

ENVIRONMENTAL SCIENCE

CLASS TEN



Department of Curriculum and Professional Development
Ministry of Education
Thimphu

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Advisor

Dr. Lam Dorji, Executive Director, RSPN, Thimphu
Kesang Choden Dorji, Director, REC, Paro
Technical Advisory Committee (TAC), ES Project

Concept design

Surjay Lepcha, Curriculum Officer, REC, Paro
Wangpo Tenzin, Curriculum Specialist, REC, Paro

Technical Experts and Compilation

Dr. Shailaja Ravindranath, Regional Director, CEE India
Pramod Kumar Sharma, Programme Coordinator, CEE India
Wangpo Tenzin, Curriculum Specialist, REC, Paro

Editors

Wangpo Tenzin, Curriculum Specialist, REC, Paro
Surjay Lepcha, Curriculum Officer, REC, Paro
Ugyen Lhendup, Environmental Education Programme Officer, RSPN, Thimphu

Proof reading

Wangpo Tenzin, Curriculum Specialist, REC, Paro

Illustrations & Lay out design

Surjay Lepcha, Curriculum Officer, REC, Paro

Copy editing

Sharda Rai, Subject Coordinator, BCSEA, Thimphu



FOREWORD

The purpose of education is to develop student's minds and equip them with relevant knowledge and competencies crucial of life to deal with realities of life so that they can lead a happy and successful life. Students have to be taught to think, understand, integrate, and to evaluate diverse situations they face in their lives as the future of the country - politically, socially, culturally and economically rests on the contributions of students. This pre-empts that education be visionary and future-oriented. Educational innovations, therefore, are an imperative, not an option.

One of the greatest challenges of the 21st century is sustainability of natural resources. Towards this, students will be required to discover how to meet the needs of the human population while protecting the capacity of the Earth to sustain human and other life forms. It is crucial to help them understand and recognize that the quality of our environment determines the long-term economic and social health of the country.

As envisioned in the Vision 2020 document of Bhutan, environmental science course is another important subject which introduces students to career opportunities in the environmental and natural resource fields through curriculum diversification. The topics in this course should provide opportunities to incorporate effective educational approaches, such as utilizing current issues, connecting with community resources and engage students in research and project-based learning. In addition to making concepts relevant to the students, integrating current issues into curriculum assists students in becoming global citizens who understand connections between their environment, economy, and society through global perspectives. Service and project-based learning helps students connect with their community, gain a sense of accomplishment, and transfer classroom learning to real-world situations. As such, the essence of environmental science should be an integral component of any educational programme under the education system in Bhutan.

Understanding of environmental science and practices of the basic laws of the subject should find link to the tertiary level and transcend to career opportunities for learners. The diverse environmental science learning experiences and opportunities should engender love and care for the natural world in every learner and to be responsible and educated stewardship of the beautiful environment that we live in. This is our insurance for transferring on the natural wealth intact and healthy as used by the present generation to the many future generations.

The Ministry of Education finds no better time and occasion to launch this maiden Environmental Science curriculum than on the joyous occasion of the 60th Birth Anniversary of our beloved Fourth Druk Gyalpo, His Majesty Jigme Singye Wangchuck, a laureate of the Champion of the Earth 2005 to launch the new curriculum. It also serves as a reminder to the Ministry of the crucial responsibilities it upholds, in shaping the future of Bhutan by rededicating ourselves to the services of Tsa Wa Sum.

Minister
Ministry of Education

Introduction

Environmental Science is the study of environmental systems, the threads of life that every life form is linked with. It offers an integrated, quantitative, interdisciplinary and students-centered approach. The multidisciplinary nature of the study integrating physical, chemical, biological and social sciences, peppered with cultural and spiritual belief of human societies brings the holistic perspective, making it unique and interesting among the widely taught school courses. It connects the concepts and principles of various sciences to the real life situations promoting practice. This quality of direct applicability attracts students to environmental science course as it touches students' lives enhancing its value to students and the society as well. This also makes environmental science easy to engage students in the demanding process of learning compared to other traditional disciplines.

The study of Environmental Science provides an insight into various interrelationships, helps analyze the actions of human societies and guides policies and practices to improve the quality of environment on the planet for the wellbeing of all life forms including humans.

The study exposes students to fundamentals of physical, chemical, geological, biological, and social processes that interact to shape the environments of the planet that we inhabit. Stemming from this is the holistic understanding of the environmental systems which students gain, promoting them to draw and relate their learning from other disciplines. This helps students to connect various processes in the system together, which is extremely important in treating challenges as a whole and not in isolation.

The study of environmental science relies heavily on applied-learning, hence it will equip students with skills and competencies that are necessary to explore, analyse and build knowledge based on various aspects of environment. It engages students in hands on experiences, exposes them to complex challenges, encourages critical thinking, and assists them to develop problem solving skills. Since field studies require students to work together, it promotes team skills on one hand and leadership qualities on the other. With this array of skills, environmental science prepares students for a wide variety of career opportunities. The training that students undergo helps them in their general education as well.

Ultimately, the study of environmental science aims to empower students to make right choices for sustainable future with global perspectives, and transform them to become responsible and productive citizens of the 21st century world.

The Goal

The goal is to build a cadre of young people equipped with knowledge, skills and values to engage them in the conservation of natural heritage, promoting sustainable and equitable use of natural resources, preventing all forms of environmental degradation in the pursuit of GNH.

Objectives

- i. To develop knowledge and skills for conserving the natural heritage including rich biodiversity.
- ii. To equip them with tools for addressing sustainable production and utilization, and equitable distribution of natural resources.
- iii. To instil positive attitudes and values towards the environment so that they demonstrate environment friendly behaviour in the sustainable management of the environment.
- iv. To motivate them to take actions towards environmental conservation and uphold the principles of GNH.
- v. To empower them to make right choices for sustainable future with global perspectives and transform them to be responsible and productive citizens in the 21st century world.
- vi. To contribute towards the general education of learners.

The Design

The development of environmental science curriculum is guided by six principles as illustrated in Figure 1. These six criteria collectively are essential to students to develop relevant environmental knowledge, skills, values, and attitudes.

- i. **Environment in totality:** The environment integrates almost all disciplines—physical, biological, social, cultural and spiritual. The holistic understanding of the environmental systems is important for students to draw and link their learning from other disciplines, and for them to connect various processes in the system together and not in isolation. The understanding of interrelationships helps students to identify environmental concerns and enables them to assess alternative solutions for resolving the challenges.
- ii. **Inter-disciplinary:** The environmental science, by its nature, contains the concepts and principles from different disciplines, such as biology, geography, physical sciences, social sciences, mathematics, history, and economics and so

on. The study of environmental science, therefore, needs to provide students with the opportunity to extend their understanding of the disciplines better. Environmental science curriculum, therefore, must draw the essential concepts and principles from these disciplines.

- iii. **Life long process:** Environment is a part of everyday life as people live in it and live by it. There needs to be continuous interaction and interdependence of all living things with each other and the habitat. Environmental science perceives the learning about the environment as a continuous life long process, beginning at the pre-school and continuing through formal and non-formal stages, for people to take conscious decisions towards the use, preservation and conservation of the environment.

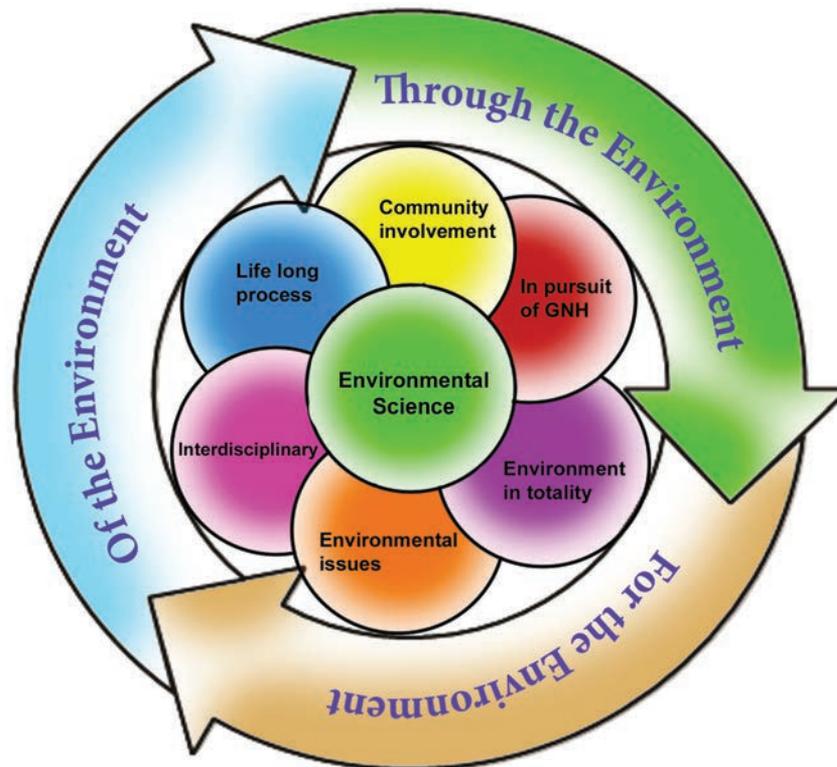


Figure. 1. Principles of Environmental Science Curriculum

- iv. **Environmental issues-based:** The diverse learning context and approaches are crucial for the meaningful learning. Students should explore the natural environment by engaging themselves in hands-on activities, including the laboratory activities, to gain deeper understanding of the issues and concerns. Students should be able to examine major environmental issues from local, national, regional and global spheres with focus on the current emerging

environmental situations. The content need to be effectively conveyed when embedded in a local context, giving students a chance to explore and experience what is around them. Effective environmental education should empower students with skills to address environmental issues, with a sense of personal and civic responsibility.

- v. Pursuit of GNH: The GNH, which is the country's developmental philosophy accords importance to the environment. Therefore, environmental sciences while deliberating on the elements of the environment need to incorporate the principles of GNH in the delivery process of the content.
- vi. Community involvement: It is evident that the local communities are the custodians of the environment; and they possess wider knowledge about the local environment passed on through many generations. Communities also play a major role in local environmental conservation. The study, therefore needs to engage students with the local communities to gain better understanding of the local environment. This understanding should serve as platform to apply to wider context.

The Strands

Strands represent major themes. Strands also show logical flow of learning, starting from the concepts to environmental concerns to management to sustainability. The following are the strands for Environmental Science:

- **Strand 1: Systems in Nature**
- **Strand 2: Environmental Issues and Concerns**
- **Strand 3: Natural Resource Management**
- **Strand 4: Sustainable Development**

Strand 1: Systems in Nature

This strand gives the basic understanding of the ecosystem, its structure, and function. Students will learn basic concepts like food webs, trophic levels, energy flow, biogeochemical cycles, etc. They will learn about the organisation in ecosystem, types of ecosystem, the diversity of flora and fauna, and the adaptations made for survival. They develop an understanding of how an ecosystem functions and its carrying capacity. Students will recognise that the components of ecosystem and their interdependency and that the nature maintains a balance. They will realise that any imbalance in nature will lead to degradation of environment and that the earth's resources are limited.

Strand 2: Environmental Issues and Concerns

From the understanding of balance in ecosystems, students move on to learning about imbalances, and how these imbalances are created. They understand the interactions of human societies with environment for subsistence, livelihood and luxury. They also realise how human societies over the years have over-harvested the Earth's resources, and have interfered in the ecosystem processes creating imbalance in nature. Students will study the consequences of such imbalance, such as the environmental degradation, depletion of natural resources, various types of pollution and how incidences of natural disasters are increasing due to such interferences. This strand gives students a knowledge of the issues and concerns of environment and human relationship with nature.

Strand 3: Natural Resource Management

Students after recognising the issues of environment caused by human actions will now move on to learn how to manage the ecosystem and its resources. They understand the meaning of terms like conservation, management. They are also introduced to the ways and methods including technologies to solve the some of the problems arising out of the human actions. Students will learn to respect indigenous knowledge and appreciate traditional practices in the management of natural resources. They will also appreciate the steps taken by the government, communities, other institutions and individuals to protect the environment and its resources like biodiversity, soil, land, water, and air. Students will be motivated to participate in the activities resulting in the conservation of resources, such as energy conservation, soil water management, and waste management. They will also learn how their lifestyle affects the environment and increase the ecological foot print. Students will realise that they need to change their consumption pattern.

Strand 4: Sustainable Development

Students after learning the conservation and management methods will understand the concepts of development, its measurement, indicators, how environment is a part of development and not an interference. Students will appreciate the contribution of natural resources in the development of the country. They will also realise that human resources are very important in the growth of the country. Finally, the concept of sustainable development makes them understand the fact that environment, economics and society are the three major pillars needed to sustain any development and must be seen in totality. They will link sustainable development concepts to GNH, the development philosophy of Bhutan.

The perspective across the strands

From local to global

As the learning progresses from local environment to regional to national to global understanding, students realise that the concerns at local level impacts the nation and the world at large. They realise that the actions at the local level is important and they as students can contribute significantly to the process of environmental conservation.

From understanding to action

Since environmental science is application oriented, approaches to its teaching and learning are extremely important. The curriculum recommends development of various skills among students through activity-based approach including indoor, outdoor activities, hands on experiences, experiments, case studies, surveys, debates, discussion, team work, folk art and so on. It encourages teachers to engage students continuously in experimentation, investigation, and project works, designing of different experiments and associated principles, reasoning and arguments with scientific evidence, analyzing and interpreting data to develop coherent knowledge and understanding.

The curriculum emphasizes techniques of focused observation, recognition of a scientific questioning that can be investigated, the need for repeated measurements and skills in devising measurement processes, ways of recording data and representing data for analysis; (e.g. understanding 'sample size' in making observations in the field), and reporting.

In the early stages of student development, the curriculum recommends only strand 1, which understands environment using all their senses and appreciate the component of environment and develop a sense of respect towards them. The curriculum does not recommend introduction of any concerns and issues and management related teaching at that level. Once students develop the sense of value, they at the later stages will develop concerns towards the natural resources and come forward to take actions for their protection is what the curriculum believes.

Assessment

Educational assessment is a process of documenting, usually in measurable terms, the outcomes of knowledge, skills, attitudes and beliefs of students. This includes the processes of gathering and interpreting information about the progress of students' learning. In order to be valuable to individuals and organization, an assessment must be accurate and objective. Students should be well informed about, what will be assessed and how will they be assessed. Teachers can play an important role in students' achievement by effectively

monitoring their learning and giving learners the feedback on how they can improve.

Assessment is an integral part of teaching and learning process because it:

- i. helps improve students' learning through the provision of feedback and comments.
- ii. enables teachers to identify which strategies and resources work best.
- iii. empowers students to be self-reflective learners who monitor and evaluate their own progress.
- iv. assesses the strengths and weaknesses of students in learning, as well as in the personal development, and identify their special needs and help them to realise their innate talents.
- v. guides teachers to incorporate varied teaching and learning strategies and resources to ensure that the students are improving their academic learning, as well as, in their personal development.
- vi. provides evidences to grade and promote students to the higher level.
- vii. helps to inform parents and other stakeholders about the achievements of students.

I. Components of Assessment in Environmental Science

The assessment in environmental science focuses on measuring students' performance and achievements, based on the three domains of environmental science learning objectives, which are briefly described below.

i. Content knowledge

Through this domain, learners will be assessed on the following areas:

Systems in Nature: students' understanding of physical and ecological systems, such as, interdependent relationships in ecosystems; cycles of matter and energy transfer in ecosystems; interaction among Earth's major systems; the roles of water in Earth's surface processes; climate change and the effects of human activities on Earth's climate; and conservation of energy and energy transfer. This area also includes humans as variables in ecosystems and Earth systems, which includes concepts associated with: the ecosystem services and natural capital on which humans (and all life) depend; adverse human impacts to these systems; and humans as agents in the protection and restoration of these systems;

Environmental Issues and Concerns: students' understanding of a variety of environmental situations that arise from biophysical impacts apparent in the natural world, and the causes and effects of those impacts; knowledge of environmental issues that arise from human conflicts about environmental problems and solutions,

including the causes and effects of those conflicts; multiple solutions to environmental issues including knowledge of past, ongoing, and current efforts, as well as of proposed and future alternatives, aimed at helping to solve environmental problems; and the legacy of efforts, the both success stories and failures, aimed at solving environmental problems using a number of dimensions (from scientific and technical to economic, regulatory or educational efforts).

Natural Resource Management: students' understanding of the limited available natural resources and their classification; causes of natural resources degradation; the forms of citizen participation, action, and community service intended to preserve natural resources or improve the environment including: restoration projects, consumer and economic action, effective communication strategies, political action, and collaborative solution seeking.

Sustainable Development: students' understanding of the various social, cultural, and political systems, as well as the historical and geographic contexts in which human populations have developed and now function; civic participation and the beliefs/practices associated with environmental problem-solving; concepts of development, sustainable development and Gross National Happiness and their measurement and indicators; and the role of environment in sustainable development and Gross National Happiness.

ii. Environmental Processes

Through the domain of environmental processes, students will be assessed on the following:

- Identifying environmental issues including the ability to describe and provide evidence for the dimensions of the issue, human disagreements central to it, and factors that cause or contribute to it;
- Ask relevant questions about environmental problems as well as human dimensions and historical or geographical features of an issue. This also includes the ability to ask higher-order questions aimed at discovering conditions that have implications for the issue;
- Analyse environmental issues by interpretation and use of knowledge regarding physical, ecological and socio-political systems, and of information about stakeholders, their positions, beliefs and value perspectives. Also, this includes the ability to determine relevant factors to discern interactions among those factors, and to predict likely consequences of issues;
- Investigate environmental issues by gathering new information about an issue as

well as locating and using relevant sources of additional information, synthesizing, and communicating the outcomes of the investigation;

- Evaluate and make personal judgments about environmental issues by constructing dispassionate evaluations and explanations based on available information and the beliefs and values of stakeholders, and articulating views about actions that may be warranted. Critical thinking is at the core of this competency;
- Use evidence and experience to defend positions and resolve issues by constructing and defending a sound evidence-based argument about what it will take to resolve or help resolve an issue; and
- Create and evaluate plans to resolve environmental issues by assuming the responsibility for acting, frequently with others, and engaging in planning based on the environmental conditions, available resources, and socio-political contexts to resolve or help resolve issues.

iii. Environmental values and attitudes

Through the domain of environmental values and attitudes, students will be assessed on the following attributes:

- Sensitivity, caring and positive feelings toward the environment;
- Attitudes, concern, and world view by responding in a favourable or unfavourable manner toward objects, events, and other referents;
- Personal responsibility, commitment and thoughtful processes that lead individuals to avoid or reduce behaviours that contribute significantly to negative environmental impacts as well as undertake behaviours that contribute significantly to positive impacts;
- The belief and/or feeling that an individual (or collectively) will be able to influence or bring about the environmental change; and
- Motivation, intentions, willingness and verbal commitment to act based on beliefs or attitudes

II. Types of Assessment

The achievement and performance of students in environmental science are assessed through the following schemes of assessment.

Continuous Formative Assessment (CFA)

Formative assessment provides feedback to teachers and students on a continual

basis, so that teaching and learning improves through the provision of feedback, and remedial learning opportunities for the needy learners as identified from the assessment. It also enables teachers to understand, which teaching methods and materials work best.

CFA facilitates teachers to diagnose the learning needs of the students, and recognize and understand students' individual differences in learning. The feedback encourages students to reflect on their achievement and performance, by which they are able to understand their strengths and weaknesses.

CFA should happen daily throughout the teaching-learning processes of the academic year. It is not graded, therefore, not reflected in promotion forms and reports to the next level, as it is used only to give continuous feedback to the students.

The techniques and tools for CFA can be seen in the Assessment Matrix, wherein the identified techniques of CFA for each domain are as follows:

Content knowledge: Interview, home work, class work, etc.

Environmental Processes: Class work, observations, project work, etc.

Environmental values and attitudes: Observations of students' conduct guided by environmental and social values.

The tools identified for CFA are **checklists** and **anecdotal records**. The sample checklists provided in this book are only suggestive. Teachers must develop their own checklists for every lesson. Checklist must be maintained for each topic and recorded for future references.

Continuous Summative Assessment (CSA)

Continuous Summative Assessment is another form of continuous assessment. Unlike the CFA, the CSA is to grade student's performance on a continual basis and provide feedback at the same time. It helps in determining the students' achievement and performance, and the effectiveness of the classroom instructions. The feedback from this assessment is to help them to improve their learning and mandates teachers to incorporate varied teaching strategies and resources in ensuring quality teaching and learning in science classes.

The CSA grades students' performances and achievements. This ensures students' active participations in the learning processes.

The techniques and tools for CSA can be seen in the Assessment Matrix, wherein the identified techniques of CSA for each domain are as follows:

Content knowledge:

Teacher is required to check all the home works assigned. Although the home works are given regularly, teacher grades only one of the learners' homework for every chapter using the rubrics. This records the students' achievements at frequent intervals. Chapter-end test is conducted upon the completion of every chapter.

Environmental Processes:

Project work begins at the beginning of the academic year. It must be assessed at different stages using the rubric. The summative marks for project work should be credited at the end of each term. This is to ensure that students undergo all the required processes of the project work and project work is a continual and progressive, not one time activity of each learner as a personal enterprise.

Environmental values and attitudes:

Environmental Profile must be maintained from the beginning of the academic year. It must be assessed at different stages using the rubric. The summative marks for Environmental Profile should be credited at the end of each term. It is a continual and progressive, not one time activity of each learner as a personal enterprise.

The main tools for CSA are: rubrics for homework, Environmental Profile and project work; and pencil paper tests for class test. The scores from the rubrics and paper pencil tests should be converted to the weighting prescribed for each technique for each domain in each term as prescribed in the **Assessment Matrix**.

Summative Assessment

Summative assessment is conducted at the end of a term and at the end of the year to determine the level of learning outcomes achieved by students. The information gathered is used by teachers to grade students for promotion, and to report to parents and other stakeholders.

The identified tools and techniques for SA can be seen in the Assessment Matrix. The questions for the term examinations should cover all the three domains of environmental science learning objectives using the Bloom's taxonomy. Therefore, it mandates teachers to prepare the test **blue print** prior to the setting of questions for the term examinations.

