BHUTAN

CLIMATE + CHANGE




Handbook

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Acknowledgement

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Message from Hon'ble Lyonpo Yeshey Dorji
Minister of Agriculture and Forests
Royal Government of Bhutan

We stand on the edge of a precipice.

The earth's temperature has increased more rapidly in the past 100 years than in all the previous 10,000 years. The forecast is even worse: according to scientists, the temperature increase in the 21st century will be far worse than the 20th century.

Human activities are at the root of this problem. Our frenetic, reckless and relentless bid to consume, more than we need to sustain our livelihood, has caused the release of inordinate amount of greenhouse gases into the atmosphere with tragic consequences. Today, we grapple with floods, heat waves, droughts, and unprecedented rise in sea level that is threatening the very survival of nations.

Inevitably, Bhutan too is caught in this quagmire. Located in the Himalayas – dubbed the Third Pole – we are already witnessing tale-tell signs of glacier-melt and GLOF, erratic rainfall and water supply, disruptions in our agricultural practices, and emergence of new pests and diseases.

Touted as a champion of environment, Bhutan has exhibited leadership in reducing greenhouse gas emissions. We have supported, endorsed or ratified innumerable international protocols and conventions on climate change. We have even pledged to the international community to remain a net carbon sink in perpetuity.

Back home, we rigorously filter all development programs with environmental friendliness as the yardstick. We have 72% of our total land area under forest cover, more than the constitutional mandate of 60%. In addition, more than half of Bhutan's geographical area is protected as national parks and biological corridors.

Are these efforts enough? Legislative and policy support is critical but so are awareness and education. It is in this light that I feel this handbook "Bhutan: Climate + Change" would be immensely useful.

Whether it is an agriculture extension official or an environmentalist or a forestry staff, this handbook provides a guide and a reference point to enable them to make informed decisions. In equal measure, it will benefit institutions like schools, working journalists, farmers and others whose daily activities have a bearing on climate change.

At the community level, the handbook will help decision-makers take the key steps required to plan for climate change adaptation and determine what strategic actions need to be taken. In so doing, our people will understand the causes and consequences of climate change better, prepare them to live with its risks and impacts, and empower them to adopt sustainable lifestyle.

Finally, I would like to place on record my immeasurable gratitude and appreciation to International Centre for Integrated Mountain Development (ICIMOD) & Bhutan Media & Communications Institute (BMCI) for this most laudable initiative.

Yeshey Dorji

Foreword

Bhutan sits in the Hindu Kush Himalayas (HKH), and, like its regional neighbors, faces numerous existential challenges, driven primarily by climate change. Warming trends and melting glaciers pose serious threats to the nation and its inhabitants.

Research, of the kind this book draws from, reveals that temperatures increase more dramatically in mountain areas, which translates into faster glacier retreat and more frequent water-induced disasters such as glacial lake outburst floods (GLOFs).The changes in the climate are believed to have also increased the intra and inter-annual variability of monsoon, leading to less predictable growing seasons, and an increase in the events of floods, flash floods and droughts. These climatic changes are compounded by other social, environmental, and economic realities, such as male out-migration, increasing atmospheric black carbon, decreasing crop yields, and urbanization.

In the face of these substantial socio-environmental challenges, policy interventions are needed to slow or reduce these harmful patterns. But countries have been slow to respond.

In Bhutan, however, the story is a little different. The Royal Government's environmental policies are an example of strong political commitment to conservation and sustainability. For example, Bhutan's government requires that 60% of the country fall under forest cover, and has pledged to remain carbon neutral in its energy consumption. But one nation's actions are not enough.

Torrential floods in southern Bhutan this year provided a stark reminder that more work remains to be done in terms of bolstering the nation's preparedness to tackle disasters of bigger scales. To this end, the National Environment Commission Secretariat recently released the Bhutan State of the Environment Report 2016. The report warns about the dangers of increased rainfall in the south and the rising risk of GLOFs in the north. Indeed, our own research confirms these concerns: between 1980 and 2010, glacial lakes in Bhutan increased in area by 8.7% while the glacier sizes shrunk by 22%.

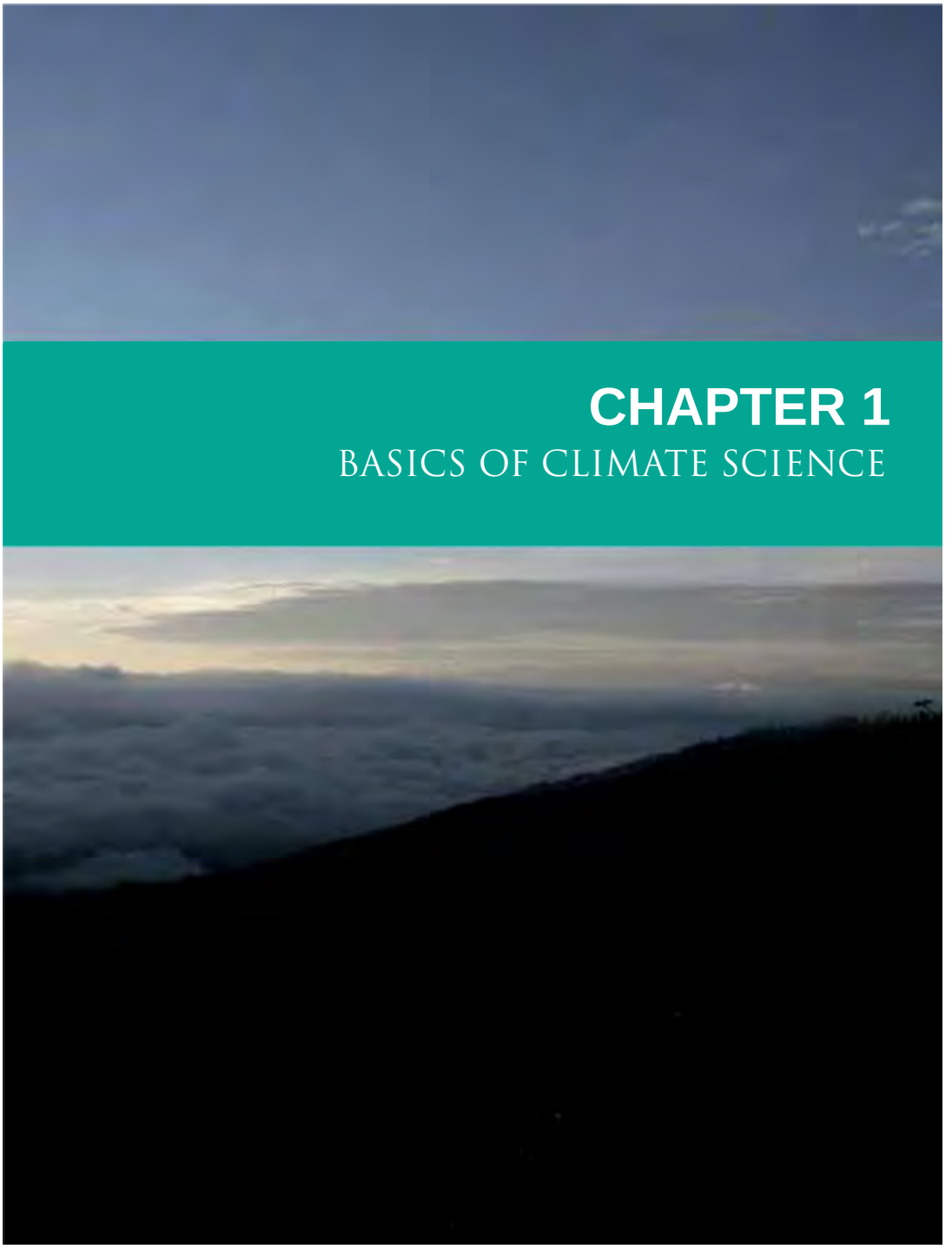
For these reasons and others, ICIMOD is pleased to work with the Royal Government of Bhutan to build and enhance the country's capacity to respond to these environmental challenges. Our work in Bhutan focuses on several areas, including cryospheric

monitoring (with the Dept. of Hydro-Met Services), air quality monitoring (with the National Environment Commission), the REDD+ Programme (with the Dept. of Forests), and rural livelihoods (with the Ministry of Agriculture).

This Climate Change Adaptation Resource Handbook has been developed as part of the activities implemented under theEU-funded Rural Livelihoods and Climate Change Adaptation in the Himalayas Initiative. This book, with its simple rendering of complex issues, will come in handy for government officials and other local policymakers who wish to understand the impacts of climate change with specific reference to Bhutan.

I want to extend my firm appreciation to all who have contributed to the production of this important publication.This book, I believe, will stand as an important milestone in our collective efforts to serve mountains and people in the HKH.

David Molden
Director General
International Centre for Integrated Mountain Development
Kathmandu, Nepal



CHAPTER 1
BASICS OF CLIMATE SCIENCE

What is global climate change?

Global climate change entails a process of increased greenhouse gas emissions as a result of human consumption of energy, food and other resources. These gases get trapped in the Earth's atmosphere, leading to a "greenhouse effect" that causes average temperatures to rise. The anthropogenic greenhouse gases enhance absorption of heat from the sun in the atmosphere and reduce the amount of heat escaping into space. This extra heat is among the primary causes of observed changes in the climate system over the 20th century.

Changes in the Earth's temperature, in turn, lead to shifts in temperature peaks, seasons and variations across different parts of the world and over time. Impacts on agriculture, glaciers and health are not completely certain, but the observed and potential impacts can range from innocuous to severe. These changes include increases in global average air and ocean temperature, widespread melting of snow and ice, and rising global sea levels.

Atmospheric and ocean circulation changes are also likely to occur and influence rainfall and wind patterns.

Precipitation patterns will shift with erratic rainfall, late arrival of the rain, and geographical shifts in rainfall distribution, which can lead to flashfloods and drought in the dry season, in combination with lower glacier run-off.

Another serious impact of increases in the greenhouse gas carbon dioxide is ocean acidification. Around a quarter of human-produced carbon dioxide is absorbed by the oceans. As the carbon dioxide dissolves in seawater it forms a weak carbonic acid, making the ocean more acidic. There are early indications that some marine organisms are already being affected by ocean acidification.

Climate change is a global phenomenon with local effects that vary by region, ecosystem and location. It highlights the inter-connectedness of humanity living on a shared planet, where changes in one country influence changes in another. The common challenge posed by climate change underscores the need to find lasting ways to build strong human development communities, everywhere in the world.

Source: IPCC, 2007. The Physical Science Basis Contribution of Working Group I to the Fourth Assessment Report, Cambridge University Press, Cambridge, MA.

CLIMATE CHANGE OVERVIEW

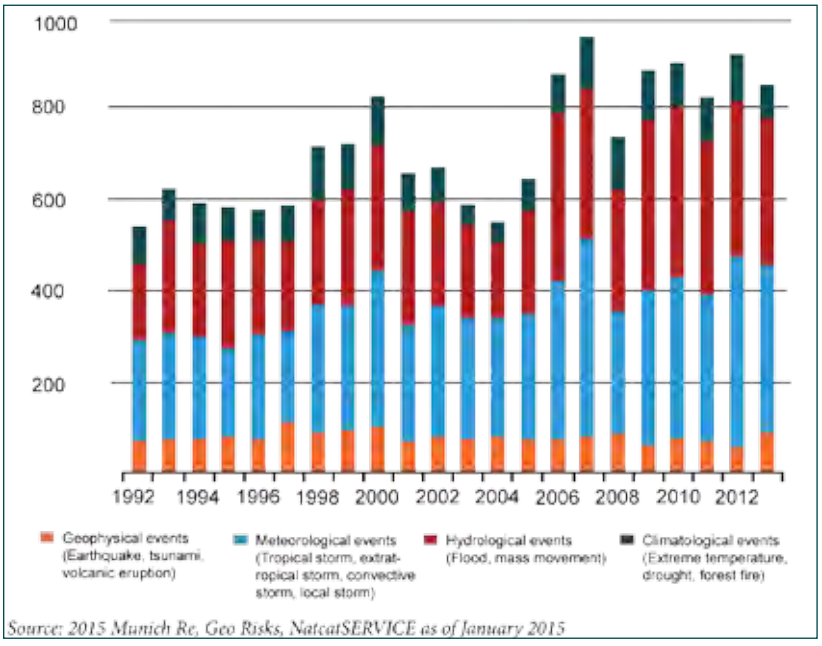
Climate change and its impacts

Many global issues are climate-related, including basic needs, such as food, water, health, and shelter. Changes in climate may threaten these needs with increased temperatures, sea level rise, changes in precipitation, and more frequent or intense extreme events.

Climate change will affect individuals and groups differently. Certain groups of people are particularly sensitive to climate change impacts, such as the elderly, the infirm, children, native and tribal groups, and low-income populations.

Climate change may also threaten key natural resources, affecting water and food security. Conflicts, mass migrations, health impacts, or environmental stresses that impact one country could raise similar complications in other parts of the world, especially in the neighboring countries and within the regions as well.

Although climate change is an inherently global issue, the impacts will not be felt equally across the planet. Impacts are likely to differ in both magnitude and rate of change in different continents, countries and regions. Some nations will likely experience more adverse effects than others.



Source: 2015 Munich Re, Geo Risks, NatcatSERVICE as of January 2015

Other nations may benefit from climate changes. The capacity to adapt to climate change can influence how climate change affects individuals, communities, countries, and the global population.

The earth is warming up

The earth is warming. The global temperature has been on the rise steadily since the beginning of the Industrial Revolution. Studies show that the rising temperature has more to do with human activity than natural variability.

Studies show that the average global temperature has increased by about 0.8°C (1.4°F) since 1880. More noticeably, about two-third of the warming has taken place after 1975, at a rate of about 0.15-0.20°C per decade.

The global temperature is an average over the entire surface of the planet. The local temperature fluctuates significantly over short periods of time because of predictable cyclical events like night and day, summer or winter, unpredictable wind and rain patterns. But the global temperature mainly depends on how much energy the planet receives from the sun and how much it radiates back into space – quantities that change very little. The amount of energy radiated by the Earth depends significantly on the chemical composition of the atmosphere, particularly the amount of heat-trapping greenhouse gases.

A one-degree global change is significant because it takes a vast amount of heat to warm all the oceans, atmosphere, and land by even that much. In the past, a one- to two-degree drop was all it took to plunge the Earth into the Little Ice Age. A five-degree drop was enough to bury a large part of North America under a towering mass of ice 20,000 years ago.

How do we know that the climate is changing?

The Earth's climate has changed throughout history. Just in the last 650,000 years there have been seven cycles of glacial advance and retreat, with the abrupt end of the last ice age about 7,000 years ago, marking the beginning of the modern climate era - and of human civilisation. Most of these climate changes are attributed to very small variations in Earth's orbit that change the amount of solar energy our planet receives.

The current warming trend is of particular significance because most of it is very likely human-induced and proceeding at a rate that is unprecedented in the past 1,300 years.

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Earth-orbiting satellites and other technological advances have enabled scientists to see the big picture, collecting many different types of information about our planet and its climate on a global scale. This body of data, collected over many years, reveals the signals of a changing climate.

The heat-trapping nature of carbon dioxide and other gases was demonstrated in the mid 19th century. Their ability to affect the transfer of infrared energy through the atmosphere is the scientific basis of many instruments flown by NASA. There is no question that increased levels of greenhouse gases must cause the Earth to warm in response.

Ice cores drawn from Greenland, Antarctica, and tropical mountain glaciers show that the Earth's climate responds to changes in greenhouse gas levels. They also show that, in the past, large changes in climate have happened very quickly, geologically speaking, in tens of years, not in millions or even thousands.

1. Sea level rise

Global sea level rose about 17 centimetres (6.7 inches) in the last century. The rate in the last decade, however, is nearly double that of the last century.

2. Global temperature rise

All three major global surface temperature reconstructions show that Earth has warmed since 1880. Most of this warming has occurred since the 1970s, with the 20 warmest years having occurred since 1981, and with all 10 of the warmest years occurring in the past 12 years. Even though the 2000s witnessed a solar output decline, resulting in an unusually deep solar minimum in 2007-2009, surface temperatures continue to increase.

3. Warming oceans

The oceans have absorbed much of this increased heat, with the upper 700m (about 2,300ft) of ocean showing warming of 0.3°F since 1969.

4. Shrinking ice sheets

The Greenland and Antarctic ice sheets have decreased in mass. Data from NASA's Gravity Recovery and Climate Experiment show Greenland lost 150 to 250 cubic kilometres (36 to 60 cubic miles) of ice per year between 2002 and 2006, while Antarctica lost about 152 cubic kilometres (36 cubic miles) of ice between 2002 and 2005.

5. Declining Arctic sea ice

Both the extent and thickness of Arctic sea ice has declined rapidly over the last several decades.

6. Glacial retreat

Glaciers are retreating almost everywhere around the world — including in the Alps, Himalayas, Andes, Rockies, Alaska and Africa.

7. Ocean acidification

Since the beginning of the Industrial Revolution, the acidity of surface ocean waters has increased by about 30%. This increase is the result of humans emitting more carbon dioxide into the atmosphere, and hence more being absorbed into the oceans. The amount of carbon dioxide absorbed by the upper layer of the oceans is increasing by about 2 billion metric tonnes per year.

8. Decreased snow cover

Satellite observations reveal that the amount of spring snow cover in the Northern Hemisphere has decreased over the past five decades, and that the snow is melting earlier.

Humans are largely responsible for recent climate change

The warming of the Earth is largely the result of emissions of carbon dioxide and other greenhouse gases from human activities. These activities include burning fossil fuels and changes in land use, such as agriculture and deforestation.

As a result, greenhouse gases are accumulating in our atmosphere. Carbon dioxide concentrations in the atmosphere since preindustrial times have increased from 280 parts per million to nearly 400 parts per million.

Greenhouse gases act like a blanket around Earth, trapping energy in the atmosphere and causing it to warm. This phenomenon is called the greenhouse effect and is natural and necessary to support life on Earth.

However, the buildup of greenhouse gases can change Earth's climate and result in dangerous effects to human health and welfare and to ecosystems.

The choices we make today will affect the amount of greenhouse gases we put in the atmosphere in the near future and for years to come.

Climate change is happening

Our Earth is warming. Earth's average temperature has risen by 1.4°F over the past century, and is projected to rise another 2 to 11.5°F over the next hundred years. Small changes in the average temperature of the planet can translate to large and potentially dangerous shifts in climate and weather.

The evidence is clear. Rising global temperatures have been accompanied by changes in weather and climate. Many places have seen changes in rainfall, resulting in more floods, droughts, or intense rain, as well as more frequent and severe heat waves. The planet's oceans and glaciers have also experienced some big changes - oceans are warming and becoming more acidic, ice caps are melting, and sea levels are rising. As these and other changes become more pronounced in the coming decades, they will likely present challenges to our society and our environment.

Climate change affects everyone

Our lives are connected to the climate. Human societies have adapted to the relatively stable climate we have enjoyed since the last ice age, which ended several thousand years ago. A warming climate will bring changes that can affect our water supplies, agriculture, power and transportation systems, the natural environment, and even our own health and safety.

Some changes to the climate are unavoidable. Carbon dioxide can stay in the atmosphere for nearly a century, so Earth will continue to warm in the coming decades. The warmer it gets, the greater the risk for more severe changes to the climate and Earth's system. Although it's difficult to predict the exact impacts of climate change, what's clear is that the climate we are accustomed to can no longer be a reliable guide for what to expect in the future.

We can reduce the risks we will face from climate change. By making choices that reduce greenhouse gas pollution, and preparing for the changes that are already un-

derway, we can reduce risks from climate change. Our decisions today will shape the world our children and grandchildren will live in.

Key concepts

i. What is the difference between weather and climate?

Weather is the fluctuating state of the atmosphere around us, characterised by temperature, wind, precipitation, clouds and other weather elements. Common examples of weather phenomena include fog, dust storm, hailstorm, and so on. Weather is the result of rapidly developing and decaying weather systems, such as low and high pressure systems, and so on.

Climate refers to the average weather and its variability over a certain time-span and a specified area. The World Meteorological Organisation (WMO) suggests 30 years as a standard time span for defining climate of a region. Common examples of climate are tropical, polar, marine, Mediterranean, and so on.

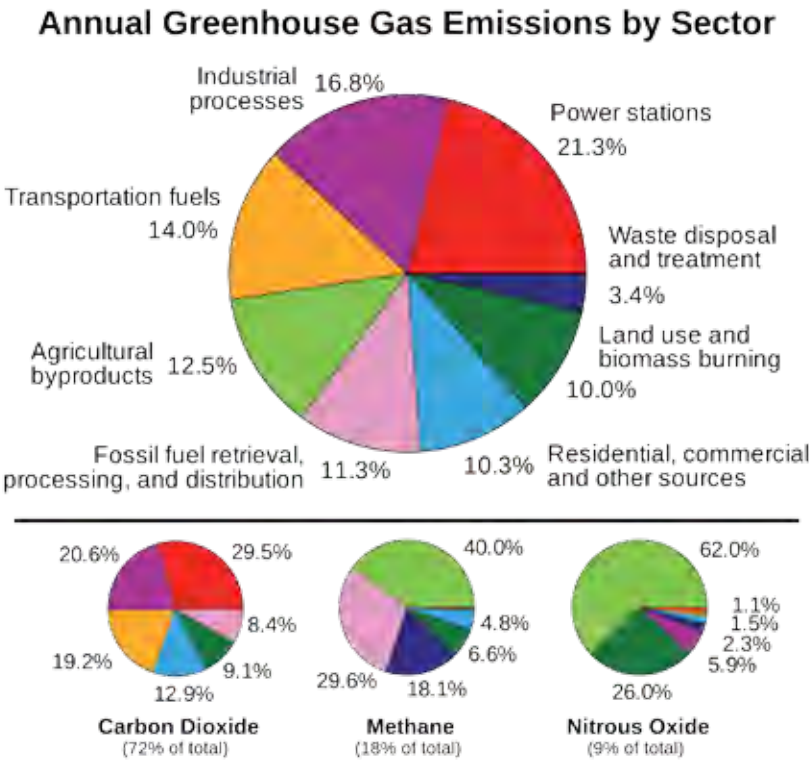
ii. What is the difference between climate change and global warming?

Global warming refers to the recent and ongoing rise in global average temperature near Earth's surface. It is caused mostly by increasing concentrations of greenhouse gases in the atmosphere. Global warming is causing climate patterns to change. However, global warming itself represents only one aspect of climate change.

Climate change refers to any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among other effects, that occur over several decades or longer.

iii.What is the greenhouse effect?

Water vapor and trace gases keep Earth about 54°F warmer than it would be without them. This function is often called the greenhouse effect, and the gases that cause it are known as greenhouse gases.



The greenhouse effect is a naturally occurring phenomenon that “blankets” the earth and warms it, maintaining the temperature that living things need to survive. Surprisingly, the atmosphere’s most abundant gases — nitrogen, oxygen, and argon — do not influence climate. Instead, it’s the molecules of trace gases, especially water vapour (H2O), carbon dioxide (CO_2), methane (CH4), nitrous oxide (N2O) and ozone (O3) that strongly absorb infra-red radiation contained in sunlight, or emitted by land and water as they cool.

When we burn fossil fuels, we release additional CO_2 that builds up and traps heat that would otherwise escape. This human-caused blanket effect leads to warming of the planet, disrupting the atmospheric balance that keeps the climate stable.

iv. What are fossil fuels?

