| A Changes in forest and other woody biomass stocks | -3,505.85 | 0 | 0 |
| B Forest and grassland conversion | 0 | 0 | 0 |
| C Abandonment of managed lands | -43.67 | 0 | 0 |
| D $CO_2$ emissions and removals from soil | 0 | 0 | 0 |
| E Others | N.A. | N.A. | N.A. |
| **5. Waste** | **N.E.*** | **N.E.** | **N.E.** |

*N.A.-not available N.E.-not estimated

## 2.2 Data and Basis of Calculations

All inventories compiled in this report were calculated using the set of methodologies provided in the Revised 1996 IPCC Guidelines for National Inventories. This version replaces the IPCC, 1995, Vol. 1-3, which has been one of the main bases used in most developed countries for their GHG inventories.

* Waste sector emissions were not estimated due to lack of 1994 data on waste management.

The compilation of the GHG inventories depends on acquiring "activity data" and "emission data". The former encompasses information such as:

- Consumption of various forms of fossil fuel
- Number and type of domestic livestock
- Type and quantity of agricultural development, including crop production, conversion of forest into agricultural land
- Type of industrial / manufacturing operations and rate of production
- Quantity of waste water and sewage generation
- Amount of waste dumped into landfill sites

Technical data specific to those prescribed by IPCC guideline categories is very limited in this country. This has been identified in all annual government statistics from the Planning Commission's CSO, LUPP Dzongkhag data sheets of 1995 and Forestry Information and Five Year Plan progress, Inception-1996/97, which reflect the limited resources for data management, the lack of skills, or both.

Emissions data, on the other hand, define the close association between the activity and the production of GHG, e.g., the quantity of carbon dioxide emitted after burning a specific mass of fossil fuel. Because activity data are a function of domestic and external demands, there is a tendency for them to vary from year to year. Emissions data, however, tend to be uniform for those emissions originating from fuel combustion, because these are determined by the chemical composition of the fuel and, to some extent, the nature of the combustion process.

Emissions and removals from sources such as agriculture and land use change, although subject to variation, occur in a much longer time period when compared to the activity time change. Further, the temporal relationship between activities like biomass decay and the subsequent greenhouse emissions or removals is complicated. The time lag between the activity and the resultant greenhouse emissions or removals may take more than 20 years for some categories, especially land use change and agriculture.

### 2.3 Levels of Confidence

According to the Revised IPCC guidelines, 1996, countries need to identify the levels of confidence in their inventories. The Bhutan GHG Inventory adopts three levels of confidence, summarized in Table 5 below. It must be pointed out that the definition of the levels is totally conceptual; this simply means that the levels of confidence were not derived from a statistical analytical procedure, but were based purely on a professional judgment of the task force that compiled the inventories. It is for this reason that uncertainties are not assigned to activity data during the computation phases. Instead, they are only assigned to the final outcome of the emissions and removals.

**Table 5: Levels of Confidence**

| Level of confidence | Code number | Energy, industry | Agricuture, land use change and forestry |
|---|---|---|---|
| High | 1 | Uncertainty<20% | Uncertainty <30% |
| Medium | 2 | Uncertainty20-50% | Uncertainty 30-75% |
| Low | 3 | Uncertainty >50% | Uncertainty >75% |

The quality of the available activity data is very much reflected from the levels of confidence assigned to different categories. Further, in assigning the levels of confidence, consideration was given to the relationship between the activity and the emissions. This is illustrated in the Energy category, in which the quality of some data is quite accurate and the relationship between combustion and emissions is not complex. Under this circumstance, the levels of confidence are rigorous compared to the other categories.

The majority of the data and, hence, the consequent emissions and removals have been assigned a low level of confidence because of poor and / or limited data.

## 2.4 Special Characteristics of the Inventories

### 2.4.1 Missing Features

This inventory excludes all contributions to the greenhouse effect from CFCs and other "ozone-depleting substances". An inventory of these pollutants will not be applicable at least for few years for Bhutan.

The PMT explored the possibility of collecting information about the use of fuelwood in Bhutan. The need arose because of the apparent significance of this fuel in the local economy. There has been no formal record available to the PMT other than what was reflected in the forestry information and Five Year Plan progress of the DFS, which is 1,200,000 $m^3$ per year. The IPCC guidelines specifically pointed out that the $CO_2$ arising from biomass or fuelwood burning is to be excluded from the national totals. If surveyed, the outcome would indicate that rural communities in particular are utilizing enormous quantities of biomass for cooking, heating and drying cardamom. Consequently, the share of the $CO_2$ emitted from this source would be relatively significant. This share cannot be calculated, however, unless the following are known:

- Exact quantity of wood harvest for fuelwood purposes because Bhutanese use fuelwood from mixed sources (trees purposely felled for fuelwood, remains of tseri burning, dry lops and tops from timber harvest, natural dry twigs, and timber chopped for housing and other construction)

- Relevant dry matter mass for various fuelwood types
- Net calorific values for each wood type

### 2.4.2 Emissions, Removals and Net Emissions

Of the five categories included in Table 4, only the energy, industry, and land use change and forestry categories recorded contributions to $CO_2$ emissions and removals in 1994. The industry category, with a net emission of 133.69 Gg, was clearly the strongest source of $CO_2$, followed by the energy sector with 94.77 Gg. Land use change and forestry, although it emitted a comparatively significant amount of $CO_2$ in the same year, indicated a net $CO_2$ removal of 3,549.5 Gg because of strong intake of $CO_2$ through forestry management and plantations as well as abandonment of managed land. This feature is important because it indicates that the atmospheric concentration of $CO_2$ can be anthropoginically controlled.