Assessment

Assessment Matrix								
Types of assessment	CFA			CSA			SA	
Definition	It is a continuous process of assessing student's problems and learning needs; provide feedbacks and to identify the needs for the remedial measures to improve student's learning. It also enables teachers to understand what teaching methods and materials work best.			It is a continuous process of grading student's performances and achievements. Based on their performance, teachers provide feedbacks for improvement. It also enables teachers to understand what teaching methods and materials work best.			Assesses student's cumulative performances and achievements at the end of each term.	
Domains	Content knowledge (CK) (Cognitive)	Environmental Processes (EP) (Psychomotor)	Environmental values and attitudes (EV) (Affective)	Content knowledge (CK) (Cognitive)	Environmental Processes (EP) (Psychomotor)	Environmental values and attitudes (EV) (Affective)	CK, EP & EV	CK, EP & EV
Techniques	Quiz & debate, self & peer assessment, class presentation, homework, class work, immediate interaction with students.	Immediate interaction with students, class work, home work, experiments, exhibition, case studies	Observation of student's conduct, group work, field trip, excursion, self & peer assessment, immediate interaction with students.	Home work and chapter end test.	Project Work	Environmental Profile-guided by environmental and social values.	Term exam.	Term exam
Assessment Tools	Q&A, checklist and anecdotal records.	Checklist and anecdotal records.	Checklist and anecdotal records.	Rubrics (HW) and paper pencil test(chapter end test).	Rubrics	Rubrics	Paper pencil test with: multiple choice questions, close test, matching, true or false Short answer questions and extended response questions	Paper pencil test with: multiple choice questions close test, matching, true or false Short answer questions and extended response questions
Components in books	Questions and Answers, Exercises, Activities	Experiments, outdoor activities, designing and making, field trip, survey, and interview.	Work: in pairs, in groups, individually, field trip, display of charts, precaution and safety.	Exercises, Topic end Questions	Experiments, outdoor activities, designing and making, field trip, interview, survey, and display of charts,	Facts, field trip, display of charts, awareness campaign, precaution and safety.	Term examination. Question should cover all the three domains.	Term examination. Question should cover all the three domains.
Frequency interval (when &how)	Checklists and anecdotal records must be maintained for each topic throughout the academic year.			HW-for every chapter, Chapter end test – for every chapter.	Project Work -assessed two times (half yearly)	Environmental Profile -assessed two times (half yearly)	Once in a term.	Once in a year.
Format in Progress Report				CK	EP	EV	Mid-Term	Annual Exam
Weightings				T1= 2.5 T2= 2.5	T1= 5 T2= 5	T1= 2.5 T2= 2.5	T1=30	T2=50

III. Assessment Techniques and Tools

The following section describes the techniques and tools that are to be used to assess student's performance and achievement.

1. Continuous Formative Assessment (CFA)

The assessment through the CFA is purely to facilitate teachers to take corrective measures in their teaching and use of materials, and provide feedback on the students' learning. No scores are provided like in the CSA. Therefore, it must be continuously used in the regular teaching and learning process by using the suggested tools stated in the Assessment Matrix. The suggested techniques to assess learners through CFA are as follows:

i. Classwork and Homework

Regular class work and homework must be given to students to assess their content knowledge, skills, and environmental values and attitudes. Class work is a planned learning activity, related to the lesson taught and is carried out by students in the classroom during the teaching period under the supervision and guidance of the teacher.

Homework is a task given to students to be completed at home. Homework includes problems to be solved, reading to be carried out, writings to be completed or other skills to be practiced. The work given to the students should be done on their own. No classroom learning activities should be assigned as a homework.

ii. Quiz and debate

Quiz and debate can be conducted on specific topic to assess student's conceptual knowledge and understanding of environmental issues and concerns, and to improve communication. It can be conducted as formal or informal activities.

Quiz and debate, as an assessment technique, are conducted to:

- i. *check learner's general knowledge in environmental science.*
- ii. *evaluate learner's communication and interaction skills.*
- iii. *assess critical and analytical thinking skills.*

iii. Group work presentation

Students working in groups provide a context in which individuals help each other to achieve a common goal. Group work provides students a constructive experience of membership in a group, and develop to an individual who is able to contribute to the life of the community.

The group work and classroom presentation, as an assessment technique, is prescribed to:

- i. assess student's progress in the development of social skills to work as a team.*
- ii. evaluate their abilities to share responsibilities in carrying out the learning activities.*
- iii. check student's ability to respect others views and opinions.*
- iv. determine learner's ability to manage resources in completing the assigned task.*

iv. Immediate interaction with learners

The teachers' interaction with students is an integral part of the teaching and learning process. It helps in understanding the progress of the students in learning, and to identify their learning needs. At the same time, immediate interactions with students can help teachers to enhance rapport with learners, crucial in building trust and confidence of learners with teachers.

Immediate interaction with students must be carried out to:

- i. determine progress in students' learning and to provide immediate feedback.*
- ii. evaluate students' communication skills.*
- iii. assess students' display of integrity, honesty, critical thinking, and attitudes towards environmental science.*
- iv. check students' abilities to follow verbal and written instructions.*

v. Experiments and exhibition

Environmental science experiment is a scientific procedure undertaken by students to make a discovery, test a hypothesis, or demonstrate a known facts; environmental science exhibition is a public display or demonstration of scientific skills to enhance learning and as well create awareness on environment. Experiments and exhibition must be carried out to:

- i. evaluate the display of environmental science ideas and concepts of students in the form of models, charts and posters.*
- ii. test student's ability to demonstrate the use of environmental processes.*
- iii. assess student's abilities to relate the environmental science concepts to their life and immediate environment.*
- iv. gauge student's ability to handle equipment with accuracy and safety.*

vi. Observation of student's conduct

Observing students carefully helps teacher to know them better. The information derived help teacher to plan, implement, assess and evaluate the teaching and learning process. In the environmental science curriculum, this technique is vital to assess the students' ability to demonstrate the essence of environmental processes and the display of environmental values of critical thinking, honesty, integrity, curiosity, team

spirit and intellectual drive in the classroom.

Observation of student's conduct, as an assessment technique, is important to:

- i. determine student's level of participation in learning activities.*
- ii. assess student's behavioural conduct with teacher, friends and community.*
- iii. gauge student's ability to handle equipment safely.*
- iv. check the demonstration of concerns towards oneself, others and environment.*

vii. Field trip or excursion

Field trip or excursion is a trip taken by a group of students to a place away from their normal classroom environment. The purpose of the field trip is usually for observation of natural phenomena in the real field for gaining first hand experiences. Field trip or excursion must be conducted as an integral part of environmental teaching and learning process to:

- i. gauge student's ability to use different tools, conventional or non conventional, to gather information.*
- ii. assess student's ability to explain the natural phenomena based on the environmental science concepts and ideas.*
- iii. determine student's level of participation in learning and social activities.*
- iv. check the demonstration of concerns for oneself, others and environment.*
- v. assess student's ability to explore and investigate environmental issues and concerns.*
- vi. measure student's ability to interpret and communicate the field trip findings to their colleagues.*

The following suggested tools can be used to assess students, while using the above techniques.

a. Checklist

Checklist is a tool for recording a characteristic is present or absent, an action is taken or not, or whether learning has taken place or not, with 'Yes' or 'No' judgment. In teaching environmental science, teacher makes a listing of environmental concepts that the learners would have learnt, skills that they would have developed, and environmental science values and attitudes that they should exhibit at the end of every topic teaching. Since there is no standard checklist developed, teacher has to develop his/her own checklists for the three domains - Content Knowledge (CK), Environmental Processes (EP), and Environmental science Values and attitudes (EV), as per the topic's learning objectives and learner's learning needs. Therefore, only a sample checklist is provided in this book.

Checklist for continuous formative assessment (CFA) on three assessment domains in environmental science

Sample checklists: Content Knowledge (CK)

No.	Class:	Content knowledge (CK)					
	Key: √- Yes X- No	Explains ecosystem	Describes biome, niche and ecology	Describes levels of ecosystem	Explains the role of components and interactions in an ecosystem	Recognizes habitats, dominant plants and animals	Comments
	Learning objectives						
Name:							
1	Tshering						
2	Wangmo						

Sample checklists: Environmental Processes(EP)

No.	Class:	Environmental processes (EP)							
	Key: √- Yes X- No	Follows the activity instructions correctly.	Participates actively in group activities.	Records the observation appropriately.	Identifies the raw materials needed for exploring ecosystem	Records all the biotic and abiotic components of ecosystem	Has a ability to use observations to answer the questions in the learning activities	Displays ability to collect relevant photographs, notes and information experiments.	Comment
	Learning objectives								
Name:									
1	Choeki								
2	Jigme								

Sample checklists: Environmental science values and attitudes (EV)

No.	Class :	Scientific values and attitudes (SV)						
	Key: √- Yes X- No	Respects others views in the group discussion.	Shares responsibilities in carrying out activity.	Shows cooperation in group discussion and activities.	Demonstrates willingness to learn and try new things.	Exhibits concerns for self, others and environment.	Demonstrates curiosity to learn more on the topic.	Comments
	Learning Objectives							
Name:								
1	Tashi							
2	Zomba							

b. Anecdotal records

Anecdotal records are used to assess student's learning, which is not identified by other assessment tools. Anecdotal records are written descriptions of the casual, or, focused observations made by the learners. They are brief descriptions of incidents and behaviours that offer the teacher a way of assessing and recording the aspects of student's learning. It can be used in a more directed way when teachers want to collect information on particular areas such as social development, work habits, aspects of language use, and the children's development as environmental science learners.

Anecdotal records are usually collected in an exercise book or a folder. Record should include the following entries:

- Name of the student observed, class, and the date and time.
- Observation areas may include individual student's behaviours, skills, and attitudes in relation to outcomes of the study programmes.
- Setting can be either in group or individual.
- Record the observations with comments to share with learners and parents.

c. Questions and answer

Asking question is a natural feature of teacher's interaction with students in the class in assessing mainly the content knowledge of the students in the learning process. Therefore, questioning is crucial to the way teachers manage the class, and engage students in content learning, encourage students participation in enhancing their understanding. Asking question is widely used as an assessment tool in the teaching and learning process. Questioning may be in the form of:

- i. verbal questioning
- ii. written question
- iii. interviews
- iv. self assessment questionnaires

2. Continuous Summative Assessment (CSA)

The techniques to assess learners through CSA are as follows:

i. Homework

The homework, as described under the CFA, is a task given to learners to be completed at home. The tasks may include, problems to be solved, survey to be carried out, reading to be carried out, writings to be completed or designing and making of models and posters. However, under no circumstances shall the classroom learning activities be assigned as homework for CSA.

The criteria given below is to ensure that the work given to the students are done on their own.

Criteria for home work

Name of student	Criteria					Total Marks
	Completion (4)	Accuracy (4)	Presentation (4)	Creativity & originality (4)	Submission date (4)	(20)
Kunzang						
Dawa						

The homework in CSA is assessed based on the “Criteria for homework” template, where the score is translated from the rubric description score. Based on the rubric, homework is graded out of 20 marks for every chapter, and the cumulative marks obtained are converted to actual marks assigned to homeworks at the end of each term and reflected in the student’s progress report. If a student fails to submit the homework after three days of the due date, the students will be awarded zero point for “Submission date” criteria. It is mandatory for teachers to assess homework with grading at least once for every chapter and necessary feedbacks provided for students to improve their learning.

The rubric to assess homework in CSA is provided below:

Rubric for Homework

Criteria	Marking range				Scores
	4	3	2	1	
Completion	Homework is 100% complete.	Homework is 70% complete.	Homework is 30% complete.	Home work is 20% complete.	
Accuracy	Homework is 100% accurate.	Homework is 70% accurate.	Homework is 30% accurate.	Home work is 20% accurate.	
Presentation	Student work is thorough, clear, and legible for all problems. Student has included all relevant illustrations and ideas.	Student shows an adequate amount of work for each problem and is legible. Student has included some relevant illustrations.	Student shows some work, but it is inadequate. Student has not included relevant illustrations.	Student shows very poor work, poor handwriting, and no illustrations.	
Originality and creativity	Display of original and creative ideas.	Display of original and partial display of creative ideas.	Display of original and little display of creative ideas.	No display of original and creative ideas.	
Submission date	Submitted on due date.	Submitted one day after the due date.	Submitted two days after the due date.	Submitted three days after the due date.	
Total score					

Teachers can adapt the above format to suit their needs, based on the learning objectives the teacher wishes to pursue through different learning activities.

ii. Chapter end test

A pencil and paper test is conducted at the end of each chapter. This is mainly to assess the student's conceptual understanding of the topic. It is important to balance the items selected for the test to include questions involving concepts, skills, values and attitudes.

The chapter end test must be conducted for each chapter, and necessary feedback provided for students to improve their learning. The teacher should maintain the record of marks obtained by individual learner for every chapter end test conducted. The cumulative marks of the chapter end test are then converted to actual marks assigned to chapter end test at the end of each term and reflected in the student's progress report.

iii. Environmental Profiles (EP)

An Environmental Profile is a formal written record of facts of phenomenon and incidents that occurred (local or global) along with personal thoughts, experiences, observations and critical analysis of the situation. Environmental profile entries can be about natural disaster or hazards, environmental degradation, mining, campaigns, climate change, green movements and policies, etc.. The entries should contain adequate photographs, illustrations, facts and figures to supplement and strengthen the entries. Student's personal thoughts, opinions and conclusions should also find a place in the entries. This type of writing tends to be insightful in nature, allowing students to reflect on the content, as well as make a critical analysis of the situation of the events as in, "Thinking is the method of intelligent learning". Environmental Profile will eventually be the archive of past, containing the events of present and global future goals on environment.

Why keep an Environmental Profile?

The use of Environmental Profile is important for many reasons. Through this, students are provided with the opportunity to model the data collection forms that researchers use. Secondly, it is to provide means of reference and resource for students throughout the year. Thirdly, the environmental profiles are also a great communication tool of students with teachers to create awareness on environment. Lastly, it provides the learner the opportunity to "expand minds" as opposed to "training minds" through critical analysis experiences.

Therefore, the Environmental Profiles ask students to document their observations about the environmental science concepts, events and phenomenon that have occurred or may occur in the locality, country, region or in the world. It also serves as an informal assessment to determine what the students have understood. Environmental Profile provides a meaningful writing assignment for children, allowing them to improve their writing skills.

Although there are no rules or limits to Environmental Profiles, below are some useful tips that can help you get the most out of keeping an environmental profiles.

- i. Use a blank notebook that is acid-free for long-life.
- ii. Write with whatever you feel most comfortable with – a favourite pen, pencil, marker, coloured pencils or other writing instrument.
- iii. At the top of your page write down the date.
- iv. Record and describe any event or incident which has relevance to environmental science that you have heard or watched, in news, radio, or read in books, internet, journals or magazines, like earthquake in Japan, Forest fires in Monggar , Rio Summit, introduction of electric vehicles in Bhutan, Protect White Bellied Heron Project, etc,. Your description may include facts and figures, causes, measures taken, response capacity and policies in place.
- v. Make sure you have conducted further research of the event, and ensure that you have enough and reliable information, data, evidences and materials before making any entry.
- vi. Write the significance of the entry, your thoughts, critical analysis and conclusion with evidences drawn from information of the entry, and your recommendations.
- vii. Avoid poems, songs and stories and other casual writings on the environment. The entries should be focussed on environmental concepts and skills for real life events or phenomena and incidents.
- viii. To add variety to your entries and avoid long textual information, consider drawing, illustrations, charts, tables, etc,. Adding photographs and illustrations can convey message more effectively.

The maintenance of Environmental Profiles can facilitate teachers to assess the display of scientific skills and values and attitudes by students. Therefore, teacher must ask students to maintain Environmental Profile from the beginning of the year. But, teacher should have a schedule to collect them to provide regular feedback to ensure that students make entries throughout the year, rather than filling up at the end of the year. Environmental Profiles should be assessed by using the rubrics suggested here.

Criteria for the Environmental Profile

Name	Criteria					Total marks (20)
	Format (4)	Background research on the event (4)	Analysis(4)	Critical and creative thinking skills (4)	Presentation & Content (4)	
Yeshi						

Rubric for Environmental Profile

Criteria	Scoring				Total score	Tr.'s remarks
	4	3	2	1		
Format	Proper format has been followed for all of the entries.	Proper format has been followed for most of the entries.	Proper format has been followed for few of the entries.	Proper format has not been followed for any of the entries.		
Background research on the event	Research is thorough and specific. All the ideas are clearly explained	Research is thorough but not specific. Most ideas are explained.	Research is not thorough and not specific. Few ideas are explained..	Research not thorough and ideas are not explained.		
Analysis	Conclusion and recommendations are supported by data & evidences. Reflection of why event happened and how we could prevent are explicitly explained	Conclusion and recommendations are supported by limited data & evidences. Reflection of why event happened and how we could prevent are well explained	Conclusion and recommendations are not supported by data & evidences. Reflection of why event happened and how we could prevent are explained	Conclusion and recommendations are not supported by data & evidences. Reflection of why event happened and how we could prevent are poorly explained		
Critical and creative thinking skills	Uses critical and creative thinking skills with a high degree of effectiveness	Uses critical and creative thinking skills with considerable effectiveness	Uses critical and creative thinking skills with moderate effectiveness	Uses critical and creative thinking skills with limited effectiveness		
Presentation & Content	Student work is thorough, clear, and legible for all entries. Student has included all relevant illustrations, data and ideas	Student shows an adequate amount of work for each entry and is legible. Student has included some relevant data & illustrations.	Student shows some work, but it is inadequate. Student has not included relevant illustrations and data.	Student shows very poor work, poor handwriting, and no illustrations, data or ideas		

Teachers can adapt the above format to suit their needs, based on the learning objectives that the teacher wishes to pursue through different teaching and learning activities.

iv. Project Work

An environmental science project will present a study of a problem with an objective to find a solution to a problem. It involves defining the problem, making hypothesis, observation, collection of data through survey or experimentation, analysing and then arriving at a conclusion to find out the solution. An important aspect of this experimentation involves identifying variables and, where possible, controlling them. It is an adventure that takes time, planning research, preparation, and lots of hard work. However, during the process students will discover a great deal about themselves, as well as, about environmental science.

An environmental science project is a unique way for students to pose questions for which they must seek answers to satisfy their own curiosity about the world around them. Curiosity begins with questions and when they have questions, they must seek answers. It is also an adventure into the world of scientific research that goes beyond their classroom and books. An environmental science projects are one of the most interesting assignments at school.

Why do environmental science project work?

The reason to do a environmental science project is that it is fun and students will learn something they did not know about before. Working on an environmental science project can be one of the most exciting adventures students will ever have, as it allows students to be the expert and demonstrate the results and findings of their investigations. They will not only perform experiments and investigations with their chosen research area, but they will also explore new ideas, new equipment, new techniques, and learn about the principles of environmental science. As they carry out the things, students will learn about the world in which they live. Students will also learn about what environmental scientists do to help understand about the world around them.

Creating a environmental science project will help students put into practice the concepts learnt in science, mathematics, economics, geography, etc.. Most importantly, an environmental science project represents their efforts of investigation into some area they found interesting. Through the development of a project, students gain a first-hand appreciation of the work of environmentalists and the value of their contributions. Students also get opportunities to play the role of environmentalist in coming up with an experiment, carrying it out, presenting it to their class and reporting on the results.

An environmental science project is one of the best opportunities to face the challenges that may be faced in real life when they want to start their own business or get a job.

Please note that doing an environmental science project is not of inventing equipment, devices or gadgets. You must gather as much information as you can, and get as much help as you need. Following are some of useful steps that students may follow.

1. Select an environmental science project

The first step in doing an environmental science project is selecting a topic or a subject. Teachers allow you to select your own subject or topic of your interest; however, they may need to approve your idea before you start your project. Make a list of the most probable project ideas and select one idea that might be the best and interesting to you.

2. Gather background information

Gather information about your topic from books, magazine, internet, people and companies. Keep notes from where you got the information.

3. Identify variables

When you think you know what variables may be involved, think about ways to change one at a time. If you change more than one at a time, you will not know what variable is causing your observation. Sometimes variables are linked and work together to cause something. At first, try to choose variables that you think act independently of each other.

4. Write your hypothesis

Based on your gathered information, make an educated guess about what types of things affect the system you are working with. Identifying variables is necessary before you can make a hypothesis. Hypothesis must be in the form of statement. For example, vehicular pollution causes acid rain.

5. Design an Experiment or Observation Method

Devise the method of the observation or design an experiment to test hypothesis. Make a systematic list of what you will do or observe to answer each question. This list is known as an experimental or observational procedure. For observations or an experiment to give answers you must have a “control.” A control is a neutral “reference point” for comparison that allows you to see what changing variable does by comparing it to not changing anything. Dependable controls are sometimes very hard to develop. They can be the hardest part of a project. Without a control, you cannot be sure what variable causes your observations.

6. Write a list of material

Make a list of materials useful to carry out your experiment or observations.

7. Write your experiment results

Experiments are often done in series. A series of experiments can be done by changing one variable at a time. A series of experiments is made up of separate experimental “runs.” During each run, you make a measurement of how much the variable affected the system under study. For each run, a different amount of change in the variable is used. This produces a different amount of response in the system. You measure this response, or record data, in a table for this purpose. A series of observations of natural phenomenon at different intervals and conditions gives a good data. The data from experiments and observations are considered as a “raw data” since it has not been processed or interpreted yet. When raw data is processed mathematically, for example, it becomes results.

8. Write a summary of your results

Summarize what happened. This can be in the form of a table of processed numerical data, or graphs. It could also be a written statement of what occurred during experiments. It is from calculations using recorded data that tables and graphs are made. Studying tables and graphs, you can see trends that tell you how different variables cause observations. Based on these trends, you can draw conclusions about the system under study. These conclusions help to confirm or deny your original hypothesis. Often, mathematical equations can be made from graphs. These equations allow to predict how a change will affect the system without the need to do additional experiments. Advanced levels of experimental science rely heavily on graphical and mathematical analysis of data. At this level, science becomes even more interesting and powerful.

9. Draw conclusions

Using the trends in your experimental data and your experimental observations, try to answer your original questions. Is your hypothesis correct? Now is the time to pull together what happened in the form of conclusion, and assess the experiments you did.

10. Write a report on the project

Having completed all the steps of experiment and investigation with appropriate results and conclusion drawn, the last thing is to write a report. The report should start with an introduction on the topic related to your hypothesis, purpose of the study, literature review, methods used, findings, and conclude with conclusions. Do not forget to acknowledge the support provided by all individuals and organizations. Write a bibliography to show your references in any form. Such information includes the form of document, name of writer, publisher, and the year of publication.

Project work, therefore, is one of the best ways to practice the application of conceptual ideas and skills. The very purpose of including project work is to provide opportunity to explore and extend knowledge and skills beyond the classroom. Students learn to organize, plan and piece together many separate ideas and information into a coherent whole. Through project work, learners learn various techniques and skills including data collection, analysis, experimentation, interpretation, evaluation and drawing conclusion. Thus, project work fosters positive attitude towards environment.

The teacher will use the rubric given below to assess the student's project work. Viva voce is a must to authenticate the originality of students' work.

Criteria for project work assessment

Name	Criteria						Bibliography (4)	Total scores (28)
	Problem and hypothesis (4)	Background research on the hypothesis (4)	Experimental design / materials / procedure (4)	Investigation (4)	Analysis (4)	Format and editing (4)		
Nima								
Dawa								

Rubrics for project work assessment

Criteria	Scoring				Total Score (28)	Remarks by Teacher
	4	3	2	1		
Problem and hypothesis	Problem is new, meaningful and well researched. Hypothesis is clearly stated in the "IF... THEN" format.	Problem is not new but meaningful. Hypothesis is clearly stated.	Problem is stated but not new and so meaningful. Hypothesis is not clearly stated.	Problem is not stated and Hypothesis is unclear.		
Background research on the hypothesis	Research is thorough and specific. All the ideas are clearly explained.	Research is thorough but not specific. Most ideas are explained.	Research is not thorough and not specific. Few ideas are explained.	Research not thorough and ideas are not explained.		
Experimental design / materials / procedure	Procedure is detailed and sequential. All materials are listed. Safety issues have been addressed.	Procedure is detailed but not sequential. Most materials are listed. Safety issues have been addressed.	Procedure is not detailed and not sequential. Few materials are listed. Few safety issues have been addressed.	A few steps of procedure are listed. No materials are listed. Safety issues were not addressed.		