Fossil fuels are hydrocarbons, primarily coal, fuel oil or natural gas, formed from the remains of dead plants and animals.

Fossil fuel is a general term for buried combustible geologic deposits of organic materials, formed from decayed plants and animals that have been converted to crude oil, coal, natural gas, or heavy oils by exposure to heat and pressure in the earth's crust over hundreds of millions of years.

v. How fast have emissions grown in recent years?

Emissions of greenhouse gases have grown at an accelerating rate in recent decades. In 2011, the annual rate of emissions was about 54% higher than the rate in 1990. Consequently, the amount of CO_2 in the atmosphere has increased by 10% in the past two decades.

There is a strong correlation between the rise in global temperature and the increasing concentration of carbon dioxide in the atmosphere.

As CO_2 increased from 1850 to 2010, the average temperature on the earth's surface increased by about 0.8°C (1.4°F). Atmospheric CO_2 continues to rise each year.

Once released, greenhouse gases remain in the atmosphere until absorbed by plants or animals, dissolved into the ocean, or degraded by sunlight or chemical reactions with other molecules. Molecules of CO_2 remain in the atmosphere for approximately 100 years, which is why it is so hard to reverse global warming once it gets started.

Climatic drivers of change

- Erratic pattern of rain
  – trend of too much and too little
- Temperature increase
  – greenhouse gases
- Drought, thunder, lightening,wind, storm
- Flood – glacier melting,flood at any season
- Monsoon gaps
- Time for snow deposit
  – less Black Carbon effects
- Decreasing trend of spring water

Non-climatic drivers of change

- Globalization –
  Market
  Demand
  Supply
- Infrastructure building
- Physical facilities
- Natural calamities –
  Earthquake
  Lightening
  Thunder
- Livelihood pattern
- Mechanization
- Migration

CHAPTER 2

CLIMATE CHANGE IN BHUTAN

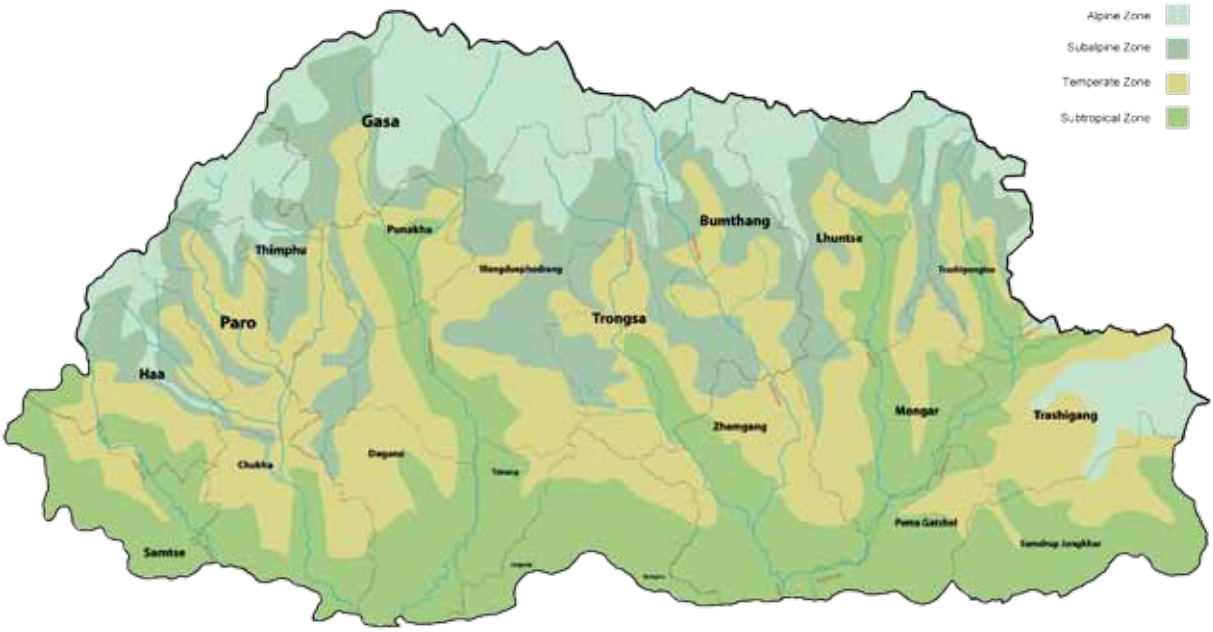
COUNTRY BACKGROUND

Location and geography

Bhutan is a small kingdom in the eastern Himalayas located between two economic giants, India and China. Its mountainous terrain and a policy of self-imposed isolation ensured that the country was never colonized in its entire history. Bhutan has the Tibetan region of China to its north and India on its west, south and east.

The country is situated between 26°45'N and 28°10'N latitudes and 88°45'E and 92°10'E longitudes. It has a maximum longitudinal distance of 330 kilometers (km) and a latitudinal distance of 180km.

Geographically, Bhutan can be divided into three major areas: southern foothills, inner Himalayas and higher Himalayas. The southern foothills rise from the plains to a height of 1,500m but are only about 20km wide. The inner Himalayas, meanwhile, gradually rise to about 3,000m 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 high mountains.



Land area and population

Bhutan is a landlocked country with a land area of 38,394 square kilometres, about the size of Switzerland. Bhutan has one of the most formidable mountainous terrains in the world, ranging from 100m to 7,550m in height. The difficult geography of Bhutan translates into varying climatic conditions. Bhutan gets intense monsoon rain in the summer, with a relatively dry winter.

About 72% of the land area is covered by forests of temperate and sub-tropical species that are a natural habitat for diverse of flora and fauna. Bhutan has one of the richest biodiversities in the world, with about 3,281 plant species per 10,000 square kilometers, and has been declared as part of one of the ten global biodiversity hotspots.

The projected population of Bhutan stands at 764,449 with a GDP per capita of US $ 2440 as of 2015, as per the National Statistical Bureau (NSB).

The population is largely rural, with 72% of the population still living in villages, despite a growth in urban drift in recent years.

Land and Land Use

Region-wise, the land area of Bhutan can be divided into regions with their distinct characteristics. These are:

i. Western Bhutan:
The western region comprises the Haa valley (2700m), Paro valley (2194m), Thimphu (2286m), Punakha valley and Wangduephodrang (1280m). This region is separated by high passes, namely Chele La (3900m), Dochu La (3050m), and Pele La (3200m) from the central region.

ii. Central Bhutan:
The Black Mountain range separates Western Bhutan from Central Bhutan. This region includes Trongsa and the rich broad valleys of Bumthang, including the Chumey, Choe- khor, Tang and Ura valleys. The passes crossed are Yotang La (3400m) Shertang La (3500m) and Thrumshing La (3700m).

iii. Eastern Bhutan:
Comprises Mongar, Lhuentse, Trashigang and Trashiyangste. Sengor valley separates central from eastern Bhutan. After Thrumshing La, passes crossed are Kori La (2390m), Yongphu La (2100m) and Narphung La (1690m) at much lower altitudes than western and central Bhutan. The forests dissipate and the altitude is lower.

Only 16% of Bhutan's land is suitable for agriculture. Of this, 8% is under cultivation. The mountainous terrain and fragile ecology does not allow any expansion, limiting development in this sector to introducing high-yielding varieties, improving farming techniques and applying enhanced inputs. However, the agricultural production has increased despite the limitations of land.

Forest and Biodiversity

The total forest area of the country is estimated at 2.9 million hectares. Forests of Bhutan are divided into three major types, namely;

i. Broadleaf forest of 50%,
ii. Conifer forest of 38% and
iii. Scrub forest of 12% (DFS).

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

i. Fir forest - The upper forest zone in the higher ridges between 2,700m and the tree line at 3,600-3,800m 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.

ii. Mixed Conifers - This forest type occupies the largest portion of the sub-alpine zone of the country, between 2,000 and 2,700m 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.

iii. Chir Pine - This subtropical tree of dry, sandy soils predominates in the deep, dry valleys between 900 and 1,800m. 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.

iv. Blue Pine - This forest type is found in the temperate valleys between 1,800 and 3,000m. Blue pine is the 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.

v. 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. It is divided into three groups as follows:

- Temperate broadleaf forests dominate the temperate hillsides between 2,000 and 2,900m. 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 2,000m. They are rich mixed forests with a wide variety of both subtropical and temperate genera.
- Tropical lowland forests occupy the low hills below 700m. 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.

Climatic Condition

Bhutan has a wide range of altitudinal zones and micro-climatic conditions which have created highly diverse ecosystems and a complex pattern of climatic conditions. It has three distinct climatic zones, corresponding broadly to the three main geographical divisions:

i. The southern belt has a hot, humid climate, with temperatures remaining fairly even throughout the year—between 15°C and 30°C - and rainfall ranging between 2,500 and 5,000 millimeters (mm).
ii. The central inner Himalayas have a cool, temperate climate, with annual average rainfall of about 1,000mm.
iii. The higher and more northern region has an alpine climate, with annual rainfall of around 400mm. 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. This diverse climatic condition has created seven major agro-ecological zones ranging from tropical and sub-tropical to alpine. The aspect of the valleys, steepness of the slopes, altitude and other physiographic factors influence precipitation, insulation and other micro climatic factors to create significant variations in vegetation and agricultural conditions within short distances.

Climate change in Bhutan

Six areas considered most vulnerable to climate change include:

i. Forests and biodiversity,
ii. Agriculture,
iii. Water resources,
iv. Glacial lake outbursts,
v. Health, and
vi. Landslides.

It appears that a temperature increase of 2°C would shift the cultivating zone further into higher elevation, and crops sensitive to low temperatures can be introduced into higher elevations with this temperature rise.

In recent years, Bhutan has seen an increase in landslides because rainfall has become erratic and extreme. The biggest climate-related threat still remains to be the glacial lake outburst floods (GLOFs). Bhutan's 24 weather stations show a rise in temperature of about 1°C in summer and 2°C in winter since the year 2000.

Recent studies show a reduction in irrigation water availability in some areas. Other global warming effects – shifting precipitation patterns, changing growing zones, more

> **Bhutan's 24 weather stations show a rise in temperature of about 1°C in summer and 2°C in winter since the year 2000.**

severe weather, worsening of air and water pollution and water scarcity - are surely on the increase. So far, Bhutan's land protection and small population density are insulating it from the scale of damaging impacts on environmental and human health seen in neighboring countries.

One survey found that 19% of farmers questioned noticed changes in cropping pattern, while 63% did not observe any change, and the remaining 19% were uncertain of the change.

The Gross National Happiness report said some farmers are shifting to earlier rice planting, which has effects on when they can plant other crops and on water allocation. Other farmers at villages higher into the mountains, according to a World Wildlife Fund study, report that temperature has risen in the last 15 years and that it is generally a good thing: higher elevation farms can now grow chili, cabbage, cauliflower, beet and eggplants.

There are water scarcity issues seasonally in Bhutan, particularly during the cultivation season.

Recent reports, including those prepared for the regional climate conference in Bhutan in November 2011, are clear and detailed about what's in store for the people of Bhutan and in all the Himalayan region:

- Landscape changes like GLOFs and landslides;
- Food insecurity;
- Increased disease, including malaria in the southern lowlands of Bhutan;
- Livelihood stresses and destruction;
- Water scarcity, in agriculture, community supply and hydropower generation;
- Population migration and cultural conflicts.

The government of Bhutan has a National Adaptation Program of Action (NAPA) and it has identified key stakeholders for involvement. The NAPA suggests urgent and immediate measures to address adverse impacts of climate change and promote sustainable development in the country.

CHAPTER 3

Impacts of climate change in Bhutan

Climate change in Bhutan

Climate change is widely recognized as one of the most critical and complex challenges facing humanity in the 21st century. While the world's poorest countries and people bear little or no responsibility for climate change, they stand to bear most of the social and economic consequences. Climate change can roll back human development for a large section of humanity, undermining the international commitment made in achieving the Millennium Development Goals (MDGs) in the process.

As a least developed, mountainous and landlocked country, Bhutan's population and ecosystems are vulnerable to climate change. Although the country is committed to a high level of environmental protection, Bhutan today experiences and will likely further experience the impacts of global climate change caused by emissions in other countries.

Extreme and unusual weather events already take place in Bhutan. But incremental changes are also likely to unfold in the near future. Factors, including income poverty; remoteness from economic activity, schools or hospitals; limited local governance capacity and; little awareness of risks and other markers of disadvantage define an individual's or community's vulnerability to climate change.

In this context, sustaining progress and confronting the demands of equity are critical issues for Bhutan. The sustainability of human development progress requires recognition of the scarcity of resources— including the earth's capacity to absorb carbon. Use and consumption of the earth's resources fundamentally entails a process of considering the capability of future generations to have similar, if not greater, freedom of use.

Bhutan's Gross National Happiness (GNH) concept and policy directives open avenues to address these concerns that are useful to build on in tackling climate change risks.

While climate change poses significant threat to human development, it can also be responded to in ways that usher in advances in private sector development and protect investments. Integrating climate change response with poverty reduction in Bhutan can prove a useful strategy. Drawing on social policy lessons from other countries holds further potential to help protect vulnerable and poor communities and individuals.

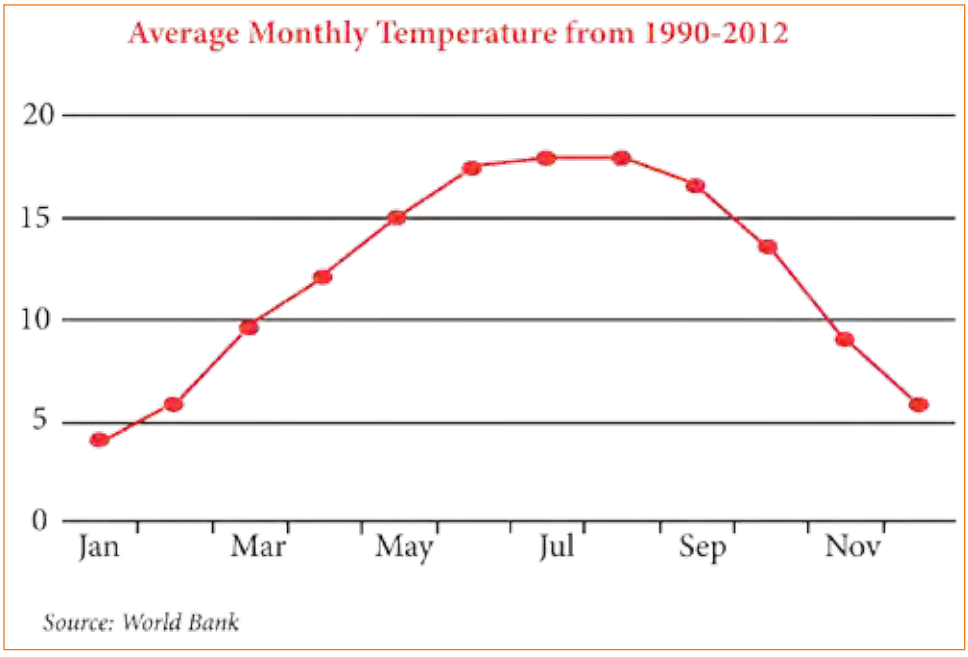
Risks in the shape of climate-related disasters, from water scarcity to glacial lake outburst floods, pose significant challenges to maintaining ecosystems and resources

protected for current and future Bhutanese generations. Bhutan's socioeconomic gains and heavily protected environment remain fragile when confronted with rising climate change risk-making adapting to the inevitable effects of a changing climate a necessary national priority. Despite aiming to maintain a net carbon sink status, Bhutan will continue to suffer from the effects of a phenomenon not of its own making.

Impacts of climate change in Bhutan

Climate change will lead to an increase in Bhutan's average temperatures. Different regions and altitudes are expected to be impacted differently. But the temperature changes will likely influence overall rainfall patterns and increase droughts.

Climate models show a likely increase in Bhutan's annual average temperature by 1°C from 2010 to 2039, and by 2°C from 2040 to 2069. These projected temperature changes vary by season. The monsoon or wet season in Bhutan is estimated to experience a 3°C temperature increase by both climate models reported in Bhutan's draft Second National Communication to the United Nations Framework Convention on Climate Change. Winter and dry season air temperature changes, however, are projected to increase at a greater magnitude between 3.5°C and 4.0°C.



Climate models also project changes in the amount and seasonality of precipitation, with wetter conditions in the warm monsoon months, and slightly drier conditions in the dry winter months. The change in the amount and seasonality of precipitation will likely affect not only the hydropower and domestic water sector of Bhutan, but also the water used for irrigation.

Bhutan's larger regional and topographical context will shape the extent to which climate change influences affect the country. Mountainous regions are particularly vulnerable, both because warming trends are often higher, and because impacts are magnified by the extreme changes in altitude over small distances. The Himalaya mountain range– known as the rooftop of the world – is especially likely to experience acute climate changes.

Life in the Hindu Kush-Himalayan region relies on monsoon systems, and these may be altered by climate change. Shifts in cropping seasons and, in the likelihood of extreme weather events, increase as a result. Shifts of crop habitat to higher altitudes constraining the agricultural space and adaptive capacity of the societies is another anticipated impact specific to mountain ecosystems. Locally, people's ability to adapt will be challenged. But changes in Bhutan and the Himalayas also hold direct impacts on the broader region, affecting the lives and livelihoods of the 1.3 billion people living in the river basins downstream.

Bhutan is likely to see climate impacts channeled through changes in its glaciers, such as enlarged glacial lakes, in the timing and severity of extreme climate shocks, such as flash floods and drought, and in the availability of ecosystem resources and services. Water resources availability in terms of quantity, quality and timeliness emerges as one of the principal climate pressures on broader human development, including health, agriculture and livelihoods.

Shrinking glaciers

One of the most visible impacts of climate change in Bhutan is the retreat of glaciers, many at higher rates of reduction than glaciers in other mountain ranges.

The permanent snow line has moved significantly higher, although the observations are too few to be able to quantify the actual loss of snow cover in the region. Continued deglacition could have a profound impact on the water in the ten large river basins originating in the Hindu Kush Himalayan region. River discharges are likely to increase

for some time due to accelerated melting, but the flow is then likely to be lower as the storage capacity of the glaciers goes down. The effects are likely to be felt most severely in the parts of the region, which are already very dry.

Glacial lake outburst floods (GLOF)

Glacial lakes have formed in many places in the area left at the foot of retreating valley glaciers. An inventory compiled by the International Centre for Integrated Mountain Development (ICIMOD) identified 8,790 glacial lakes within selected parts of the Hindu Kush-Himalayas.

The October 1994 glacier lake outburst flood in Bhutan underscores the nature of the risk. Occurring 90km upstream from Punakha Dzong, the outburst flood from Lugge Tsho led to massive flooding on the Pho Chhu River, damaging the Dzongchu and causing casualties.

With the emerging risk of glacial lake outburst floods from Thorthomi and Raphstreng Tsho, a National Adaptation Program of Action project is underway to artificially lower the water level of Thorthomi Tsho.

Flash floods and landslides

Bhutan is prone to flash floods, especially in the eastern and southern foothill regions, due to the steep terrain and fragile geology. These flash floods have become more frequent and intensified in the last decade due to increasing intensity of rainfall, and untimely start and end of monsoons. Landslides are a recurrent phenomenon in Bhutan and closely linked with flooding events.

In May 2009, cyclone Aila, originating in the Bay of Bengal, resulted in incessant rainfall causing one of the worst disasters in Bhutan. Record breaking rainfall, measuring up to 76mm over a 24 hour period, was recorded as one of the highest in the last five years, according to the Thimphu Meteorology Department (UNDP 2009-2011).

Subsequently, the rainfall also led to swelling of rivers and streams to dangerous flood levels. These rivers and streams were never recorded to have such volumes of water in the past forty years; in fact, river-gauging stations in the Punatsangchhu show that the water flow in the river during cyclone Aila exceeded the water flows during the 1994 GLOF.

In 2010, landslides and flash floods damaged more than 2000 acres of agricultural land, affecting some 4165 households over 20 dzongkhags, and damaged farm roads and irrigation channels affecting 529 households (DoA, MoAF 2010).

Based on the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) 2007, tropical cyclones will become more intense, with larger peak wind speeds and heavier precipitation.

Windstorms

Windstorms have been recorded in the national newspaper, as early as 1994, and incidents of windstorms have been recorded every year. However, the severity and frequency of windstorms in Bhutan have increased over the past few years, especially in the pre-monsoon season.

In April 2008, windstorms damaged 249 rural houses in lower Trashigang. Lumang gewog was worst hit, with 148 households affected; followed by 41 in Kangpara, 39 in Khaling, 21 in Thrimshing, and one each in Sakten and Shongphu. Eight school buildings, four lhakhangs and one forest office were also damaged by the windstorm (Kuensel April 2008).

In recent years, farmers have had to deal with increasing frequency of hail and windstorms. In 2010 alone, more than 5000 acres of agriculture crops were affected by hail and windstorms, damaging a wide range of staple crops, such as maize, rice, potato, chili, buckwheat and others (Project profile, DOA, MoAF April 2011). Windstorm damaged 432 houses in 2010 (DDM, MoHCA 2010).

Droughts

Bhutan has been experiencing extreme variations in its climate and weather patterns. Although evidential data and information is limited, there are cases where individual municipalities or agencies have made observations on selected sites. The winters of 2005 and 2006 experienced unusually dry winter with no rain and snow (NDRMF 2006).

The majority of Bhutan's population depends on subsistence farming, for which timely precipitation is necessary. Drought and erratic rainfall make the Bhutanese communities, especially the rural population, highly vulnerable to impacts of extreme weather patterns. Forest fires are a common threat.

Land degradation and soil erosion

Bhutan has a geologically fragile mountainous ecosystem with rugged and steep terrain, which makes it prone to different forms of land degradation and soil erosion. Land

degradation is a serious threat to Bhutan, as there are limited resources of productive land due to the topography and altitude of the country, as expressed in the National Environment Strategy (NEC 1998) and the Bhutan Vision 2020 document. Widespread forms of both in-situ and physical land degradation are reported in the country.

Some of the physical forms of land degradation are topsoil capping, sheet erosion, rill erosion, gullies, mass wasting of soils and landslip.

It is also estimated that 8.6 metric tonnes (MT) of soil per hectare (or 3.48MT/acre) is lost to erosion, especially during rainy season in traditional farming practices (DoA, 2010).

Landslides on highways, agricultural land and other infrastructures, causing economic loss and risk to human lives are a constant and major concern in Bhutan. However, extreme rainfall episodes exacerbate the situation.

Depleting springs

Springs, one of the major sources of water for human need and livelihood in Bhutan, are reportedly depleting. Such incidences are increasing by the day, especially during the longer dry season, thus posing threat to people's livelihood and the rural economy.

Because of the seasonal dry winters and greater incidences of springs drying up, water shortages have been reported in most places in eastern and southern regions of Bhutan. This is happening in spite of the fact that Bhutan has one of the highest per capita availability of 109,000 cubic metres of water in the region.

The poor communities have been the most vulnerable to this impact of climate change. They confront challenges when it comes to access to safe drinking water and water for irrigation purpose. Farms are left fallow and some farmers have migrated to urban areas looking for better opportunities, thus eventually lowering food production and driving the poor communities into harsh situations.

Pests and diseases

The warming trend, which has been projected as an impact of climate change, will spread events of pests and diseases in areas where they never existed before. Bhutan has also experienced outbreak of pests and diseases, which are related to change in climatic conditions.