$CH_4$ was emitted from one of the five categories, Agriculture, and no significant $N_2O$ was emitted in any of the sectors in Table 4.

### 2.4.3 Energy

The energy sector has comparatively good data. The main data source, the CSO, Planning Commission, has an up-to-date database that includes petroleum products. Keeping a proper record of these items is very important because the government pricing process for petroleum products depends on it.

Road transport, residential, and manufacturing industries and construction were the three major components of the energy sector that contributed significantly to its share of the $CO_2$ emissions in 1994. Of the total $CO_2$ emissions from the energy category, transport accounted for nearly 45.3%, followed by residential/commercial with 28.7%, manufacturing industries with 17.1% and only 8.9% from energy transformation. The methane and nitrous oxide emissions are not significantly reflected in the energy category.

### 2.4.4 Industry

Industrial GHG emissions are estimated based on production quantity in 1994 submitted by the individual industries.

Limestone and dolomite are mining activities rather than production from industry in Bhutan. Therefore, fugitive emissions should have been there, but no proper data were available. As such, mining activities are not much focused on in this report.

*Highest contribution to national GHG emissions in Bhutan is identified from the industrial sector.*

Total emissions from the industrial sector are 133.69 Gg of $CO_2$, which is the highest contributor to the national $CO_2$ emissions with 58.5%, including significant contributions from cement industries and 1.9 Gg of NMVOC from cement production and alcoholic beverages.

### 2.4.5 Agriculture

The GHG inventory data for the agriculture category are reliable, with sourcing from the LUPP Dzongkhag data sheets of 1995, for livestock census and irrigated rice cultivation. Data for synthetic fertilizer use in the agricultural system are from the Semtokha-based Soil and Plant Analytical Laboratory (SPAL) of the Department of Research and Development Services (DRDS) under the Ministry of Agriculture. Only 19.17 Gg of $CH_4$ is reflected as emitted from the agriculture category, with 16.9 Gg contributed from enteric fermentation due to livestock. Except for 2.13 Gg of $N_2O$, no other significant GHGs are emitted.

*Rearing of livestock is an integral part of the farming systems in Bhutan.*

Ironically, some 85% of the Bhutanese population rely heavily on agriculture to meet their everyday needs (MoA, 1995). Despite the strong emphasis placed by the MoA in collecting agriculture-based data, rural agricultural data are still not adequate. This requires immediate attention because the climate change impacts are not known, even though a large percentage of the population depends on agriculture.

The Royal Government and the people of Bhutan are trying to phase out shifting cultivation, which employs a fallow system of agriculture. Therefore, reliable data were not maintained that could be used for savanna burning emissions in the agriculture category.

Crop residues are hardly burned in the field. Most are usually harvested to be used as feedstock for cattle in dry seasons and the remains are left to decompose in the field. The lack of quantitative data about these items, however, excluded them from the inventory.

### 2.4.6 Land Use, Land Use Change and Forestry

**Land Use, Deforestation and Land Degradation**

Reliable and comparable data on changes in land use are not currently available. Nonetheless, it is clear that human influence over hundreds of years has reduced the total forested area and increased some competing land uses, according to the MPFD. However, this statement contradicts the 1994 findings of the Ministry of Agriculture, which were based on remote sensing techniques, where the forest cover has actually increased. Similar land use classification will soon be carried out based on digital imaging by the Ministry of Agriculture under the ESPS. Moreover, the Japan Forest Technical Association (JAFTA) will be conducting similar studies whose results will be available by the end of the year 2000; the JAFTA study will focus more on the detailed classification of forest types. These three similar types of information / data described above would give a much more reliable picture of the land use change for Bhutan. That would then precede the real start for building up the land use change database in the country. Even in the absence of any reliable land use change information / database, the Master Plan for Forestry Development has made an attempt to assess the extent and rate of land use change in Bhutan. Only two main tools exist for this purpose:

- Pre-Investment Survey (PIS) of Forest Resources based on 1978-79 aerial photos, and their comparison with MPFD SPOT-based information of 1989; and evaluation of dynamics of the natural habitats and trying to reconstruct how original habitats looked interventions.

**Table 6: Comparison of Land Use Pattern between PIS and MPFD**

| Land use types | PIS (1958) | MFPD (1989) |
|---|---|---|
| Agriculture | 299 | 554 |
| Broadleaf forest | 1,485 | 1,056 |
| Conifer forest | 1,011 | 1,006 |
| Degraded and others | 1,245 | 1,426 |

The MFPD attempted to compare the present land use pattern with the above two benchmarks:

It can be concluded from the above comparison that the conversion of broadleaf forests to agricultural and grazing purposes. Conifer forests had remained quite stable.