Criteria	Scoring				Total Score (28)	Remarks by Teacher
	4	3	2	1		
Investigation	Variables have been identified, controls are appropriate and explained. Sample size is appropriate and explained. Data collected from at least 4 sources.	Variables have been identified and controls are appropriate but not explained. Sample size is appropriate. Data collected from at least 3 sources	Variables have somewhat been identified, controls are somewhat known. Sample size is not appropriate. Data collected from at least 2 sources.	Missing two or more of the variables or the controls. Sample size is not considered. Data collected from only 1 source.		
Analysis	Conclusion is supported by the data. Explanation is made for how or why the hypothesis was supported or rejected. Reflection of what was learned and how it could be made better is made.	Conclusions are supported by the data. Not enough explanation is made for how or why the hypothesis was supported or rejected. Reflection of what was learned and how it could be made better is made.	Conclusions are not supported by enough data. Not enough explanation is made for how or why the hypothesis was supported or rejected. Reflection of what was learned and how it could be made better is not clear.	Conclusions are not supported by data. Not enough explanation is made for how or why the hypothesis was supported or rejected. Reflection of what was learned and how it could be made better is not stated.		
Format and editing	Correct format followed throughout. Report is free of errors in grammar, spelling or punctuation.	Only one aspect of format is incorrectly done. Report contains a few errors in grammar, spelling, and punctuation.	Only two aspects of format are incorrectly done. Report contains some errors in grammar, spelling, punctuation	Three or more aspects of format are missing or incorrect. Report contains many errors in grammar, spelling, and punctuation.		
Bibliography	Five or more references are cited in APA format and referenced throughout the paper and presentation.	Three or four references are cited and referenced throughout the paper and presentation.	One or two references are cited and referenced throughout the paper and presentation.	No references made.		

Teachers can adapt the above format to suit their needs, based on the learning objectives teachers wish to pursue through different teaching learning activities.

3. Summative assessment

The techniques and tools for assessment through summative assessment (SA) are the term examinations and the end of year examinations. In SA, students are graded and marks reflected in the student's progress report. The main purpose of the assessment through SA is to assess student's conceptual knowledge, understanding of the environmental processes, and the inculcation of values and attitudes in environmental science learning.

The tools used in SA are test blue print and pencil paper test. The pencil paper test may include variety of questions, such as multiple choice questions, fill in the blanks, matching, true or false, short answer questions, extended response questions, etc.

These questions will test the competencies of students in the three domains of assessment. The questions will also be of varying levels of difficulty guided by the principle of Bloom's taxonomy.

The written examinations will be for 2 hours consisting of two sections and out of 100 marks.

Section A (compulsory) will contain questions that cover the entire syllabus. This section will be assessed out of 50 marks. Candidates will be required to attempt ALL the questions in this section. This section contains the following objective type questions.

- i. Multiple choice questions - 25 marks
- ii. Fill in the blanks - 5 marks
- iii. Matching - 5 marks
- iv. True & False (correct the false statements) - 5 marks
- v. Reasoning questions -10 marks

Section B will contain six questions of 10 marks each covering the entire syllabus. Candidates will be required to answer ANY FIVE of these six questions. This section will also be assessed out of 50 marks. Each question consists of multiple short answer questions of various difficulty levels

Chapter-wise time allocation and weighting

Chapters	Chapter title	Maximum time required (mins)	Weighting (%)
Chapter 1	Ecosystem: Structure & Functions	585	12%
Chapter 2	Balance of Nature	450	9%
Chapter 3	People and Environment	585	12%
Chapter 4	Natural Resources Degradation	450	9%
Chapter 5	Disaster and Environment	450	9%
Chapter 6	Pollution & Climate Change	450	9%
Chapter 7	Biodiversity Conservation	450	9%
Chapter 8	Land use & Management	540	11%
Chapter 9	Energy Resources	450	10%
Chapter 10	Environment and Sustainable Development	450	10%
Total		4860	100.00%

The total time required to complete the topics is 4860 minutes or 96 periods of 45 minutes in a period.

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Ecosystem

Structure and Functions

Chapter

No organism exists in isolation. All organisms live together in an ecosystem and depend on each other through different types of interactions and relationships, such as predation, competition and symbiosis. These relationships and interactions together with abiotic components play vital roles in nutrient cycles. The richness of biodiversity ensures that these interactions exist to maintain the health of the ecosystem. However, threats to biodiversity, such as habitat destruction, species introduction, hunting and others have disturbed the ecosystem and led to change in habitat, and even the extinction of some organisms.

1. Biogeochemical cycle

Learning Objectives

On completion of this topic, you should be able to:

- *explain biogeochemical cycle.*
- *describe carbon, nitrogen, calcium and phosphorus cycles.*
- *explain how humans influence or disrupt the biogeochemical cycles.*
- *identify the roles of biogeochemical cycles in maintaining the nutrient flow.*

An ecosystem consists of biotic and abiotic components. Within biotic components, flow of energy takes place through feeding relationships called food chains and food webs. The hierarchical levels in a food chain are called trophic levels. The abiotic components provide materials and energy for the survival of biotic components. Hence, there exists continuous interactions between biotic and abiotic components that contribute to biogeochemical cycles.

The biogeochemical cycle or nutrient cycle is the complete cyclic path of essential elements of living matter, such as carbon, hydrogen, oxygen, nitrogen, water and phosphorus within the living and nonliving components of an ecosystem. The biogeochemical cycles are classified into gaseous cycles and sedimentary cycles. Gaseous cycle includes carbon cycle, nitrogen cycle, water cycle, etc. Sedimentary cycle includes phosphorous cycle, calcium cycle, iron cycle, etc.

A. Gaseous biogeochemical cycles

Activity 1.1: Studying composition of atmosphere

Instruction:

In groups, study Figure 1.1 and Figure 1.2, and answer the questions that follow.

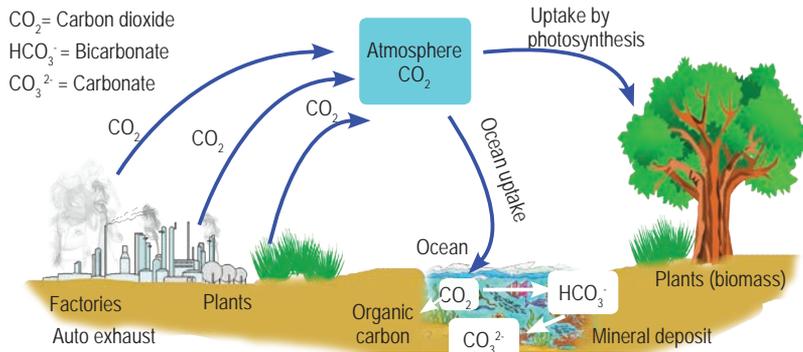


Figure 1.1

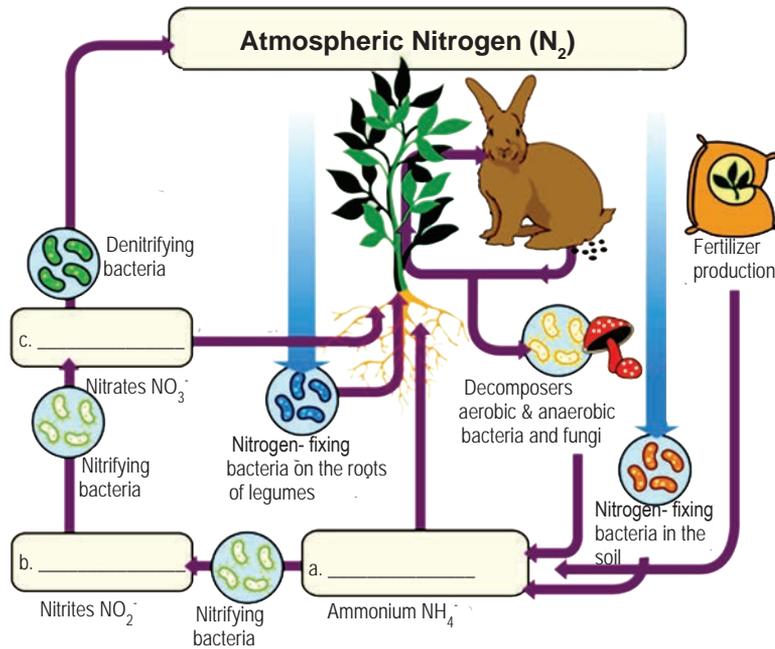


Figure 1.2

Answer the following questions.

- i. What biogeochemical cycles are described by Figure 1.1 and Figure 1.2?
- ii. Identify any two biotic and abiotic components involved in the above cycles.
- iii. Explain the role of ocean in Figure 1.1 with the help of a suitable chemical equation.
- iv. Fill in the blanks a, b and c in Figure 1.2, with the correct processes.
 - a)
 - b)
 - c)
- v. Trace out how the rabbit gets nitrogen in the cycle?
- vi. How do human activities influence these cycles?
- vii. What are the roles of these cycles in the environment?

B. Sedimentary biogeochemical cycles

i. Calcium Cycle

Most minerals important for life follow a natural cycle by passing through different stages. Calcium is the fifth most abundant element in both the Earth's crust and human body. It is not found freely on the Earth's crust but chemically combined with other minerals. Examples of calcium containing minerals are calcite and aragonite. Calcium, in the form of calcium pectate, helps in holding together the cell walls of plants. When calcium is deficient, new tissue, such as root tips, young leaves, and shoot tips often exhibit distorted growth from improper cell wall formation. Calcium is vital in activating certain enzymes and to coordinate certain cellular activities.

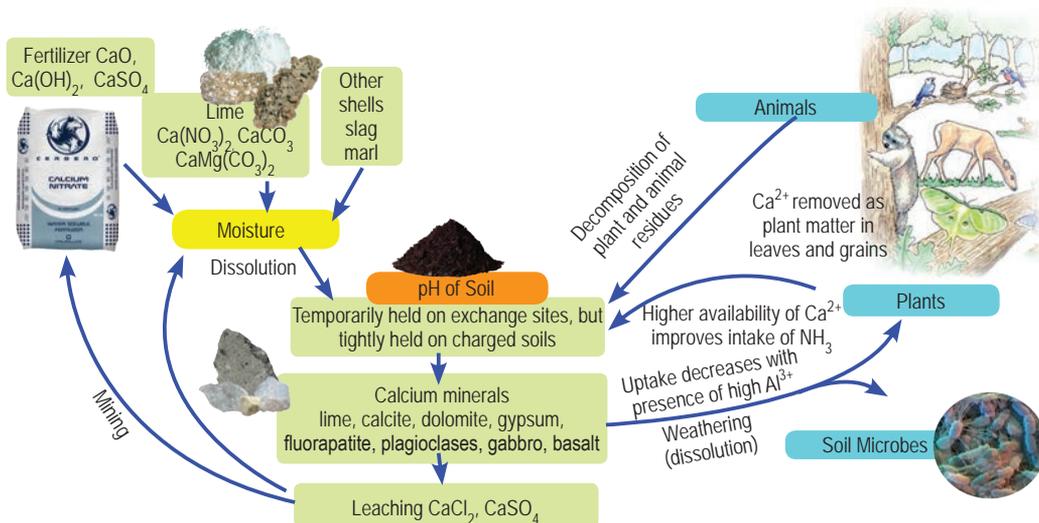


Figure 1.3 Calcium cycle

Calcium cycle is one of the important biogeochemical cycles and occurs in three phases, namely;

- a. Calcium entering into the soil from biosphere.
- b. Calcium present in the soil.
- c. Calcium present in plants and animals.

Calcium enters the soil from biosphere and other sources in the form of dust particles. When animals and plants die, their bodies decompose and the calcium present in their bodies eventually enters the soil. During rainy season, water carries calcium to, or from the soil through the process of weathering and leaching. Through the process of mineralization, calcium gets stored in rocks as calcium carbonate. Plants growing on the rocks absorb calcium in the form of solution for their metabolic activities. Animals derive calcium from plants and water through food chain. Once these plants and animals die, decomposers break down the organisms and calcium returns to water or soil. Through these processes, calcium is continually recycled through plants, animals and soil. Hence, calcium cycle is a sedimentary cycle.

ii. Phosphorous cycle

Phosphorus is an essential element for all living organisms. Plants use phosphorous in the production of energy in the form of Adenosine Triphospahte (ATP). When animals consume plants, the energy is transferred in the food web as shown in Figure 1.4.

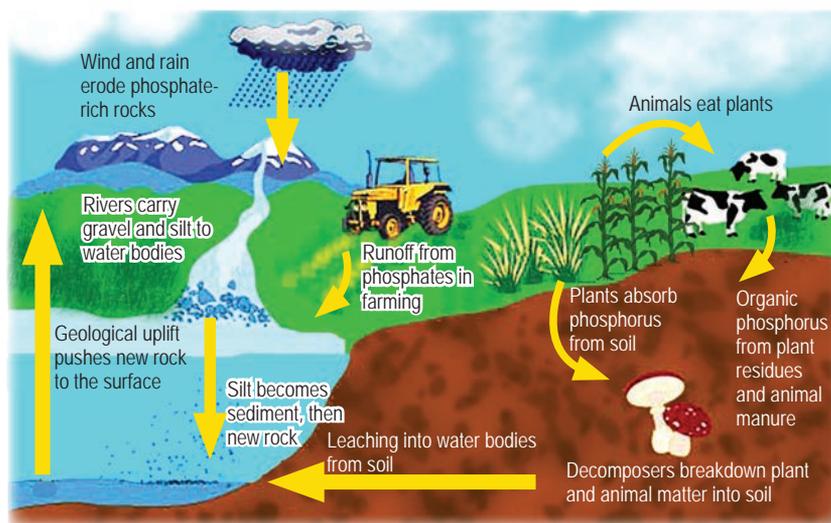


Figure 1.4 Phosphorus cycle

Plants absorb phosphorous from the soil through the phosphorous cycle, which is a sedimentary biogeochemical cycle. Phosphate rock deposits are the chief source of

phosphorous on the land. Through natural and human induced processes, phosphate from these rock deposits is washed into rivers and land. Plant roots absorb phosphates from the soil, by which, phosphorous is carried up through the food chain and eventually returns to the soil through animal wastes and decay processes. It is also added through the use of fertilizers in farm lands. However, these returns are small compared to the amount of phosphate which is continuously eroded from the land to the oceans each year through leaching, erosion and surface runoff.

Questions

1. Compare gaseous biogeochemical cycle and sedimentary biogeochemical cycle.
2. Biogeochemical cycles maintain the health of the environment. Justify.
3. Explain the potassium cycle as illustrated in Figure 1.5.

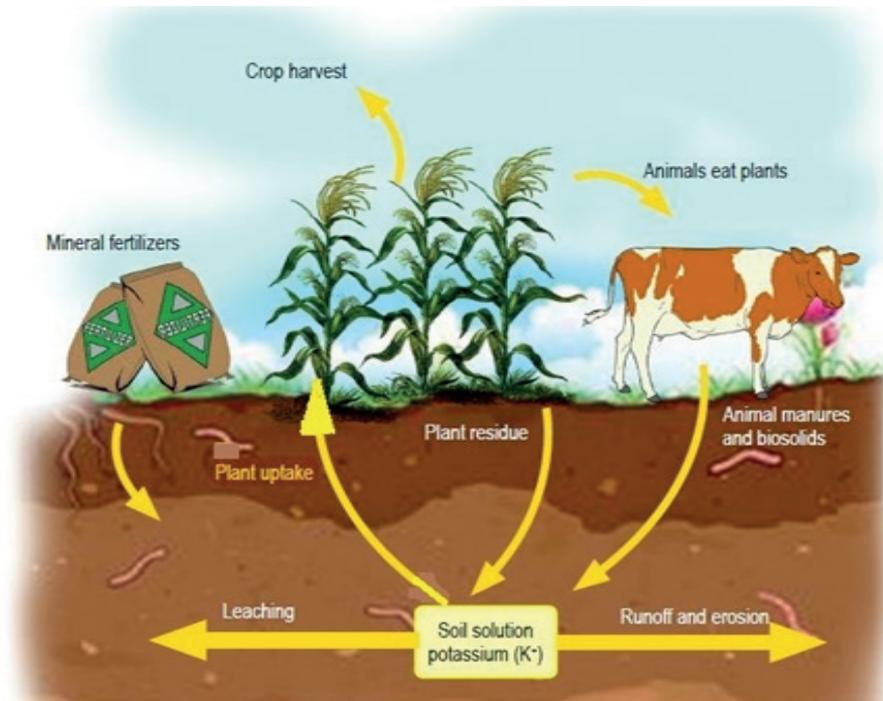


Figure 1.5 Potassium cycle

2. Ecological Interactions

Learning Objectives

On completion of this topic, you should be able to:

- explain the various kinds of interactions that exist in an ecosystem with examples.
- distinguish between interspecific and intraspecific competitions.
- discuss the roles of interactions amongst different organisms in sustaining a healthy ecosystem.

All organisms interact with each other in order to maintain balance in the ecosystem. These interactions are brought about by the needs of organisms for food, shelter, protection and reproduction. Ecologists define interaction as a relationship between two or more organisms that affects the growth, survival or reproduction of these organisms. Each organism or a group of organisms in an ecosystem possesses a unique characteristic which makes it different from rest of the community and has specific roles to play in the environment. The roles and position of an organism in the environment to meet its needs for food, shelter, protection and reproduction to survive is called ecological niche. Niche also includes all its interactions with the biotic and abiotic factors of its environment.

Organisms compete for their basic needs in their habitat and establish interactions among themselves. The various kinds of interactions amongst the organisms in an ecosystem are illustrated in Figure 1.6.

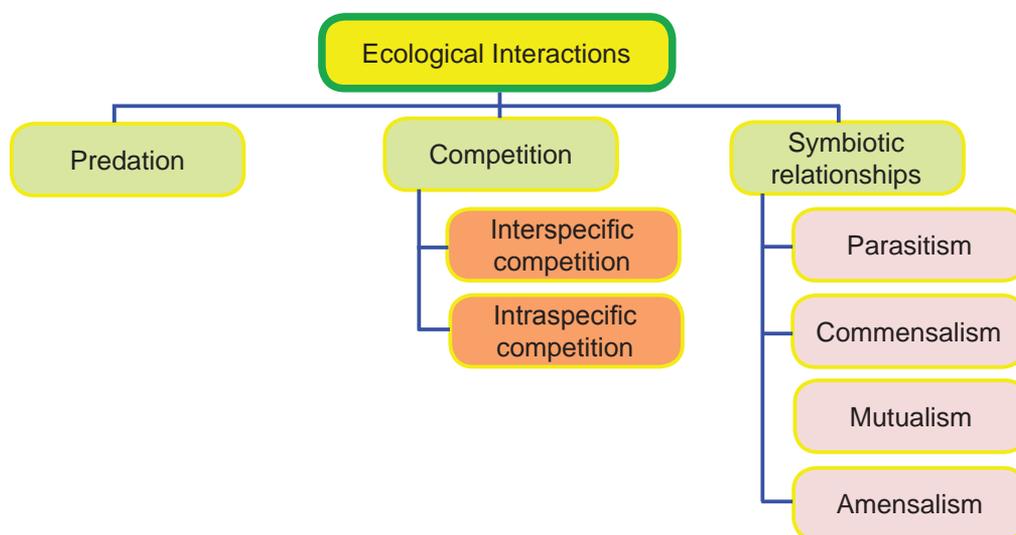


Figure 1. 6 Types of ecological interactions among organisms

A. Types of Ecological Interactions

i. Predation

Predation is the relationship between a predator and a prey. Predation occurs when one animal, known as the predator, kills and eats another animal, known as the prey. Most of the predatory organisms are animals, but there are some plants (carnivores) especially fungi, which feed upon other animals. A number of fungi, such as species of *Dactylella*, *Zoopagus* capture animals as prey. Figure 1.7(a) shows a portion of the *Arthrobotrys dactylella* capturing nematode as its prey.

Other examples of predation include carnivorous plants, such as Pitcher plant (*Nepenthes*), Sundews (*Drosera*), Venus flytrap (*Dionaea muscipula*) which consume insects and other small animals for their food. Predation enhances the biodiversity in an ecosystem by preventing some species becoming dominant.

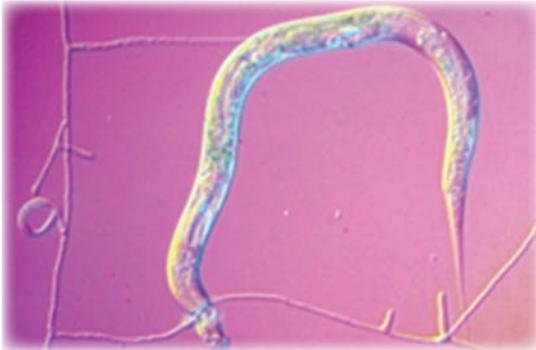


Figure 1. 7 (a) Nematode being trapped by fungal rings.



Figure 1. 7 (b) A crow feeding on insect (predator-prey relationship)



Figure 1. 7 (c) Insect trapped by *Drosera*.



Figure 1. 7 (d) Insect trapped by *Dionaea muscipula*

ii. Competition

Competition occurs when individuals attempt to obtain a resource that is inadequate to support all the individuals seeking it, or even if the resource is adequate, individuals harm one another in trying to obtain it. The competition becomes more severe when the niche of one organism overlaps with that of another organism. Humans also influence competition in nature through activities, such as intentional or accidental introduction of some exotic species, or destroying the natural habitat for development and agriculture. Competition can be either intraspecific or interspecific.

a. *Intraspecific competition*

It is the competition between members of the same species for food, shelter, protection and reproduction. Here, the niche of different organisms of the same species overlaps. For example, plants that produce many roots typically reduce the soil nitrogen to very low levels, eventually killing neighbouring plants with fewer roots and weaker plant bodies.

Many wild canine and feline species mark their territories with scent. This tells other members of the same species in that area that, they have claimed the territory and all the resources within it. This competition provides a type of control on the population size. If the population keeps growing without any increase in the amount of available resources, after a certain time, the population will no longer increase in size due to the limited resource.

b. *Interspecific competition*

It is a competition between members of different species for common resources. Many species of organisms depend on the same resource. When the supply of resources



Figure: 1.8 Interspecific competition between lion and hyenas.

is inadequate, intense competition may occur, putting pressure on the resource available. Over the time, a superior competitor can eliminate an inferior one from the area, resulting in competitive exclusion. For example, eucalyptus tree species in a dense forest grows taller than the surrounding tree species and is able to absorb more sunlight, moisture, and nutrients than the other species of plants growing underneath. Figure 1.8 shows hyenas and lion sharing the same ecological niche leading to a fierce interspecific competition. The presence of one species negatively impacts the others because they have to compete for the same food.

iii. Parasitism

Parasitism is a negative symbiotic relationship in which one organism, known as the parasite, lives inside or on the body of another organism, known as the host, from which it derives nourishment. Although the host is harmed by this interaction, it is generally not killed immediately by the parasite. However, in the long run, survival of the host may be affected.

Parasites that live on the body of the hosts are known as ectoparasites. Fleas, ticks, lice, mites, and some moulds and mildew are examples of ectoparasites as shown in Figure 1.9 and Figure 1.10. Other parasites, such as tapeworms, malarial parasites, and many kinds of bacteria are called endoparasites, because they live inside the body of the host.