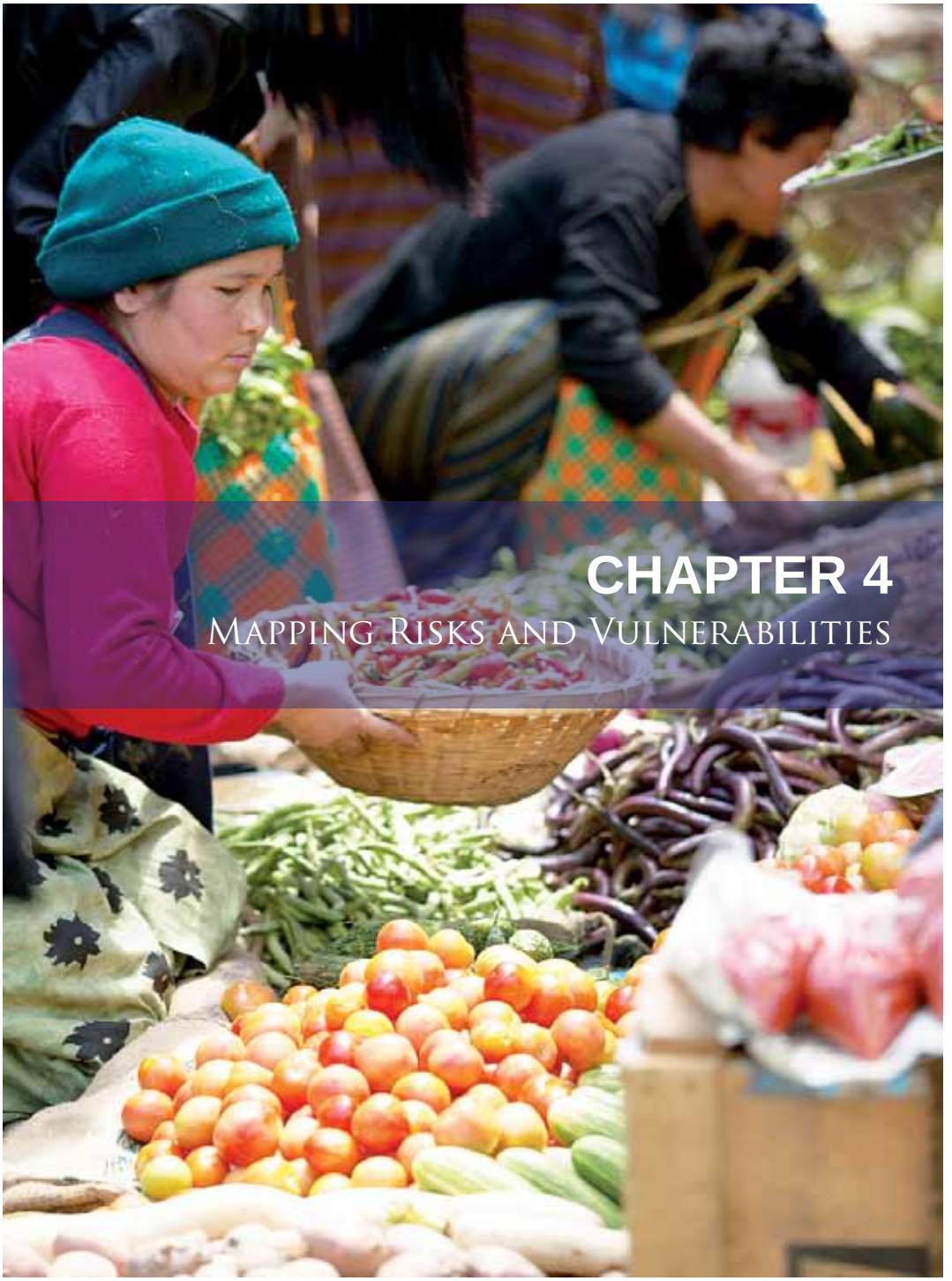
> **Climate factors increase incidence of vector-borne diseases, particularly malaria and dengue, which have become major public health problems in countries like Bhutan.**

Bhutan also suffers from high rates of a series of climate-sensitive health burdens. Climate factors increase incidence of vector-borne diseases, particularly malaria and dengue, which have become major public health problems in countries like Bhutan (NEC 2011).

The induced spread of infectious diseases due to changing environmental conditions are projected to increase the incidences of vector borne diseases as they move to higher altitudes due to warming. Increasing temperatures are also complicating control of vector-borne diseases in Bhutan.

Climatic factors, such as temperature, rainfall, humidity, and anomalous weather events, have a direct influence on malaria transmission, by either hindering or enhancing vector and parasite development and survival.

Dengue is a significant emerging infectious disease in Bhutan. Dengue was first documented in Bhutan in 2004 and is now endemic during the monsoon period (MoH 2010).



CHAPTER 4

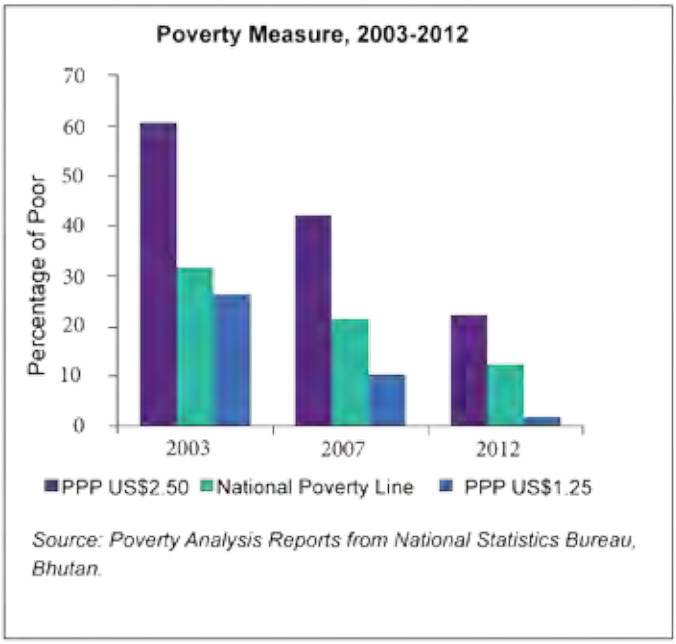
Mapping Risks and Vulnerabilities

Climate change impacts, leading to erratic and extreme weather events, floods, landslides, droughts, and glacial lake outbursts, will have multiple effects on food sources, biodiversity, energy, water resources including water supply, human health, and infrastructure.

As the majority of the Bhutanese are farmers living in rural areas, they are the ones most vulnerable to the impacts of climate change— many of whom hold limited knowledge and resources to adapt. The effects of climate change are also expected to severely impact the sustainable development prospects of already low-income households.

Poverty and inequality

Marginalization in Bhutan is unique and yet simple: it is primarily the prevailing divide between the rural and urban population. Inequalities between the rural and urban population are relatively high, with poverty being more of a rural phenomenon. Of the 23.2% of the poor Bhutanese, only 1.7% of the urban population is poor compared to 30.9% of the rural population.



Source: Poverty Analysis Reports from National Statistics Bureau, Bhutan.

Poverty rates were found to be high in Zhemgang, Samtse, Mongar, Lhuentse, and Samdrup Jongkhar. Among these dzongkhags, Zhemgang and Samtse have very high poverty measures.

The percentage of under-weight children less than five year old halved from 1989 to 19% in 2000. By 2010, 12.7% of children were moderately to severely under weight for age. Poverty serves as a marker of separation: low birth weight is severe among the poorest Bhutanese in terms of income (12.2%) compared to richer households (7.3%).

Climate change can threaten to widen this gap. One in three farmers reports food insufficiency. Subsistence agriculture is under threat from climate change. And the gender differences in poverty are likely to grow—in this case, against male-headed households. Research into these differences is critical to help prevent further inequalities and deprivations.

Challenges to connectivity: roads and infrastructure

Connectivity is crucial for improvements in access to better health and education services, in linking farmers to markets, and opening up other economic avenues. Without connectivity, the rural mass will continue to remain marginalized, and the prevailing social and economic disparities will only increase. The climate change resilience and adaptive capacity of communities will further suffer. Therefore, underscoring it as a special priority, the Royal Government of Bhutan committed to provide road and communication centers to every gewog.

According to the Population and Housing Census Survey 2005, about 21% of Bhutanese households live one to four hours walking distance from the nearest all-season road, and another 21% live in places that are more than four hours walking distance.

At the beginning of the Tenth Plan, Bhutan had a total network of 4,545km of roads, including 1,556km of national highway and 597km of farm roads. During the Tenth Plan, 34 suspension bridges, with another 18 under construction; 201 km of new roads; and 166 km of feeder roads, including feasibility studies, were being undertaken, as of June 2010.

Construction of quality roads entails large costs. Budgetary problems have resulted in poor quality works, leading to vulnerability to extreme rainfall patterns. Farm roads and

power tiller tracks are often damaged during the rainy season, thus de-linking farmers. Landslides further hinder access. The absence of good quality roads limits incentives to produce, and restricts rural-urban linkages.

The rugged terrain makes it difficult and expensive to install information and communications technology infrastructure, like phone lines and radio towers. The low income of rural citizens makes the cost of information and communications technology goods and services relatively high. Limited availability of skilled information and communications technology workers makes it difficult to meet the demands of government and industry.

To improve efficiency and transparency in the public sector, and to reduce the overall turnaround time in accessing public services, 109 community centres are being established. The centers are expected to provide online public services and also offline services, such as photocopying, printing, etc. With the national broadband network using fiber optics is now available in all the 20 dzongkhags, this facility will be extended through Dielectric Self-Supporting technology to connect 131 community centers and ensure high-speed Internet connectivity and faster services.

Rural livelihoods

Rural livelihood in Bhutan depends on renewable natural resources and constitutes the core of the Bhutanese economy, with more than 65% of the population living on subsistence farming. With only 7.7% of the total land area arable, prospects of agricultural expansion are limited, and the success of agricultural operations depend largely on sustainable management of natural resources and protection of ecosystems services in the face of increasing threat from climate change.

Rice and maize are the most important cereal crops. And some of the important cash crops cultivated by the Bhutanese farmers are potato, apple, orange and chili. These cash crops are a major source of income for the rural residents. For example, apples and oranges accounted for 90% of Bhutan's fruit production. One of the policy objectives of the Tenth Five Year Plan is to enhance sustainable rural livelihood. Improved agricultural and livestock productivity and expanded commercial prospects shape support towards achieving this objective.

Due to changing weather patterns, humidity and temperatures, there has been a dramatic rise in pest and disease outbreaks in many crops. In maize, two devastating fungal diseases, turcicum leaf blight and grey leaf spot, caused huge losses in maize production. The diseases occurred on an epidemic scale throughout the country in 2006. Likewise in rice, a major epidemic outbreak of blast disease occurred in 1995,

leading to a loss of 1,099MT of rice or Nu 11 million. The disease is associated with high rainfall and overcast conditions.

The government accords high priority to promote and support the growth of cottage and small industries. The government will support these enterprises for the development of business services, establishment of linkages with large industries as ancillary activities, credit guarantees, access to micro credit facilities and space in the industrial areas.

Promoting non-greenhouse gas emitting cottage industries at the rural community level is fully in favor of the carbon neutral commitment. Targeting agriculture investment, the Ministry of Agriculture and Forests introduced the 'One Gewog Three Products' program in 2009 as a strategy to strengthen product diversification and value addition. About 61 products have been identified as priority products, which would support community business and enterprises.

There are several marketing outlets for agricultural products. The popular channel is the weekend markets, such as the Farmers' Centenary Market in Thimphu, which are in place in all 20 dzongkhags. The government is making efforts to improve access to markets and marketing facilities. The initiatives include facilitating the formation of co-operatives, farmer associations and developing services and capacity. Further, policy support is underway to develop an efficient marketing infrastructure, including retail, wholesale, assembly markets and storage facilities.

In the last few years, the agriculture ministry mainstreamed sustainable land management practices in all dzongkhags, and protected forest areas were opened for ecotourism.

In managing forestry resources sustainably, the concept of community forestry management is being promoted as a means to improve natural resource management and local governance, and thus to contribute to poverty reduction. By having decision-making power over natural resources, the local communities are expected to be able to better adapt to the consequences of climate change.

Non-Wood Forests Products also have great potential for income generation for the poorer sections of Bhutanese society if resources are harvested in a sustainable manner. For instance, legalization of harvesting cordyceps earned a total of Nu 89 million for some high altitude rangeland communities across Bhutan in 2010. Many opportunities for adaptation to climate change lie in the ability to manage non-wood forests products through various policy, institutional, implementation and legal frameworks.

Climate vulnerabilities and human development

Climate change is likely to cause a series of shifts and shocks in Bhutan's temperatures and precipitation patterns:

- Increase in mean temperature in particular during winter and in high altitudes.
- Increase in mean temperature in particular during summer in southern Bhutan.
- Reduction in long-term precipitation in particular during the monsoon seasons.
- Increase in immediate precipitation due to more frequent extreme climate shocks.
- Increased climate variability.

Each temperature and precipitation change poses a range of impacts on Bhutan's environmental and natural resources—which in turn affects human interaction with these resources and results in impacts on human development.

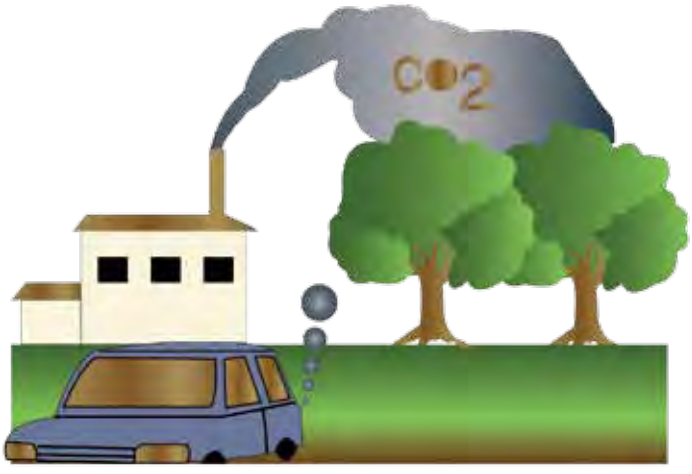
Climate change shocks consist of the known and expected influences of climate change on extreme hazard events, weather, seasons, precipitation and other anticipated impacts. In Bhutan, these changes will manifest differently, shifting pressures in the form of increased or transformed exposure to climate-related risks.

Vulnerability can be defined as the risk of a decline in human development resulting from a lack of adequate adaptive or coping knowledge and measures. Countries and people are vulnerable when their human development is threatened by various risks, such as those posed by climate change.

Bhutan to be a net carbon sink forever

Bhutan's Buddhist values of respect for nature and life set an example to the rest of the world for protection of forests, biodiversity and habitat. Export of unprocessed timber is banned and the forest cover is reported to be 72%. It is because of absorption of atmospheric carbon by these forests that Bhutan ranks among the few countries in the world with a net sink of carbon dioxide gas. In United Nations climate change negotiations, the government has made a commitment to sustain its carbon negative status forever. Bhutan made the commitment at the COP 15 summit in Denmark in 2009.

"In United Nations climate change negotiations, the government has made a commitment to sustain its carbon negative status forever. Bhutan made the commitment at the COP 15 summit in Denmark in 2009."



Comparing carbon footprints

Bhutan's GHG emissions in 2008 amounted to 2,040Gg of CO_2 equivalent. By global standards, this is insignificant. Although such emissions are relatively small, they reflect a steady increasing trend. Bhutan's forests, however, continue to absorb more carbon than the consumption for agriculture, energy and industry combined, maintaining Bhutan's net greenhouse gas emissions at -4,771Gg of CO_2 equivalent.

At a per capita level, Bhutan's carbon emissions almost tripled between 1990 and 2000, and such trends need to be monitored. This increase resolved into a steady emissions rate into the first decade of the 21st century. Data on energy consumption and resulting greenhouse gas emissions remain difficult to estimate in Bhutan. But ongoing national exercises to improve understanding of the climate challenge produce increasingly reliable and accurate information.

What climate change means for Bhutan's development

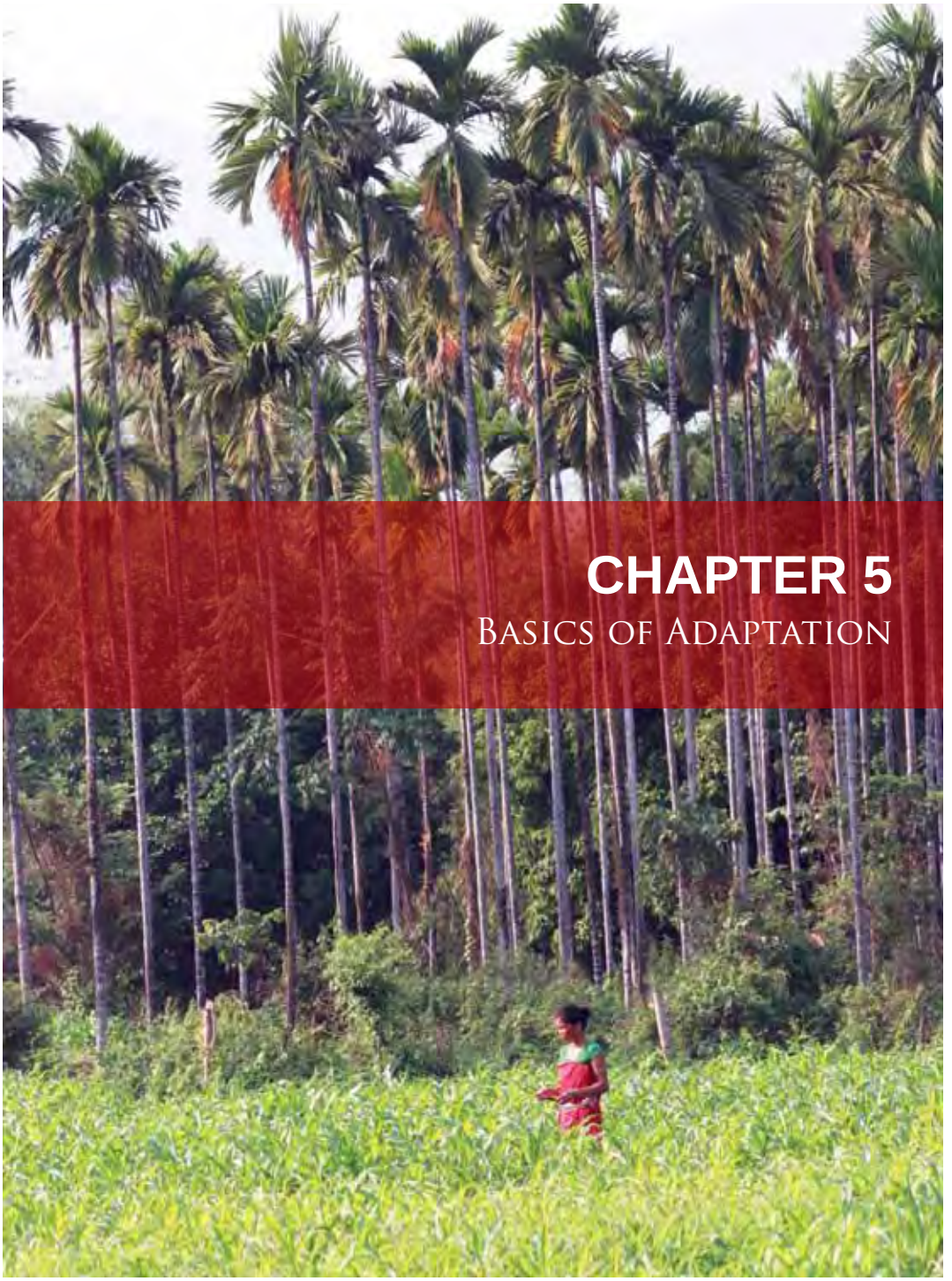
The United Nations Development Program's Global Human Development Report 2007/2008 estimated that stabilizing greenhouse gas concentrations in the atmosphere at a level that prevents catastrophic climate change would require a 50% reduction of greenhouse gas emissions by 2050 from 1990 levels. To achieve this global objective, the report recommended that developed countries cut greenhouse gas emissions by at least 80% by 2050, with 20–30% cuts by 2020.

For major emitters in developing countries, it recommended emissions trajectory that peaks in 2020, with 20% cuts by 2050. The scope of the challenge requires a global response.

While global in nature, the effects of climate change in Bhutan will be highly localized. The people most at risk from climate change live in countries like Bhutan that contribute the least to the energy emissions linked to the recent increase in the rate of warming of the planet.

As a least developed country with scarce income and other resources, Bhutan would be one among many other countries least able to cope. The dual challenge is to find ways to attract enough direct investment to meet Bhutan's development aspirations and need to sustain its economic development. At the same time Bhutan needs to drive these direct investments towards lower carbon technologies, so that the nation is not locked into unsustainable paths for 30 to 50 years.

A rapid scaling up of decisive action on adaptation will also require a dramatic increase in financing. The Global Human Development Report 2007/2008 estimated that $86 billion would be required annually for building resilience in developing countries by 2015. The financing needed in Bhutan still demands more precise calculation—but the scale of the challenge will likely be larger than any other Bhutan has confronted. It will also demand a shift in the country's planning mechanisms and strategies. Placing climate change at the center of Bhutan's development goals is critical.



CHAPTER 5

Basics of Adaptation

The United Nations Framework Convention on Climate Change (UNFCCC) defines adaptation to climate change as:

Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

The European Commission explains it thus:

Adaptation means anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the damage they can cause, or taking advantage of opportunities that may arise. It has been shown that well planned, early adaptation action saves money and lives later.

Examples of adaptation measures include:

i. Using scarce water resources more efficiently
ii. Adapting building codes to future climate conditions and extreme weather events
iii. Building flood defenses and raising the levels of dykes
iv. Developing drought-tolerant crops
v. Choosing tree species and forestry practices less vulnerable to storms and fires
vi. Setting aside land corridors to help species migrate

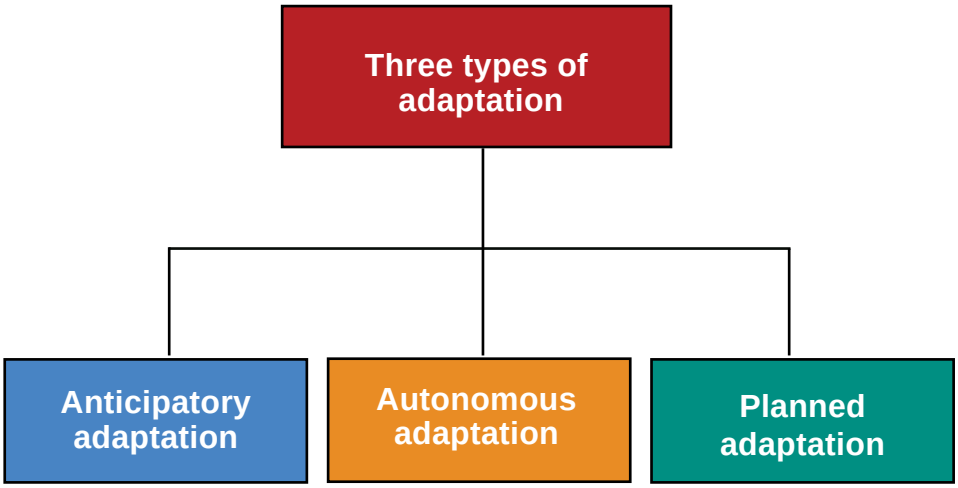
There are two main policy responses in addressing climate change – mitigation and adaptation.