The main summary of the results by MFPD was that looking to history, one could see that an expanding population needed agricultural and supporting land for food production. Looking at the present situation, the same factors are still present.

However, the weakness of the above comparison is that the PIS covered only about 72% of the country. Moreover, the rate of change of land use during the PIS period and now could be different because agricultural land cannot be expanded forever given the terrain conditions. More importantly, forest laws are being implemented more effectively now than before. Therefore, the rate of land use changes (from forest to non-forest) can be expected to be very slow.

At this moment, the land use change direction is confusing. As stated above, the MPFD in 1991 estimated forestland could change annually into other competing land use forms for a couple of years. The MPFD estimated that about 13,600 ha of broadleaf forest would disappear annually, giving way to 8,000 ha of agricultural land and 5,600 ha of other open land. At the same time, the Ministry of Agriculture found that forest cover had increased. This could perhaps be attributed to different methodology used in each of the survey.

Land use change and forestry was identified as a major sink for carbon in 1994 from changes in forest and other woody biomass due to forest management and plantation activities. Because the forested area is considered government forest reserve land, timber harvests are controlled with scientific management, and afforestation in barren land and reforestation in harvested areas are intensified annually; thus, the entire 2.9 million hectares of forest cover is considered managed forest.

Abandonment of managed land also could be net sinks for carbon, but literature records are not available.

Orchard plantations in Bhutan represent conversion of barren land or dry agricultural land to orchards of large growing trees (apple / pear in the temperate zone and orange, walnut and betel nut in the sub-tropical zone). Therefore, orchard plantations as of 1994 also have been counted in the Land Use Change and Forestry category, applying the default values of the fast-growing hardwood trees.

Therefore, although a significant emission of $CO_2$ was emitted in 1994, forest and forest management activities has resulted in a net removal of 3,321.05 Gg of $CO_2$ (see table 4).

However, Land Use Change and Forestry has been assigned a high uncertainty because of the absence of quality data required for inventory purposes. Minimizing this uncertainty depends very much on the Department of Forestry Services improving their database quality and soliciting the required information for future GHG inventories.

Forest fires, although rare, do occur. In the past prescribed burnings were misunderstood / misinterpreted in Bhutan and early writers reported the use of fires to clear land for agricultural purposes.

### 2.4.7 Implications

The emissions of GHG in Bhutan are relatively insignificant by world standards. Nevertheless, Bhutan is among the most vulnerable countries to the impacts of the "greenhouse effect." It is ethical, therefore, that Bhutan should recognize its obligation toward developing GHG sinks.

A crucial constraint reflected from the inventory is the lack of quality data. It is important to acknowledge this as urgent; hence, Bhutan needs to address this issue properly and promptly. Data management is also identified as generally poor, which makes it a priority issue that must be rectified. If these constraints are resolved, an improved GHG Inventory will be submitted. As a result, more realistic estimates of GHG emissions and removals will become available and accessible. This information is important to planning and policy making, both in the government and private sector.

The GHG inventory needed to incorporate participation from all sectors of the national economy. Improvement of the above issues is dependent on a well-coordinated system where sufficient quality data can be easily accessed

and managed. Addressing this issue therefore calls for an integrated system that employs comprehensible and user-friendly mechanisms that allow for closer cooperation between key government and non-government agencies.

The GHG estimates, despite being relatively small, will definitely increase with population growth and the fast pace of economic development that requires the use of more energy. Thus, with the absence of a proper control mechanism, GHG emissions are likely to be enhanced in the future.

However, it is evident from the inventory that $CO_2$ alone can be controlled, by intensifying plantation activities, controlling timber harvest, improving land use techniques, and improving / transferring energy efficiency technology and enlarging the renewable energy supply horizon.

Other strategies also are available for controlling emissions of all GHGs including $CO_2$. These include regulatory measures that set up legislation controlling the import of fossil fuel, automobiles and regulation that activates a monitoring system for the emission rate of greenhouse gases.

The underlying rationale for all these implications is to ensure that Bhutan, within its own territory, can provide an optimum environment for its people. There is compelling evidence that the “greenhouse effect” and climate change are intimately linked. So, for Bhutan to produce the best for its people in terms of a favorable environment, it must educate its citizens on the issues and address these issues to the GHG-contributing nations because the effects are trans-boundary in nature.

# Chapter 3:
# Vulnerability and Adaptation

## 3.1 Introduction

Climate change is likely to have adverse impacts on Bhutan, hampering its search for sustainable development. Some of these impacts could include significant declines in agricultural production, as well as effects on forest and water resources.

Bhutan's greenhouse gas (GHG) inventory indicates that its emissions are relatively small. This, however, does not imply that it will not be adversely affected by the impact of climate change. The 1994 glacier lake outburst in Lunana, one of the northern highlands, seriously damaged the lower valleys of Punakha and reminded us of the high degree of Bhutan's vulnerability to extreme events. Bhutan therefore needs to take prompt action to ensure that the adverse consequences of climate change do not have the potential to endanger human life and impose a threat to the biophysical environment, from which communities derive their livelihood.

In recent years signs of unusual change in the climatic system had been seen. A rare dry-spell with no snowfall was experienced in the winter of 1998 and even rarer mid-summer snowfall occurred in some places in the north in July 1999. Flash floods in early August 2000 caused by torrential rains have claimed dozens of lives and caused significant damage to infrastructures and natural resources within the country.