Figure 1.9 Mistletoe growing on a tree



Figure 1.10 Ticks on dogs

iv. Commensalism

Commensalism is a relationship between organisms in which one organism benefits while the other is not affected. For example, Figure 1.11 shows orchids growing on the branch of a large tree. It neither harms nor helps the host tree, but uses the host tree to establish itself. It derives moisture and nutrients from the surroundings and prepares its own food through photosynthesis. Other example of commensalism includes the

relationship between golden jackals and tigers. The golden jackals attach themselves to a particular tiger, trailing it at a safe distance in order to feed on the big cat's kills. The jackals even alert the tiger with a loud sound to kill a prey.



Figure 1.11 Orchids growing on the limbs of a tree (commensalism)

The four common types of commensalism are:

a. Chemical commensalism

It is most often observed between two species of bacteria. It involves one species of bacteria feeding on the chemicals produced, or the waste products of the other bacteria.

b. Phoresy

Phoresy is an interaction in which one animal attaches itself to another, exclusively for transport. Examples include arthropods like mites thriving on insects (bees, flies, beetles), as shown in Figure 1.12, pseudoscorpions thriving on mammals, millipede on birds, etc..



Figure 1.12 Mites on body of a bee

c. Inquilinism

Inquilinism is the use of second organism for permanent housing. An example of inquilinism can be observed between barnacles and whales. Barnacles are normally sessile or non-moving sea creatures. They rely on currents to bring

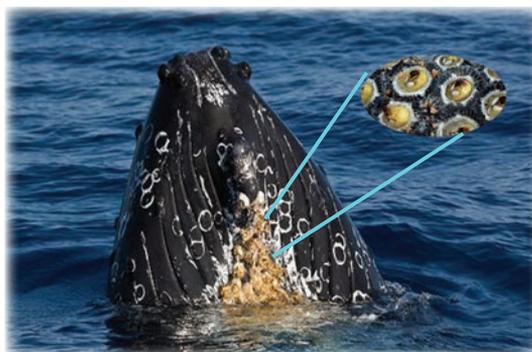


Figure 1.13 Barnacles on body of a whale

food past them in order to feed. However, some barnacles have attached themselves to the bodies of various sea lives, such as whales in order to have a more advantageous position in life (Figure 1.13). These barnacles benefit by receiving transportation all over the ocean, which exposes them to more currents and feeding opportunities than they would normally experience. The whale neither benefits nor is harmed by the barnacles.

d. Metabiosis

Metabiosis is a more indirect dependency, in which one organism creates or prepares a suitable environment for another organism. Examples include maggots, which feast and develop on corpses, and hermit crabs, which use gastropod shells to protect their bodies as shown in Figure 1.14.



Figure 1.14 Hermit crab

v. Mutualism

Mutualism is another kind of symbiotic relationship beneficial to both the organisms involved. In most of the cases, the relationship is often permanent and obligatory, where one species cannot live without the other.

Figure 1.15 and Figure 1.16 show mutualistic relationship between lichens and a tree, and the bee and a flower respectively. The lichen consists of an algae and a fungus growing together. The fungus gets food from the photosynthesizing algae and the algae gets substratum to establish itself. On the other hand, the bee collects nectar from the flower, and in the process pollen grains stick to the bee's body helping flower in pollination. The common types of mutualism include the following:



Figure 1.15 Lichens growing on the trunk of a tree.



Figure 1.16 The pollen collects on its body of bee while collecting nectar

a. Defensive mutualism

It is the relationship shared by two organisms, wherein one organism depends on the other for protection against predators or parasites and returns the favor by providing food and shelter to its protector. For example, aphids provide food for ants and the ants in turn protect aphids from predation by beetles and other insects.

b. Dispersive mutualism

It is a kind of relationship observed in the pollination process in plants. Insects are resource beneficiaries, i.e., they derive food resource in the form of nectar and plants benefit from pollination carried out by these insects, which help plants reproduce. Interestingly, several species of plants tend to mimic insects to facilitate the entire process. For instance, the floral structure and color of various orchid species closely resemble a female wasp, by which male wasps are deceived into the process of pollination.

c. Trophic mutualism

This is a type of mutual relationship, wherein both species involved benefit in the form of resources. For example, in the relationship between the algae and fungus in lichen, fungus gets food from the algae, and algae gets water and support from the fungus. Another example is zooxanthellae (single cell algae), which lives within coral polyps. In this case, coral polyps depend on the photosynthesis process carried out by zooxanthellae for food, while zooxanthellae depend on nitrogen which the coral polyps derive from hunting at night.

vi. Amensalism

It is a negative symbiotic association between two species in which one species is harmed without any benefit for the other. For instance, algal blooms can lead to death of many species of fish, in which the death of the fish do not benefit the algae (Figure 1.17).



Figure 1.17 Algal bloom kills fish

Activity 1.2 Identifying the types of ecological interaction

Instructions:

Study the pictures of the organisms in Table 1.1 and identify the types of ecological interaction.

Table 1.1

Picture	Description	Questions
 <p>(a)</p>	The black walnut tree from its roots secrete toxic chemicals in the soil that harms the neighbouring plants.	<ol style="list-style-type: none"> 1. Explain the relationship in the picture. 2. What is the role played by the black walnut tree? 3. Give another example.
 <p>(b)</p>	The mistletoe growing on the branches of the tree	<ol style="list-style-type: none"> 1. Identify the relationship in the picture. 2. What is the role of the tree? 3. Mention the role of mistletoe in the picture. 4. Give another example which shows the same relationship.
 <p>(c)</p>	The crow is feeding on the parasites on a deer.	<ol style="list-style-type: none"> 1. Identify the relationship in the picture. 2. How is the deer in the picture benefiting as a result of this relationship? 3. What is the role of the crow in the picture? 4. Give another example which shows similar kind of relationship.

 <p>(d)</p>	<p>Remoras hitching a ride on sharks and feeding on the food morsels.</p>	<ol style="list-style-type: none"> 1. Identify the relationship in the picture. 2. How do the remoras benefit by this relationship? 3. What is the role played by the shark? 4. Give another example that illustrates the relationship.
 <p>(e)</p>	<p>The fox and vultures feeding on the carcass of a zebra.</p>	<ol style="list-style-type: none"> 1. Identify the relationship in the picture. 2. Will the relationship still remain the same if there is only one type of scavenger? Give reason. 3. The given relationship is a negative interaction. Justify. 4. Give another example.

Questions

1. Describe interactions of any two organisms in your locality. Explain their significance.
2. Yak and buffalo cannot thrive in the same habitat. Justify.
3. How do humans interfere in the interaction amongst the organisms in an ecosystem?
4. Explain the roles of interactions amongst different organisms in sustaining a healthy ecosystem.

Summary

- All organisms live together in an ecosystem and depend on each other through different types of interactions and relationships.
- Continuous interactions between biotic and abiotic components contribute to biogeochemical cycles.
- The biogeochemical cycles are classified into gaseous cycles and sedimentary cycles.
- Ecology is the study of organisms and their interactions with their surroundings, which include both biotic and abiotic components.
- Organisms are adapted to a particular locality in the habitat called niche. The niche provides organisms with all the necessary food, shelter and protection and mates.
- Competition arises when two or more organisms strive to obtain the same limited resource from the ecosystem.
- A superior competitor can gradually eliminate an inferior one from the area, resulting in competitive exclusion.
- Symbiosis is a close, often long lasting, physical relationship between two different species.

Exercise

1. Fill in the blanks with the correct word(s).

- a. Plant uses and also produces carbon dioxide through the process of cycle.
- b. A is a particular place in a habitat where organisms obtain food, shelter, protection and mate.
- c. The kingfisher lives on fishes for its food, and this relationship between them is called
- d. The main nitrogen reservoir in the biosphere is the
- e. The interaction between orchids and trees is an example of.....

2. Each question is followed by four possible choices of answers. Choose the suitable response for each item.

- a. The main source of calcium in its cycle is
 - A. air.
 - B. rocks.
 - C. plants.
 - D. ocean.

- b. In a stable, long existing community, the establishment of a single species per niche is most directly the result of
 - A. parasitism.
 - B. competition.
 - C. interbreeding.
 - D. over production.

- c. The interactions between the biotic and the abiotic components of an ecosystem is responsible for
 - A. biogeochemical cycle.
 - B. hydrological cycle.
 - C. cnitrogen cycle.
 - D. phosphorus cycle.

- d. The phosphorus cycle lackscomponent
 - A. a mineral
 - B. an aquatic
 - C. an organic
 - D. an atmospheric

- e. Level III in Figure 1.18 is an example of
 - A. a population
 - B. an ecosystem
 - C. an individual
 - D. a community

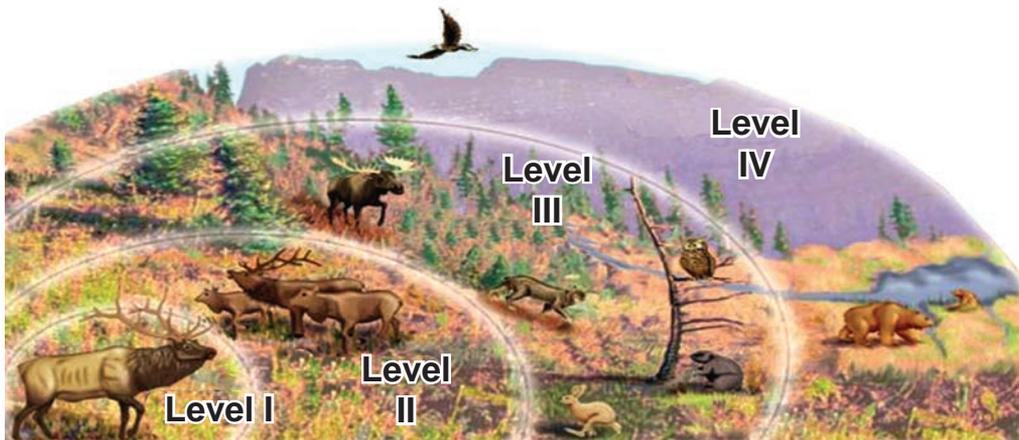


Figure 1.18

3. Write TRUE or FALSE for the following statements. Correct the false statements and write them down.

- a. In phoresy relation, one organism gets food and the other protection.
- b. A population is a group of communities.
- c. When a jellyfish paralyses a tiny fish with its poisonous tentacles, the jellyfish is the predator.
- d. Phosphorous cycle is an example of gaseous biogeochemical cycle.
- e. Intraspecific competition occurs between organisms of different species.

4. Answer the following questions

- a. Explain why an ecosystem with a variety of species might be more stable over a long period of time than an ecosystem with fewer species.
- b. Explain how industries and automobiles affect the carbon cycle.
- c. Calcium and phosphorous cycles are sedimentary cycles. Justify.
- d. What are the three types of mutualism? Explain them briefly.
- e. Identify and explain two physical processes responsible for eroding phosphorous from the land.

h. Use Figure 1.19 to answer questions i to iv.

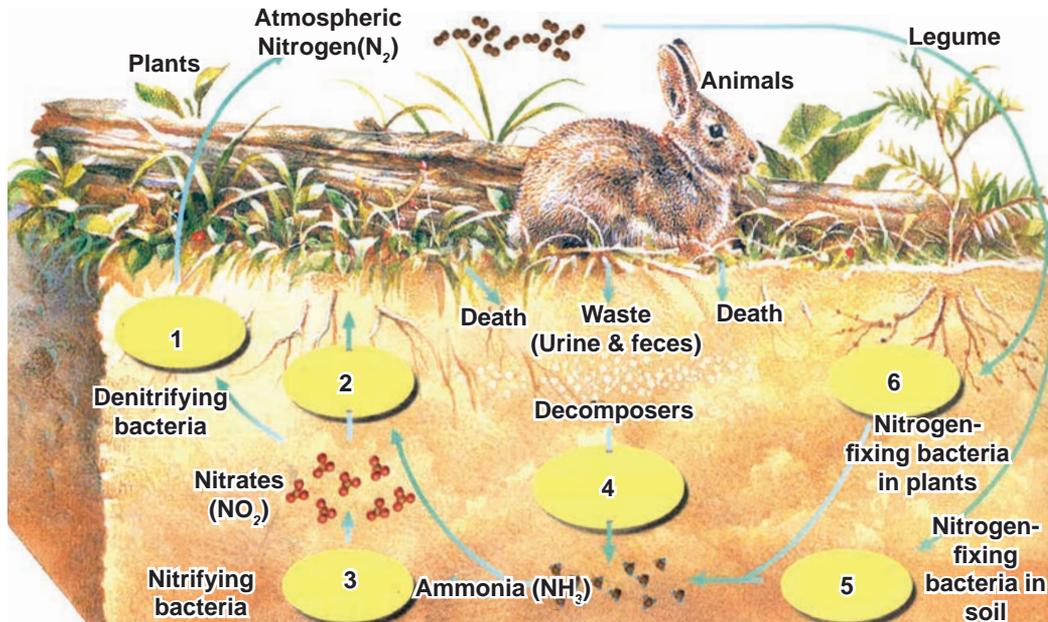


Figure 1.19 Nitrogen cycle

- i. Where are nitrogen-fixing bacteria located on legumes?
- ii. What are two ways in which nitrogen can get into the soil?
- iii. Name the process marked 1 to 6 in Figure 1.31?
- iv. Describe three different pathways that nitrogen can take through the nitrogen cycle.



Balance in Nature

(Ecosystem Stability and species diversity)

An ecosystem is composed of both living and non-living things. These components, biotic and abiotic, are directly or indirectly interdependent and are responsible for maintaining the balance in nature.

Living organisms need various resources, biotic and abiotic, to grow, reproduce and survive. However, any given ecosystem can produce only a limited amount of resources. The type and population of species in an ecosystem depend on the availability of resources. Thus, the populations of species as well as the species composition of an ecosystem may change over time.

1. Carrying Capacity

Learning objectives

On completion of this topic, you should be able to:

- *explain carrying capacity.*
- *relate population, production and consumption to carrying capacity.*
- *calculate the carrying capacity of an ecosystem.*

A. Carrying capacity of an ecosystem

The ecosystem contains numerous types of living organisms in varying population sizes interacting for food and shelter. However, there is limitation to the capacity of the ecosystem to support these organisms. This capacity of the ecosystem to support the organisms is called carrying capacity. The number of organisms supported by the ecosystem depending on the availability of the resources is called carrying capacity.

In an ecosystem, the number of organisms that can be supported depends on its productivity. The productivity of an ecosystem is the capacity of that ecosystem to produce resources in a given time. The resources are mainly light, air, water, food,

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energy and shelter. These resources are consumed and transformed by living organisms in the ecosystem. This process of use and transformation of natural resources or energy by a given species of living organism is called consumption. The population of a species has the ability to grow without limit when resources availability is unlimited. This ability to grow is known as biotic potential of a species. Figure 2.1 (a) shows a “J-shaped” curve, which represents the biotic potential of a species. On the other hand, if resources are limited, growth slows down before the population size reaches the maximum. In this situation, we get a sigmoidal or “S-shaped” curve as shown in Figure 2.1 (b).

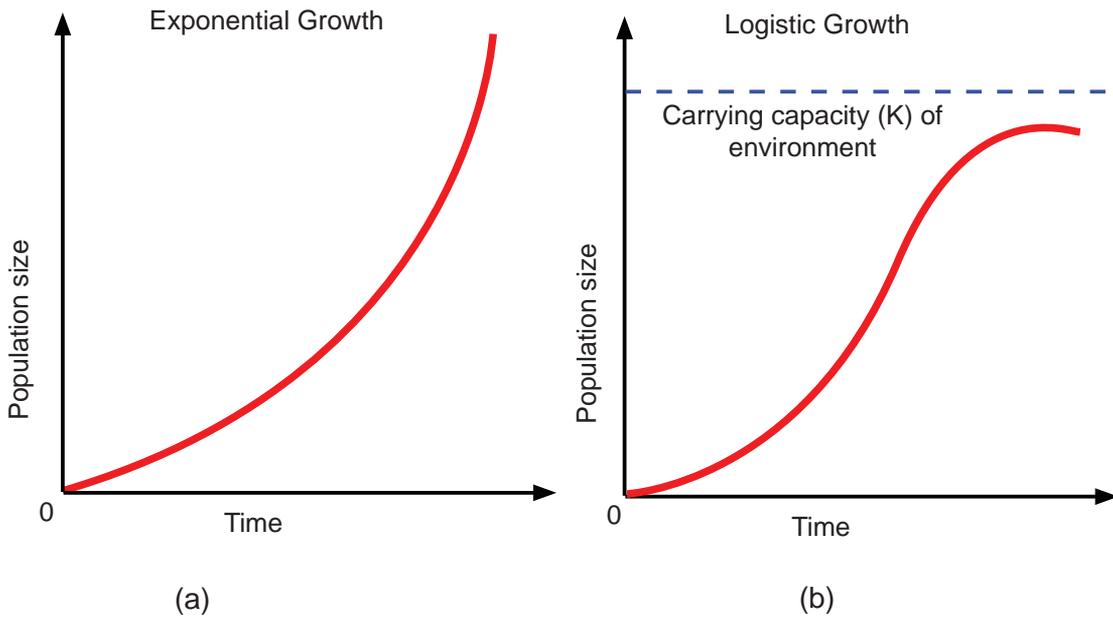


Figure 2.1 Exponential versus logistic population growth

Activity 2.1: Analogy of carrying capacity

Instruction

Work in groups. Study Figure 2.2 a and Figure 2.2 b and hold a healthy discussion with the group to answer the questions that follow. At the end, each group makes a presentation to the class.

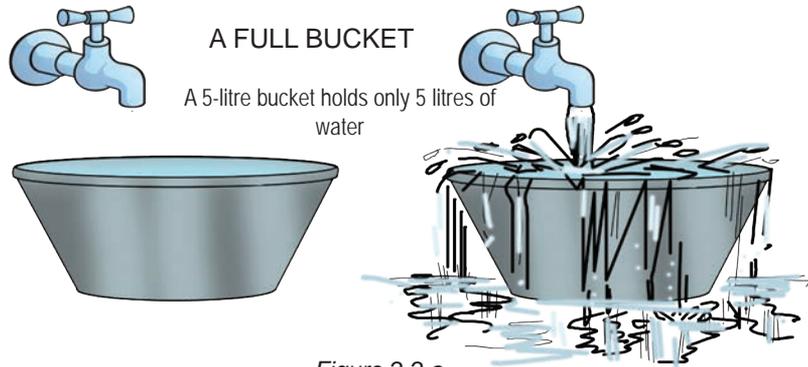


Figure 2.2 a

A given area of land or water supports only the number of animals whose need for food, water, cover and living space are supplied

LIKEWISE

Surplus fish and wildlife from breeding populations or stocking disappear or die.



Figure 2.2 b

Answer the following questions:

1. Observe figure 2.2 a and 2.2 b and write down your observations.
2. Why are some animals in the Figure 2.2 b trying to 'escape' ?
3. How do you relate the two figures 2.2 a and 2.2 b to concept of carrying capacity?

The carrying capacity of an ecosystem may vary for different species and may change over time. This may be due to the following conditions:

- a. Different species of organisms may need or use different resources. For instance, a crane and a snake that live in the same ecosystem feed on fish and frogs respectively. However, when the resources needs of the two or more species living in the same ecosystem are same, they may compete for the resources. Take a cow, a sheep and a goat grazing on the same grassland as shown in Figure 2.3. Competition for resources may also occur within the

same species when the required resources are limited. For example, a large population of cattle grazing on grassland with limited grass. Those species or organisms within a species that are not able to compete for the resources (or get the resources) may not be able to survive in the same ecosystem. Hence, the carrying capacity of the ecosystem for this particular species may change.



Figure 2.3 Competition for resources

- b. The productivity of an ecosystem may vary over time due to various factors like change in temperature, rainfall, natural disasters (like floods, drought, diseases, earthquakes, landslides etc), soil conditions, etc. For instance, the amount of grass produced by grassland varies from one season to the other depending on these factors; thus, this situation affects the carrying capacity.

B. Measuring carrying capacity of an ecosystem

The carrying capacity of an ecosystem may vary for different species and the methods to calculate carrying capacity may also differ from one species to another.

Activity 2.2.: Calculating the carrying capacity of a pasture land

Instructions

1. Read the information given below.
2. Answer the questions that follow.



Ap Gyembo of Laya has 10 yaks. Each yak needs an average of 20 Kg of grass per day. The yaks' only source of grass is 50 acres of grasslands whose production varies from season to season and within seasons as well. The average grass production per day for different months of a year is given in Table 2.1

Table 2.1: Average daily grass production by the grassland and its carrying capacity for different months of the year.

Month	Average grass production by the grassland/day (Kg)	No. of Yaks the grassland can support (carrying capacity)	Whether the carrying capacity has been reached (+) or not (-)
January	60	3	-
February	60		
March	100		
April	140		
May	200		
June	240		
July	300		
August	240		
September	200		
October	140		
November	100		
December	60		

Answer the following questions.

- Calculate the carrying capacity of the grassland for the rest of the months. Determine if the carrying capacity for each month is positive (+) or negative (-).
- Plot line graphs for the following:
 - Average grass production by the grassland from January to December.
 - Number of yaks the grassland can support from January to December.
- Explain the relation between the two graphs with reference to the carrying capacity of the grassland.
- Ap Gyembo also has five sheep. Each sheep needs an average of 4 kg of grass per day. He wants to let his sheep graze in the pasture when there is abundance of grass. In your opinion, during which months and how many sheep can Ap Gyembo graze along with his 10 yaks in the grassland?
- Explain why Ap Gyembo cannot let his sheep graze in the same grassland with his yaks in February.
- If Ap Gyembo continues to keep his yaks in the grassland throughout the year, what do you think will happen to the yak's population and why?

Questions

1. What is the relationship between the productivity and consumption of resources by an organism that lives in that ecosystem?
2. What is the relationship between the carrying capacity and productivity of an ecosystem?
3. In an ecosystem, the only available water source is a small pond. A number of wolves, crocodiles, buffaloes, deer and fish live in the ecosystem. The pond is drying up slowly. What do you think will happen to the population of different species of organisms in that ecosystem? Why?
4. Why is the knowledge of carrying capacity important for people?

2 .Ecosystem Stability

Learning objectives

On completion of this topic, you should be able to:

- *explain ecosystem stability.*
- *describe the factors influencing the equilibrium of an ecosystem.*
- *relate species diversity with ecosystem stability.*

The natural world is very dynamic. The varieties of species and their populations in an ecosystem may change over time. These changes are influenced by various factors that affect their growth and reproduction. Nevertheless, the ecosystem as a whole always tends to remain in an equilibrium.

A. State of an ecosystem

Under natural circumstances, if the population of one species in an ecosystem decreases, or becomes extinct, the population of another species may increase, or new species may appear in the ecosystem. These phenomena tend to maintain the overall population of different species and the number of species in an ecosystem at a stable state. The balance in the number of species and their populations in an ecosystem is called ecosystem stability. When the number of species and populations remain fairly unchanged, the ecosystem is said to be in equilibrium, or that there is balance in nature.

The ecosystem equilibrium is maintained by the interaction of various organisms in an ecosystem, as well as their interactions with abiotic factors. Limitations in resources affect growth, reproduction and survival of some species. For instance, shortage of food leads to intraspecific or interspecific competition, which may result in the decrease of population of organisms, or even the extinction of some of the species. As a result, competition for food reduces allowing the ecosystem to regenerate. This ability of an ecosystem to regenerate after disturbance is called resilience.