Mitigation efforts include activities that address the root cause of climate change, which is reducing greenhouse gas emission. Adaptation measures are those that lower the risks posed by the consequence of climate change. Adaptation measures help reduce vulnerability.

Both mitigation and adaptation are necessary to address climate change, because if emissions increase, adaptation is necessary to address the impacts it will cause.

Human beings have always been adapting to their immediate changing environment by coming up with new practices, cultures and livelihoods suited to their own local conditions. But climate change impacts entail preparing for changes even beyond the local scenario, as its impacts are global in nature, like rise in temperature, increase in the frequency of disasters like floods, which our ancestors were not even aware of.

Low-income countries tend to be more vulnerable to climate risks and some adaptation measures – such as increasing access to education and health facilities – will overlap with existing development programs. But adaptation goes beyond just development to include measures to address additional risks specifically caused by climate change, such as raising the height of sea defenses.



Three types of adaptation

Adaptation measures can be distinguished broadly into anticipatory, autonomous and planned adaptation:

i. Anticipatory adaptation – Adaptation that takes place before impacts of climate change are observed. Also referred to as proactive adaptation.

ii. Autonomous adaptation – Adaptation that does not constitute a conscious response to climatic stimuli, but is triggered by ecological changes in natural systems, and by market or welfare changes in human systems. Also referred to as spontaneous adaptation.

iii. Planned adaptation – Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed, or are about to change, and that action is required to return to, maintain, or achieve a desired state.

Adaptation Needs and Priorities

Bhutan's challenging geography and topography makes climate vary considerably from one place to another. Bhutan has three climatic zones:

i. The southern plains, which are subtropical and characterized by high humidity and heavy rainfall.
ii. The central belt of flat valleys, characterized by cool winters and hot summers,with moderate rainfall; and
iii. High valleys with cold winters and cool summers.

Such a complex climate in a small country makes the summer monsoon typically last from late June through to late September. The monsoon has been getting harsher every year and often causes flash floods and landslides. The monsoon generates about 70% of the annual rainfall in Bhutan.

Modeling of the projected impacts of climate change has not yet been done for Bhutan, mainly because of inadequate data and the lack of capacity in the country. Even the meteorological network in the country is limited at best, with stations only in interior and southern Bhutan. All these stations require manual recording.

Climate modeling in Bhutan also faces the additional challenge of handling its complex mountain topography, and the implications this geography has on local climatic conditions. However, the country's National Adaptation Program of Action (NAPA) anticipates that an increasing trend of precipitation will occur. This conclusion is consistent with climate modeling for South Asia as a whole, which projects that the region will experience: a median increase in temperature of 2.3°C by 2100; that the greatest amount of warming will take place at higher altitudes; precipitation during the dry season will decline by 5% by 2100.

Bhutan's National Environment Strategy, "The Middle Path," highlights hydropower development, industrial growth and intensification of agriculture as the three major avenues for sustainable development in Bhutan. Tourism is also an important economic sector. All these sectors are highly climate sensitive and vulnerable to the adverse effects of climate change.

Hydropower critically depends on predictable and stable patterns of precipitation, which will be perturbed due to climate change. Subsistence farmers will be directly affected by temperature changes and monsoon patterns that are less predictable as a result of climate change. Bhutan's roads and other important infrastructure will suffer more damage from landslides and flashfloods. The rapid melting of glaciers, besides affecting the base flow of Bhutan's rivers, will dramatically increase the risk of GLOFs. Bhutan's extensive forest cover, rich biodiversity and clean water resources will also be affected by climate change, which will then negatively impact the tourism and service sectors.

> **"Tourism and hydropower sectors are highly climate sensitive and vulnerable to the adverse effects of climate change."**

Why people should adapt and the benefits thereof

Adaptation practices are designed and planned to minimize impacts of climate change, and even capitalize on it. The global climate debate often overlooks how adaptation can result in economic and financial opportunities for farmers living in villages. Taking into account long-term climatic changes and market forces, farmers can capitalize on opportunities to diversify their production and spread climate risk across different income streams, or sustainably intensify to maintain stable harvests in a more resilient natural environment.

The economic benefits of adaptation include:

i. Sustained or increased agricultural production,
ii. Higher household incomes,
iii. Enhanced environmental services,

iv. Protection of the asset base,
v. Less vulnerability to extreme weather events.

There are a number of methodologies one can use when trying to reach an economic valuation for adaptation measures. Cost-benefit comparisons, which are standard in economic assessments, offer limited utility, since adaptation generally results in non-monetary impacts. In some cases, more can be understood by using a cost-effectiveness approach (selecting the options that have the lowest cost to supply an environmental service). In others, a risk-based approach, where practices that are adjusted to reduce a specific climate risk level are chosen, may be more appropriate (UNFCCC, 2009).

At the global level, the International Fund for Agricultural Development (IFAD) is calling for climate finance to prioritize investments in small-scale agriculture. Small-scale farmers produce up to 80% of the food in sub-Saharan Africa and parts of Asia.

In the least-developed countries, agriculture is the backbone of the economy, accounting for a large segment of gross domestic product (GDP), and employing as much as 70% or more of the workforce. Given the development imperative of maintaining healthy and productive food systems, targeted financing instruments are crucial to enabling small-scale farmers to make the necessary investments that will avoid crop losses.

The adaptation options available to smallholder farmers depend on contextual climate risks, geographic location, asset base and livelihood strategies.

With access to better technical assistance on climate risk analysis, including tools, such as satellite-based monitoring, Geographic Information Systems (GIS) and scenario-based modelling, farmers can supplement traditional, tried-and-tested adaptation practices with innovative know-how.

IFAD's Adaptation for Smallholder Agriculture Programme (ASAP), launched in 2012, is a unique instrument that directs resources to small-scale farmers so that they can increase their climate resilience through 'multi-benefit' adaptation approaches.

For instance, improved access to meteorological forecasts and training of extension services complement investments in mixed cropping and the adaptive engineering of rural roads. IFAD's climate adaptation projects also take due consideration of local social and economic contexts. These factors ultimately help in determining the appropriate technologies and strategies that are congruent with community institutions and the values of affected groups.

Adaptation Needs

Countries with mountainous ecosystems, like Bhutan, are among the most vulnerable to the adverse impacts of climate change. The vulnerabilities for Bhutan in regards to climate change and variability include:

i. Size and limited resource base
ii. Vulnerability to existing weather events, like heavy monsoon rainfall, dry season drought, tropical storms such as cyclones
iii. Restricted economic opportunities exacerbated by globalisation and trade barriers
iv. Limited economic resources
v. Rugged terrain, poor soil, and limited cultivation land makes economic and living conditions difficult

The UN notes that adaptive capacity of human systems is generally limited in mountainous developing countries, such as in Bhutan, where vulnerability is high. Being a mountain country with glaciers, the climate-driven glacier melt and Glacial Lake Outburst Floods (GLOF) pose a serious threat and can bring the economy to a standstill.

Key vulnerabilities and adaptation needs for Bhutan are important to understand in broad sectors including:

i. Agriculture
ii. Forests and biodiversity
iii. Human health
iv. Water resources
v. Glaciers
vi. Energy

Publications on Climate Change Adaptation in Bhutan

CHAPTER 6

Vulnerability and Adaptation in Agriculture, Forest and Biodiversity, and Health sectors

In this chapter, vulnerability and adaptation issues of the following three sectors are covered.

i. Agriculture
ii. Forest and biodiversity sectors
iii. Human health

Agriculture

Bhutan has always been a society dependent on agriculture and about 70% of the population still depends on agriculture for livelihood. But agriculture in Bhutan is challenged by low soil fertility, poor infrastructure, small landholding size and occurrence of natural disasters like floods, and the mountainous terrain, all of which make the activity labor intensive.

The main crops in Bhutan are rice, maize, wheat, potato, buckwheat, barley and millet. Socioeconomically, rice, maize and potato are the three most important crops in Bhutan.

Rice is the staple food of the Bhutanese people, closely followed by maize. Potato is an important cash crop of communities living at higher elevations. Rice is grown mainly in the western region, in Thimphu, Paro, Punakha and Wangdue districts, and the southern districts of Samdrup Jongkhar, Sarpang, Tsirang and Samtse, followed by notable areas in Lhuentse, Trashiyangtse and Trashigang in the east.

In total, the country is around 60% self-sufficient in cereals. Other key crops, which are exported, are potatoes, spices (mainly cardamom), and fruits, such as oranges and apples. However, export of vegetables is gaining importance, especially during the summer months.

Current vulnerability of agriculture sector

Some observed symptoms of climate change impacts on agriculture in Bhutan include:

i. Loss of crops to unusual outbreaks of pests and diseases
ii. Erratic rainfalls
iii. Windstorms, droughts and flash floods
iv. Landslides that are increasing annually

Most farmers in Bhutan are totally dependent on monsoons for irrigation. The late arrival of the monsoon can lead to drought, while excessive monsoon rains cause natural disasters, such as floods and landslides. Such extreme climatic events also put rural communities at increased risk, as many remain disconnected in largely scattered settlements in the most challenging geographic conditions.

In terms of food access and access to markets, as a mountainous and landlocked country, climate change not only affects the physical aspect of the farming environment, such as land degradation in Bhutan, but also affects food distribution systems, and hence results in price distortion of essential commodities.

Adaptation for Agriculture

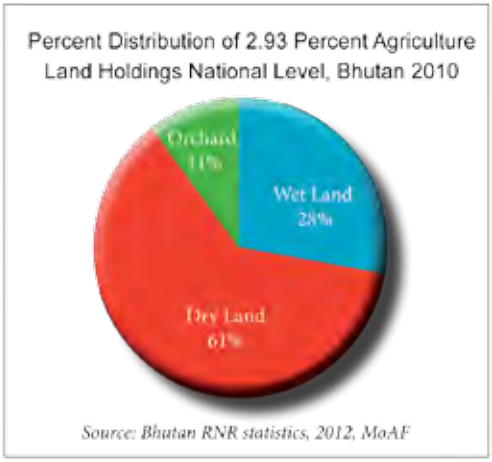
The overtime impacts of climate change will force crop yields to be impacted.
The decline in essential crops, like rice and maize, would call for adaptation measures such as;

i. Change in crop cultivars
ii. Change in location of cultivation sites
iii. Improvements in water and pest management

For crops like potato, the changing climate may allow for agricultural production of potato on a larger scale in the future. Adaptation and policy options should be implemented to take advantage of potential positive impacts by:

i. Adjusting the mix of crops to allow for more potato production
ii. Securing export markets for increased potato production

However, climate change will affect not only the physical aspect of the farming environ-



ment in the form of crop losses, but also other dimensions like land degradation, and distribution systems and prices of the essential commodities.

In the difficult geographic setting, where rural settlements are scattered over a rugged mountainous terrain, extreme events due to climate change will also increase risks and impacts.

In terms of adaption options, the solution not only lies in increasing the yield and productivity of agricultural crops, and improved efficiency in irrigation through increased investment in research and development in the agriculture sector, but also ensuring proper food distribution systems and pricing mechanisms.

Forests and Biodiversity

Bhutan has a rich biodiversity and a forest cover of 70.46% equivalent to 27,052.9sqkm. The interaction of topography, climate and human use has resulted in a complex pattern of vegetation and habitat types.

The three major vegetation zones of Bhutan are:

i. Alpine zone (above 4000m)
ii. Temperate zone (2000 to 4000m)
iii. Subtropical Zone (150 to 2000m)

The broadleaf forests (62.43%) and the mixed conifer forest (22.69%) form the dominant forest types. These diverse ecosystems harbor a spectacular assortment of biodiversity, with a recorded total of 5,603 species of angiosperms and gymnosperms, close to 200 species of mammals, and 678 species of birds, recorded to date.

From the ecological standpoint, the country's inherently fragile geologic conditions, rugged mountain terrain and high precipitation levels necessitate conservation and sustainable use of natural resources to mitigate natural disasters, such as landslides and flash floods. Furthermore, the forests of Bhutan have an immensely important role in carbon sequestration and alleviating the impacts of climate change.

Current Threats to Biodiversity

Conservation and sustainable use of biodiversity are becoming increasingly challenging in Bhutan as the country opens up to meet new development needs of a growing and modernizing population. There are both direct and indirect causes affecting biodiversity in Bhutan.

The direct causes affecting biodiversity in Bhutan include:

i. Forest harvesting for housing and construction and fuel wood
ii. Wood-based industries
iii. Infrastructure development
iv. Livestock grazing of pastures and forests

v. Forest fires
vi. Human-wildlife conflicts and poaching
vii. Land use change and conversion
viii. Urbanization
ix. Mining and quarrying
x. Infrastructure development
xi. Invasive species
xii. Hydropower and industrial development

The indirect causes affecting biodiversity in Bhutan include:

i. Growing population
ii. Poverty
iii. Changing consumption trends and market forces
iv. The new threat is from climate change.

It is already known from global experiences that climate change leads to ecosystem changes, such as phenological shifts, altitudinal and latitudinal range shifts, and upward migration of species, colonization by new species, extinction of certain species, epidermis burning of vegetation, shifts in species occurrence and habitat changes for plants, birds and mammals, and upward shift of cultivation and grazing activities.

While there is a general lack of resources and capacity to conduct studies on climate change and biodiversity in Bhutan, a survey of people's observations and perceptions in 2010 was one of the first attempts in this regard.

The survey, conducted across four broad eco-floristic zones in the country reported changes in a number of animal species across all the eco-floristic zones, with an observed increase in the population of animals, such as the blue sheep, wild boar, takin, snow leopard, bear, and birds, such as laughing thrushes, the blood pheasant and monal pheasant. Some of the animals observed to have declined in population were the musk deer, barking deer, wild fox, leopard and tiger, and birds, such as the eagles, hornbills, cuckoos, vultures and common large billed crow, etc. While such changes in populations may not necessarily be attributed to climate change, there are notable changes being observed. For example, there are reports of Himalayan black bear sightings during the hibernation season, leading to conflicts with farmers in rural areas.

Impacts and Adaptation: Forestry and Biodiversity

i. Changes in distribution of fauna

In view of the fact that the major forest zones are expected to shift northwards with climate change, faunal and avifaunal species that are tied to climate and land cover would also be expected to migrate northwards. For instance, elephants that are now mostly concentrated in the subtropical rain and tropical dry forests on the southern fringes of Bhutan may migrate northwards towards the interior.

Tigers that are today mostly found in the southern two-thirds of Bhutan may in future be found in riverine habitats spread across Bhutan. Birds, commonly found in southern and central parts of Bhutan under the current climate, (e.g. migratory water birds, and hornbills), are likely to move to higher altitudes in the future.

ii. Loss of species

Many of the species in Bhutan are already at risk of extinction due to pressures arising from natural processes and human activities. Climate change will further exacerbate these pressures, especially for threatened and vulnerable species. The further changes from northward migration of habitats especially threaten mountaintop and location restricted species.

A study by WWF and Wangchuck Centennial Park (2011) on the vulnerability in Wangchuck Centennial Park indicates considerable loss of habitats for the snow leopard (an endangered top predator of alpine areas) under future climate. Endangered and globally significant birds with restricted habitats, like Black-necked Crane and White-bellied Heron, would likely be at additional risk.

iii. Increased establishment of invasive species

The threat to biodiversity due to alien invasive species is considered only second to that of habitat loss. Climate change will expedite the colonization of some areas by invasive species, in both terrestrial as well as fresh water ecosystems, which will have severe ramifications on native species.

The northward migration of such species can also be expected in light of the northward migration of forest types in the future under a changing climate.

iv. Increased risk of forest fire

Forest fires are considered to be one of the key threats to coniferous forests in the country, with 526 incidents of forest fire, affecting over 70,000 ha of forest, from 1999/2000 to 2007/2008.

While most fires in Bhutan are caused by human activity, the rising temperature and long spells of drought due to climate change are likely to increase the risk of forest fires, resulting in further reduction and degradation of forest resources.

Such examples include the fires in the winter of 1998/99, which was characterized by a prolonged spell of dry (snow-less) weather, with forest fire incidents even in places without a known history of forest fires. Forest fires in Bhutan mostly occur in Blue pine and Chir Pine zones.

v. Loss of agro-biodiversity

Agricultural biodiversity plays a crucial role for adapting to altered climatic conditions through genetic variability of crops and livestock species which can be bred to better adapt to climate change impacts. It is widely accepted that genetic diversity is important, both in its own right, and in determining resilience of species to impacts of climate change and other pressures.

Now climate change poses additional threat to agricultural biodiversity, by increasing genetic erosion of land races and threatening wild species, including crop wild relatives. Climate change will also bring new and enhanced demand for genetic resources. National and international breeding programs are already targeting new varieties of crops for adaptation to future climatic stresses.

vi. Increased incidences of pests and diseases

Recent moderate warming has been linked to improved forests productivity, but these gains are expected to be offset by the effects of increasing drought, fire and insect outbreaks as a result of further warming.

There were outbreaks of bark beetle in spruce forests, increased incidence of mistletoe infestation, and moisture–stress related problems in blue pine forests. It is likely that, with rising temperature and erratic dry and moist periods, intensity and incidences of diseases and pests will increase.

Human Health

The basic requirements for good health are clean air and water, sufficient food and adequate shelter, and each of these conditions are very likely to be affected by future

> **Many of the necessary preventive actions to deal with the additional risks of climate change are already clear. Widening the coverage of proven, effective health interventions will be critical to the global effort to adapt to climate change.**

climate changes. As such, climate change affects the health of millions of people globally. Climate change imposes new challenges to control infectious diseases. Many of the major killers are highly sensitive to temperature and rainfall, including cholera and diarrheal diseases, as well as vector borne diseases, including malaria and dengue.

Assessment of sensitive malaria zones

Malaria is one of the important vector borne diseases in Bhutan, especially in southern parts of the country.

An assessment has been conducted to assess how the sensitive zones of malaria may be impacted by climate change in the future (2010-2039 and 2040-2069). It shows that the highest incidence of malaria cases are highest in the warmer and wetter southern and lower altitude dzonkhags of Samtse, Chukha, Sarpang, Zhemgang, Mongar, Pemagatshel, Trashigang and Samdrup Jongkhar.

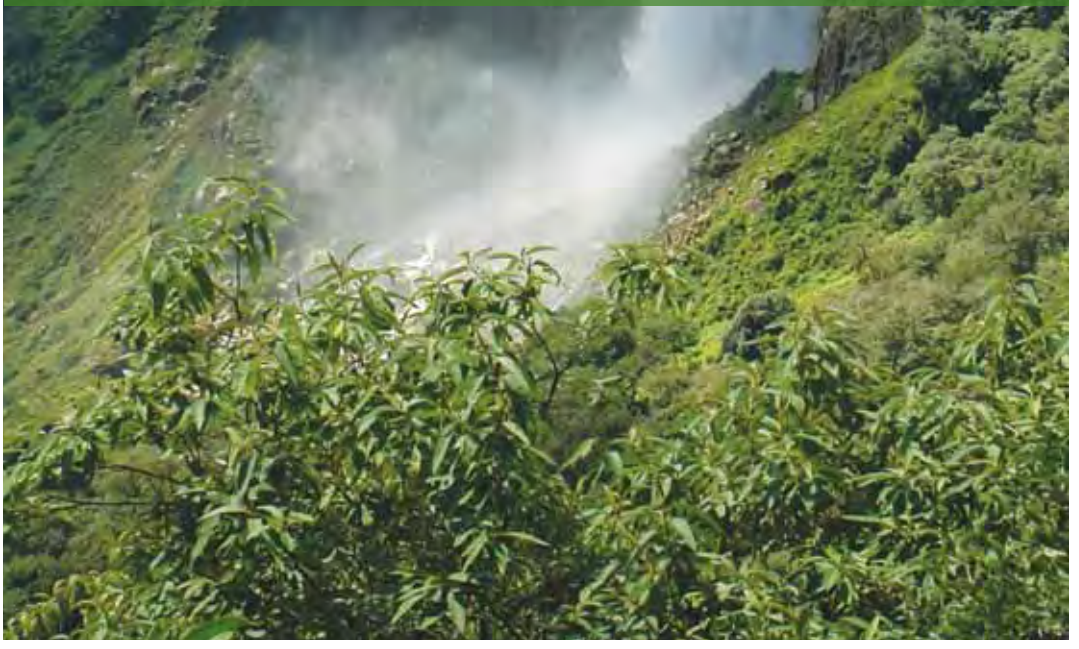
For the period 2010-2039, the optimal climate conditions occur mainly in the wet monsoonal season from June to September and now extend to Chukha, Dagana, Punakha, Mongar, Pemagatshel, Samdrup Jongkhar, Samtse, Sarpang, Trashigang, Tsirang and Zhemgang, being districts for optimal temperature, whereas the condition of optimal rainfall is met in all districts.

Adaptation: Health Sector

The global public health community has a wealth of experience in protecting people from climate sensitive hazards. Many of the necessary preventive actions to deal with the additional risks of climate change are already clear. Widening the coverage of proven, effective health interventions will be critical to the global effort to adapt to climate change. As a matter of fact, health impacts of climate change will be determined by both climate change and non-climatic factors, such as health care and the health condition of the population (WHO, 2010).

CHAPTER 7

Vulnerability and adaptation in water resources, glaciers and energy sectors



In this chapter, vulnerability and adaptation issues of the following three sectors are covered.

i. Water resources
ii. Glaciers
iii. Energy

Water resources

Bhutan has four major river systems, with numerous tributaries streams and natural lakes, which are dependent mainly on glaciers, snow, forests and seasonal rainfall.

Bhutan's four major rivers are:

i. The Amo Chhu (Toorsa)
ii. Wang Chhu (Raidak)
iii. Punatshang Chhu (Sunkosh) and
iv. Drangme Chhu (Manas)

All the four rivers drain into the Brahmaputra River in India. Other smaller rivers are the Nyera Ama Chhu, the Jomotshangkha Chhu and the Shaar Chhu. All the river systems originate within the country, except three rivers, viz. Amo Chhu, Gongri and Kuri Chhu, all of which originate in the southern part of the Tibetan Plateau.

The main rivers are generally located at the bottom of valleys or deep gorges and ravines, where accessibility remains a daunting challenge. As such, the major sources for drinking and irrigation are mainly from local springs, streams and minor east-west tributaries.

Although Bhutan has not experienced severe water shortages in the past, reports of dwindling water sources are increasing, and climate change may render the country much more vulnerable. All dzongkhags have noted the issue of acute water shortages for drinking and attributed such recent issues, as increasing fallowing of agricultural land in the rural communities, to the drying of water sources.

Adaptation for water resources sector

The increasing demand for water flowing in from all over the country means that adaptation measures are necessary for the efficient use of water, and also to deal with impacts of climate change on water resources.

UN projections show that, by 2050, access to freshwater in Asia will decrease, as well as increasing extremes of dry and wet periods. Climate change is also likely to lead to increase in the magnitude and frequency of precipitation-related disasters, such as floods, landslides, typhoons and cyclones.