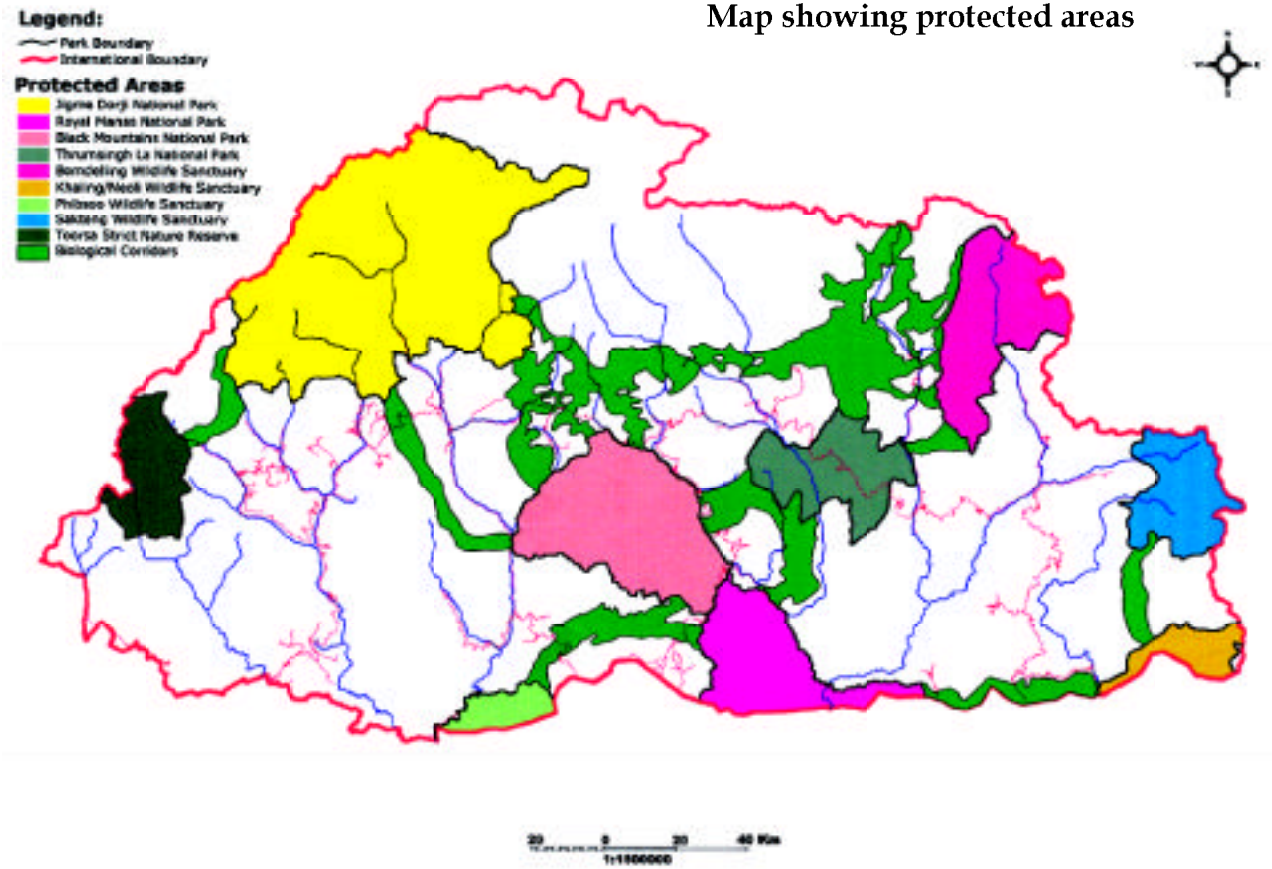
Bhutan's changing food production systems and population density, especially in urban areas, pose a threat to food security in the country. This problem arises mainly from the high food demand from the expanding urban population. In the past, agriculture has shown resilience and the capacity to adapt despite a series of extreme events and pest and disease outbreaks. Even so, there is urgent concern about the impact of the deteriorating biophysical environment and increased frequency of extreme events.

Urbanization and overcrowding are emerging problems faced by the nation, and water consumption is high. Heavy rains exacerbate problems associated with water supplies, in particular, the increase in the degree of turbidity.

## 3.2 Current Scenario and Possible Impacts of Climate Change

Studies elsewhere have indicated that adverse impacts caused by climate change will be severe on fragile mountain ecosystems and island states. Although Bhutan did not experience disastrous events in the past it does not mean that it is free from climate change impacts because they are trans-boundary phenomena.

Map showing protected areas



As a least developed country situated in a mountain ecosystem, Bhutan therefore is highly vulnerable to possible climate change impacts. In the Bhutanese perspective, six areas considered most vulnerable to climate change are: (i) forests and biodiversity, (ii) agriculture, (iii) water resources, (iv) glacial lake outbursts, (v) health, and (vi) landslides.