When an ecosystem undergoes disturbances that are non-catastrophic over time, the particular ecosystem may adjust or show little deviation to the disturbances. This is called resistance. If the resistance persists over time, the new organism that have inherited traits, which better fit them to the environment, will out-compete others of the same or different species. They reproduce and are better represented by descendants in future generations. Gradually, individuals bearing the same successful traits become abundant in the population with adaptive genetic traits producing more surviving offspring than others without such traits.

i. Factors influencing ecosystem stability

The ecosystem stability may be influenced either by extrinsic or intrinsic factors....

a. Extrinsic factors

The external factors, like changes in natural environment, and human activities that influence the ecosystem stability are extrinsic factors. Climate change and natural disasters affect the natural biogeochemical cycles and bring about changes in landscape creating an unstable ecosystem. Human activities like hunting, agriculture practices, and industrialization lead to excessive use of resources from the ecosystem. Such activities impact the ecosystem permanently, affecting its ability of resistance and resilience. When the magnitude of disturbance is high, ecosystem takes more time to regenerate, or the ecosystem completely shifts to form new ecosystem.

b. Intrinsic factors

These are factors that arise from within an organism, or within the population of the same species that affect the growth and reproduction of organisms in the ecosystem. For example, an organism may be sterile, or may not get the chance to breed, or die before it can reproduce, thereby affecting their population in the ecosystem. Sometimes, some animals may become cannibals, and at other times, the population of a species may grow beyond the carrying capacity of the ecosystem in which they live. All of these affect the stability of the ecosystem.

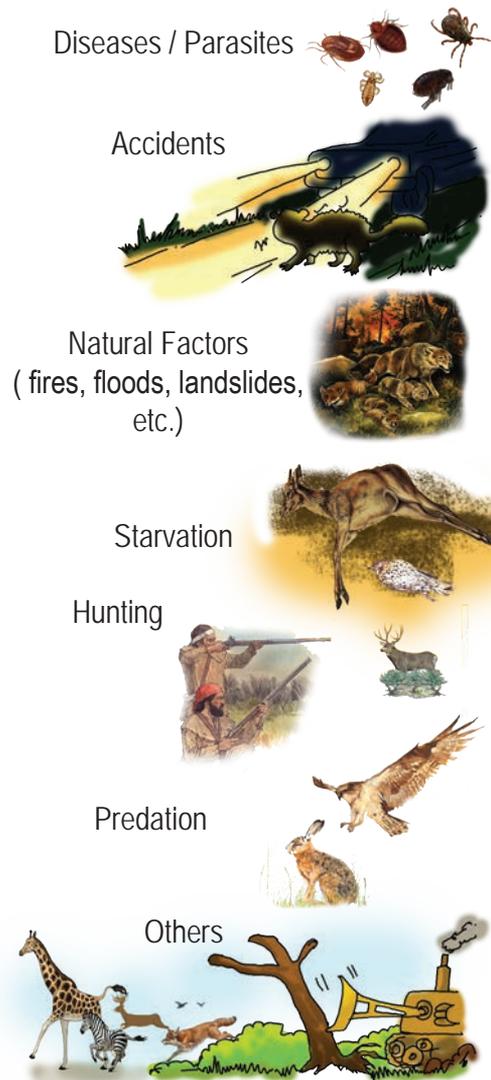


Figure 2.4 Factors influencing ecosystem stability

B. Species diversity and ecosystem stability

Species diversity is a measure of the diversity within an ecological community based on species richness, the number of species in a community, and the evenness of species' abundance. Different species of organisms living in an ecosystem have different resource requirements and tolerance to environmental changes. They may also interact differently with other species. Hence, the number of different species living in a particular area and their populations have major influence on how the ecosystem functions, and therefore, on ecosystem stability.

As illustrated in Figure 2.5, plants use solar energy, water, soil, and air to grow and reproduce. If the environmental conditions of an ecosystem are favourable, more species of plants will grow.

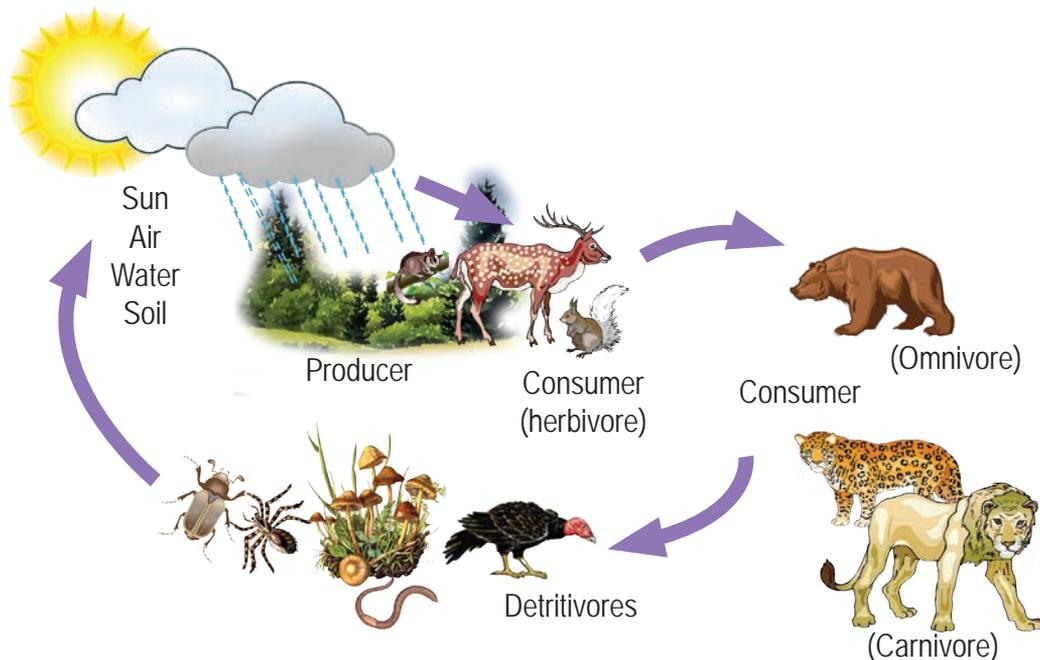


Figure 2.5 Interactions in nature

Thus, more species of plants means a broader food resource base for different species of animals, which depend on plants for their food. This in turn means that more species of animals can live, grow, and reproduce in that ecosystem. There are those species of animals that live on other animals. Thus, larger number of species of primary consumer in an ecosystem means a broader food resource base for the secondary consumers. Furthermore, different species of plants grow at different seasons. This guarantees a continuous supply of food for the primary consumers, which in turn

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supports the secondary consumers. This ensures that there is always a variety of food available for different species of decomposers. The decomposers break down the dead bodies into various nutrients that are sent back to the soils for the producers to use. All these ensure that there is something for every organism to live on.

Therefore, the natural law is that an ecosystem will maintain its stability, either by its ability of resilience or resistance, unless either it is destroyed or its resources are over exploited. Maintaining of ecosystem stability is vital because it ensures life for the organisms that live in it.

Activity 2.3.: African Serengeti

Instruction:

Study the short text given below and answer the questions that follow.

Return of the Paradise

Not long ago, there was prolonged drought for many months in the African Serengeti. Many waterholes dried up completely, while some were gradually becoming undrinkable due to high concentration of alkali content or pollution due to the rotting aquatic animals.

Most of the vegetation, mostly grasses and shrubs, of the otherwise lush grassland dried up, leaving only a few hardy plants. Some species of plants totally disappeared. The only life line river that supported a large number of hippopotamus, also dried up.

The large population of giraffes, buffaloes, gazelles, elephants, wildebeests, hyenas, cheetahs, lions, jackals, foxes, monkeys and various species of birds that used to wander the grassland began to decline as

the drought raged on. Many hyenas, jackals, and foxes died of starvation. Some hyenas were even eating their own kind to survive.

To make the matters worse, there was a major bushfire (wildfire). The fire raged on for many days, consuming whatever came its way. However, finally, Mother Nature came to Serengeti's rescue. The rains came, and along with it, the life to the grassland returned. Today, the grassland is lush and full of life as it used to be. There are more varieties of plants and trees than before, sparked by the bush fire. Big animals like elephants and giraffes fed on tall trees, while smaller animals fed on grasses and bushes. Carnivores like cheetahs, lions, leopards started to thrive and grow well as food became abundant. Swarms of insects



Figure 2.6 A gazelle, giraffe and a wildebeest found in the African Serengeti

adorned the air alongside birds, performing their crucial role of pollination for plants to produce seeds to propagate and sustain

their genetic hereditary.

Thus the ecosystem regained its beauty and glory!

Answer the following questions.

1. What is the main factor that affected the grassland and disturbed its stability?
2. What are the extrinsic and intrinsic factors that affected the populations of different animals?
3. Why do you think the hyenas took to cannibalism?
4. How did the bush fire affect the ecosystem stability of the grassland?
5. Explain how the coming of the rains would have helped bring about the equilibrium in the grassland ecosystem. Use key words like waterholes, grass growth, nutrient recycle, species composition (both plants and animals), population, ecosystem stability, and equilibrium in your answer.

Questions

1. Figure 2.7 shows changes that might occur over time after a fire in a forest area. Explain what would happen to the ecosystem gradually due to the fire.

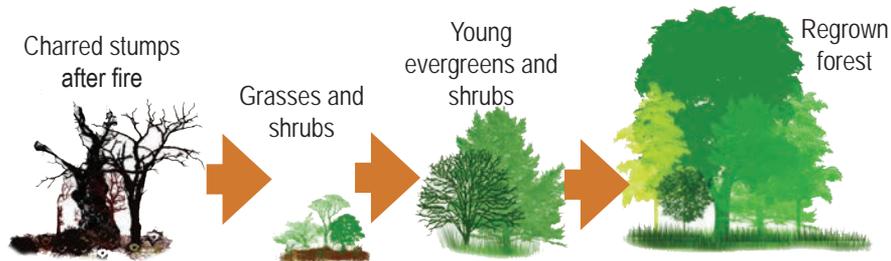


Figure 2.7

2. Ecosystem is a dynamic system in nature. Explain.
3. Explain how populations and species composition of an ecosystem may change with the change in ecosystem stability.
4. Why is a stable ecosystem crucial for the health of animals on the Earth?

Summary

- Different species may need or use different resources. They may also interact differently with other species and resources. Thus, carrying capacity of an ecosystem may vary for different species.
- An ecosystem is always in a dynamic process of change. Therefore, its carrying capacity may change over time.
- Analysis of the carrying capacity of an ecosystem with simple calculations can provide us insights on the stability of that ecosystem at a given time.
- Both abiotic and biotic components of an ecosystem may change over time, but the ecosystem as a whole always tends to remain in a state of equilibrium.
- Ecosystem's resistance and resilience are the two components that characterize the condition of the ecosystem.
- The stability of an ecosystem is influenced either by extrinsic or intrinsic factors.
- Species diversity is an example of intrinsic factor that affects the ecosystem stability.

Exercise

1. Fill in the blanks with the correct word(s).

- a. As per the of a species, it can grow beyond limit when resources availability is unlimited.
- b. As the population of wild dog decreases due to poisoning, the population of boar increases resulting in excessive foraging in the forest. This situation upsets the of an ecosystem.
- c. When the number of species and populations in an ecosystem remain almost constant, the ecosystem is said to be in.....
- d. In several dry seasons, the bush fires in Eastern Bhutan often damage acres of forest, but the forest regains its status after a few years due to the forest ecosystem's characteristics.

2. Each question in this part is followed by four possible choices of answers. Choose the suitable answer.

- a. In the Manas National Park, if the population of elephants and mithuns increases steadily, its carrying capacity will
 - A. increase.
 - B. remain the same.
 - C. decrease.
 - D. not be affected.
- b. In spring season, school flower gardens bloom with young plants and flowers, and more insects infest the garden. In such a situation, an ecosystem may:
 - A. create competition for resources.
 - B. result to decrease in populations.
 - C. increase the carrying capacity.
 - D. create disequilibrium.
- c. The biotic potential of a population is
 - A. the maximum reproductive rate of a population.
 - B. the current rate of growth of a population.
 - C. an expression of how many offspring survive to reproduce.
 - D. determined only by studying an age structure diagram

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- d. Many years ago, cardamom plantations in Bhutan perished due to fungal pest, affecting the income of many farmers. This may be because, the cardamom plantation ecosystem
- A. had organisms competing for resources.
 - B. lacked the ability to resist the change in the ecosystem.
 - C. was a specialized niche.
 - D. had high resilience to change.
- e. The state of any given ecosystem is
- A. always at equilibrium
 - B. constantly changing
 - C. always degrading
 - D. always improving.
- 3. Write TRUE or FALSE for the following statements. Correct the false statements and write them down.**
- a. Consumption increases as population increases.
 - b. Birth rate of a species can affect its population growth rate.
 - c. A patch of land that has abundant food and shelter has large carrying capacity.
 - d. Carrying capacity of an ecosystem does not affect its stability.
 - e. Species composition may be higher in a stable ecosystem as compared to an unstable ecosystem.
- 4. Match the word or phrase numbered (a) to (e) in Column A with the appropriate word or phrase numbered (i) to (v) in Column B.**

Column A	Column B
a. Bear	i. Extrinsic factor
b. Population growth of a species	ii. Carrying capacity
c. Population size at a given time	iii. Ecosystem stability
d. Air	iv. Intrinsic factor
e. Equilibrium	v. Omnivore

5. Answer the following questions.

- a. What do you think will happen to the snake population in an area, if the frog and mice populations start to decrease gradually?
- b. There are five tigers in a forest. Their only source of food is the 16 deers and 24 wild boars. Each tiger must eat an average of 35 Kg of meat per week. Killing of a deer produces an average of 25 Kg of meat, while that of a wild boar produces an average of 55 Kg of meat. Other things remaining constant, calculate the monthly carrying capacity of the forest in relation to the tigers? How long can the tigers survive under this condition?
- c. Making use of two species of plants or animals and a common resource in a given ecosystem, explain the relationship between population, productivity, consumption and carrying capacity of that ecosystem.
- d. Study the graphs that represent the carrying capacities at two situations, Graph A and Graph B, in Figure 2.8 and answer the question that follows:

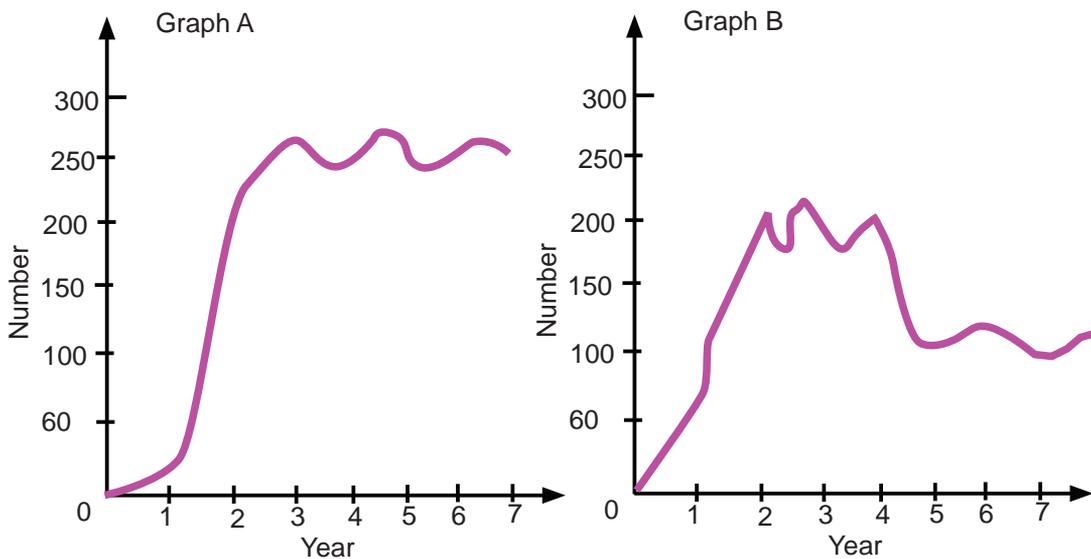


Figure 2.8

- a. What are the carrying capacities shown by graph A and B in the 7th year?
- b. Which graph represents a stable carrying capacity? Why?

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- e. A food web is shown below in Figure 2.9. State what would happen to the plant population, if the number of decomposers were to decrease, and explain why this would happen.

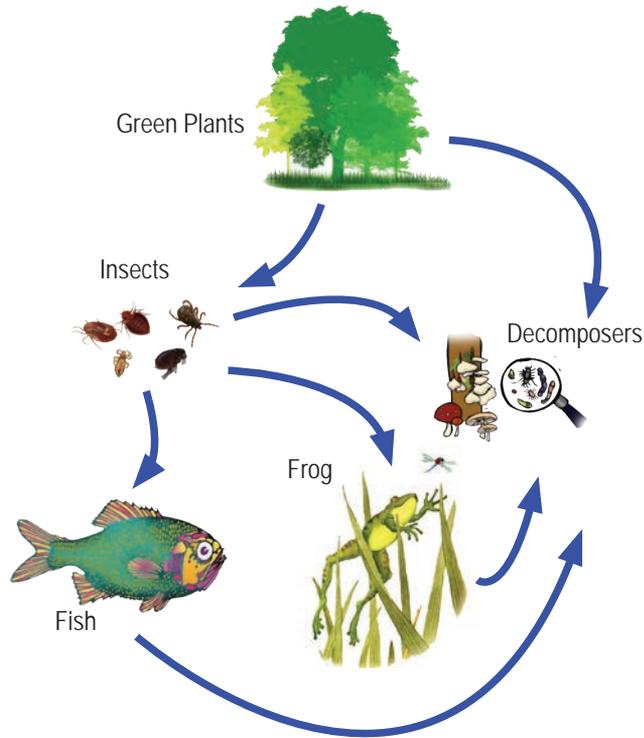


Figure 2.9



People & Environment

Chapter

The environment supports all forms of life found on the Earth. There has been mutual interconnection and interdependence between people and the environment. It has supported the human race since the early periods of human settlement. People rely on the environment to meet their needs, whether vital or secondary. The dependence of human beings on the environment is so great that people are destroying the environment at a rate which the environment is not able to replenish itself. This is due to the increasing population pressure, change in lifestyle, and factors like industrialization, which have resulted in exploitation of environmental resources for economic purposes. Hence, humans have greater role to play in the conservation of environment and the natural resources. Some human culture and tradition has helped in conservation of the environment. In Bhutan, most of the natural features like rivers, lakes, rocks, and trees are considered important religious sites.

In this chapter, you will learn about the relationship between people's way of life, resources consumption, their impacts on the environment, and measures to tackle overharvesting of natural resources.

1. People and resource consumption

Learning Objectives



On completion of this topic, you should be able to:

- *explain the term lifestyle.*
- *list factors influencing the lifestyle of people.*
- *discuss the relationship between lifestyle and the resource consumption.*

A. Lifestyle

The term 'lifestyle' refers to the way people live, which is influenced by natural environment, social, economic, cultural, political, and other conditions people live in. It is generally expressed through our consumption patterns, habits, attitudes, tastes, and moral standards.

In recent years, advancement in science and technology has also brought about major changes in people's lifestyle. For example Figure 3.1 shows the difference in lifestyle of people living in rural and urban places.



Figure 3.1 Lifestyles in rural and urban.

Activity 3.1: Analysing the changes in lifestyle

Instruction

1. Work in groups.
2. Visit a nearby community during your leisure to collect the information.
3. Every group shall identify 3 persons each in the following age groups
 - age group 1: 51 to 80 years,
 - age group 2: 21 to 50 years
 - age group 3: 10 to 20 years (this age group may include you and your classmates)
4. Interview each person and fill up the questionnaire provided.
5. Compile your findings from the questionnaires, and write a report on the differences in the lifestyles of three age groups.
6. Present your findings to the whole class.

Questionnaire

Section A: Bio data

Name _____ (Optional)

Age _____

Village _____

Urban/rural _____

Section B: Survey questionnaire

As a teenager (10 -20 years):

- i. Did/do you attend school?
- ii. How long did/do you take to reach school?
- iii. How did/do you spend your leisure?
- iv. What were/are the occupation of your parents?
- v. What were/are the things that are considered basic necessities by your parents?
- vi. How many hours in a day did/do you spend in prayers?
- vii. Did/do you or other members of your household have mobile phone?
- viii. What fuel did/do you use most often for cooking?
- ix. What was/is the main source of lighting in your house?
- x. What was/ is the type of toilet that is used in your household?
- xi. How well do people in your neighbourhood help each other these days?
- xii. How much meat did/do you consume in a week?
- xiii. What kind of dress did/do you prefer to wear?
- xiv. When sick, what kind of remedies did/do you use?
- xv. How much did/do you spend in a week?
- xvi. What did/do you use at work?
- xvii. How many meals did /do you take in a day?
- xviii. How did/do you get the news of the country?

Compile the report to answer the following questions with appropriate data and evidence.

Questions

1. What conclusion can you draw from the survey about the changes in lifestyles of people?
2. Why do the lifestyles of people change?
3. What were some of the challenges in doing this survey?
4. What do you think are the importance of survey in the environmental science study?
5. Lifestyles of people are affected by technological advancement. Justify.

Report Title:.....

Group Name:..... Date.....

Introduction

State the purpose/aim of the survey, and when and how the information was gathered.

.....
.....
.....

Main Body

All the information collected and analysis are presented clearly in detail (break down the respondents into age groups). Appropriate subheadings, numbers, or letters are to be used to separate each piece of information.

.....
.....
.....

Conclusion

Sum up the points mentioned above. If necessary, a recommendation can be included as well (one way of summing up is making some general comments).

.....
.....

B. Lifestyle and resource consumption

In today's world of consumerism, production and consumption are the economic phenomena. The word consumption is the use of goods and services by an individual, while production is the rate of generation of resources. The availability of resources influences the consumption, and therefore affects the lifestyles of people.

Historically, lifestyle and resource consumption pattern of people have undergone major transformation at different stages of development. Earlier, people only used the readily available natural resources to satisfy their basic needs, such as food, water, fuel and shelter. Their daily activities involved hunting and gathering of food. However, with increasing population and industrial revolution, people now engage more activities in commerce, industry, agriculture and transportation by exploring and exploiting every resource available on the Earth. This resource consumption pattern of people over time is responsible for transformation of people's lifestyles.

The current consumption patterns and lifestyles have been formed through centuries by our civilization and are driven by economic forces, technological progress, political settings, and cultural contexts.

Activity 3.2: Identifying the relationship between lifestyle and resources consumption.