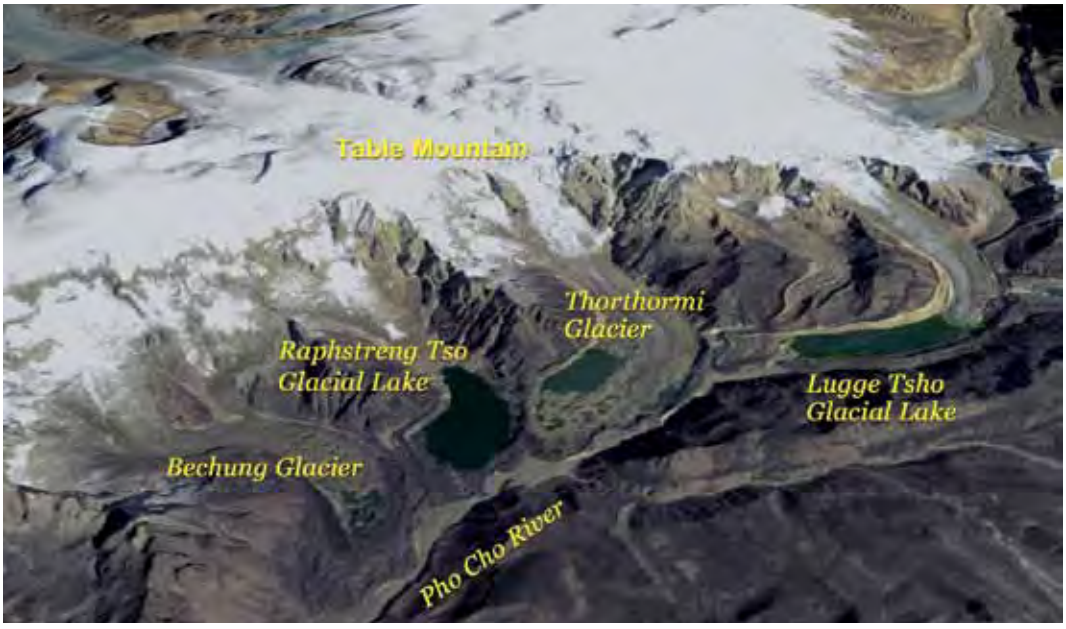
In light of such projected impacts and lack of information in the country on the status of water security, one of the urgent activities needed for both resource management and adaptation to climate change is baseline assessment of water resources. In Bhutan, there has been no comprehensive study of the water sources, their historical trend, and inventory on the use of the water for various purposes.

Glaciers and GLOFs

Bhutan's northern frontiers lie in the eastern Himalayas and it has 677 glaciers and 2,674 glacial lakes and subsidiary lakes. As such, the biggest climate related threat in Bhutan is the Glacial Lake Outburst Flood (GLOF).

GLOF takes place in heavily glaciered mountain regions and are triggered by natural forces, such as heavy rains, landslides and avalanches and earthquakes.

Bhutan has been described as being prone to dangerous GLOFs. Of the 2,674 glacial lakes in Bhutan, 25 have been identified as most dangerous and prone to GLOF. Among the 25 lakes, three lakes are in the Chamkhar Chhu basin, one is in the Kuri Chhu basin, seven are in the Mangde Chhu basin, five are in the Mo Chhu basin and eight are in the Pho Chhu basin.



Of greatest concern are the 9 lakes in Pho Chhu basin, where there have been four GLOF incidents in recent times. The most serious GLOFs along Pho Chhu River occurred in 1958 and 1994. The "unexpected" Lugge Tsho GLOF of 1994 caused damage to Punakha Dzong, houses, bridges, agricultural land, and the loss of 21 lives.

Some of the vulnerabilities from glacial retreat and GLOF identified in Bhutan's NAPA include:

i. Loss of lives and livelihoods through impacts on agricultural lands and people from GLOF.
ii. Loss and damage to essential infrastructure, such as hydropower systems, industrial estates/infrastructures, human settlements, historical and cultural monuments, roads, bridges and communications infrastructure.
iii. Reduction of water resources (possible shortages/variations for downstream uses in agriculture and hydropower) due to receding glaciers.

Currently, Bhutan is implementing one of the first NAPA projects to address these three priorities under the LDC Fund and entitled "Reducing Climate Change-induced Risks and Vulnerabilities from Glacial Lake Outburst Floods in the Punakha-Wangdi and Chamkhar Valleys".

The project aims to:

i. Artificially lower water levels in Thorthormi Lake by 5m
ii. Increase capacity for disaster risk management in affected valleys
iii. Installing Technical Early Warning System for glacial lake outburst floods

Adaptation for GLOFs

The government has initiated numerous structural measures to reduce the possibility of future GLOF incidents. Measures, such as draining of lake levels, installation of early warning systems, and building river protection embankments, have been initiated.

In parallel, the Department of Disaster Management of the Ministry of Home and Cultural Affairs is spearheading the National Disaster Risk Management Framework, which proposes an institutional framework at three different levels - national, dzongkhag and local administration (dungkhag/gewog/thromde) levels - to discharge responsibilities in both pre-disaster as well as the post-disaster phases.

Following the 1994 Lugge Tsho GLOF, the Royal Government of Bhutan promptly started further structural GLOF mitigation initiatives and response measures to avoid similar catastrophic incidents in the future. Following up on preliminary studies of the dangerous glacial lakes in Pho Chhu, a series of short-term and long-term measures were recommended.

The short-term measures recommended include:

i. Unloading the crown of the landslide near the Tshopda Tsho outlet and constructing gabiontoe walls on either banks of Pho Chhu
ii. Lowering the outlet of Thorthormi Tsho by 10m in stages to reduce the hydrostatic pressure
iii. Restoring the original section of the morainic barrier of Raphstreng Tsho washed away by the 1994 flood
iv. Lowering the level of Raphstreng Tsho by 20m to reduce the volume by 38%

The long-term measures recommended include:

i. Construction of check dams, river draining dykes and other energy dissipation measures downstream
ii. Stabilization of slopes by plantations

iii. Detailed monitoring of glacial lakes
iv. Establishment of seismic stations to record earthquakes in the Lunana area
v. Establishment of meteorological station in the lake area to record micro-climatic variations

Furthermore, the Royal Government of Bhutan, in recent years, has recognized the importance of developing a comprehensive disaster risk reduction strategy that minimizes the impact of both natural and man-made catastrophes (MoHCA, 2006).

The Royal Government of Bhutan has also elevated GLOF to the position of "among the most serious natural hazard potentials in the country", and specifically seeks to achieve the following expected outputs pertaining to GLOF within the overall context of the National Disaster Risk Management Framework.

Energy (Hydropower)

The most commonly used energy resource in Bhutan is wood (biomass), followed by hydropower. A 2010 study of the Department of Energy shows that fuel wood is the primary energy at 56.8% of total primary energy supply, with electricity at 15.7%, 19% from petroleum fuels and coal at 8%. Fossil fuels used in Bhutan include imported petrol,

diesel, LPG, kerosene and aviation turbine fuel.

Small deposits of coal are found in southeastern Bhutan. Solar energy is harnessed by the rural electrification program for lighting homes, as a source for powering telecommunication equipment, and in heating water for some institutions. The feasibility of tapping wind energy is being explored, and presently data is being collected.

However, hydropower is considered the backbone of the Bhutanese economy and con- tributes about 45% of the national revenue, and constitutes about 19% of the country's GDP. The rugged mountainous terrain and swift flowing rivers have made Bhutan a natural haven for hydropower, with an estimated potential for 30,000MW, out of which 24,000 MW has been found to be techno-economically feasible.

The total installed capacity as of December 2010 was 1505.32 MW. The government has also set an ambitious program to install a minimum of 10,000 MW generating capacity by 2020 through 10 hydropower projects under the "accelerated hydropower development program".

> **The rugged mountainous terrain and swift flowing rivers have made Bhutan a natural haven for hydropower, with an estimated potential for 30,000MW, out of which 24,000 MW has been found to be techno-economically feasible.**

With almost total dependency on hydropower for electricity, and hopes for the sector to be the major source of economic growth and future source of revenues for development activities, Bhutan has become most vulnerable to climate change.

While the country is endowed with abundant water resources, any change in flow regimes will have a direct impact on ensuring energy security.

The issues of concern in the hydropower sector include:

i. Predicting future flows;
ii. Managing hydropower systems for potential future flows;
iii. Reservoir sedimentation;
iv. Floods, including flash floods and GLOFs;
v. Increasing glacier retreat and less snow cover;
vi. Erratic rainfall patterns

Current vulnerabilities in the energy/hydropower sector as identified in Bhutan's NAPA include:

i. Threats to hydropower systems from Glacial Lake Outburst Floods;
ii. Temporal and spatial variation in flow, affecting electricity production/exports, due to disruption of average flows for optimum hydropower generation;
iii. Increased sedimentation of rivers, water reservoirs and distribution network;
iv. Reduced ability of catchment areas to retain water/increased runoffs with enhanced soil erosion (deterioration of environment).

Hydropower vulnerability

A recent study on 'Climate change impacts on the flow regimes of rivers in Bhutan and possible consequences for hydropower development', conducted by the Norwe-

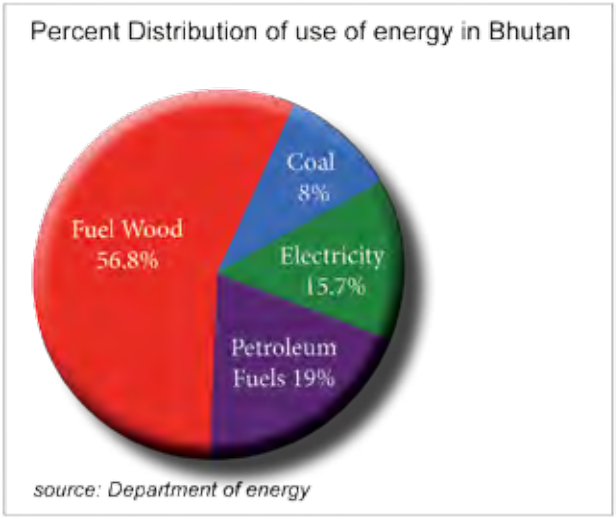
gian Water Resources and Energy Directorate, shows that the change in mean annual discharge available for hydropower production from 1981-2010 to 2021-2050 varies between 13% decrease and 7% increase for all catchments and both climate scenarios. The change in mean annual discharge available for hydropower production from 1981-2010 to 2071-2100 is influenced by reduced contribution to stream flow from glacier ice melt.

Since there is the possibility of reduced river flows, there is the risk of reduced hydropower potential and loss of revenues, especially during the dry winter months.

Adaptation for energy sector

As Bhutan is heavily dependent on the hydropower sector, and reports show that the sector is vulnerable, there is a necessity for major adaptation measures in the sector. The measures would need to consider the current run-of-river hydropower schemes to capture water for the lean season, diversification of energy sources and other policies to increase energy efficiency.

Furthermore, given the fact that emissions from Bhutan are almost negligible due to dependence on hydropower and forest biomass, measures to promote energy efficiency and diversification in Bhutan will have to be considered as adaptation rather than mitigation measures.



CHAPTER 8

Climate change mitigation in Bhutan

What is climate change mitigation?

Climate change mitigation refers to efforts to cut or prevent the emission of greenhouse gases - limiting the magnitude of future warming. It may also encompass attempts to remove greenhouse gases from the atmosphere.

Mitigation can mean using new technologies and renewable energies, making older equipment more energy efficient, or changing management practices or consumer behavior. It can be as complex as a plan for a new city, or as a simple as improvements to a cook stove design. Efforts underway around the world range from high-tech subway systems to bicycling paths and walkways. Protecting natural carbon sinks like forests and oceans, or creating new sinks through silviculture or green agriculture are also elements of mitigation.

> **“Mitigation can mean using new technologies and renewable energies, making older equipment more energy efficient, or changing management practices or consumer behaviour.”**

It differs from climate change adaptation, which refers to the actions taken to manage the unavoidable impacts of climate change.

We will look into mitigation issues in Bhutan broadly in five areas:

1. Energy
2. Industries
3. Transport
4. Residential
5. Agriculture

Energy

Hydropower contributes the highest revenue to the government and it is also seen as a clean source of energy. At present, there are two registered CDM projects in the country.

The first is the 'E7 Bhutan Micro Hydro Power CDM project' with an installed capacity of 70kW at Chendebji in Trongsa, and other is the 114MW Dagachhu Hydro-power Project in Dagana.

The government has plans to register many other projects, including hydropower and biogas, as CDM projects in the future. The government has instituted control of vehicle emission through vehicle emission standards, together with improving the fossil fuel quality imported into the country. There also exist progressive tax rates for larger vehicles and tax exemption for low emission vehicles, like electric vehicles.

Renewable Energy

The Renewable Energy Policy 2011 aims to reduce heavy dependence on hydropower, reduce the use of fossil fuels in the transport sector, and introduce environment-friendly and locally available fuels/energy resources to meet demand for energy, especially in remote and dispersed locations.

RE generation cost is extremely high and would not be competitive with hydropower generation costs. To aggravate the situation, domestic tariffs are subsidized, which would make sale of RE nonviable.

The renewable energy policy 2011 states, "The promotion of RE sources in Bhutan therefore needs to be seen as a broad and long-term strategy. Nurturing and development of the RE would result in the diversification of the present and future energy-mix, enhance national energy security and more importantly, ensure sustainable development."

The policy states that Bhutan shall strive to generate 20MW by 2020 through a mix of RE technologies as follows:

i. Solar- 5 MW
ii. Wind- 5 MW
iii. Biomass- 5 MW
iv. Others- 5 MW

Some of the potential renewable energy sources, other than hydropower, include:

i. Wind energy

Bhutan has good wind potential, but the development of wind farms is constrained by various issues, including limited infrastructure development like roads, which may not be adequate to transport such blades and heavy machinery. Small wind machines of less than 100kW and mechanical wind pumps could be used to generate electricity, or water pumping for irrigation and drinking, for small villages.

ii. Solar energy

Bhutan has good solar energy potential in several valleys throughout the country, but these data will need further ground data validation. Solar photo voltaic technologies, though expensive, are an alternative to electricity production.

iii. Geothermal energy

Geothermal energy is the heat energy available in the core of the earth. There are several hot springs around the country, which are traditionally used for bathing, as the water is considered to have medicinal and healing properties.

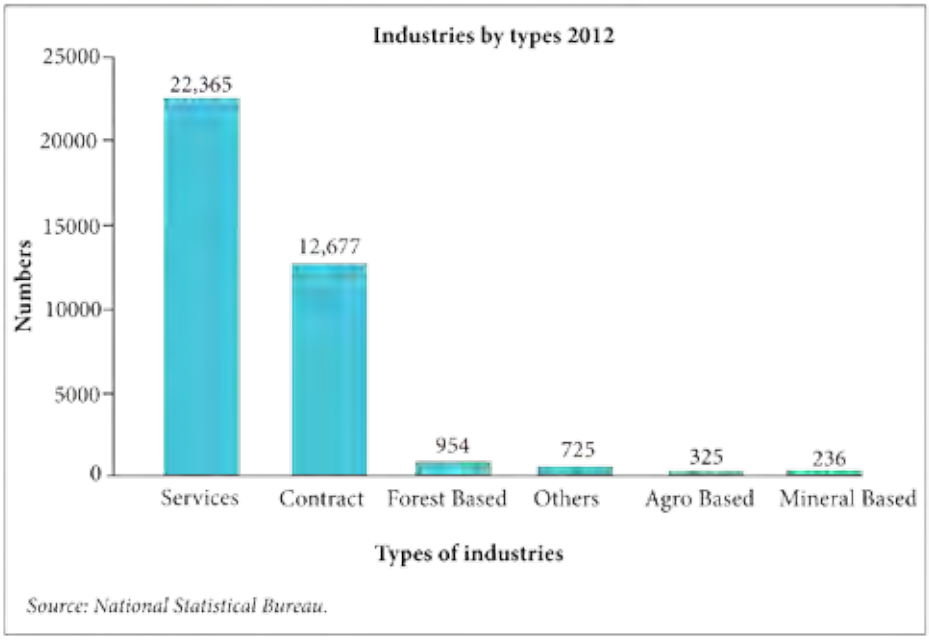
iv. Biomass-based power generation

Biomass-based power generation – either through direct combustion or through gasification– is an established technology worldwide. It can supplement the power generation capacity for continuous power generation. Using biomass, off-grid power generation is possible, and thermal applications for heating and cooking in residence and institutions are also possible. Pellets from agro waste, sawdust and pines needles can be used to come up with pellet stoves and space heaters.

Energy demand in the industrial sector

Bhutan has the lowest electricity tariffs in the region, and it could be the reason that there has been a rapid growth in industrial activities in the past few decades. The industrial sector as a whole consumed about 25.5% of total energy in the country and 64.7% of total electricity in 2005 (DoE 2005). Other fuels that are used in the sector include coal, furnace oil, kerosene, light diesel oil (LDO), and fuel wood.

Though the industrial sector in Bhutan has many small and medium scale industries, energy consumption in the industrial sector is dominated by few large energy-intensive industries.



Electricity consumers are categorized in three groups:

i. Low voltage consumers (230 volts and 415 volts)
ii. Medium voltage consumers (6.6kV, 11kV, and 33kV) are medium-scale and some small-scale industries
iii. High voltage consumers (66kV and above) are heavy, power-intensive industries

The six major power intensive industries are Bhutan Ferro Alloys Ltd, Bhutan Calcium Carbide Ltd, Penden Cement Authority Ltd, Druk Cement Company Ltd, Druk Iron and Steel Ltd, and Bhutan Steels Ltd. In 2005, these six energy intensive industries consumed close to 90% of the total sectoral energy consumption, and 62% of the country's electricity consumption.

Mitigation measures in the industrial sector

The industrial sector is dominated by a small number of cement, chemical, ferro alloy, steel rolling mill, carbide, agro processing and forest-and wood-based plants like furniture, medium density fiber board and plywood.

The Economic Development Policy (EDP) 2010 provides up to 15% income tax rebate for industries that implement environmentally friendly technological upgrades beyond what is required by law.

i. Ferro Alloy

The Ferro alloy industry is one of the most energy intensive industries in Bhutan, accounting for more than one-third of domestic electric consumption. As such, saving energy in this sector can make a significant difference to the total electricity scenario for Bhutan. As more applications flow in to start new Ferro alloy companies, the use of energy-efficient technologies need to be used extensively.

ii. Iron and steel

The iron and steel industry, along with the Ferro alloys industry, has more emissions than the cement industry. The energy audits carried out show that the industries have the potential to save energy and reduce GHG emissions.

iii. Cement industry

The cement industry is not only a heavy user of electricity, but also the biggest consumer of coal in the country. The commissioning of the Dungsam Cement Plant is expected to triple the carbon dioxide emission from this sector. Better technology, including process optimization, load management, and operational improvement, can lead to significant energy saving in this sector.

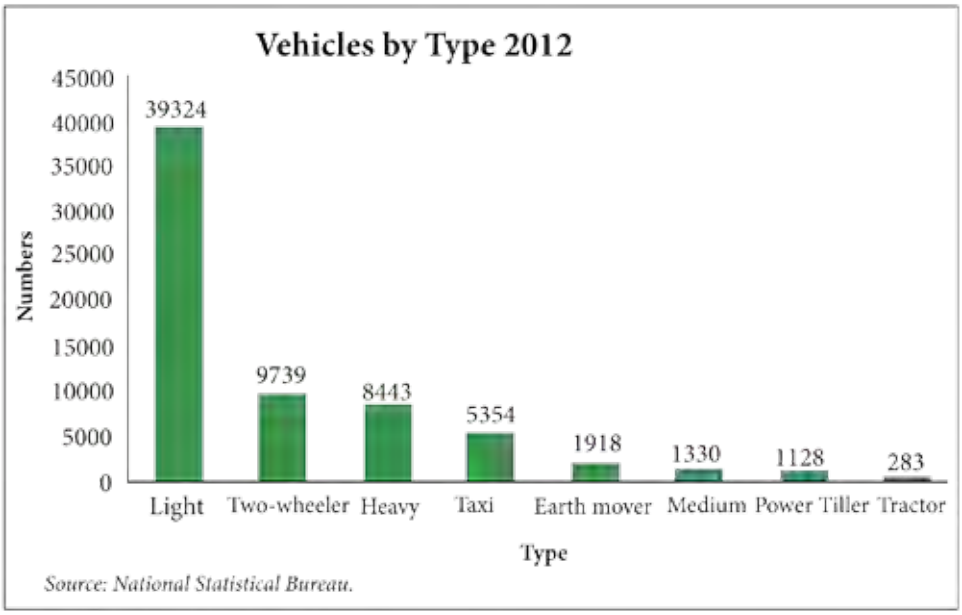
iv. Chemical sector

The production of chemical products (i.e., carbide production) accounts for the least emissions, at about 7% in 2000, but proper interventions could bring down the emission by 22% in this sector.

Mitigation options for transport sector

In Bhutan, the transport sector is dominated by road and air transport, as water transport is not a feasible option. Ropeways are used in certain places, and animals like ponies and yaks are used in places where there are no roads.

The transport sector is one of the significant sectors contributing to emissions in Bhutan. Diesel, gasoline, and ATF are the main fuels consumed in the transport sector, and diesel is the most consumed fossil fuel in the country. Petrol imports increased by three times between 1995 and 2005, while diesel increased by 2.5 times in the same period.



The Surface Transport Master Plan for Bhutan provides mitigation options for the transport sector, which include:

i. Improving efficiency of petrol and diesel vehicles through standards like the vehicle emission standards.

ii. Introduction of vehicles running on alternative fuel: Options for Bhutan include compressed natural gas, liquefied petroleum gas, and biofuels.

iii. Electric vehicles: The government has already put tax incentives in place and is encouraging the use of electric/hybrid vehicles for personal transport.

iv. Electric trolley bus: Cheap hydropower in Bhutan is an advantage for electric trolley buses, with motors powered by electricity from overhead wires and rubber tyres.

v. Bus Rapid Transit (BRT) is the most viable and flexible option for Bhutan. These buses, running on dedicated lanes, or by providing priority on roads, could be powered by electricity and the need to create an electric bus trolley line will not be necessary.

Mitigation options in the residential sector

The residential sector mainly consumes fuel wood, kerosene, liquefied petroleum gas (LPG), and electricity. The sector accounts for 48.7% of the total energy consumption, making it a highest energy consumer. For this sector, 91% demand is met by biomass in the form of fuel wood, while the remaining 9% comes from other fuels, like LPG, electricity, and kerosene.

In this sector, about 66% of the total energy share is used for cooking, and 26% is used for fodder cooking.

Improvement in overall efficiency

For the residential sector, a very good way to reduce fuel consumption and GHG emissions is to improve the overall efficiency of appliances used for cooking, space heating, and lighting. This could be achieved by:

i. Promoting improved cook stove to reduce GHG emissions and fuel wood consumption for cooking and space heating in rural households
ii. Using improved cook stoves for fodder cooking
iii. Promoting CFLs, LED lamps, and other energy-efficient lighting fixtures in electrified areas

Use of modern fuel and renewable energy sources

The use of LPG stoves in rural areas can bring down the use of fuel wood significantly, and reduce emissions. Promoting the use of briquettes made from sawdust in areas outside Thimphu would go a long way to reduce fuel wood for bukharis in the winter months.

The use of solar lanterns and home lighting systems in areas without electricity connectivity would also reduce the use of fuel wood and kerosene. The use of solar water systems would also help reduce emissions.

Building suitably designed houses and buildings can reduce energy consumption for lighting and space heating, reducing emissions significantly. Eco-friendly houses, designed to reduce heat loss, and using daylight for internal lighting, would make a lot of difference. The government could play a key role by piloting energy-efficient building designs for new housing complexes.