### 3.2.1 Forests and Biodiversity

Climate change could have enormous impacts on forests and forest resources in Bhutan, with temperature changes creating competition between high-elevation tree species and new arrivals. Weedy species with a high ecological tolerance will have an advantage over cold-adapted species (IPCC, 1998). While warming may have positive effects on the growth of some trees, it also could reduce tree survival by benefiting insects or pests. Warmer winters would imply reduced snow cover and less carryover of water to the growing season, which could lead to drought-induced forest decline (IPCC, 1996).

Bhutan is part of one of the 10 global biodiversity "hotspots". Today its rich biodiversity resources still make a large contribution to the economy. Unfortunately, human activities are increasingly threatening all the existing ecosystems. In addition, several species are already endangered by climate change and extreme events. This assessment, however, employs a general approach with no specification to clarify the impact of climate change to Bhutan's biodiversity.

The combination of climate change with the pressures of deforestation, land use changes, habitat degradation and fragmentation presents a significant threat to biodiversity. Climate change can affect biodiversity either directly, by changing the physiological responses of species, or indirectly, by changing the relationships between species (IPCC, 1996). For example, a change in the insect population could influence the evolution of plant biodiversity and vice versa. Ironically, the projected climate change, with some increase in rainfall and temperature, is favorable for the richness of diversity; this is because a warmer world has greater potential for plant productivity, together with a movement of many species towards higher latitudes. Some species, however, will die out or become extinct as temperatures exceed their tolerance limits. Sufficient water supply will mean enough water for plants and animals for their survival and production. An increase in rainfall, on the other hand, also will enhance soil erosion and will affect vegetation and other biodiversity.

### 3.2.2 Agricultural Activities

Agricultural activities are broadly classified into livestock and crops; the main crops of Bhutan are rice, wheat, maize and potato. However, as many as nine varieties (Dru-naa-gu) of crops are cultivated in general in Bhutan. Upland crop production, practiced close to the margins of viable production, can be

highly sensitive to variations in climate (IPCC, 1996). Agricultural productivity is sensitive to two broad classes of climate-induced effects: (a) direct effects from changes in temperature, precipitation or carbon dioxide concentrations, and (b) indirect effects through changes in soils, distribution and frequency of infestation by pests, insects, diseases or weeds. A temperature increase of 20C would shift the cultivating zone further into higher elevation. This means that crops that are sensitive to low temperatures can be introduced into higher elevations with this temperature rise. Although this may seem a useful aspect, a closer examination indicates that the landforms at this altitude are mainly steep slopes, unsuitable for agriculture. Related cropping patterns would be affected.

Warming may have positive impacts on crop yields if moisture is not a constraint, but increases in the occurrence of extreme events or pests may offset any potential benefits. Both crops and livestock would be affected by increased pestilence of alien / invasive pests and diseases. An increase in temperature, despite a reduction in humidity, can reduce the ability of farmers to work. As a result, low-income rural populations that depend on traditional agricultural systems or on marginal lands are particularly vulnerable to climate change.

*Almost 100% rice in Bhutan is cultivated under terraced, irrigated in single areation patern. Climate change could effect cropping paterns affecting majority of the people.*

### 3.2.3 Water Resources

Bhutan has easy access to rivers, streams and natural pond water. These resources are dependent mainly on glaciers, snow, forests and seasonal rainfall averaging 1,000 mm per year. Although Bhutan did not record water shortages till now, climate change may render the country highly vulnerable to scarcity of water. Anglo et al (1966, Regional Impacts) confirm that water resources in the tropical Asia region, covering Bhutan, are very sensitive not only to changes in temperature and precipitation but also to changes in tropical cyclones. Therefore, stringent measures need to be put in place to ensure the sustainability of the water supply.

An increase in rainfall intensity, which some models have projected, may increase runoff, enhance soil erosion on cleared land and accelerate sedimentation in the existing water supplies or reservoirs. Not only will such an event reduce the potential of a catchment to retain water, but it will also cause water quality to deteriorate. A reduction in the average flow of snow-fed rivers, combined with an increase in peak flows and sediment yield, would have major impacts on hydropower generation, urban water supply and agriculture.

### 3.2.4 Glacial Lake Outbursts

In the northern region of the country there are numerous snow-clad mountains and glacial lakes. Increases in temperature caused by global warming will result in the retreat of glaciers, increasing the volume of such lakes and ultimately provoking glacial lake outburst floods (GLOFs) with potential catastrophes. The October 1994 flash flood on the Pho Chhu river following a glacial lake outburst in the Lunana area was one such example. A mission set up to analyze the above cause highlighted a strong correlation between high temperatures and lake outbursts.

*Glacial lakes in northern Bhutan have been growing rapidly due to receding of glaciers and pose serious disaster threads to settlements down stream.*

Possible significant impacts of glacial lake outbursts in the context of Bhutan include perturbation in the quantity of river water used for hydropower generation; destruction of settlements, infrastructure, and agricultural lands; and loss of biodiversity, and even human lives downstream.