Instruction

1. Work in groups
2. Study Figure 3.2 and answer the questions that follow.

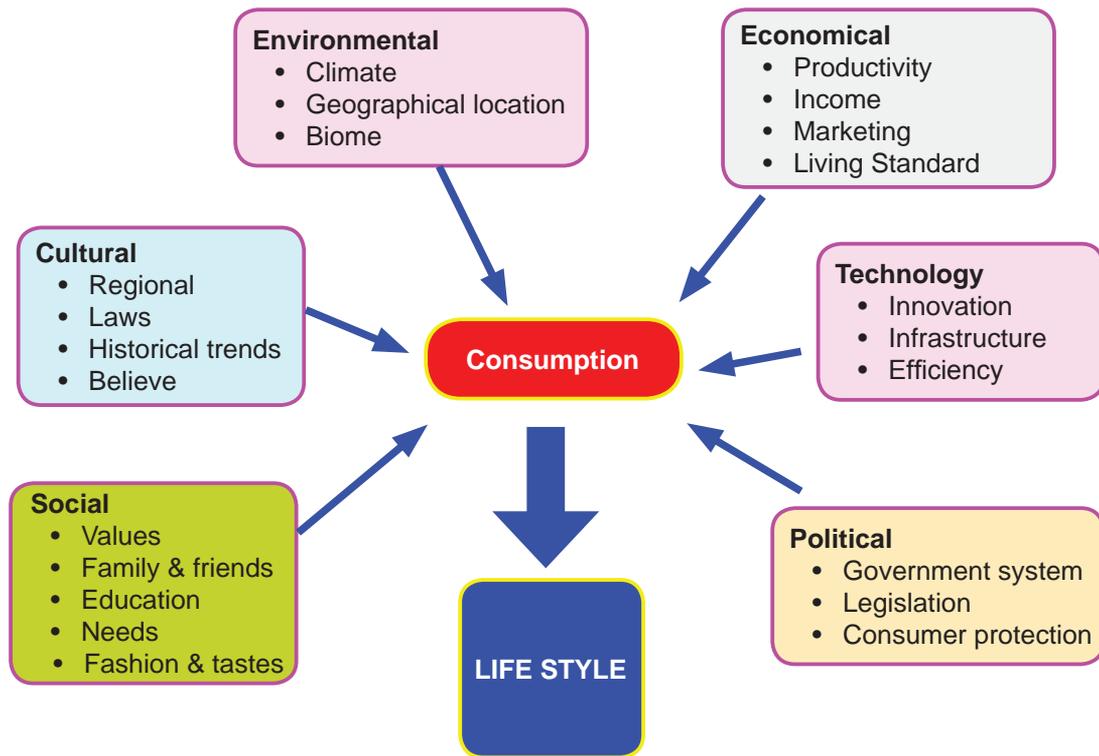


Figure 3.2

Answer the following questions.

1. How do politics, technology and culture of the community influence the lifestyles of people?
2. Lifestyle is also shaped by social factor. Justify.
3. Draw the relationships between lifestyles and resource consumption.
4. List two examples of how consumption has influenced the lifestyle of your community.

Questions

1. What is meant by lifestyle of people?
2. Identify some of the factors responsible for changes in lifestyle?
3. The two teenagers, one from Thimphu and the other from Sakteng in the East, are residing in same house. What conflicting interests will they have? Why?
4. How does the lifestyle of people affect the environment?
5. What type of lifestyle will you adopt to minimize your resource consumption?

2. Ecological Footprint

Learning Objectives

On completion of this topic, you should be able to:

- *explain the concept of Ecological Footprint.*
- *identify the factors influencing Ecological Footprint.*
- *calculate one's own resource consumption using the Ecological Footprint.*

A. Measuring Ecological Footprint

A lot of resources are consumed by people to improve their lifestyles. The resources required are derived from the bio-productive areas of the Earth. Bio-productive areas of the Earth include both land and sea, which provide resources people consume and absorb the waste generated. Cropland, grazing land, forest, built-up land and fishing grounds are some examples that are provided in Figure 3.3. The amount of resources required by people and its availability in the bio-productive areas is best explained by Ecological Footprint. The Ecological Footprint is the area of productive land and water ecosystems required to produce the resources that the population consumes and to absorb the wastes that the population produces.

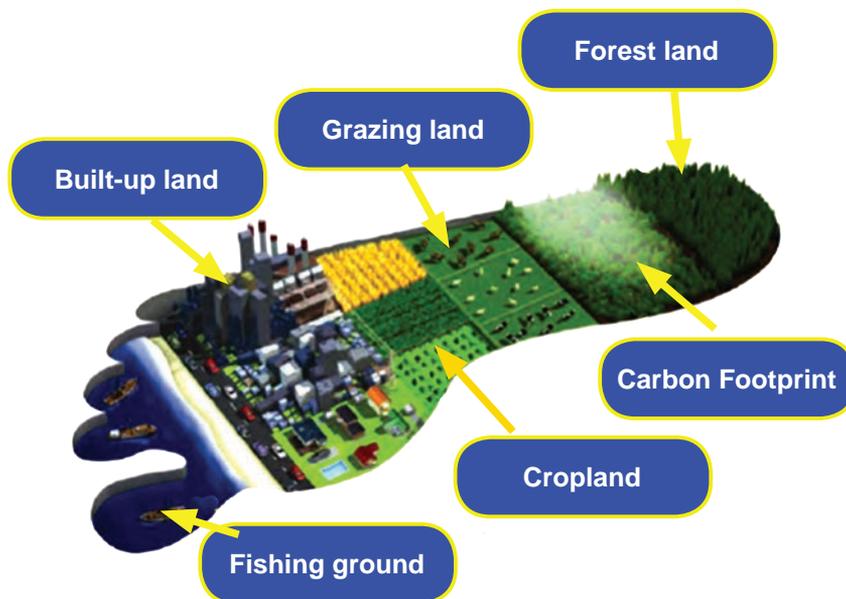


Figure 3.3 Bio-productive areas

Bio-productive area such as cropland is used for production of crops and foods required by human. Forest is an important bio-productive area used as a source for raw material for construction, fuel and for the carbon absorption. For instance, in 2008, 12 billion hectares of bio-productive area was available out of 51 billion hectares of the Earth to support human population of 6.7 billion. If we are to calculate the bio-productive area available for an individual, it would be only 1.8 hectares. Figure 3.4 shows the resource consumption and its Ecological Footprint.



Figure 3.4 Ecological Footprint

Ecological Footprint analyzes the consumption and lifestyles of an individual, country or any activity against the nature’s ability to provide resources for consumption. This tool can provide information by examining the extent to which a nation uses more or less than is available within its territory, or the extent the nation’s lifestyle would be replicable to worldwide. The Ecological Footprint can also be a useful tool to educate people about the carrying capacity and over-consumption to change the lifestyle of people.

If an individual person requires larger bio-productive area due to consumption pattern, the ecological footprint will be bigger. If everyone were to lead the same lifestyle, the number of planets required to support will be more. The size of an individual’s footprint is measured in hectares, and compared to global hectare, which is the Earth’s ability to renew and supply the resources. Ecological Footprint Standards uses global hectares (gha) as a measurement unit, which provides data and the results are compared globally.

Activity 3.3: How big is your Ecological Footprint?

Instructions

1. A copy of the questionnaire will be given to you. The instructions provided in the questionnaire will be explained to you, and you will be assisted during the activity.
2. Fill up the questionnaire and calculate the Ecological Footprint.
3. After completing the questionnaire, answer the following questions.



Figure 3.5 My ecological footprint

Chapter 3

Personal Ecological Footprint Calculator

Procedure: Complete each of the charts for a typical day in your home community. Add the points on each chart to obtain a subtotal for that category, and transfer it to the summary chart. Use the grand total to calculate your Ecological Footprint

Water Use	My Score	Transportation	My Score
1. My shower (or bath) on a typical day is: <ul style="list-style-type: none"> No shower / no bath (0) 1–2 minutes long / one-fourth full tub (50) 3–6 minutes long / half full tub (70) 10 or more minutes long / full tub (90) 	_____	1. On a typical day, I travel by: <ul style="list-style-type: none"> Foot (0) Bike (5 per use) Public transit (30 per use) Private vehicle (200 per use) 	_____
2. I flush the toilet: <ul style="list-style-type: none"> Every time I use it (40) Sometimes (20) 	_____	2. Our vehicle's fuel efficiency is liters/100 kilometers <ul style="list-style-type: none"> less than 6 liters / (-50) 6–9 liters / (50) 10–13 liters / (100) More than 13 liters / (200) 	_____
3. When I brush my teeth, I let the water run. (40)	_____	3. The time I spend in vehicles on a typical day is <ul style="list-style-type: none"> No time (0) Less than half an hour (40) Half an hour to 1 hour (60) More than 1 hour (100) 	_____
4. I washed the car or watered the lawn today. (80)	_____	4. How big is the car in which I travel on a typical day? <ul style="list-style-type: none"> No car (-20) Small (50) Medium (100) Large (SUV) (200) 	_____
5. We use water-saving toilets (6-9 liters/flush). (-20)	_____	5. Number of cars in our driveway? <ul style="list-style-type: none"> No car (-20) 1 car (50) 2 cars (100) More than 2 cars (200) 	_____
6. We use low-flow shower heads (-20)	_____	6. On a typical day, I walk/run for <ul style="list-style-type: none"> 5 hours or more (-75) 3 to 5 hours (-25) 1 to 3 hours (0) Half an hour to 1 hour (10) Less than 10 minutes (100) 	_____
7. I use a dishwasher on a typical day. (50)	_____		
Subtotal 1: _____	_____	Subtotal 3: _____	_____
Food	My Score	Shelter	My Score
1. On a typical day, I eat: <ul style="list-style-type: none"> Beef (150/portion) Chicken (100/portion) Farmed fish (80/portion) Wild fish (40/portion) Eggs (40/portion) Milk/dairy (40/portion) Fruit (20/portion) Vegetables (20/portion) Grains: bread, cereal, rice (20/portion) 	_____	1. Number of rooms per person (divide number of rooms by number of people living at home) <ul style="list-style-type: none"> Fewer than 2 rooms per person (10) to 3 rooms per person (80) 4 to 6 rooms per person (140) 7 or more rooms per person (200) 	_____
2. _____ of my food is grown locally. <ul style="list-style-type: none"> All (0) Some (30) None (60) 	_____	2. We share our home with non-family members. (-50)	_____
3. _____ of my food is organic. <ul style="list-style-type: none"> All (0) Some (30) None (60) 	_____	3. We own a second, or vacation home that is often empty. <ul style="list-style-type: none"> No (0) We own/use it with others. (200) Yes (400) 	_____
4. I compost my fruit/vegetable scraps and peels <ul style="list-style-type: none"> Yes (-20) No (60) 	_____		
5. _____ of my food is processed. <ul style="list-style-type: none"> All (100) Some (30) None (0) 	_____		
6. _____ of my food has packaging. <ul style="list-style-type: none"> All (100) Some (30) None (0) 	_____		
7. On a typical day, I waste: <ul style="list-style-type: none"> None of my food (0) One-fourth of my food (100) One-third of my food (150) Half of my food (200) 	_____		
Subtotal 2: _____	_____	Subtotal 4: _____	_____

Energy Use	My Score	Stuff	My Score																							
1. In cold months, our house temperature is: <ul style="list-style-type: none"> • under 15°C (59°F) (-20) • 15 to 18°C (59 to 64°F) (50) • 19 to 22°C (66 to 71°F) (100) • 22°C (71°F) or more (150) 	_____	1. All my garbage from today could fit into a: <ul style="list-style-type: none"> • shoebox (20) • large pail (60) • garbage can (200) • no garbage created today! (-50) 	_____																							
2. We dry clothes outdoors or on an indoor rack. <ul style="list-style-type: none"> • Always (-50) • Sometimes (20) • Never (60) 	_____	2. I reuse items rather than throw them out. (-20)	_____																							
3. We use an energy-efficient refrigerator <ul style="list-style-type: none"> • Yes (-50) • No (50) 	_____	3. I repair items rather than throw them out(-20)	_____																							
4. We use compact fluorescent light bulbs <ul style="list-style-type: none"> • Yes (-50) • No (50) 	_____	4. I recycle all my paper, cans, glass, and plastic.(-20)	_____																							
5. I turn off lights, computer, and television when they are not in use. <ul style="list-style-type: none"> • Yes (-50) • No (50) 	_____	5. I avoid disposable items as often as possible. <ul style="list-style-type: none"> • Yes (-10) • No (60) 	_____																							
6. To cool off, I use: <ul style="list-style-type: none"> • conditioning: car / home (30 for each) • Electric fan (-10) • Nothing (-50) 	_____	6. Add one point for each dollar you spend in a typical day. <ul style="list-style-type: none"> • Today was a Buy Nothing Day (0) 	_____																							
7. Outdoors today, I spent <ul style="list-style-type: none"> • 7 hours (0) • 4 to 6 hours (10) • 2 to 3 hours (20) • 2 hours or less (100) 	_____	Subtotal 7: _____	_____																							
Subtotal 5: _____	_____	Fun	_____																							
Clothing	_____	1. For typical play, the land converted to fields, rinks, pools, gyms, parking lots, etc., Air added together occupy <ul style="list-style-type: none"> • nothing (0) • less than 1 hectare / 2½ acres (20) • 1 to 2 hectares / 2½ to 5 acres (60) • 2 or more hectares / 5 or more acres (100) 	_____																							
1. I change my outfit every day and put it in the laundry. (80)	_____	2. On a typical day, I use the TV or computer <ul style="list-style-type: none"> • not at all (0) • less than 1 hour (50) • more than 1 hour (80) 	_____																							
2. I am wearing clothes that have been mended or fixed. (-20)	_____	3. How much equipment is needed for typical activities? <ul style="list-style-type: none"> • none (0) • very little (20) • some (60) • a lot (80) 	_____																							
3. One-fourth of my clothes are handmade or secondhand. (-20)	_____	Subtotal 8: _____	_____																							
4. Most of my clothes are purchased new each year. (120)	_____	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 75%; text-align: left;">Summary: Transfer your subtotals from each category and add them together to obtain the grand total</th> <th style="width: 25%; text-align: center;">Score</th> </tr> </thead> <tbody> <tr> <td style="padding-left: 20px;">• Water use (Subtotal 1)</td> <td style="text-align: center;">_____</td> </tr> <tr> <td style="padding-left: 20px;">• Food (Subtotal 2)</td> <td style="text-align: center;">_____</td> </tr> <tr> <td style="padding-left: 20px;">• Transportation (Subtotal 3)</td> <td style="text-align: center;">_____</td> </tr> <tr> <td style="padding-left: 20px;">• Shelter (Subtotal 4)</td> <td style="text-align: center;">_____</td> </tr> <tr> <td style="padding-left: 20px;">• Energy Use (Subtotal 5)</td> <td style="text-align: center;">_____</td> </tr> <tr> <td style="padding-left: 20px;">• Clothing (Subtotal 6)</td> <td style="text-align: center;">_____</td> </tr> <tr> <td style="padding-left: 20px;">• Stuff (Subtotal 7)</td> <td style="text-align: center;">_____</td> </tr> <tr> <td style="padding-left: 20px;">• Fun (Subtotal 8)</td> <td style="text-align: center;">_____</td> </tr> <tr> <td style="text-align: right;">Grand Total:</td> <td style="text-align: center;">_____</td> </tr> <tr> <td colspan="2">My Ecological Footprint is: Grand Total divided by 100 =hectares (To convert to acres, multiply hectares by 2.47)</td> <td style="text-align: center;">_____</td> </tr> </tbody> </table>		Summary: Transfer your subtotals from each category and add them together to obtain the grand total	Score	• Water use (Subtotal 1)	_____	• Food (Subtotal 2)	_____	• Transportation (Subtotal 3)	_____	• Shelter (Subtotal 4)	_____	• Energy Use (Subtotal 5)	_____	• Clothing (Subtotal 6)	_____	• Stuff (Subtotal 7)	_____	• Fun (Subtotal 8)	_____	Grand Total:	_____	My Ecological Footprint is: Grand Total divided by 100 =hectares (To convert to acres, multiply hectares by 2.47)		_____
Summary: Transfer your subtotals from each category and add them together to obtain the grand total	Score																									
• Water use (Subtotal 1)	_____																									
• Food (Subtotal 2)	_____																									
• Transportation (Subtotal 3)	_____																									
• Shelter (Subtotal 4)	_____																									
• Energy Use (Subtotal 5)	_____																									
• Clothing (Subtotal 6)	_____																									
• Stuff (Subtotal 7)	_____																									
• Fun (Subtotal 8)	_____																									
Grand Total:	_____																									
My Ecological Footprint is: Grand Total divided by 100 =hectares (To convert to acres, multiply hectares by 2.47)		_____																								
5. I give away the clothes that I no longer wear. <ul style="list-style-type: none"> • Yes (0) • No (100) 	_____		_____																							
6. I buy hemp instead of cotton shirts when I can. (-10)	_____		_____																							
7. I never wear% of the clothes in my cupboard. <ul style="list-style-type: none"> • Less than 25% (25) • 50% (50) • 75% (75) 	_____		_____																							
8. I have _____ pairs of shoes <ul style="list-style-type: none"> • 2 to 3 (20) • 4 to 6 (60) • 7 or more (90) 	_____		_____																							
Subtotal 6: _____	_____		_____																							

Questions

1. What is your ecological footprint?
2. Suppose the Average Earth Share for an individual is 4.7 acres, determine whether the Earth could sustain the human population if everyone lived a same lifestyle as yours.
3. Illustrate your Ecological Footprint in the form of pie diagram by the using the information from summary chart.
4. In which category do you consume high amount of resources?
5. What are the initiatives that you can take to change your lifestyle so that the Ecological Footprint becomes smaller?
6. What conclusion can you draw from the activity?
7. State the significance of measuring Ecological Footprint.

3. Overharvesting of Natural Resources

Learning Objectives

On completion of this topic, you should be able to:

- *explain the term overharvesting.*
- *describe the consequences of overharvesting.*
- *discuss measures to prevent overharvesting.*

A. Overharvesting and its consequences

The nature has the capacity to replenish itself, if resources are utilized sustainably. However, in many cases, natural resources are extracted to such an extent that it has caused the extinction of many species of plants and animals. It reduces the resources to such low levels that their exploitation no longer becomes sustainable. Overharvesting happens when the extraction of the Earth's natural resources faster than they can naturally be replenished. In other words, overharvesting refers to harvesting a renewable resource to the point of diminishing return.

Increasing human population, changing lifestyles, economic activities, and development of international trade are some of the main factors responsible for over harvesting of the Earth's natural resources. Overharvesting the natural resources for extended period of time depletes them until they can recover within a short period of time, or never recover. Increase human activities are causing overharvesting of natural resources. Overfishing is the most cited example of overharvesting as shown in Figure 3.7. It is estimated that almost 80 percent of the world's fisheries are on the verge of collapse due to over harvesting. Apart from affecting the particular fish species, over harvesting also disturbs the balance of the entire food web, which includes human beings too.



Figure 3.6 Over fishing

Chapter 3

Over fishing has reduced food supply of coastal communities, particularly in the developing countries, as most of them depend on fish as their primary source of protein. Similarly, Figure 3.8 shows other examples of over harvesting wood products and collection of medicinal herbs.



Figure 3.7 Overharvesting natural resources

The unregulated and inappropriate harvesting of natural resources can lead to over harvesting or over exploitation, resulting in ecosystem degradation, loss of biodiversity, etc. Overharvesting not only threatens the resources being harvested, but can directly or indirectly impact humans as well. For instance, a significant proportion of drugs and medicines are natural products, which are derived directly or indirectly from biological sources.



Figure 3.8 Animal poaching

Animals, such as rhinoceros, elephants, tigers and plant species, such as teak, ebony, sandalwood, and mahogany have been endangered due to over harvesting. The overharvesting has caused an imbalance in the natural ecosystem, and remains to be one of the biggest threats to biodiversity and environmental sustainability.

Activity 3.4 A case study on over harvesting

Instruction

1. Read the case study on “The Curse of Cordyceps Collection”.
2. Answer the questions that follow.

The Curse of Cordyceps Collection

As much as the collection of cordyceps has helped improve the livelihood of people living in the highlands, it has also caused degradation of the alpine habitat. A study on the impact of collecting cordyceps carried out in 2013 found that land with no cordyceps was still fertile and green, while where cordyceps were picked, the soil was degraded.

During the collection of fungus, young shrubs and herbs were also uprooted for fuel. The horses and yaks that the collectors bring along have also caused over grazing in many areas. Mr. Dagay, the range officer of Jigme Dorji National Park, said that apart from the land, the collection has also impacted the habitat of wildlife and other medicinal plants. He further added that there is an increasing number of human and snow leopard conflict. This is because, when land degrades and has less forage, the number of prey, on which the snow leopard feeds, decreases. If these issues are not addressed at the earliest, poaching snow leopard could also occur, said the range officer.

The increasing numbers of collectors bring large numbers of plastic bags but are reluctant to dump waste from cordyceps habitat to the designated pits. “They dump all the plastic bags before leaving for their village,” he said. “This garbage contains



chemicals that will attribute to the extinction of cordyceps.”

While figures are not available, cordyceps collection has also impacted the social lives of highlanders. “We found many students and monks are dropping out of these institutions to get into cordyceps business,” he said. “Most villagers are also seen migrating to urban places.”

Mr. Dagay said that there is a need to revise the process of issuing cordyceps collection permit, because many families split to get extra permit from the gup (local leader). “Today they pay Nu 310 for each permit, and there is no age limit...the government should really look into this and revise the permit rule.” In a stakeholder meeting held in 2009, it was decided that civil servants, monks and army are not eligible for cordyceps collection.

<http://www.kuenselonline.com/the-curse-of-cordyceps-collection/#.UxOUw3MXIhQ>

Questions

1. How has cordyceps collection affected the social aspects of the highlanders.
2. What are some of the benefits of collecting cordyceps?
3. Discuss the various forms of impacts of cordyceps collection on the environment.
4. Discuss the government policy on the collection of cordyceps.

B. Measures to prevent overharvesting

Many countries have adopted strict rules and regulations on hunting, logging, and restrictions on harvesting threatened species. Demarcating certain areas as nature reserves, wildlife sanctuaries, and national parks have helped in minimizing overharvesting largely.

There are also many agreements at the regional and international levels that aim to tackle the issue of overharvesting. Restricting international trade on endangered species and regulating the extraction and trade of certain animals and plants have helped to reduce poaching and overharvesting. The Convention on Biological Diversity (CBD) is an example of an international agreement to tackle overharvesting of biological resources, which is signed by more than 150 countries of the world.

The Convention on Biological Diversity has three main goals:

- i. *conservation of biodiversity.*
- ii. *sustainable use of the components of biodiversity, and*
- iii. *sharing the benefits arising from the commercial and other utilization of genetic resources in a fair and equitable way.*

The CBD recognizes that natural resources play an important role in the socio-economic development and must be used for the benefit of humans. The natural resources are finite and rapidly depleting. Therefore, it must be used in such a way that it does not lead to the long-term decline of biological diversity and degradation of the natural environment. As a precautionary measure, harvesting of resources must be avoided if there is any threat of significant loss of biological diversity. In line to this, different countries have adopted various policies and strategies to protect their biodiversity and curtail overharvesting of natural resources.

Bhutan has set an exemplary role in protecting the biodiversity and safeguarding the country's natural resources. The policy to maintain 60 percent of the country under forest covers at all times; initiative to preserve biodiversity through protected areas system; ban on hunting and trading of wildlife products; stringent laws and policies on the harvesting of natural resources are a few good examples that have helped Bhutan to maintain its natural environment.

Questions

1. Why do we need to reduce overharvesting of the Earth's resources?
2. Explain the three main goals of CBD.
3. Name three measures adopted by Bhutan to check overharvesting of natural resources.