Agriculture

With 70% of the population dependent on the sector, mainly through subsistence farming, the Renewable Natural Resources (RNR) sector, comprising agriculture proper, livestock and forestry, remains the largest and single most sector of the Bhutanese economy.

The most significant sources of emission in this sector are enteric fermentation (40% in 2000) and agricultural soils (37%), followed by manure management (17%) and rice cultivation (6%). Emission from field burning of agricultural residues is negligible. The emissions from enteric fermentation, agricultural soils and manure management are due to livestock rearing by subsistence farmers.

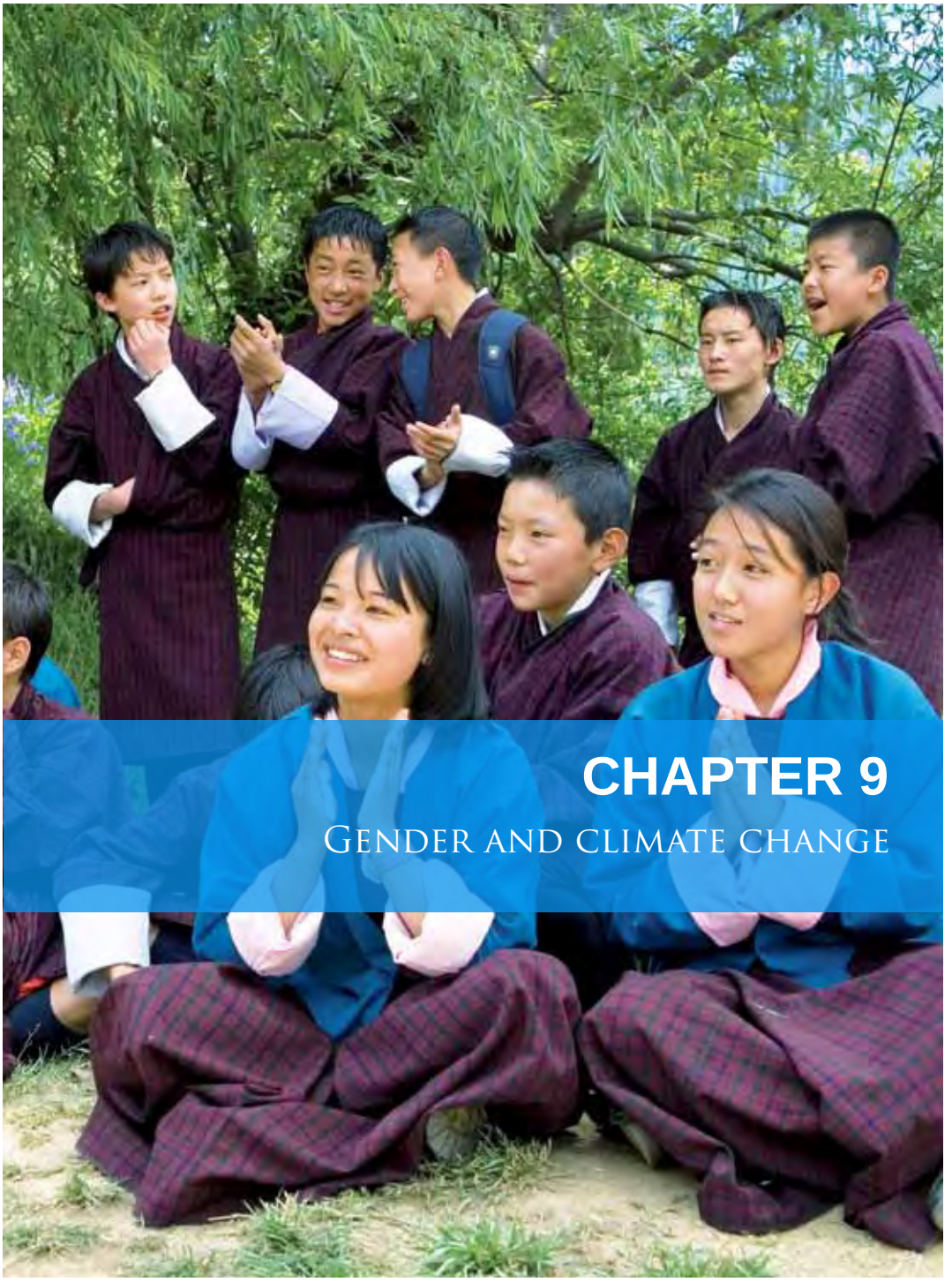
Mitigation options for the agricultural sector

The contribution of the agriculture and forestry sector to GDP has been decreasing, and the pressure on agricultural land from urbanization and farm labor shortage is increasing, and under the circumstance, it is unlikely for the GHG emissions from the agriculture sector increase in future. The implementation of sustainable land management practices will help reduce GHG emissions in land-based economic activities.

Livestock is also a crucial part of this sector and mitigation efforts have to consider the livestock sector.

The mitigations options include:

i. Livestock management
ii. Use of manure and biogas
iii. Increasing the digestibility of forage and feeds
iv. Adopting a good manure nutrient management plan
v. Understanding of crop fertilizer needs
vi. Soil testing to establish nutrient requirement
vii. Use of organic manure as a nutrient source
viii. Determining amount of manure produced
ix. Application of compost
x. Mineral additions to compost and improve moisture and aeration.



CHAPTER 9

Gender and climate change

Gendered impacts of climate change

Gender issues have been rarely addressed, particularly in relation to climate change impact, in global climate change initiatives and policy meetings. Debates have focused primarily on mitigation efforts (reduction of carbon emissions and other greenhouse gases), and on the associated actions required by governments and institutions to mitigate climate change. Insufficient attention has been paid to climate change adaptation strategies – actions taken for and by people, to prepare and make changes to protect themselves against climate change.

Adaptive actions are taken to reduce the threat to food supply, health and wellbeing, livelihoods and security. Women's roles are not adequately recognized or accounted for in climate change mitigation and adaptation efforts, in national and global climate change negotiation talks, or in the context of natural disasters influenced or exacerbated by climate change.

> **"Women's roles are not adequately recognized or accounted for in climate change mitigation and adaptation efforts, in national and global climate change negotiation talks, or in the context of natural disasters influenced or exacerbated by climate change."**

Despite the guiding principles within the United Nations (UN) system to incorporate gender considerations, climate change policy-making (most visibly, the UN Framework Convention on Climate Change, UNFCCC) has failed to adopt a gender-sensitive approach. This failure not only generates concerns in terms of respect for gender equity, it also leads to shortcomings in the efficiency and efficacy of climate-related adaptation and mitigation measures and instruments.

Vulnerability to climate change can exacerbate the impacts of non-climatic stressors, such as increased migration, rapid urbanization, uncertain energy security, unsustainable management of natural resources and the loss of traditional coping mechanisms.

Responding to climate change is not simply a matter of reducing the amount of greenhouse gas emissions into the earth's atmosphere, but is also about helping countries

to build adaptive capacity, and develop a sense of preparedness, to reduce its negative impacts. In order to achieve this, it is important to understand the framework of analysis for gender and climate change that addresses vulnerabilities, adaptation, mitigation and the manner in which engagement can take place.

Compared to men, women are affected differently, and often more severely by climate change and associated natural disasters, such as floods, droughts, cyclones and storms. This is largely because men and women are bound by distinct socio-economic roles and responsibilities that give rise to differences in vulnerability and ability to cope with these climate change consequences.

Consequently, vulnerable groups – especially poor women – are likely to be faced with problems, such as food insecurity, loss of livelihood, hardships due to environmental degradation that lead to displacement and a host of other potentially devastating economic and social consequences. It is poor women, who are most vulnerable, and will bear the adaptation burden, despite their comparatively insignificant contribution to greenhouse gas emissions. In addition to these vulnerabilities, women are still underrepresented in decision-making, with respect to plans and actions to mitigate, and adapt to, climate change.

The dependency on biomass as the main fuel source in the rural areas of most developing countries means that women and children, as primary end-users, are at the receiving end of energy shortages and energy use-related pollution impacts. Women

also suffer more due to their restricted mobility and lack of exposure to training and information. This is particularly evident in relation to warnings about, dangers of, and courses of actions to take in response to natural calamities that may have been influenced or impacted by climate change. Furthermore, disasters, irrespective of their causes, generally accentuate discrimination, and women may not receive equal aid benefits that predominantly target male household heads.

And finally, gender perspectives on climate change, in terms of agriculture and food and water security in different ecosystems should be considered while developing recommendations and strategies for the long-, medium- and short-term. Since the climate is changing rapidly, the policy approach should be flexible enough to adapt as new climate change-related information and knowledge becomes available. Women need to be meaningfully involved, not only as beneficiaries, but also in the decision-making process, especially in the areas of adaptation and mitigation. Understanding how the different social roles and economic status of men and women affect, and are affected differently by climate change will improve actions taken to reduce vulnerability and combat climate change, particularly in the developing world.

The role of women in mitigation actions

In many communities in developing countries gathering, transporting and purchasing household fuels is the responsibility of women. This becomes increasingly difficult with dwindling availability of food and biomass energy resources. Women without access to modern forms of energy are exposed to indoor air pollution and related health problems, such as bronchitis, asthma and miscarriage. Access to nonpolluting fuels that do not damage peoples' health should be an important element of mitigation programs. But it is essential that such considerations be integrated in an effective manner and with proper consultation regarding their effect on women. The policies, technological changes and instruments being proposed to mitigate carbon emissions must use and develop both gender-sensitive criteria and indicators to ensure their impacts do not bypass or negatively affect women.

However, there are concerns that, as women switch to modern fuels, carbon dioxide emissions will increase and expose women to the price fluctuation and scarcity associated with resources, such as oil. These alterations could further harm rural women, who have little influence on foreign exchange imbalances, fossil fuel scarcity or excessive greenhouse gas emissions.

Climate change and gender linkages in adaptation

Climate change impacts filter down to men and women, and ultimately impact more profoundly on rural women, who depend on their environment for their livelihood.

Land clearance for agriculture, forestry and commercial purposes is causing deforestation of natural ecosystems, restricting access to traditional forestry products and placing women increasingly under strain, as a large amount of their time is spent trekking in search of diminishing fuel wood resources.

Women's dependency on agriculture, forests and biofuels increase their exposure to climate change and illustrates the large role women play in the management of resources, and how their contribution and participation will affect the ultimate success of resource management initiatives.

Adaptation to the environmental impacts of climate change

Women, as subsistence farmers in the developing countries in these areas, are responsible for 70–80% of household food production. Traditional food supply sources, both agricultural and forest products, may become more unpredictable and scarce due to

climate change, thus disproportionately affecting women. Climate change may also exacerbate existing shortages of water. Sea-level rise will impact on whole communities, including the fishermen and fisherwomen in terms of fish-catch, where the main impact is on breeding grounds of fish. Sea-level rise also causes salt-water intrusion into fresh water reservoirs, salinity in agriculture and forestry areas, coastal erosion, flooding and increases the impacts of storm surges. Women will be disproportionately affected by such impacts, largely due to their responsibility for water collection, and their exposure to the climatic conditions that affect water quantity and accessibility.

The social and economic considerations of adaptation

Female-headed households, as men migrate as a result of extreme events and disasters, and wives of seasonal migrants may not receive remittances or have alternative sources of income. The workloads of these women, their children and the elderly, increase significantly as a result of male out-migration, which is likely to expand as climate change related impacts escalate.

In mountainous landlocked countries, when male out-migration happens it is the women who are left behind and have to look after domestic and agricultural works. Their situation is further exacerbated by the hard geographical terrains of the country, thereby having negative effects on the food production, besides leading to extra hardships for women.

There are many other negative impacts associated with such movement of people, including the increased risk of HIV infection among women from husbands, who migrated in search of employment.

Additionally, where there is increased male out-migration, due to resource shortages and unreliable job markets caused by climate change, women are left behind with additional agricultural and household duties. Poor women's lack of access to and control over natural resources, technologies and credit mean that they have fewer resources to cope with seasonal, episodic weather and natural disasters. Consequently, traditional roles are reinforced, girls' education suffers, and women's ability to diversify their livelihoods (and therefore their capacity to access income-generating jobs) is diminished.

More women than men work in the informal sector and in small enterprises, which are often the worst hit, and the least likely to recover from the effects of disasters, because

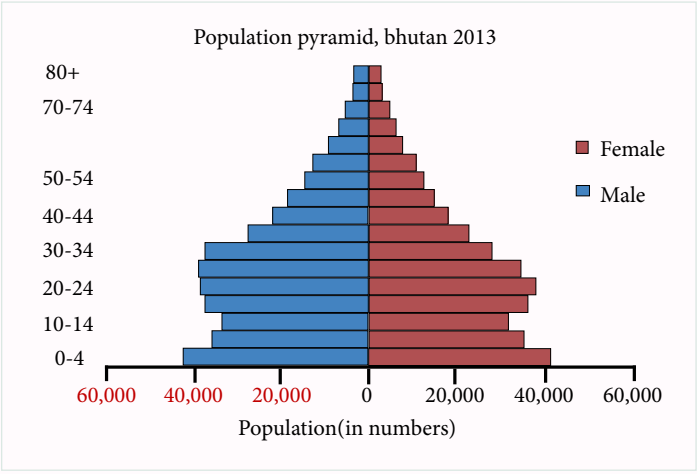
of their low levels of capital accumulation, lower assets, and weaker access to credit and information. Furthermore women are further constrained by discriminatory land and inheritance rights, and limited access to credit and other agricultural extension services.

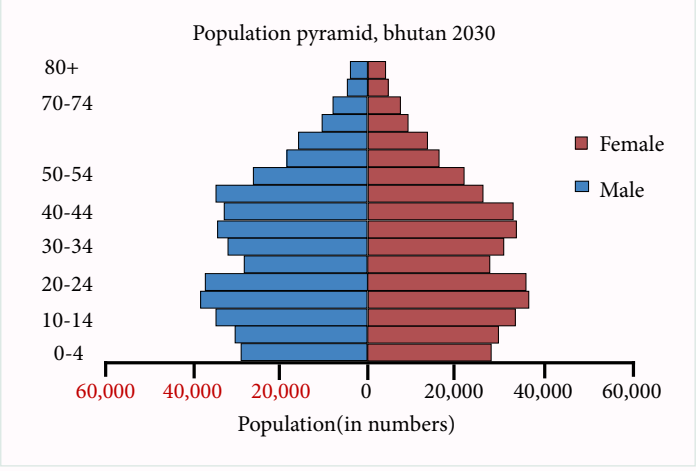
Finally, climate change causes resource shortages and market instability, which impacts highly on women. A distinction between increases in income and women's empowerment should be made, measuring important indicators, such as income, time and decision-making power. The collection and use of gender disaggregated data is imperative in promoting the gendered dimensions in developing both climate change adaptation and mitigation policies/models. Reduction in women's drudgery for fuel supply needs to be addressed. Women need to diversify the energy resources they use, and actions to facilitate the introduction of alternative fuels for household energy consumption could well constitute an essential part of climate change mitigation and adaptation strategies.

Addressing gender concerns in climate change projects

The UN has been increasingly active in supporting innovative climate change adaptation projects across a range of sectors and countries. However, gender issues have previously been inadvertently neglected. One reason for this is that men from the energy and finance sectors have traditionally dominated decision-making positions and have not priotized gender. The fact that stakeholders and project proponents are not gender-sensitive, or simply do not understand the gender equity aspects of climate change and energy projects, has also contributed to this situation. However, this is slowly changing.

There are new initiatives on gender and climate change at various levels, such as the Global Gender and Climate Alliance (GGCA) that was formed in partnership by UNDP, UNEP, IUCN and WEDO, with the aim of ensuring inclusion of women's voices in decision-making, policy development and building capacity at global, regional and local levels. It focuses on ensuring that UN financing mechanisms on mitigation and adaptation address the needs of poor women and men equitably. The GGCA partners work with the UNFCCC Secretariat to develop gender road maps, and develop and utilise gender guidelines for climate change financing mechanisms. It also developed a Resource Guide on Gender and Climate Change.


Population pyramid, bhutan 2013
80+
70-74
50-54
40-44
30-34
20-24
10-14
0-4
Female
Male
60,000
40,000
20,000
0
20,000
40,000
60,000
Population(in numbers)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Female
Male
60,000
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20,000
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20,000
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Population(in numbers)

CHAPTER 10

Climate change and related concerns for Bhutan

Climate change awareness

A study was undertaken in Bhutan to access the level of climate change awareness of the policy makers and other stakeholders, and to provide necessary recommendations for the policy makers related to planning and climate change. In this process, many policy documents and reports, related to completed and ongoing climate change activities, were reviewed.

A survey was also conducted as part of the study to assess the awareness of the various stakeholders at the institutional and policy making levels. The key findings were as follows:

i. The majority of the policy makers are aware of climate change issues. A majority (94.6% of respondents) agreed that climate change was important and must be considered while developing any kind of plans and policies.

ii. The survey showed that all the respondents have heard of 'climate change' before the interview. Similarly, all respondents believe that the climate change is a reality (with 70.9% strongly agreeing).

iii. The Bhutanese planners and policy makers are aware about climate change. They believe that climate change has impacts on people's health, and feel that Bhutan must have climate change adaptation programs.

iv. Respondents suggested the need of awareness programs on climate change in schools, institutes, and public. 92.7% agreed on the need for awareness programs, 94.5% agreed that Bhutan should initiate adaptation programs, and 85.4% disagreed that 'climate change has no impacts on health', meaning they know that it has impacts on human health.

v. Exactly 81.8% of the respondents disagree with the statement, 'climate change will not have any effects on our developmental projects/ activities', and that proper plans and policies should be adopted to minimize the impacts.

vi. The respondents have greater concerns regarding future effects of climate change in Bhutan. A majority of 70.9% of the respondents was of the view that it was important to worry and think about future climate change impacts.

vii. The majority of respondents rated 'glacial lake outburst flood' as the possibl future impact of climate change.

viii. The study summarized that, currently, planners and policy makers of Bhutan are aware of what climate change means in general. Almost all the respondents have an idea and basic knowledge of what climate change is, indicating that the numerous awareness activities in the country and media have helped create climate change awareness.

ix. However, while planners and policy makers are aware about climate change issues in general, there seems to be a lack of in-depth technical knowledge on climate change. This can be attributed to the lack of research and information regarding climate change in Bhutan until recently. The lack of funds and technological resources for a small developing country like Bhutan is another problem, since it limits the extent of research carried out in climate change. However, there are a few people, like environmental officers and planners in the technical divisions of government ministries and agencies, who have technical capacity about climate change issues. However, lack of technical capacity or in-depth knowledge in dealing with climate change and its effects can act as barriers to actually develop appropriate adaptation programs and implementing them.

Education and capacity building for climate change

A report, commissioned by the NEC, for the Joint Support Program on Capacity Development for Mainstreaming Environment, Climate Change and Poverty Concerns in Policies, Plans and Programs (JSP, 2011) assessed the existing capacity situation and various proposed capacity development actions for strengthening capacity for in-country training in the area of Environment Climate and Poverty (ECP) mainstreaming.

The assessment covered eleven institutes, namely the College of Natural Resources, College of Science and Technology, Gaeddu College of Business Studies, Institute for Management Studies, Paro College of Education, Royal Institute of Management, Royal Thimphu College, Sherubtse College, Ugyen Wangchuck Institute for Conservation and Environment, Jigme Namgyal Polytechnic and Samtse College of Education.

The assessment found that institutional capacities exist in the form of favorable programmatic structures of the environmental institutes to infuse ECP mainstreaming training, good institutional partnerships with international institutes, existence of cours-

es and modules that offer substantial scope to embed ECP mainstreaming elements, very good training infrastructure and facilities, and good location of the institutes in relation to their training/educational programs.

However, systemic capacity constraints include market uncertainties for training courses customized for ECP mainstreaming, especially if similar courses are offered by a number of institutes, lack of recognition of short training courses in career advancement, and lack of mechanism for coordination between in-country training institutes.

As a result of the assessment several capacity building priorities to address ECP were proposed as follow:

i. Development of coordination mechanism to foster inter-institutional collaboration and synergy for training in the area of ECP mainstreaming;

ii. Advocacy of ECP mainstreaming in the context of the policy for GNH-infused learning;

iii. Review and enhancement of existing curricula/modules to build in or enhance ECP mainstreaming elements;

iv. Development of new courses, such as those been envisioned by institutes such as the College of Natural Resources and College of Science and Technology, with special attention to ECP mainstreaming topics;

v. Development of teaching aids/materials and knowledge for ECP mainstreaming training depending upon the design of revised/newly developed curricula and modules;

vi. Development and conduct of customized short training courses addressing specific ECP mainstreaming topics on a pilot basis, with the dual objectives of providing hands-on training experience to faculty members, and of developing knowledge and skills on specific ECP mainstreaming approaches and tools among certain target groups;

vii. Development of partnerships with overseas institutes with expertise in ECP mainstreaming;

viii. Development of knowledge and skills of the faculty members in the various institutes, through an in-country training workshop on ECP mainstreaming in the short-term for orientation and general understanding about the subject, followed by specialization courses (short-term intensive courses and postgraduate diploma or masters degree courses) in the medium-term for advanced knowledge and skills in ECP mainstreaming topics

Recommendations to improve climate change actions in Bhutan

During the survey, consultations and review of reports on climate change programs and activities, several recommendations to enhance awareness, capacity building and mainstreaming of climate change in Bhutan were suggested.

The key recommendations are summarized below.

i. Comprehensive climate change strategy should be developed

While several separate assessments and action plans, like the SNC, NAPA, National

Road Map for the Climate Summit, Technology Needs Assessment and Carbon Neutral Strategy, are ready or being prepared, there is a need for a comprehensive and cohesive national climate change strategy.

ii. Research and capacity development on climate change

NEC can coordinate support for research and capacity development, with all relevant institutions, including developing capacity of technical staff and awareness at the local government level, as well as the tertiary education and civil society. Research proposals and small studies on climate change in Bhutan should be funded.