### 3.2.5 Human Health

Little is known about the relationship between health and climate change in Bhutan. A predicted temperature increase of $2^0$C is likely to affect human health not only because of heat stress but also because of increased outbreaks of vector-borne diseases. Similarly, an increase in rainfall and flooding, which provide favorable conditions for water-borne diseases, also can increase our vulnerability to health hazards. There have been several examples of malaria and cholera outbreaks in the recent past. However, developing a correlation between such outbreaks and climate change was not possible because of the absence of relevant data. Still, the persistent occurrence of malaria despite efforts toward its eradication provides an indication of Bhutan's vulnerability. Another significant climate change-related health concern is the increase of water-borne diseases such as gastroenteritis and diarrhoea, which are identified with poor water quality and turbidity during rainy seasons.

### 3.2.6 Landslides

The Himalayan mountains are considered young and still in the growing stage. Various parts of Bhutan, especially the south, fall within major fault lines of different geological formations, making the region highly unstable and susceptible to landslides. This situation combined with heavy rainfall and
external disturbance—e.g., construction of roads, mining, deforestation and so forth—causes landslides that disrupt the economy and social communications. Moreover, this impact is significant given the fact that Bhutan depends largely on its road network for transport and trade.

## 3.3 Integrated Assessment of Effects

Bhutanese life and culture are integrally related to the land and mountains. People in Bhutan have maintained a delicate balance between their lifestyles and the fragile mountain ecosystem, which could be seriously disrupted by climate change. Although current studies provide some indications of the likely impacts of climate change on the resources of Bhutan, net impacts are very likely to be cumulative. This cumulative effect is determined by the synergistic interaction between the above impacts and the continual environmental and socioeconomic changes.

### 3.3.1 Identifying Vulnerabilities

Bhutanese have traditionally been in harmony with their biophysical environment; this may be reflected from their customs and traditions. The

least-cost options (economic, social and environmental) for adaptation to climate change are those related to activities that are either ongoing or likely to be easily implemented with local resources. On the other hand, there are a number of “no-regrets” strategies related to the most severe effects and the greatest vulnerabilities, but some could be high-cost options. With proper planning and good timing, however, these strategies can be realized within a set time frame.

In the case of a glacier mitigation strategy, for example, regular monitoring is required to ensure timely remedial and preventive actions. In this case, intermediate steps may involve relocation of people to higher land to avoid inundation from flood surges. High-priority areas need to be identified for drawing up the impact mitigation strategy.

### 3.3.2 Assessment of Adaptation Opportunities

It is important that Bhutan’s adaptation strategies take a “no-regrets” approach. These strategies should increase the ability of ecosystems and communities to cope with ongoing environmental stresses and climate variability. In addition, the “no-regrets” strategies benefit both the society and the environment in the long-term, in spite of initial economic costs.

Sectoral adaptation measures needs to be qualitatively assessed in the future on the basis of the economic and environmental cost, cultural suitability and practicability.

The following basic measures, however, have to be undertaken, not only to meet climate change, but also in the context of the countryís development process:

***Human Health***

1. A reliable and safe drinking water supply is essential. To ensure safe drinking water for all, the number of water treatment plants must be increased.
2. The development of proper waste disposal methods needs to be encouraged to minimize the existence of vector breeding habitats.
3. Regular cleaning and vaccination campaigns are conducted at sites where the mosquito vector is abundant. There is a need to further improve public health measures.

***Water Resources***

1. Community involvement and awareness are very important in using water resources more sustainably.
2. Land use planning should be improved to promote afforestation in degraded water catchment areas.

3. There is a need to extend, improve and maintain water supply infrastructure, including water tanks, pipes and so forth.

***Agricultural Activities***

1. There is a need to develop varieties of crops and livestock with greater resilience to limited arable land and extreme temperature events.
2. Quarantine surveillance should be increased against alien / invasive species with higher temperature optima and others, which may be adapted to higher elevations.
3. Agro-forestry or agro-silvo-pastoral systems may be utilized to reduce erosion and run-off on steep slopes. This could also be used to mitigate heat stress and respiration problems, as well as soil fertility loss.

***Forests and Biodiversity***

1. Community-based forest management and afforestation projects should be encouraged in areas where there is rich biodiversity. The method of forest management should be done in such a way as to contribute to its proper purpose, which includes national land conservation, water resource conservation, nature conservation, wood production and human living environment conservation, as well as contributing to the prevention of global warming.
2. Research in developing a sustainable socioeconomic system, which can ensure that society is in harmony with the natural environment, should be initiated.
3. Research in tree species that are fast-growing and more resistant to insect damages from diseases, natural phenomena and forest fire should be initiated.
4. Improvement to an appropriate database for natural resources such as forests—not only in the context of climate change but also for support to other development strategy frameworks—is urgently required.
5. Banning of export of raw timber products by the Royal Government in the recent years was one good example of adaptation measures for the sustainability of the forest cover.

*Export of raw timber has been banned in Bhutan.*

**Renewable Energy**

1. Technology and financial support to hydropower potential access, including transmission and distribution.
2. Research for other renewable energy alternatives, including solar power.
3. Enhancement of Power Master Plan.
4. Research for replacement petrol / diesel engine motor transport.