Summary

- The term lifestyle refers to the way people live, influenced by the resources and the environment that they live in. It is, generally expressed through our consumption patterns, habits, attitudes, tastes, and moral standards.
- Lifestyle, generally, is influenced by the environmental, social, economic, cultural, political, and other conditions in which people live.
- The word consumption is the use of goods and services by an individual, while production is the rate of generation of resources. The availability of resources influences the consumption, and therefore affects the lifestyles of people.
- Historically, lifestyle and resource consumption pattern of people have undergone major transformation at different stages of development.
- Bio-productivity areas of the Earth include both land and sea which provide resources people consume, and absorb the waste generated.
- The Ecological Footprint is the area of productive land and water ecosystems required to produce the resources which the population consumes and absorb the wastes that the population produces.
- Ecological Footprint analyses the consumption and lifestyles of an individual, country or any activity and against the nature's ability to provide resources for consumption.
- The Ecological Footprint can also be a useful tool to educate people about the carrying capacity and over-consumption of the bio-productive area to change the lifestyle of people.
- Overharvesting is the extraction of the Earth's natural resources faster than they can naturally be replenished. In other words, overharvesting refers to harvesting a renewable resource to the point of its exhaustion.
- The policy to maintain 60 per cent of the country under forest cover at all times; initiative to preserve biodiversity through protected areas system; ban on hunting and trading of wildlife products; stringent laws and policies on the harvesting of natural resources are a few good examples that have helped Bhutan to maintain its natural environment.
- The "Convention on Biological Diversity" (CBD) is an example of an international agreement to tackle overharvesting of biological resources, which is signed by more than 150 countries of the world.

Exercise

1. Fill in the blanks with the correct word(s).

- a. is the extraction of the Earth's natural resources faster than they can naturally be replenished.
- b. The highlanders depend on nature for their basic needs. Therefore, the place where they live influence people's
- c. The relationship between the carrying capacity of the ecosystem and the consumption and production of wastes by people is
- d. Nature has the capacity to itself, if resources are utilized in a sustainable manner.
- e. Overharvesting of resources endangers the biodiversity, and sometimes some species become

2. Each question in this part is followed by four possible choices of answers. Choose the correct answer.

- a. The difference in lifestyle leads to inequality in
 - A deforestation.
 - B consumption.
 - C desertification.
 - D conservation.
- b. The consumerist society refers to
 - A primitive society.
 - B agricultural society.
 - C industrial society.
 - D present society.
- c. In Bhutan, the most overharvested resource is
 - A forest.
 - B soil.
 - C minerals.
 - D fisheries.

- d. The Conservation of Biodiversity (CBD) is one of the international treaties, whose main objective is
- A conserve overharvesting of resources.
 - B conserve the heritage wealth of the community.
 - C prevent the loss of forest.
 - D prevent overharvesting of resources.
- e. Bhutan has protected areas spread across the country. The main objective of this is to
- A sustain the use of natural resources for local people's livelihood.
 - B conserve the flora for healthy ecosystem
 - C conserve biodiversity.
 - D conserve the fauna.

3. Write TRUE or FALSE for the following statements. Correct the false statements and write them down.

- a. Primitive societies consumed more resources than the modern society.
- b. Modern lifestyle is defined by the quality of food we eat, and cars we drive.
- c. The low-income groups have larger Ecological Footprint than the high-income groups.
- d. Harvesting of resources must be avoided, if there is any threat of significant loss of biological diversity due to it.
- e. Resource consumption is related to its availability.

4. Match the word or phrase numbered (a) to (e) in Column A with the appropriate word or phrase numbered (i) to (v) in Column B.

Column A	Column B
a. Lifestyle	i. contributes to the resources we consume
b. Ecological Footprint	ii. extraction that may lead to extinction of species
c. Bio-productive land	iii. it is different for the urban and rural people.
d. Overharvesting	iv. poaching wildlife
e. Endangered species	v. means by which people can understand the status of resources.

5. Answer the following questions

- a. Define the following terms:
 - a. Ecological Footprint.
 - b. bio-productive land.
- b. How do we express our lifestyle?
- c. What are the main factors responsible for overharvesting of natural resources?
- d. Name three components of the bio-productive land that influence the Ecological Footprint.
- e. Forest plays a dual role in influencing the Ecological Footprint. What are they?
- f. Discuss the factors that are responsible for the changes in lifestyle with reference to Bhutan.
- g. Explain ways of controlling one's own Ecological Footprint.
- h. Discuss the measures to curb the overharvesting of natural resources?
- i. Bhutan is a mountainous country; rivers, hills, mountains, valleys, cliffs, etc., cut off communities from each other. Some communities have access to varieties of modern amenities, while others depend mainly on what nature can offer. The dependence of communities on natural resources resulted in endangering and gradual extinction of a few species. Discuss the characteristics of ways of living of these different groups of communities, and their impacts on the environment.

Natural Resources Degradation



Natural processes and human activities put pressure on natural resources. Humans have been exploiting the natural resources since the start of the industrial revolution in the 18th century. The quality of the natural resources have been deteriorating due to various forms of pollution, such as of air, water and soil. The quantity and the quality of the resources have been in decline due to deforestation, land degradation and biodiversity loss. The environmental degradation has had various implications on the well-being of all living organisms on the Earth.

Bhutan has one of the best conservation policies as envisioned by our leaders. Hence, Bhutan has been able to maintain a pristine natural environment. However, like other countries, Bhutan's natural resources are also under pressure resulting in various forms of natural calamities and deterioration of the health of ecosystems. The health of an ecosystem can be studied through its carrying capacity.

In this chapter, you will study the relationship between the natural resource degradation and the carrying capacity of an ecosystem.

1. Natural resources degradation and Carrying capacity

Learning Objectives

On completion of this topic, you should be able to:

- *identify various forms of pressures on natural resources.*
- *explain carrying capacity of an ecosystem.*
- *relate pressures, impacts and carrying capacity to natural resources and environmental degradation.*

A. Pressures and impacts on natural resources in Bhutan

Unlike other countries around the world, Bhutan has been able to conserve its environment fairly well so far. This is mainly due to its small population size, late start of developmental activities, and timely implementation of sound environmental

conservation policies and laws. Three major environmental achievements of Bhutan are:

- The Constitution of the Kingdom of Bhutan mandates the country to maintain a minimum of 60% forest cover for all times to come;
- About 70% of the total land area of Bhutan is under forest cover, and over 50% of the total area is protected as either National Parks or Biological Corridors;
- Bhutan is carbon negative. This means that, Bhutan soaks up more greenhouse gases than it emits; thus, not contributing to climate change.

Despite the above achievements, Bhutan's natural resources are increasingly coming under various pressures mainly due to gradual increase in population, urbanisation, industrialisation and change in people's lifestyles. Furthermore, the increasing frequencies and intensities of natural disasters intensify the pressures.

The pressures on natural resources either deteriorate the quality of the available resources or reduce their availability. This leads to natural resource degradation, which in turn results in the environmental degradation.

Activity 4.1: From pressures to impacts

Instructions: Read the case study below and answer the questions that follow.

Fuel-wood consumption by the Cordyceps collectors in the alpine area of Chajeyna in Bumthang

In recent years, Cordyceps has become one of the most expensive fungi in the world. The sale of Cordyceps is one of the main sources of income to the local people living in the area.



Besides exerting pressure on the Cordyceps resources, the collectors' hiking, camping,

cooking, and disposing of human and other wastes in the pristine high alpine environments have had adverse environmental effects. Above all, the collectors consume significant amounts of fuel-wood from Rhododendron for cooking and heating. Besides, there are also a large number of yak herders who have been living in the area harvesting Cordyceps as well as using the available resources for a long time.

The yak herders were concerned about the dwindling fuel-wood resources near their summer camps. Some reported that at the present extraction rates, the fuel-wood resources may run out within the next few years affecting their livelihood. This was confirmed by one of the Rhododendron plots having completely dried out.

Estimates by the researcher also showed that based on the current rate of fuel-wood consumption, standing biomass and annual growth increment, Chajeyna will likely be devoid of woody vegetation in less than 13 years. Besides, recent reports indicate that

the Cordyceps resources are dwindling due to increased number of collectors.

Source: <http://sangayw.blogspot.com/search/label/Fuelwood>

Questions

1. What are the main natural resources being discussed in the case study?
2. What is happening to the natural resources and why?
3. If the pressures on the natural resources continue, what do you think will happen to:
 - i. livelihood of yak herders and the Cordyceps collectors?
 - ii. biodiversity of Chajeyna in the long run?
4. Suggest some ways by which the natural resources under degradation can be protected without compromising the welfare of the yak herders and the Cordyceps collectors.

B. Environmental degradation and carrying capacity

Environmental degradation can have various implications on the lives of organisms, including humans. If the pressure on a given resource in an ecosystem increases, the resource degrades both in quality and quantity. Thus, it becomes less available to the organisms using it. Consequently, the ability of an ecosystem to sustain life declines. This ability of an ecosystem to sustain life is called carrying capacity. The carrying capacity of an ecosystem is the size of the population that can be supported by the available resources and services of that ecosystem indefinitely. It gives us an indication of what population size of a species that an ecosystem can sustain within the limits of the available resources without negative impacts on the species.

Living within the limits of an ecosystem depends on three factors; the amount of resources available in the ecosystem, the size of the population, and the amount of resources each individual consumes. For example, in a life boat after a ship wreck, the carrying capacity is the number of people who could survive in the life boat. Their survival depends on how much food and water they have, how much each person drinks and eats each day, and how many days they are to remain afloat.

The carrying capacity for any given area is not fixed. The change in carrying capacity can be brought about by the species through their interactions, by improved technology, and increase in population. As the environment gets degraded, carrying capacity actually shrinks, leaving the environment no longer able to support the

organisms. No population can live beyond the carrying capacity of an ecosystem for very long.

Activity 4.2: How over-population and degradation impact the carrying capacity

Instruction: Read the case study given below and answer the questions that follow.

The Saga of Easter Island: A History of Over-population



One of the most remote habitable places on the earth, Easter Island, lies about 3200 km west of South America, the nearest continent, and more than 2000 km from the closest occupied island (Pitcairn). With a mild climate and fertile volcanic soils, Easter Island should have been a tropical paradise, but when it was “discovered” by Dutch explorer Jacob Roggeveen in 1722, it resembled a barren wasteland more than a paradise. Covered by a dry grassland, the island had no trees and few bushes more than a meter tall. No animals inhabited the island except humans, chickens, rats, and a few insects.

The 2000 people living on the island at the time eked out a pitiful existence. Having no seaworthy canoes, they couldn’t venture out on the ocean to fish. With no trees to provide building materials or firewood, the island’s cool, wet, windy winters were miserable; meagre gardens hardly produced enough food for subsistence.

And yet, scattered along the coastline were thousands of immense stone heads, some as large as 30 meters tall, weighing more than 200 metric tons. How could such a

small population have carved, moved, and erected these enormous effigies? Was there once a larger and more advanced civilization on the island? If so, where did they go?

Historical studies have shown that conditions on the island were once very different than they are now. Until about 1500 years ago, the island was covered with a lush subtropical forest and the soil was deep and fertile. Polynesian people apparently reached Easter Island about A.D. 400. Anthropological and linguistic evidence suggests they sailed from the Marquesas Islands 3500 kilometers to the northwest. Excavations of archaeological sites show that the early settlers’ diet consisted mainly of porpoises, land-nesting seabirds, and garden vegetables. Populations soared, reaching as much as 20,000 on an island only about 15 km across.

By A.D. 1400 the forest appears to have disappeared completely-cut down for firewood and to make houses, canoes, and rollers for transporting the enormous statues. Without a protective forest cover, soil washed off steep hillsides. Springs and streams dried up, while summer droughts made gardens less productive. All wild land birds became extinct and seabirds no longer nested on the island. Lacking wood to build new canoes, the people could no longer go offshore to fish. Statues carved at this time show sunken cheeks and visible ribs suggesting starvation.

At this point, chaos and warfare seem to have racked the land. The main bones found in fireplaces were those of rats and humans.

Cannibalism apparently was rampant as the population decreased by 90 percent. The few remaining people cowered in caves, a pitiful remnant of a once impressive civilization. When we try to imagine how people reached this condition, we wonder why they didn't control their population and conserve their resources. What were their thoughts as they cut down the last trees, stranding themselves on this island of diminishing possibilities?

The debate over the carrying capacity of
Source: The McGraw-Hill Companies, Inc.

the earth for humans remains one of the most contentious and important issues in environmental science. Some demographers warn that we are headed for a disaster similar to that of Easter Island. Others hope that we will be more clever and perceptive than the unhappy people who destroyed the resource base on which they depended. What do you think?

Source: The McGraw-Hill Companies, Inc.

Questions

1. List the resources that were used by the island's colonizers, and classify which resources declined over time.
2. Discuss the changes that took place on Easter Island after colonization.
3. What factor or factors finally limited the growth of the human population on the Easter Island?
4. What does this study tell you about unchecked population growth?
5. How can we address population and carrying capacity challenges?
6. Make a hypothetical explanation of Malthusian Theory of Population based on the case study.

Questions

1. List the resources that were used by the island's inhabitants, and identify which resources declined over time.
2. What factor or factors finally limited the growth of the human population on the Easter Island?
3. Is Easter Island an example of what could happen to the rest of us if our population grows and we use up our store of resources? Justify.

2. Carrying Capacity of the Earth

Learning Objective:

On completion of this topic, you should be able to:

- *justify that the carrying capacity of Earth is limited.*
- *describe carrying capacity overshoot.*

The carrying capacity of a biological species in an environment is the maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment. The carrying capacity of a given ecosystem can be extrapolated to larger ecosystems, or even the whole world. Extrapolation of simple calculations of the carrying capacity of an ecosystem to the Earth can give us insights into the capacity of the Earth's resources to support life on the Earth.

It is a normal trend that as the population increases, birth rate often decreases and death rate typically increases. The difference between the birth rate and the death rate is the natural increase. The carrying capacity could support a positive natural increase, or could require a negative natural increase. In other words, the carrying capacity is the number of individuals an environment can support without significant negative impacts on the given organism and its environment. Below carrying capacity, population typically increases; while above, it typically decreases. A factor that keeps population size at an equilibrium is known as a regulating factor. Population size decreases above carrying capacity due to a range of factors depending on the species concerned, but can include insufficient space, food supply, or sunlight. The carrying capacity of an environment may vary for different species and may change over time due to a variety of factors, such as food availability, water supply, environmental conditions and living space. For the human population, more complex variables, such as sanitation and medical care are sometimes considered as part of the necessary establishment.

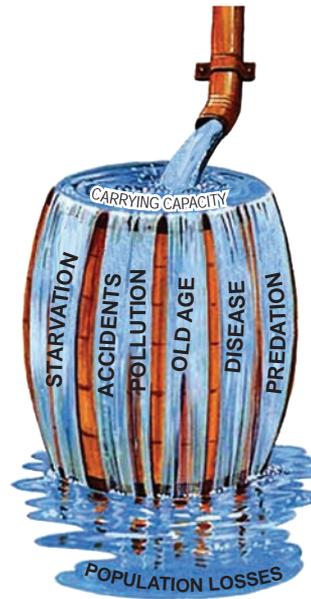


Figure 4.1 Carrying capacity and population

We understand that the Earth's carrying capacity is limited, given the food, habitat, water, and other necessities available in the environment are not infinite. To understand this, we take only one species (humans) and one resource (food) as an example. Let us say that 800 people lived in a village at the end of 2010. The village can produce enough food to support a maximum of 1000 people at any given time. Hence, 1000 is the carrying capacity of that village. Now, let us assume that the annual birth rate of the village exceeds its death rate by 5%. This means that the population of the village increases by 5% annually. So, the population increases as given in the Table 4.1.

Table: 4.1

Year	Initial population	Increase in population (5% of Initial population)	Total population (Initial population + increase in population)
2011	800	$(800 \times 0.05) = 40$	$800 + 40 = 840$
2012	840	$(840 \times 0.05) = 42$	882
2013	882	$(882 \times 0.05) = 44$	926
2014	926	$(926 \times 0.05) = 46$	972
2015	972	$(972 \times 0.05) = 48$	1020
2016	1020	$(1020 \times 0.05) = 51$	1071

As you can see from Table 4.1, the village is within its carrying capacity from 2011 to 2014. However, by 2015, the village reaches and also exceeds its carrying capacity. Thus, beyond 2014, the village's food production can no longer sustain its population.

Figure 4.2 illustrates the population growing rapidly beyond the limits of the carrying capacity, resulting in carrying capacity overshoot.

Since the carrying capacity is defined as the maximum population that an environment can maintain indefinitely, overshoot is a temporary phenomenon of an ecosystem. Populations always decline to (or below) the carrying capacity. How long they stay in overshoot depends on the stored resources needed to support their inflated numbers.

With the limited availability of freshwater, there are indeed constraints on the amount of food that the Earth can produce. Even in the case of maximum efficiency, in which all the grains grown are dedicated to feeding humans (instead of livestock, which is an inefficient way to convert plant energy into food energy), there is still a limit to how far the available quantities can stretch. This indicates that the carrying capacity of the Earth is limited.

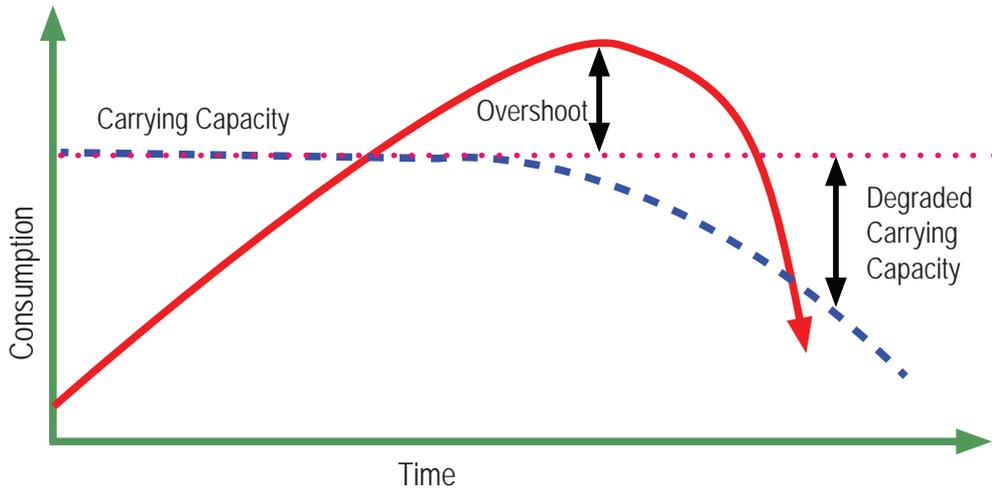


Figure 4.2 Carrying Capacity overshoot.

Humans are using more than what the planet can provide. The pattern of human using our natural resources faster than the Earth can replenish can be compared to people spending more than their income. In planetary terms, the costs of our ecological overspending are becoming more evident by the day. Climate change, as a result of greenhouse gases being emitted faster than they can be absorbed by forests and oceans, is the most obvious and arguably pressing result. Other consequences include shrinking forests, species loss, fisheries collapse, higher commodity prices and civil unrest. These environmental degradation and economic crisis may decrease the carrying capacity of the Earth.

Questions

1. Write a short essay of about 100 – 150 words explaining what you think might happen to the well-being of humans if the human population exceeds the carrying capacity of the Earth.
2. What factors help to prevent populations reaching their carrying capacity?
3. Refer to the statement to answer the questions that follow.

“The carrying capacity of a lake for trout is 150”

- i. If the lake becomes half the size of the original, can the lake still sustain 150 trouts? Justify.
- ii. If chemical fertilizers are drained into the lake, what would happen to the carrying capacity of the lake for the trouts?

Summary

- The increase in population, industrialisation, urbanisation and change in the lifestyle of the people are increasingly imposing various pressures on Bhutan's natural resources.
- The Constitution of the Kingdom of Bhutan mandates the country to maintain a minimum of 60% forest cover for all times to come.
- About 70% of the total land area of Bhutan is under forest cover, and over 50% of the total area is protected as National Parks, Strict Nature Reserves, Wildlife Sanctuaries and Biological Corridors.
- Bhutan is carbon negative. Carbon negative means that the forest absorbs more greenhouse gases than emitted; thus, not contributing to climate change.
- Pressures on Bhutan's natural resources are pollution of air, water and soil, deforestation, degradation of land/soil, biodiversity loss and depletion of natural resources.
- The impacts of the pressures on natural resources decline the quality and/or quantity of the available natural resources.
- The carrying capacity of an ecosystem is the size of the population that can be supported by the available resources and services of that ecosystem indefinitely.
- Over-exploitation of natural resources increases the pressures and their impacts on the natural resources. This leads to natural resource depletion, and therefore, environmental degradation.
- Environmental degradation can have various implications on human well-being.
- The limitations in the Earth's carrying capacity can be roughly estimated by extrapolating the carrying capacity of a given ecosystem.
- Pressures on natural resources are directly proportional to the impacts on natural resources, natural resource degradation vis-a-vis environmental degradation and carrying capacity.
- The overshoot in the carrying capacity of an ecosystem may lead to sudden collapse of the ecosystem. Humans are using more than what the planet can provide.

Exercise

1. Fill in the blanks with the correct word(s).

- a. As per the Constitution of the Kingdom of Bhutan, Bhutan must maintain forest cover of a minimum of at all times to come.
- b. The Ministry of Agriculture in Bhutan encourages farmers to replace low milk yielding cows with a fewer high milk yielding ones, so that the of the cows in the ranch is not affected.
- c. A factor that keeps population size at equilibrium is known as factor.
- d. The shrinkage in the carrying capacity is related to a environment.
- e. The surplus population in an ecosystem results to in carrying capacity.

2. Each question in this part is followed by four possible choices of answers. Choose the correct answer.

- a. Carrying capacity applies to
 - A animals.
 - B plants.
 - C humans.
 - D all living organisms.
- b. Carrying capacity is usually diagrammed on a graph showing
 - A population size versus resource use.
 - B population size versus time.
 - C resources use versus time.
 - D population size versus resource availability.

- c. Food resources may get degraded due to increase in
 - A crop production.
 - B population.
 - C agriculture practices.
 - D biodiversity.
- d. The Earth's human carrying capacity
 - A cannot be predicted for certain.
 - B will decrease over time because resources are being depleted.
 - C will increase over time because of technological advances.
 - D can be expanded indefinitely.
- e. There is hardly any grass left in the grassland for the blue sheep to graze. This means that the grassland
 - A has reached its carrying capacity.
 - B Blue sheep do not like the grass.
 - C Snow Leopards are also around in the grassland.
 - D Blue sheep are being hunted for meat.

3. Write TRUE or FALSE for the following statements. Correct the false statements and write them down.

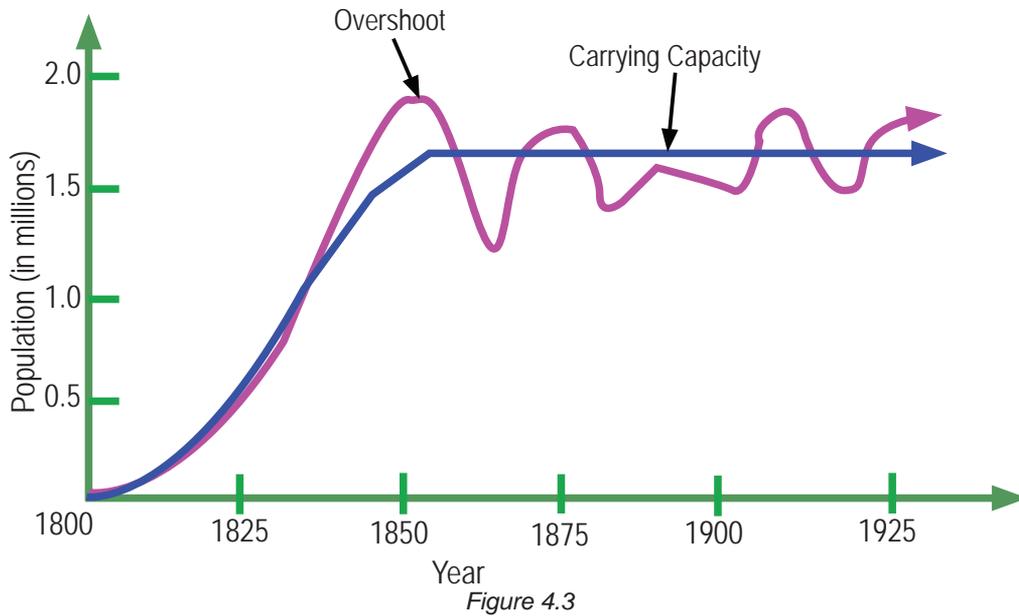
- a. Eutrophication affects the carrying capacity of an ecosystem.
- b. The environmental pressure results in impacts on lives and the environment.
- c. Water pollution in Bhutan is more noticeable in remote areas than urban areas.
- d. A steady increase in the population of wild boar can affect the carrying capacity of an ecosystem.
- e. The carrying capacity of the Earth is unlimited since it produces lot of natural resources.