> **"Climate change mainstreaming should be promoted in development plans and policies at all levels. This is important to ensure that development activities are implemented, keeping in mind potential impacts of climate change or potential impact on the national policy to remain carbon neutral."**

iii. Better coordination among stakeholders and donors

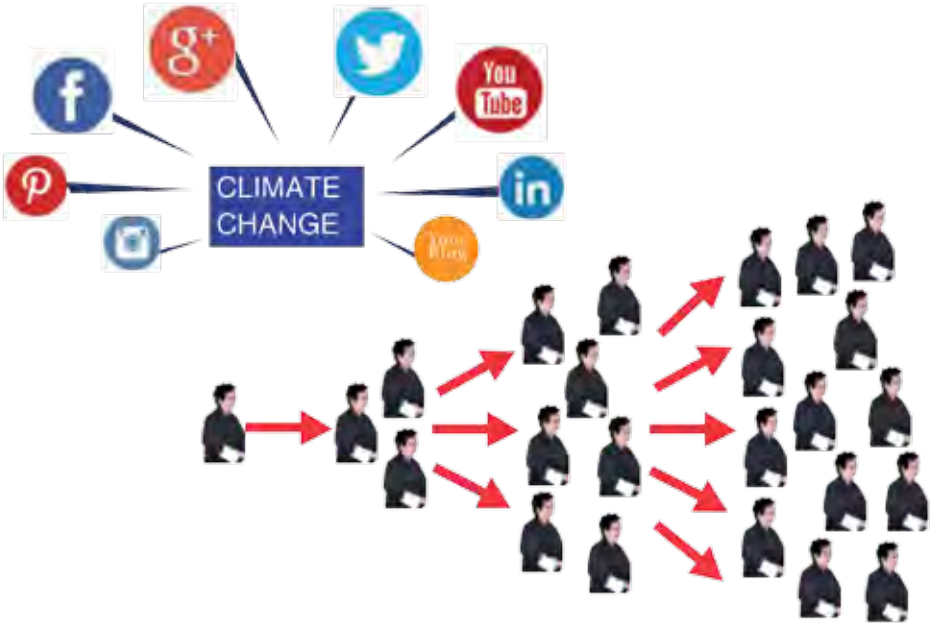
In the area of climate change, NEC could take a lead role for donor coordination, in cooperation with the GNHC. This would be in line with the recommendations of the "2005 Good Governance Plus" exercise to establish inter-agency coordination mechanisms to minimize duplications.

iv. Mainstreaming climate change

Climate change mainstreaming should be promoted in development plans and policies at all levels. This is important to ensure that development activities are implemented, keeping in mind potential impacts of climate change or potential impact on the national policy to remain carbon neutral.

v. Climate financing options

It is understood that actions to address climate change will require additional financing on top of regular development activities that are already being pursued. It is recommended that options of securing climate change finance from the various emerging funding sources be explored.



vi. Media and awareness

The media and conservationists should educate citizens on climate change and hold policy makers accountable for policies that have a negative impact on the environment. Policy makers should be informed on climate change issues and be accountable for the environmental impact of any initiatives executed under their leadership, be it hydro- power projects, large-scale farming, or industrial development.

vii. Climate change in education curriculum

Climate change can be incorporated as a subject at the earliest possible. The youth of today will become the policy makers of tomorrow and need to be informed adequately about the science and issues surrounding climate change. NEC should take a lead role in creating awareness in schools. RSPN, in collaboration with NEC, can develop environmental education programs for the general public and school children. NEC and RSPN can develop a curriculum with the Ministry of Education to create awareness at the school level.

viii. NEC should be given more authority

NEC is the apex environmental agency in Bhutan, but it does not have the power or authority to override decisions made by the ministries or government as a whole. NEC

should have authority to be able to ensure better implementation of all policies and to ensure that defaulters are punished.

ix. More investment towards R&D in climate change

There is a need to reorient research plans and programs to seek policy and financial support to prepare for the changing local environment. There is a need to increase budget allocation, improve research facilities, and equip researchers with technical know-how to address issues of food, water, and energy security and climate change, and impacts on local resources like forests and biodiversity. A research fund can be created for financing long-term climate change research and development.

x. Vulnerability and adaptation of human settlements and infrastructure

Vulnerability and adaptation (V&A) assessments should cover human settlements, critical infrastructure and mapping of vulnerable populations and areas. Mapping vulnerable areas and populations will help mainstream climate change by providing information to planners at different levels. This exercise should build other efforts, including assessment of the state of the environment reports at national and local levels, and other vulnerability mapping exercises, such as the different hazard mappings under the NAPA implementation program.

Annexure 1 CASE 1

Bhutan to pay for others' climate sins

On May 4, 2007, Simon Denyer of Reuters News Agency covered an article titled 'Bhutan to pay for others' climate sins,' which highlights climate change issues in Bhutan. The article is reproduced here as it explains how Bhutan is suffering for having strict environmental policies despite not contributing anything to the global change in climate.

High in the Himalayas, the isolated mountain kingdom of Bhutan has done more to protect its environment than almost any other country.

Forests cover nearly three quarters of its land, and help to absorb the greenhouse gases others emit. Its strict conservation policies help to guard one of the world's top 10 biodiversity hotspots, often to the chagrin of its own farmers.

Yet Bhutan could pay a high price for the sins of others -- global warming is a major threat to its fragile ecosystem and the livelihoods of its people.

"Our farmers are paying a high price for our strict conservation policies," Agriculture Minister Sangay Ngedup told Reuters in an interview. "We are sacrificing a lot, but the world is not making a positive contribution to us."

"The effect of climate change and global warming is going to cause havoc to our ecosystem here."

The most dramatic threat is posed by what scientists call Glacial Lake Outburst Floods. As the Himalaya's glaciers recede, these lakes are forming and filling with melt water all along the mountain range, dammed by the rocks of glacial moraine.

In 1994, one of those lakes burst its banks in Bhutan, and unleashed a torrent of flood water which claimed 17 lives in the central Punakha valley, sweeping away homes, bridges and crops.

Some of Bhutan's glaciers are believed to be retreating at 20 to 30 metres a year. And as that glacial melt accelerates, 24 of Bhutan's 2,674 glacial lakes are in danger of bursting.

Some studies predict the wall separating two lakes in central Bhutan could burst as

early as 2010, unleashing 53 million cubic metres of water, twice the volume of the 1994 outburst.

“You get what is almost a mountain tsunami, which can wipe out anything in its path,” said Nicholas Rosellini, resident representative of the United Nations Development Programme.

The government, with the U.N.’s help, is beginning the delicate task of trying to lower water levels in some of the high risk lakes, by making holes in the moraine dams without causing the whole structure to burst.

Some people in remote places have been given radios to act as a rudimentary early warning system, and studies are being conducted to map the most vulnerable lakes and populations. But much remains to be done.

Economic Backbone

The retreat of Bhutan’s glaciers presents an even more formidable and fundamental challenge to a nation of around 600,000 people, nearly 80% of whom live by farming.

Bhutan's rivers sustain not only the country's farmers, but also the country's main industry and export earner -- hydro-electric power, mostly sold to neighbouring India.

For a few years, Bhutan's farmers and its hydro power plants might have more summer melt water than they can use. One day, though, the glaciers may be gone, and the "white gold" upon which the economy depends may dry up.

The threat led the government's National Environment Commission to a stark conclusion.

"Not only human lives and livelihoods are at risk, but the very backbone of the nation's economy is at the mercy of climate change hazards," it wrote in a recent report.

Scientists admit they have little solid data on how Bhutan's climate is already changing, but say weather patterns are becoming increasingly unpredictable.

There was no snow during the winter of 1998 and, even more rarely, snow in mid summer in the mountainous north in 1999. In August 2000 flash floods caused by torrential rains claimed dozens of lives.

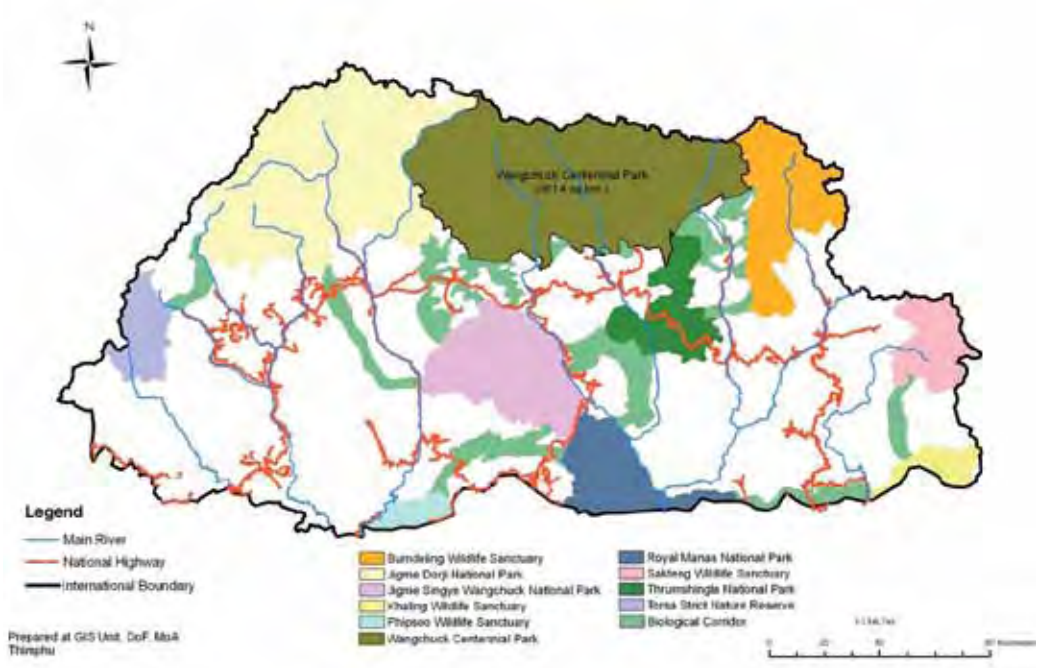
Droughts and landslides are likely to be increasingly commonplace concerns for Bhutan's mountain folk. Malaria, dengue and water-borne diseases like diarrhoea are also marching higher into the Himalayan foothills as temperatures rise.

"In places where there was no malaria, malaria is appearing in higher altitudes," said Dr Ugen Dophu, director of the Department of Public Health. "There is also a risk of epidemic outbreaks."

National Plan

Former King Jigme Singye Wangchuck made protection of Bhutan's rich environment a cornerstone of the country's philosophy of Gross National Happiness, the idea that lifestyle and values were as important as material gains.

A quarter of the country's 38,400 square km (14,800 square miles) is set aside as national parks or wildlife sanctuaries, and parliament has passed a law that forest cover should never fall below 60%.



Yet environmental protection does not come cheap, says minister Ngedup. Farmers would love to convert some of the forest to arable land, while many lose livestock and crops to depredation by wild boar, tigers, leopards, bears and barking deer.

Bhutan's government is drawing up a national plan to address the problems of climate change, with task forces looking at the effects on agriculture, forests and biodiversity, health, water resources and energy, and the risk of natural disasters.

But even the best planning in the world will not be enough if the predictions of the global Intergovernmental Panel on Climate Change come true.

"Even a slight increase of 1.5°C (2.7°F) could have a devastating impact on our ecosystem," said Ngedup. "It would change the whole way of life for humans, as well as animal species and plants."

Annexure 2 Case 2: Rural out-migration scenario in Khaling Gewog, eastern Bhutan

Non-climate drivers of change

There are several situations caused by non-climatic changes. One of the most pertinent issues is rural to urban migration and the government is keen to understand and ad- dress the issue. Jamyang Choda of Sherubtse College wrote a paper titled, "Rural out- migration scenario in Khaling Gewog, Trashigang, Eastern-Bhutan" following a survey in December 2011. A summary of the report is outlined below to understand the issue.

Rural out-migration scenario in Khaling Gewog, Trashigang, Eastern-Bhutan

A micro-level survey was conducted in Khaling gewog in December 2011 and data was collected from 210 households in the gewog. Generally out-migration in Khaling gewog was found to be very high with almost 50% of its registered population absent from the household for more than a year during the time of survey. It was also found that huge chunk of out-migrants constitutes of working age population (15-64) and

more than 70% had at least primary and above education. Most prominent reasons for leaving home were found to be socio-economic reasons such as family move, employment, education and marriage.

The flow of migration was found to be maximum towards urban hubs in Bhutan like Thimphu, Phuentsholing and Samdrup Jongkhar.

Materials and Methods Experimental site:

The gewog lying in the area of 154.5 km2 has 19 major villages and has 508 households with total population of 2,715 (Fig. 1). Barshong, Bremung, Rasung, Brekha, Beyphu/Tokaphu, Gomchu, Dewang, Kholdung, Dawjor, Lemi/Changjar and Jeri/Leza are the major villages of the gewog. Paddy, maize and wheat are the main crops grown in the gewog.

Results and discussion

Table 1 depicts the household member status during the time of survey (December 2012) in Khaling Gewog. Without considering the duration of absentees from the household, it was found that more than 50% of the registered household members were absent and only 49% of the registered household members were present in the household.

Member Status	Frequency	Percent
Present	1040	49.1
Absent	1076	50.9
Total	2116	100.0

Table 1. Household member status during the time of survey (irrespective of duration)
However, every household member absent from the household cannot be categorized as out-migrants without considering the duration of absence. Therefore, in order to exclude those individuals who were absent temporarily like students, going for pilgrimage, visiting family members, going for medical check ups, migration period threshold was kept as one year. In other words a person who has been absent from the particular household for more than one year was considered as out-migrants in this study.

Table 2 shows almost 50% of the people out-migrated from Khaling Gewog. With almost 50% of its registered population out of the gewog, the out-migration scenario seems to be high in the gewog. It confirms to the United Nations Human Development Report (UNHDR, 2009) that Bhutan is experiencing highest internal migration rate in the region with 6%.

Member Status	Frequency	Percent
Non migrants	1134	53.6
Migrants	982	46.4
Total	2116	100.0

Table 2. Migration status of the household members (Duration above one year)

Table 3 shows the general characteristics of out-migrants by sex, age and education level in Khaling gewog. It was found that comparatively there are more male out-migrants (54.2%) compared to their female counterparts (45.8%). Looking at the age group of the out-migrants it was found that 75.8% belong to working age group (15-64) and only 1.3% was above 65 years. Which means that huge chunk of working population has out-migrated elsewhere to work and earn their living. It would certainly lead to labor shortage in the community and in the recent years this problem has been vivid in most of the rural parts of Bhutan where most rural agricultural lands are left fallow without any cultivation. On the other hand urban places are observing rapid rise in population especially young peoples in search of jobs.

Widespread establishment of schools in Bhutan could be also important factors leading to rural out-migration. Today schools are established in every nook and corner of the country. As people get educated they gradually move out of rural areas and go to urban places in search of jobs. It was found that among out-migrants 30.7% didn't have any education, but almost 70% of the out-migrants have at least primary education and above.

According to literatures, reasons for migration can be clubbed into three categories; economic, socio-political and environmental. It seems that out-migration from Khaling gewog could be mainly credited to socio-economic reasons.

It was found that out-migration due to family move (32%) was the top most reason followed by employment (31%), marriage (20%) and education (10%). Family move refers to especially children who move along with their parents and marriage refers to women who move along with their husbands. This movement mainly happens for

unemployed and uneducated women. In terms of migration because of education, in Bhutan most of the higher education institutes are located away from gewog and rural areas. Therefore, once children complete their primary and lower secondary education level in their respective gewogs they move to other places to study. This finding also confirms to the findings of Rural-urban Migration Survey 2005 of Bhutan where it was found that socio-economic factors were the main determinants of rural urban migration.

Flow of migration in Bhutan is also similar to any other countries in the world were people migrate from rural to urban areas. As expected top five destinations of out-migrants from Khaling gewog are major urban areas in the country. Majority of the out-migrants have moved to Thimphu followed by Phuentsholing, Samdrup Jongkhar, Wangdue and Gelephu. All these towns except Wangdue are classified as A category towns in Bhutan. As per the PHCB 2005 Thimphu city has a population of 79,185 followed by Phuentshoing town with 20,537, Gelephu town with 9,199, Wangdue town with 6,714 and Samdrup Jongkhar town with 5,952 people. Thimphu is the capital of Bhutan and all the major offices are located there. Therefore, people from all walks of life move to Thimphu in search of job and carry out other official works. Besides Thimphu, Phuentsholing, Gelephu and Samdrup Jongkhar are the gateway to India and rest of the world for trade. Moreover these three towns constitutes of major manufacturing industries. Wangdue attracts people from different places in Bhutan mainly because of two mega hydro projects currently being constructed.

Table 3. Characteristics of out-migrants (N=982)

Characteristics	Percent
Sex	
Male	54.2
Female	45.8
Age group	
0-14	22.9
15-64	75.8
65 & above	1.3
Education level	
No education	30.7
Primary	26.6
High school	34.3
Diploma, degree & above	8.5

Annexure 3 Hydropower projects in Bhutan

The hydropower sector has been the highest contributor to the government exchequer for decades now and continues to do so. Almost all major hydropower project, with exception of the Basochhu project, are built in cooperation with the India which is also the only external market for all power produced in Bhutan. The power production pattern is predictable as all plants produce excess power in summer months when the rivers are roaring and running at its prime and as the rivers dry up in the winter months, the power production also dwindles.

As of 2011, the Bhutanese government supplied electricity to 60% of rural households, a significant increase from about 20% in 2003. Bhutan remains overall carbon-neutral and a net sink for greenhouse gases.

Some of the major hydropower projects include:

i. Chhukha Hydropower Plant

Chhukha Hydroelectric Project, Bhutan's first mega power project, with an installed

capacity of 336 MW, is located on the Wangchhu and uses the discharges of the Thimphu, Paro and Haa valleys. The Chhukha Hydropower Plant was financed by the government of India through an Agreement which was signed in 1974 between the two governments. The total cost of the project on completion was Nu.2,460 million. With the 336 MW installed capacity, the project generates over 1,800 million units annually.

ii. Basochhu Hydropower Plant

The construction of the project was financed by the government of Austria and the Royal Government of Bhutan after a preliminary design was carried out in 1994. The project was built in two stages; the upper stage with an installed capacity of 40 MW commissioned in 2005 at a total cost of Nu. 3,261 million. The upper stage plant of 24 MW has a mean annual energy generation of 105 million units. The lower stage plant with an installed capacity of 40 MW has a mean annual energy generation of 185 million units.

iii. Kurichhu Hydropower Plant

The first investigations for the Kurichhu Hydroelectric Project were undertaken in the early 1980s for meeting the energy needs of eastern Bhutan. The detailed project report was reviewed by the National Hydroelectric Power Corporation in 1993, based on which the government of India agreed to finance the construction of the 60 MW project on a turnkey basis in 1994. With an installed capacity of 60 MW built at a total cost of Nu. 5,600 million, the Kurichhu project generates over 380 million units and with its associated transmission network, it is today the only source of electricity for the eastern and central Dzongkhags of Bhutan.

iv. Tala Hydropower Plant

The Tala Hydroelectric Project is located just downstream of the Chhukha plant. Bhutan and the government of India entered into an agreement in 1996 to construct the project through financing from the government of India. The government of India funded the total project cost of Nu. 41,258 million, excluding the interest accrued during construction, on 60% grant and 40% loan basis as with the Chhukha and Kurichhu projects. The Tala project is the biggest hydropower plant in Bhutan with an installed capacity of 1,020 MW. It is rated to generate over 4,865 million units annually.

Some major upcoming projects include:

Punatsangchhu-I Hydroelectric Project

As of September 2014, the 1,200 MW (6 x 200 MW) Punatsangchhu-I Project between 7 km and 18.5 km downstream from the Wangduephodrang Bridge was under construc-

tion. It is funded 40% by Indian grant and 60 by loan. Construction began in November 2009 and its completion is expected by November 2018.

Punatsangchhu-II Hydroelectric Project

The construction of the 1,020 MW (6 x 170 MW) Punatsangchhu-II Project was ongoing as of September 2014. It is funded 40% by Indian grant and 60 by loan. Construction began in the year 2013 and its completion is expected by June 2017.

Mangdechhu Hydroelectric Project

As of September 2014, the construction of the 720 MW (4 x 180 MW) Mangdechhu project was ongoing. It is funded 40% Indian grant and 60 by loan. Construction began in the year 2013 and its completion is expected by September 2017.

Dagachhu Hydropower Project

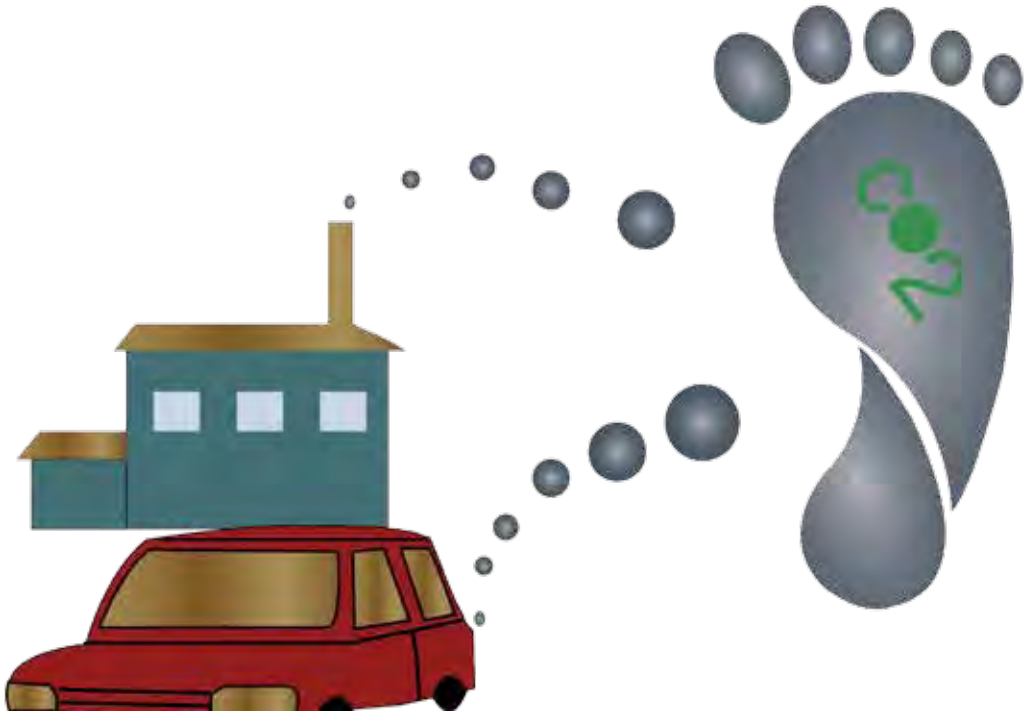
The 126 MW Dagachhu project is in Dagana District. Construction began in 2008 and its first generator was commissioned in February 2015.

Other projects

Bhutan also has many small hydro projects, with capacities ranging between 0.36 MW and12 MW. In 2008, there were 24 smaller mini-macro hydropower plants generating about 4 MW of energy altogether. The largest of these were in Rangjung in Trashigang, and Chhumey in Bumtahng. The country's first mini-hydroelectric facility was built in 1967 in Thimphu.

SL.	NO HYDROPOWER PLANT	CAPACITY
1	Basochhu Hydropower Plant	64 MW
2	Chhukha Hydropower Plant	336 MW
3	Kurichhu Hydropower Plant	64 MW
4	Tala Hydropower Plant	1020 MW
5	23 Plants (8 MW)	8 MW
Total		1,488 MW

Annexure 4 What's my "Carbon Footprint"?



A carbon footprint is "the total sets of greenhouse gas emissions caused by an organization, event, product or person."

All human activities have a carbon footprint. A carbon footprint measures the amount of carbon dioxide produced during an activity or through the creation of a product.

Carbon dioxide cannot be produced by natural occurrences and it is difficult to calculate the total carbon footprint as it requires huge amounts of data.

Greenhouse gases (GHGs) are emitted through all human activity like transportation, manufacturing goods, wood, roads, buildings and services. For simplicity, it is often expressed in terms of the amount of carbon dioxide, or its equivalent of other GHGs, emitted.

Carbon footprint is one of a family of footprint indicators, which also includes water foot- print and land footprint.