## 3.4 Identifying Gaps and Priority Needs

### 3.4.1 Information Gaps

Preparing the vulnerability and adaptation assessment for Bhutan has been constrained mainly by information gaps and the dearth of data in the following issues and areas:

- Future climate change scenarios for Bhutan
- Status and health of mountain ecosystems and their sensitivity to climatic and non-climatic stresses
- Land elevation and land at risk from flooding and inundation
- Erosion processes, sediment transport dynamics and areas at risk from erosion, especially in already erosion-prone areas
- Effect of climate change on water resources
- Possible risk of damage from floods to housing and infrastructure
- Links between climate change and health
- Climate-related diseases such as diarrhoea, malaria and dengue fever
- Future climate variability and extremes in Bhutan
- Present cross-sectoral interactions and the possible effect of climate changes on these interactions
- Cumulative effects and indirect impacts of climate change effects
- Cost in environmental and social consequences, practicability, and effectiveness of adaptation opportunities, including mitigating measures and policy strategies

### 3.4.2 Capacity Building Needs

Further capacity building is needed to promote an awareness of Bhutan's vulnerability to climate change impacts, particularly in the following areas:

1. Upgradation / improvement of meteorological organization / infrastructures and education on general climate change issues
2. Upgradation / integration into line Ministerial organizations of Central Statistical Organization and training in database development / improvement, especially green sector, for future GHG inventories
3. Training on vulnerability to climate change, especially in lower mountain valleys, and feasible adaptations that are culturally, environmentally and economically acceptable

4. Strengthening institutions such as environmental NGOs as well as Government departments and ministries, especially MTI, MoA, MoC, Planning Commission, NEC and Dzongkhags
5. Priority given to public awareness regarding vulnerabilities and adaptations
6. Education of communities to understand their own vulnerabilities, to make suitable adaptations, and to subsequently decide on the most feasible mitigation

# Chapter 4:
# Meeting Global Environmental Objectives

Bhutan is fully committed to the UNFCCC objectives, and it embraces all opportunities to fulfill them. It also welcomes support from the global communities, which share the same need to make the world a better place, to live through establishing suitable adaptive and mitigation mechanisms.

This National Communication clearly presents a setting that reflects a need for Bhutan to act with prudence and vision regarding its preparedness to adapt and to introduce mitigation measures against possible adverse impacts caused by climate change. Despite Bhutan's initiative in this respect, it is evident that Bhutan has to build its capacity urgently in order to fulfill its obligations and commitments under the UNFCCC and the Kyoto Protocol.

To implement appropriate and effective responses to climate change, the following are priorities for Bhutan:

## 4.1 Improved Database in all Ministries

The national data and information systems are in their nascent stages, and for any effective development strategies, as also environmental strategies, institution of appropriate systems is of prime importance for Bhutan. Although the Government has taken some steps in this regard and some official publications are available, a concerted drive to install data and information retrieval systems in all Ministries is a top priority for the country.

## 4.2 Devising of a Robust Policy for Sustainable Development That Meets National Imperatives as well as Global Environmental Issues

The Royal Government is keenly aware of the issues pertaining to sustainable development, as shown in "The Middle Path: National Environment Strategy" and the so called "Vision 2020" document. Bhutan needs financial and technical assistance in instituting measures that will meet local needs while addressing global environmental issues.

A menu of mitigation options relevant in the case of Bhutan includes the following outlined in sections 4.2.1 to 4.2.3.

### 4.2.1 Renewable Energy Technology Options

Although Bhutan is dependent mainly on hydropower, a relatively clean and benign source of energy, for its electricity requirements, extension of the grid to far-flung and remote areas is an expensive option. In this context, it is worthwhile to examine other renewable energy technologies, including micro-

hydels, mini-hydels, solar and biomass gasifiers, as decentralized energy options. For this, an assessment of future energy needs and availability of various renewable sources and a cost-benefit analysis of each are required, as is also development of project proposals for techno-economic assistance.

### 4.2.2 Improved Technology to Reduce Fuelwood Consumption

Most Bhutanese households use wood for cooking and heating purposes. Improved stoves will be a solution not only for indoor air pollution or fuelwood consumption, but also for the local environment. The Royal Government is aiming to introduce electric heaters in households, but this is expensive and beyond the purchasing power of an average household.

Another measure that is of relevance in the cold climes of Bhutan is improvement in building designs for more effective insulation.

### 4.2.3 Introduction of Fuel-Efficient Vehicles

The vehicle fleet now plying the country is not fuel-efficient and therefore is one of the major sources of CO2 emission. Nevertheless, monitoring systems are now evolving to check vehicular emissions. The import of reconditioned cars is banned as one-control measures.

An evaluation of these options is required to establish local and global environmental benefits, as is also identification of financial and economic implications of the options.