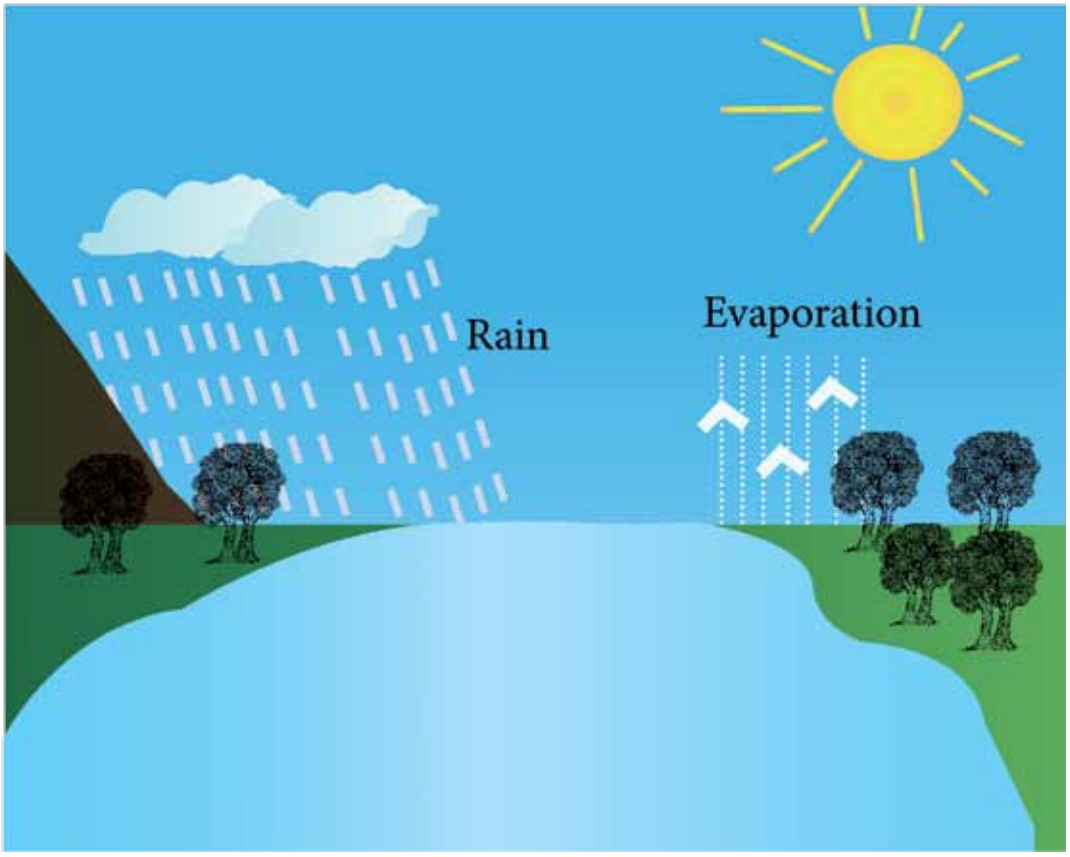
The carbon footprint of an individual, organization or a nation can be measured by undertaking a GHG emissions assessment or other calculative activities denoted as carbon accounting. Once the size of a carbon footprint is known, a strategy can be devised to reduce it, e.g. by technological developments, better process and product management, changed Green Public or Private Procurement (GPP), carbon capture, consumption strategies, carbon offsetting and others.

Several free online carbon footprint calculators exist. These websites ask you to answer more or less detailed questions about your diet, transportation choices, home size, shopping and recreational activities, usage of electricity, heating, and heavy appliances such as dryers and refrigerators, and so on. The website then estimates your carbon footprint based on your answers to these questions.

The mitigation of carbon footprints through the development of alternative projects, such as solar or wind energy or reforestation, represents one way of reducing a carbon footprint and is often known as carbon offsetting.

The main influences on carbon footprints include population, economic output, and energy and carbon intensity of the economy. These factors are the main targets of individuals and businesses in order to decrease carbon footprints. Scholars suggest the most effective way to decrease a carbon footprint is to either decrease the amount of energy needed for production or to decrease the dependence on carbon emitting fuels.

Annexure 5 Hydrological cycle or Water cycle



The water cycle explains the movement of water, which is always changing its form from liquid to vapor to ice to water again. This cycle of water has been going on since forever and life on earth is dependent on this cycle of water movement.

Since water is always changing its state, there is no starting point of water cycle. The sun drives the water cycle. It heats up the water in the oceans and the surface water evaporates as vapor into the air. The vapor rises into the air where cooler temperature causes it to condense into clouds. Air currents move the clouds around the globe, and cloud particles collide, grow, and fall out of the sky as precipitation. Precipitation can be in the form of rain, hailstone, or snow.

The precipitating snow accumulates as ice caps and glaciers. When temperatures rise, the snow melts and feeds into rivers, which ultimately runs into the oceans once again.

The oceans - a storehouse of water

The water cycle is always happening. But more than the volume of water that is involved in the water cycle at any given point of time, there is much more water 'in storage' in the oceans.

It is estimated that of the 332,600,000 cubic miles (mi^3) (1,386,000,000 cubic kilometers (km^3)) of the world's water supply, about 321,000,000 mi^3 (1,338,000,000 km^3) is stored in oceans. It is about 96.5%. It is also estimated that the oceans supply about 90% of the evaporated water that goes into the water cycle.

Evaporation

Evaporation is the process by which water changes from a liquid to gas or vapor. It is because of evaporation that there exists atmospheric water vapor. Studies have shown that the oceans, seas, lakes, and rivers provide nearly 90% of the moisture in our atmosphere via evaporation, with the remaining 10% being contributed by plant transpiration. Just as human release water vapor when they breathe, plants also release water vapor to the atmosphere but in case of plants, the term used is 'transpire' and not 'breath'.

The sun, which is the source of heat energy, is necessary for evaporation to take place. The heat energy breaks the bonds that hold water molecules together and when it reaches the boiling point (212° F, 100° C), evaporation takes place.

Precipitation

Precipitation is water released from clouds in the form of rain, freezing rain, sleet, snow, or hail. It is the primary connection in the water cycle that provides for the delivery of atmospheric water to the Earth. Most precipitation falls as rain.

Condensation

Condensation is the process by which gas or vapor changes into liquid. It is the opposite of evaporation.

It generally occurs in the atmosphere when warm air rises, cools and looses its capacity to hold water vapor. As a result, excess water vapor condenses to form cloud droplets.

Condensation is crucial to the water cycle because it is responsible for the formation of clouds. These clouds may produce precipitation, which is the primary route for water to return to the Earth's surface within the water cycle.

Sublimation

Sublimation describes the process of snow and ice changing into water vapor without first melting into water. Sublimation is a common way for snow to disappear in certain climates.

It is not easy to actually see sublimation happen, at least not with ice. One way to see the results of sublimation is to hang a wet shirt outside on a below-freezing day. Eventually the ice in the shirt will disappear.

Annexure 6 Efforts of Bhutan: Some highlights of the NAPA document

Status of 2006 NAPA Priority Projects

Status of three NAPA projects under implementation

Of the nine priority activities identified in the 2006 NAPA, the following three are under implementation with financing from the LDC Fund and other donors:

1. Artificial lowering of Thorthormi lake
2. GLOF hazard zoning (Pilot scheme- Chamkhar Chu basin)
3. Installation of early warning system on the Pho Chu river basin

These adaptation priorities are being implemented under the project 'Reducing climate change induced risks and vulnerabilities from glacial lake outburst floods (GLOF) in the Punakha-Wangdue and Chamkhar valleys funded by the LDCF (US$ 3.4m), with co-financing from the Royal Government of Bhutan, the United Nations Development Program, the Austrian Development Agency and the World Wildlife Fund (WWF-Bhutan).

The main objective of the project is to enhance adaptive capacity to prevent climate-change induced GLOF disasters in Bhutan. Implementation started in 2008 with expected project duration of 5 years.

By the first quarter of 2012, the implementation status under each of the four project outcomes is as follows:

Outcome 1: Improved national, regional, and local capacities to prevent climate change- induced GLOF disasters in the Punakha-Wangdue and Chamkhar Valleys

- GLOF hazard zonation and mapping has been completed along with identification of high-risk zone and evacuation sites in the Punakha-Wangdue and Chamkhar valleys.

- In terms of capacity development, the project has established District Disaster Management Committees, District Disaster Management Awareness and Planning Teams, and Gewog Disaster Management Committees in all three districts covered by the project. The project has trained these committees in Community Based Disaster Risk Management (CBDRM) including GLOF and climate risk management.

- GLOF and flood awareness has been promoted through the media. This includes the development and dissemination of a hazard awareness map and publishing of a handbook on Emergency Safety and First Aid.

Outcome 2: Reduced risks of a GLOF from Thorthormi Lake through an artificial lake level management system

- The project was able to successfully lower the Thorthormi Lake level by 504 centimeters and 366 and 508 centimeters for two subsidiary lakes adjacent to Thorthormi Lake achieving the overall target of reducing the lake level by 5m in October 2012.

Outcome 3: Reduced human and material losses in vulnerable communities in the Punakha-Wangdi Valley through GLOF early warnings

- The manually operated GLOF Early Warning System is operational with focal persons provided with mobile phones in 21 particular vulnerable communities to warn population living downstream vulnerable area and will be the backup system to the Automatic GLOF EWS installed. The installation of the automatic GLOF Early Warning System in the Punakha-Wangdue Valley is complete and operational since September 2011.

- Since the budget from the LDCF project was not enough to cover the installation of a comprehensive GLOF EWS system for the entire Punatsangchhu valley and due to the urgency of the requirement, the Government installed 13 additional EWS stations along the Punakha-Wangdur valley further downstream near the Punatshangchu Hydro Electricity projects by incorporating the additional costs into the loans borrowed for the hydropower projects (Nu. 20 million co-financing from PHPA).

Outcome 4: Enhanced learning, evaluation and adaptive management

- Under this outcome, lessons learned from the project are being captured and disseminated through, amongst other, the Adaptive Learning Mechanism (ALM) and knowledge-sharing with other GLOF-prone areas. Project case studies and factsheets identifying project challenges, lessons learned and solutions have been made available on the ALM in 2008, 2010 and 2011.

- A number of media and advocacy materials have also been published to generate public awareness on the issues and challenges associated with climate change and the risks of GLOF.

Annexure 7 An example from Merak & Sakteng

The government is helping the people to adapt to the changing climate in multiple ways. Under the agriculture sector, the government continues to provide high yielding varieties and climate resilient crops to farmers among many other initiatives. The government also trains farmers to adapt to new and more efficient practices. In such an en- deavor, the government built 32 greenhouses for the highland Brokpa community to ensure that they could grow different types of vegetables beating altitudes.

The article below was written by Tshering Dema and appeared in the monthly RNR newsletter of February 2015.

Greenhouses to encourage Brokpas venture into vegetable production

Thirty-two greenhouses have been established in Merak and Sakteng gewogs under Trashigang Dzongkhag through a pilot project called 'Agro-tourism development in Merak and Sakteng'. The project was implemented by the Sakteng Wildlife Sanctuary (SWS) with financial support of Nu 14.35 million from Market Access and Growth Intensification Project (MAGIP).

The greenhouses were established as conservation incentives to avail vegetables for Brokpas' consumption while also helping them in enhancing their agricultural production to meet the emerging vegetables demand from tourists and hotels in Trashigang. As the Brokpas have been depending mostly on their cattle for living and income, such establishment is expected to provide them an alternative income-generating source.

Thirteen green houses at Merak and 14 at Sakteng were provided, of which 11 were for communities, one each for school and the Park Range Office and one for Dungkhag of- fice in Sakteng. At Joenkhar, two green houses were provided while another three were established for three schools at Phongmey.

According to SWS, the green houses were issued on a cost-sharing basis to interested households for vegetable production, which were identified during a consultative meeting. For each greenhouse, Nu. 64000 was provided through the project while labor contribution were borne by the beneficiaries.

Technical support to fix and monitor the maintenance of green house structure whenever required will be provided by SWS. The park office has also trained the beneficiaries on vegetable production and management in collaboration with the Dzongkhag Agriculture Sector.

Almost all vegetables and crops like cauliflower, cabbage radish, carrot, broccoli, potato, beans, maize, wheat and barley can be grown in both the gewogs. The beneficiaries are expected to produce the green vegetables and sell the surplus to the tour operators visiting their gewogs.

With green houses establishment, the Brokpas are happy and expresses their appreciation to the Ministry for supporting them. They shared that with such help they hoped to have something green always to eat despite seasonal changes and be able to grow vegetables even during winter.

Mr. Kezang Jigme from SWS said that the project would provide an opportunity to enhance the livelihoods of the people in the two gewogs while also making them their conservation partners. He added that this is the first phase of the project. If found successful, MAGIP and other donor agencies may support to further expand and upscale the activities.

In the past, both gewogs were restricted to visitors. It was formally opened to tourism in September 2010. Following the opening, many eco-tourism activities are being sup- ported by government and donors such as the construction of campsites, guest houses, home stays, garbage pits, signages along the trek to provide opportunities for the Brokpa community.

Annexure 8 Green House Gases: Some examples from local level

The green house gas emission has been gradually increasing in the country although the country has a rich sequestration capacity, which means carbon absorption capacity of the country. The constitution stipulates that the country shall always have a minimum of 60% of the country's land area under forest cover for all times to come. The government has also declared in 2009 to remain a net carbon sink (also called carbon neutral) for all times to come.

Bhutan is prioritizing to harness its hydropower as clean energy, which means without emitting GHG to the atmosphere and the government is prioritizing to register most of the hydropower projects as Clean development Mechanism (CDM) projects. The Daga- chu hydropower project was registered as the first CDM project in the country.

The above table presents total GHG emissions by sources and removals by sinks for the year 2000.

On April 14, 2010, the news site, Environmental Protection, wrote an article titled 'Bhutan Hydropower Project to Lower GHG Emissions in South Asia.' The article explains the significance of the power project and how it would help lower emission in the region.

Bhutan Hydropower Project to Lower GHG Emissions in South Asia
April 14, 2010

A hydropower project supported by the Asian Development Bank (ADB) and the governments of Austria and Japan has been registered as the first cross-border initiative under the Clean Development Mechanism (CDM). The 114-megawatt Dagachhu hydropower project in Bhutan will promote cross-border power trade and reduce greenhouse gas (GHG) pollution in the South Asia region.

Aimed at encouraging developing nations to invest in GHG emission reduction projects, the CDM has been established under the United Nations Framework Convention on Climate Change.

Part of ADB's Green Power Development Project for Bhutan, the hydropower project is expected to reduce carbon dioxide (CO_2) emission by about 500,000 tonnes per year, especially through exports to India, which relies heavily on coal-fired power plants for its electricity generation. The project will help prevent carbon emission in India while generating additional revenue from CDM to make the project viable in Bhutan.

"ADB is pleased that the Dagachhu hydropower project has been registered for CDM. It will encourage regional trade in clean and renewable energy while contributing to environmental protection," said Thevakumar Kandiah, director of ADB's South Asia Department.

A notable feature of the hydropower project is participation by multiple Bhutanese and international stakeholders, marking it as the first public-private partnership in infrastructure investment in Bhutan. The special company established to manage the project is led by Bhutan's state-owned utility, Druk Green Power Corporation (DGPC) and India's leading energy company, Tata Power Company.

The total cost of the project is around $200 million. ADB has committed an $80 million loan to the project, of which $51 million from ADB's Ordinary Capital Resources is financed for debt while the balance of $29 million is used for DGPC's equity. Co-financing is being provided by the National Pension and Provident Fund of Bhutan and the Raiffeisen Zentralbank Österreich AG (RZB) of Austria through export credit of Österreichis- che Kontrollbank AG (OeKB).

The Austrian government through the Austrian Development Agency has provided engineering support toward the project while ADB is providing assistance with overall capacity development to help strengthen policy and institutions of the Bhutan power sector.

"This project will deliver economic and social benefits on wider fronts. The project's royalties will contribute to low-cost electricity supply to rural domestic customers in Bhutan and at the same time provide the government of Bhutan with a long-term revenue stream to support its development programs for poverty alleviation," said Kaoru Ogino, senior energy specialist of ADB's South Asia Department.

The project structuring was promoted with support from the Japan Special Fund, established by the government of Japan and administered by ADB. It has also received as- sistance from ADB's Technical Support Facility under its Carbon Market Initiative during the process of the CDM registration.

GHG Sources & Sinks	Total (CO2, CH4 and N2O), CO_2-equiv	GHG, Giga grams						
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
1 Energy	270.23	260.31	0.38	0.01	1.76	9	1.30	0.96
2 Industrial Processes	237.76	237.76	0.0	0.0	0.0	0.0	1.69	0.1
3 Solvent & Other Product Use	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 Agriculture	1005.30	0.0	25.85	1.49	0.2	0.41	0.0	0.0
5 Land-Use Change & Forestry	-6,309.6	-6,309.6	0.0	0.0	0.0	0.0	0.0	0.0
6 Waste	46.27	0.0	2	0.01	0.0	0.0	0.0	0.0
Total GHG Emissions, excluding LUCF	1,559.56	498.07	28.23	1.51	1.78	9.41	4.7	1.05
Total GHG Emissions, including LUCF	**-4,750.04**	**-5,810.9**	**28.23**	**1.51**	**1.78**	**9.41**	**4.7**	**1.05**

Annexure 9 Glossary of Acronyms

- ABI - Association of Bhutanese Industries
- ABTO - Association of Bhutanese Tour Operators
- BAFRA -Bhutan Agriculture and Food Regulatory Authority
- BAP -Biodiversity Action Plan
- BCCI -Bhutan Chamber of Commerce and Industry
- BHU -Basic Health Unit
- BPC -Bhutan Power Corporation
- BRT -Bus Rapid Transit
- BTC -Bhutan Tourism Corporation
- BTFEC - Bhutan Trust Fund for Environment and Conservation
- CAB -Construction Association of Bhutan
- CAN -Calcium Ammonium Nitrate
- CCD - Climate Change Division
- CCU - Climate Change Unit
- CDM - Clean Development Mechanism
- CLSH -Climate Summit for a Living Himalayas
- CNG -Compressed Natural Gas
- CNR -College of Natural Resource
- CO -Carbon Monoxide
- CO_2 -Carbon Dioxide
- CoRRB -Council of Renewable Natural Resource Research of Bhutan
- CSO –Central Statistical Organization
- CTEM - Cleaner Technology and Environmental Management
- DAMC -Department of Agriculture Marketing Cooperatives
- DDM -Department of Disaster Management
- DGM -Department of Geology and Mines
- DGPC -Druk Green Power Corporation
- DLG -Department of Local Governance
- DoA -Department of Agriculture
- DoE -Department of Energy
- DOFPS -Department of Forests and Park Services
- DoI -Department of Industry
- DoL -Department of Livestock
- DoPH -Department of Public Health
- DoT -Department of Trade
- DRE -Department of Renewable Energy
- EA -Environment Assessment
- EIA -Environment Impact Assessment
- EMD -Environment Monitoring Division
- ESD -Environment Service Division
- EU -European Union
- FAO -Food and Agriculture Organization
- FMU -Forest Management Unit
- FYM -Farmyard Manure
- GCMs -General Circulation Models
- GDP -Gross Domestic Product
- GEF -Global Environment Facility
- GHG -Greenhouse Gas
- GLOF -Glacial Lake Outburst Flood
- GNH -Gross National Happiness
- GNHC -Gross National Happiness Commission
- Ha -Hectare
- HCFC -Hydrochloroflurocarbons
- HFCs -Hydrofuorocarbons
- HMSD -Hydro Metrological Service Division

- ICIMOD -International Center for Integrated Mountain Development
- ICS -Information Communiction and Services
- INC -Initial National Communication
- IPCC -Inter-governmental Panel on Climate Change
- JDWNRH -Jigme Dorji Wangchuck National Referral Hospital
- LED -Light Emitting Diodes
- LPG -Liquefied Petroleum Gas
- MoAF -Ministry of Agriculture and Forests
- MoE -Ministry of Education
- MoEA -Ministry of Economic Affairs
- MoHCA -Ministry of Home and Cultural Affairs
- MoIC -Ministry of Information and Communication
- MoWHS -Ministry of Works and Human Settlement
- MSTCCC -Multi Sectoral Technical Committee on Climate Change
- MSW -Municipal Solid Waste
- MT -MetricTonnes
- MU -MegaUnits
- MW -Megawatts
- NAPA -National Adaptation Program of Action
- NBC -National Biodiversity Center
- NCCC -National Climate Change Committee
- NCD -Nature Conservation Division
- NEC -National Environment Commission
- NECS -National Environment Commission Secretariat
- NRDCL -Natural Resources Development Corporation Limited
- NSB -National Statistical Bureau Engineering Division
- PPD -Policy Planning Division
- REMP -Rural Electrification Master Plan
- REP -Renewable Energy Policy
- RGoB -Royal Government of Bhutan
- RNR -Renewable Natural Resources
- RNR-RC -Renewable Natural Resource Research Center
- RSPN -Royal Society for Protection of Nature
- RSTA -Road Safety and Transport Authority
- TCB -Tourism Council of Bhutan
- UNDP -United Nations Development Program
- UNEP -United Nations Environment Program
- UNFCCC -United Nations Framework Convention on Climate Change
- UWICE -Ugyen Wangchuck Institute for Conservation and Environment
- V&A -Vulnerability and Adaptation
- WB -World Bank
- WCD -Wildlife Conservation Division
- WCP -Wangchuck Centennial Park
- WHO -World Health Organization
- WR -Water Resources
- WWF -World Wildlife Fund

Project funded by the European Union

ICIMOD

About ICIMOD

The International Centre for Integrated Mountain Development, ICIMOD, is a regional knowledge development and learning centre serving the eight regional member countries of the Hindu Kush Himalayas – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – and based in Kathmandu, Nepal. Globalization and climate change have an increasing influence on the stability of fragile mountain ecosystems and the livelihoods of mountain people. ICIMOD aims to assist mountain people to understand these changes, adapt to them, and make the most of new opportunities, while addressing upstream-downstream issues. We support regional transboundary programmes through partnership with regional partner institutions, facilitate the exchange of experience, and serve as a regional knowledge hub. We strengthen networking among regional and global centres of excellence. Overall, we are working to develop an economically and environmentally sound mountain ecosystem to improve the living standards of mountain populations and to sustain vital ecosystem services for the billions of people living downstream – now, and for the future.

Rural Livelihoods and Climate Change Adaptation in the Himalayas (Himalica)

The Rural Livelihoods and Climate Change Adaptation in the Himalayas (Himalica) Initiative is financed by the European Union and aims to support poor and vulnerable mountain communities in the Hindu Kush Himalayan region in mitigating and adapting to climate change. This Initiative will work to reduce poverty, increase the resilience of local communities, and ensure the equitable and sustainable wellbeing of men and women in the Hindu Kush Himalayas by building the capacity of local institutions, promoting new livelihood options, and encouraging regional cooperation in the promotion of equitable approaches to sustainable mountain development.

Bhutan Media & Communications Institute

A vibrant democracy can only be sustained by an active participation of citizens through a process of open democratic discourse taking place at all levels of the society and the media has to become a platform for public discourse.

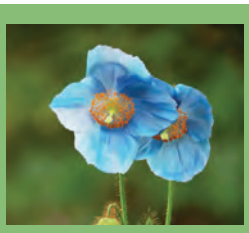
Therefore, BMCI was founded in 2011 as a Social Enterprise to build the capacity of the media professionals, focal persons, local leaders, media planners and communities to understand the role of media and learn to communicate issues of concern to them.

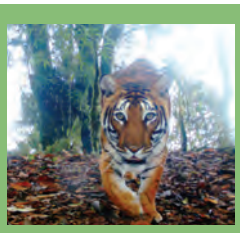
BMCI is ICIMOD's Knowledge Partner in Bhutan. BMCI has been engaged in research and development of local Knowledge products, translation into local language, organising media workshops and awareness campaign on Climate Change and celebration of ICIMOD's International Days in Bhutan with relevant local partners.

Project funded by the
European Union

ICIMOD

BMC
Bhutan Media & Communications Institute



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