## 4.3 Studies on Impacts of Climate Change on Bhutan

The vulnerability of Bhutan to likely changes in climate can be better defined only after an analysis of the impacts on the mountain ecosystem of the country. Projects to analyze the likely impact on water resources, agriculture and

*Royal Government of Bhutan is exploring methods for reducing firewood consumption.*

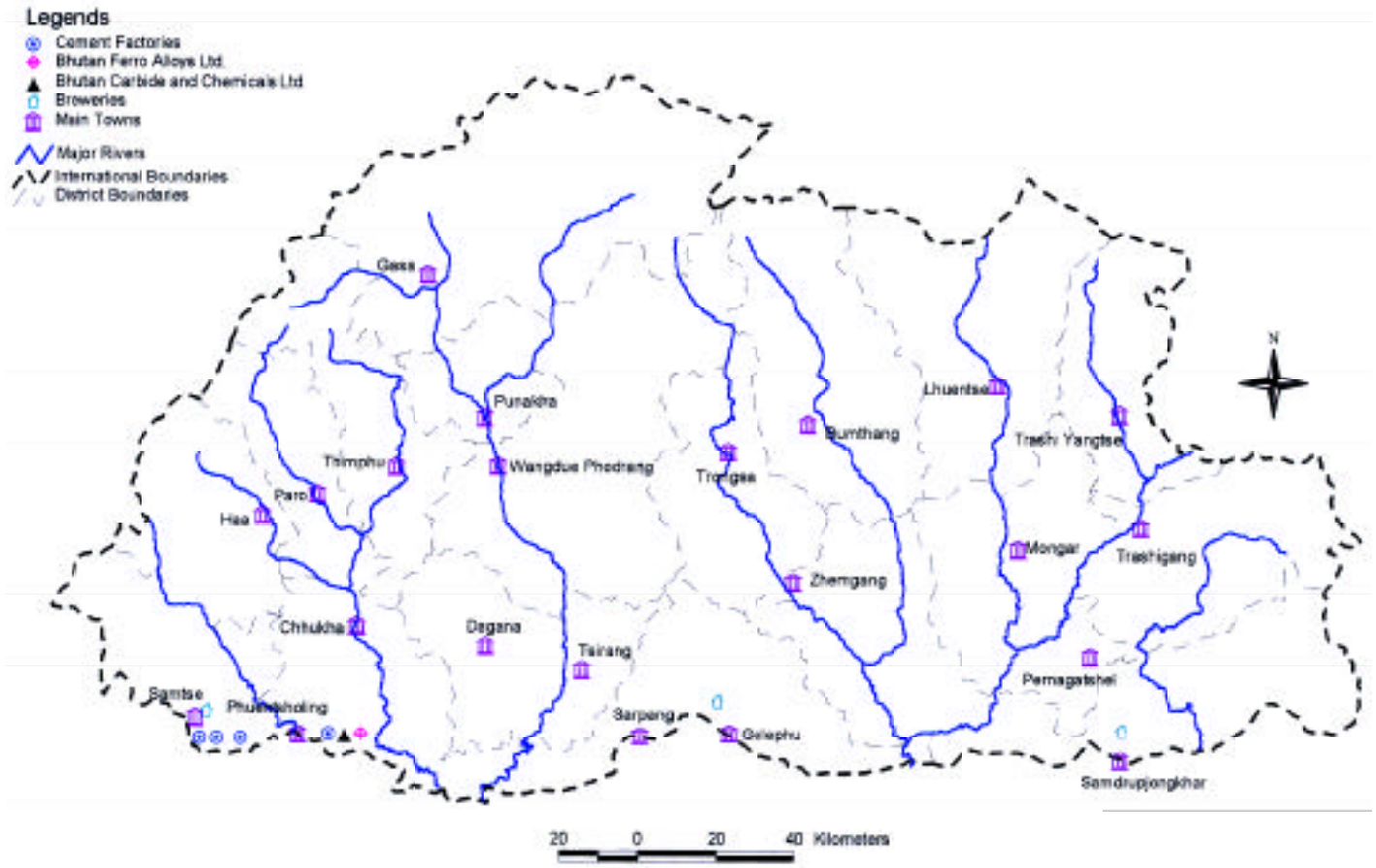
livestock are extremely relevant, not only in the context of the livelihood of a majority of Bhutanese, but also of the importance to the economy of export earnings from sales of hydropower.

Enhanced capability to predict extreme events such as glacial lake outbursts is needed to ensure preparedness, thereby reducing socioeconomic impacts.

Other areas relating to human health, agriculture and water where further work is required are mentioned in the preceding chapter.

Development of a national policy framework to facilitate implementation of appropriate and effective mitigation measures and adaptation strategies is important. This will require institutional strengthening, community participation, development of national capacity and local and regional expertise. It also will include developing locally appropriate methodologies for analyzing these effects and increasing understanding of current interactions of climate and environmental and socioeconomic effects and changes.

Bhutan has limited internal resources to deal with the foregoing and will need assistance from the international community, both bilateral and multilateral. This assistance should aim not only to take stock of the current scenario and establish a baseline but also to aid in instituting sustainable policies and technologies, and to prepare for any adaptation to climate change that may become imperative, especially in the context of a high level of vulnerability.


Legends
Cement Factories
Bhutan Ferro Alloys Ltd.
Bhutan Carbide and Chemicals Ltd
Breweries
Main Towns
Major Rivers
International Boundaries
District Boundaries
Gasa
Punakha
Thimphu
Wangdue Phodrang
Paro
Haa
Trongsa
Bumthang
Lhuentse
Trashi Yangtse
Mongar
Trashigang
Zhemgang
Chhukha
Dagana
Tsirang
Samtse
Phuentsholing
Sarpang
Gelephu
Pemagatshel
Samdrupjongkhar
N
20 0 20 40 Kilometers

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