4. Match the contents of Column A with that of Column B.

Column A	Column B
1. Regulating factors	i. Above the carrying capacity
2. Overshoot	ii. Farming, industries, etc
3. Positive carrying capacity	iii. Food and shelter
4. Anthropogenic causes of environmental degradation	iv. Environmental degradation
5. Pressure on the resources	v. The country to maintain a minimum of 60% forest cover for all times to come

5. Answer the following questions

- a. Why has Bhutan been able to conserve its environment better than most countries?
- b. Describe the graph given in Figure 4.3 to explain the resilience of an ecosystem.



- c. What do you think are the possible reasons for increase in Black necked crane population in Phobjikha? Give at least two reasons.
- d. In not more than 100 words, explain the implications of changing lifestyles of Bhutanese on the environment. The implications may be either positive or

negative.

- e. Hundreds of kilometres of roads are constructed in Bhutan during the Five Year Plans. What do you think are some of its effects on natural resources and their impacts on the environment?
- f. Study the Figure 4.4 and answer the question that follow:



Figure 4.4

1. What human activity is depicted by Figure 4.4?
2. Explain the impacts of this activity on the carrying capacity of that area.
3. Suggest some measures that can help curb the above activity.
4. Mention any policies or laws implemented in Bhutan to protect and preserve our forests?

Disaster Risk & Management



The environment is our life support system. We already learnt that it supplies the basic necessities for life, such as food, shelter, water, air, soil, energy, medicines, fibres, raw materials, and many other things. The environment maintains atmospheric composition and protects all life forms on the Earth. As the dependence of humans on the environment accelerates, the quality of environment degrades at a greater pace, leading to various kinds of man-made disasters, and may trigger natural calamities.

We all feel the impact of environmental degradation and disaster on our health, social life, economy and politics. In this chapter, we shall study the relation of environmental degradation to natural calamities and disasters, and some strategies to reduce the impacts of disasters.

1. Environmental degradation and disaster

Learning objectives

On completion of this topic, you should be able to:

- relate environmental degradation to disasters.
- discuss various impacts of environmental disasters on human well-being.

A. Environmental health and disaster

The environment by itself remains stable due to the ecological balance in nature. The degradation of environment occurs as people carry out excessive exploitation and unscientific management of natural resources in craving for fast materialistic development. For example, a catastrophic and misguided interference with nature resulted in the 'dust bowls' that hit North America in the 1930s. The fertile soil seemed ideal for intensive agriculture, but a combination of deep ploughing and a lack of crop rotation weakened the soil structure. Following years of drought, high

winds which removed all the topsoil and millions of acres of once fertile farmland turned it into a virtual desert.

An example of unforeseen agricultural disaster was Moa Zedong's 1958 decree to eliminate sparrows. Sparrows were considered to have been robbing the people of the fruits of their labour. The campaign was very successful, but it cleared the way for swarms of locusts to descend on the farms. Crops were decimated, leading to a famine that resulted in the death of 38 million people.

The above cases are some of the evidences of environmental degradations leading to series of disasters that impact the life of every people.

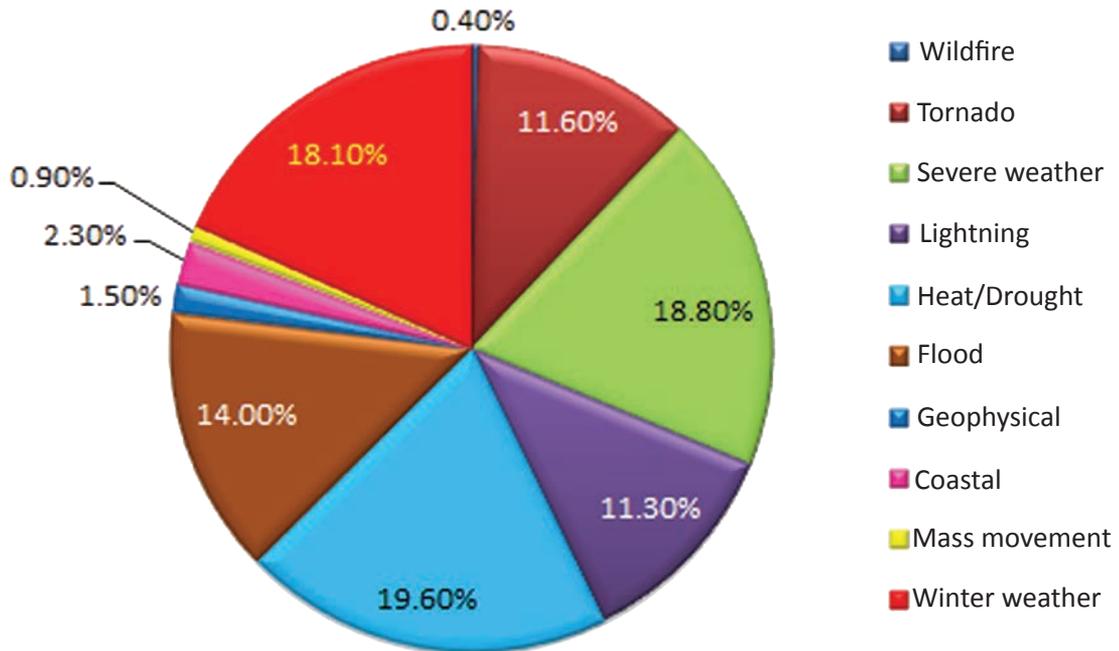


Figure 5.1: Natural disasters.

One classification distinguishes two generic disaster groups: natural and technological disasters. The natural disaster category includes six disaster groups, namely biological, geophysical, meteorological, hydrological, climatological and extra-terrestrial. Each group covers different disaster types and sub-types. The technological disaster includes nuclear plant fallouts, industrial accidents, infrastructure collapse, etc

Table: 5.1: Example of classification of disaster

Disaster generic group	Disaster group	Disaster main type	Secondary Hazard
Natural Disaster	Geophysical	Earthquake	Ground shaking, Tsunami
		Volcano	Volcanic eruption
	Meteorological	Storm	Tropical storm, extra-tropical cyclone (Winter storm), local/Convective storm
	Hydrological	Flood	General (river) flood, flash flood
		Mass movement (wet)	Storm surge/coastal flood, rockfall, landslide
	Climatological	Extreme temperature	Heat wave, cold wave, extreme winter conditions
		Wild fire	Forest fire, land fires (grass, scrub, bush, etc.)
	Biological	Epidemic	Viral and bacterial infectious diseases, parasitic Infectious diseases, etc
	Extra-terrestrial	Meteoroid/Asteroid	Explosion, geomagnetic storms, shock waves, tsunami, fires.

Source: CRED/Munich RE, 2009

Activity 5.1 Investigating environmental degradation in your locality

Materials required: Notebook, Pen, pencil, camera, chart papers, colours,

Instruction

Before the site visit

1. Discuss with your teacher to visit a place nearby where an environmental degradation has occurred. Prepare a set of questions to find information on the following areas. You may ask these questions to elderly citizens residing in the area.
 - Name of the place
 - Description of place before and after degradation
 - A brief history of the event (what happened? When did it happen? What was it like?)
 - How many people were affected?
 - How did the people react?
 - How did human activities contribute to this degradation?
 - How did people overcome the effect of degradation?

During the site visit

1. Observe the place carefully. Note down the changes brought by the degradation. You may take snapshots of the place. Write a comprehensive report based on your findings and share it with the whole class.

Question

1. What are the causes of the degradation?
2. What are the impacts on the environment and people's livelihoods?
3. What could have been done by the people to prevent the degradation?
4. What kind of disaster may occur if these degradations are left unchecked? Why?

B. Impacts of disaster

Our Earth's system by itself is stable due to balancing nature of the environment. However, with the changing time, environment experiences different forms of changes due to natural phenomenon and anthropogenic activities. These factors lead to occurrence of different forms of disaster.

Disasters are the convergence of hazards with vulnerabilities. As such, an increase in physical, social, economic, or environmental vulnerability may cause increased frequency of disasters. These events adversely impact the natural environment leading to environmental disaster. Environmental disasters disrupt people's lives, and generally greater impact is seen in remote regions. This is mainly due to the difficulty in providing timely and adequate relief services.

Activity 5.2 : Identifying the impacts of disasters

Instructions

1. Read about the impacts of disaster caused by environmental degradation given below.
2. Select the most appropriate information pertaining to each type of disaster and complete Table 5.2.

Impacts of Disasters

- a. Uncontrollable shivering, slow speech, memory lapses, frequent stumbling, drowsiness, and exhaustion.
- b. Collapsing buildings due to earthquake claim by far the majority of lives, but the destruction is often compounded by mud slides, fires, floods, or tsunamis. Smaller tremors/aftershocks that usually occur in the days can complicate rescue efforts and cause further death and destruction.

- c. They can have significant impacts on local air quality, visibility and human health. Emissions from forest fires can travel large distances, affecting air quality and human health.
- d. Loss of human life, damage to property, destruction of crops, loss of livestock, and deterioration of health conditions owing to waterborne diseases, sewage overflow and chemical releases from roads, farms and factories. Unsafe water supplies.
- e. There are several impacts on transportation. For example, aircraft lose lift at high temperatures, concrete roads have been known to “explode” lifting 3 - 4 foot pieces of concrete, mechanical failures due to highways buckle, train rails develop sun kinks and distort.
- f. Injuries and deaths are generally increased, increased ground motion, and structural damage. The intense winds of tropical storms can destroy whole communities, buildings and communication networks. Besides their own destructive energy, the winds generate abnormally high waves and tidal surges.
- g. Release of magma, explosive effects, expulsion of large projectiles, pyroclastic flows (flow of hot molten material), ashfall, release of clouds of very hot gases, lahars, mudflows and ground shaking.
- h. Economic losses include those resulting from impaired dairy and beef, crop, timber, and fishery production.
- i. Ash and coarser particles inhaled from hot, dense pyroclastic flow or surge, always results in death from burns or asphyxiation.
- j. Loss of topsoil due to rapid drainage or surface runoff, deforestation and water siltation, sediments affect the optimal performance of hydropower plants.
- k. It can lead to famine due to lack of water for irrigation and an increase in poverty.
- l. Trees and plants can be uprooted, and diseases in the soil are spread. Wildlife loses their lives or habitat, effects the food chain and disrupts the whole environment.
- m. Bhutan needs to develop safety standards and guidelines, especially for professional fire fighters and the public at large, to reduce casualties and prevent fatalities.
- n. Livestock, such as rabbits and poultry, are severely impacted; millions of birds die. Milk production and cattle reproduction also decreases during heat waves. Pigs are also adversely impacted by extreme heat. Wheat, rice, maize, potato, and soybean crop yields can all be significantly reduced by extreme high temperatures at key development stages.

- o. Victims also exhibit a characteristic abrasion pattern on exposed skin that is due to the fine particles of soil, mud, sand, and even water which strike the body at highly accelerated speeds.
- p. A thick blanket of snow or ice on roads makes driving difficult, and metropolitan transportation systems are usually affected first and hardest.
- q. Changes in rainfall patterns can increase the likelihood of armed conflict in countries that are dependent on agricultural production.

Table 5.2

Types of Disaster	Impacts	Reasons (for your choice of impacts)
1. Drought		
2. Earthquakes		
3. Forest Fires		
4. Floods, Hurricanes, Typhoons and Cyclones		
5. Heat Waves		
6. Volcanoes		
7. Tornadoes		
8. Windstorm		

Questions

Study Figure 5.2 and answer the questions that follow.



Flood



Volcano eruption



Wind storm



Wild fires



Earthquake



Drought

Figure 5.2

1. Which of these disasters is most common in our country? Justify.
2. Which of the disasters given in Figure 5.2 may lead to severe famine?
3. What kind of support are needed by people when these disasters occur?
4. Relate environmental degradation to disaster.

2. Disaster risk reduction

Learning objectives

On completion of this topic, you should be able to:

- explain some of the strategies in reducing the impacts of disaster.
- describe the importance of disaster management cycle.
- practice all of the phases of disaster risk reduction in school or at home.

Different forms of disasters affect the condition of the environment and people's lives. The effects of any disaster are of varied nature and magnitude. At times, a disaster may lead to other disaster. For example, a flood leads to an epidemic.

Disasters are seen as catastrophic events beyond human control. However, their impacts on the environment and humans can be minimized by following a proper Disaster Risk Reduction (DRR) procedures.

A. Reducing the impacts of disaster.

The rapid deterioration of the environment around the world has increased the recurrence of natural calamities and disastrous events. Any person can become a victim of a disastrous event. We cannot prevent natural disasters from occurring.

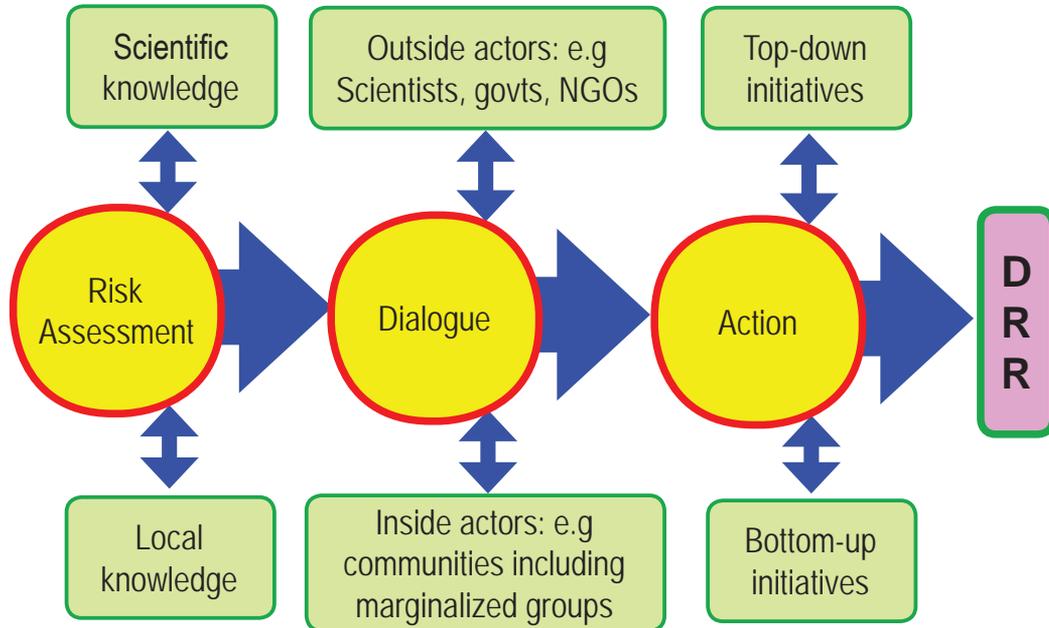


Figure 5.3 Framework for integrating knowledge, actions and stakeholders for disaster risk reduction

However, we can reduce the effects of disaster by undertaking relevant risk reduction measures.

The Disaster Risk Reduction (DRR) is a systematic approach to identify, assess and reduce the risks of disaster. It aims to minimize the vulnerabilities, avoid or limit the adverse impacts of hazards on people and properties. Understanding Disaster risk, improving disaster management system and investing in DRR by preparing Disaster Management and Contingency plan, which includes evacuation plans are some of the ways to reduce the disaster risks and its impacts.

One of the components of DRR is to develop and maintain a evacuation map.. A good risk map will clearly mark risk areas and community resources with clear symbols, which is informative and easy to read.

Activity 5.3 Developing a hazard assessment map

Procedure:

1. Work in groups. Gather information from elderly people to identify any significant dangers their community has faced in the past, or would face in future. You may ask what disasters have taken place in the area. What happened? When did it happen? What did people do?
2. Prepare a hazard assessment map by following the instructions given below.
 - i. Using the information, draw a risk map for the community or your school. You may include
 - b. School (Academic blocks, MP hall, Toilets, Hostels, Staff quarters)
 - c. Hospital/BHU
 - d. Police station
 - e. Army Camp
 - f. Fire station
 - g. Town
 - h. Electricity sub-stations
 - i. Factories
 - j. Houses
 - k. Water tanks
 - ii. Draw a different symbol for each kind of building to differentiate them. Identify all the roads, rivers, electricity lines, water supply and sewage systems and waste dumps. Provide a legend for your map.
 - iii. Identify local hazards in the area if any and shade them in different colours.
 - iv. Indicate areas for safe evacuation and help centres on the map.
 - v. Mark the route with clear directions for entry and exit during any disastrous event.
3. Share and discuss different possible solutions for reducing the risks of disasters in your community. What suggestions would you make to reduce the impact of disaster that may occur in the future?

4. Find out a suitable place to display the hazard assessment map to educate the community.

Questions

1. How important are hazard maps for the community or school?
2. Why do you use different colours and symbols in the map?
3. Why should Help Centres be clearly marked on the map?
4. Why did you choose the particular area for safe evacuation?
5. Why should the entry and exit routes be clearly marked on the map?
6. What measures can be taken to reduce the impacts in the event of a disaster?
7. What are some of the roles you can play as a responsible person during a disaster?

B. Disaster risk management

The geo-physical location of Bhutan makes it one of the most seismically active regions in the world. The earthquake on 21 September 2009, the most devastating in Bhutan's recent history, killed 12 people and damaged a large number of houses, public buildings, and cultural and religious monuments. Climate change is causing glaciers to recede forming glacial lakes. Some of the glacial lakes have high potential to result in glacial lake outburst floods (GLOF). For proactive Disaster Risk Reduction initiatives, effective coordination and better recovery efforts in the country, the Royal Government has enacted the National Disaster Management Act in 2013.

This Act provides for the establishment and strengthening of institutional capacity for disaster management, the mainstreaming of disaster risk reduction, and for integrated and coordinated disaster management focusing on community participation. The Act provides for the establishment of the National Disaster Management Authority and defines its composition and functions.

Functions of the Authority include: approve the Disaster Management Strategic Policy Framework; approve the National Disaster Management and Contingency Plan which shall make provision for the prevention, mitigation and preparedness, the maintenance of emergency stockpiles, the efficient response and relief during disasters; approve hazard zonation and vulnerability map; and approve structural and non-structural measures. Dzongkhag Disaster Management Committees shall also be established to coordinate and manage all disaster management operations in the Dzongkhag under the direction and supervision of the National Disaster Management Authority.

The National Disaster Management Authority shall also constitute an Inter-Ministerial Task Force and shall notify every agency including the private sector to institute a Disaster Management Unit in its organization. The Act further provides for: financial arrangements; the classification of disaster for the purpose of immediate and effective response and relief measures; establishment of critical disaster management facilities; relief assistance and compensation; offences and penalties; etc.

Figure 5.4 National Disaster Risk Management Act of Bhutan

Questions

1. Why did the government endorse the National Disaster Management Act?
2. What are the objectives of the Act?
3. What are the functions of National Disaster Management Authority?
4. What are the functions of the Dzongkhag Disaster Management Committee?
5. Why is integrated and coordinated risk management system important?

Disaster risk management involves the systematic process of using administrative decisions, operational skills and capacities to implement policies. It also consists of strategies and coping capacities of the society to lessen the impacts of natural hazards and technological disasters as shown in Figure 5.5.

Disaster risk education and public awareness play a crucial role in enhancing people's knowledge of disaster risks, changing their attitudes, and motivating them to adopt a culture of disaster prevention and resilience. Disaster resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including the preservation and restoration of its essential basic structures and functions.

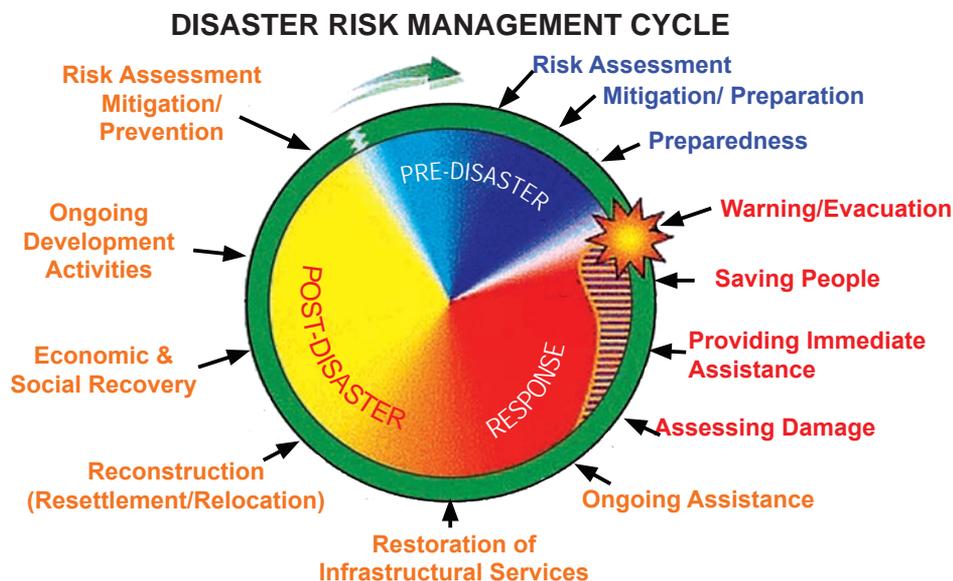


Figure 5.5 Disaster risk management cycle

i. Disaster mitigation

Mitigation focusses on long term measures for reducing the risk and impact of a hazard or disaster. These activities are designed to reduce the risk of loss of life and injury with good evacuation plans, environmental planning, and standard structural designs. For example, improving the quality of structures of schools, houses and other buildings minimize the risk during a disaster.

Activity 5.4 Recognizing the challenges in disaster mitigation process

Instruction

1. Read the story carefully and answer the questions that follow.

With only half the workers recruited, taming Bhutan's most dangerous glacial lake becomes tougher!



The set target for this year is to reduce the water level by 1.4 meters but it appears farfetched given that only half the number of manual workers has turned up this year. This year only 165 workers have been recruited to lower the water level at Lake Thorthormi, the biggest and the most dangerous glacial lake in Bhutan. This is just 50% of the number of workers required for the project. The project manager, Dowchu Drukpa, said it will be difficult to achieve the target if only 165 workers will be working at the site. "This year the response is very poor and I don't know why," he said. The target

of the project is to reduce the water level by five meters (17,100,000 cubic meters). The project manager said there could be several reasons why people didn't come forward this year. "It could be the advertisement of the work, the local government elections as it coincided with our registration and also it could be because of the three deaths, but you never know," he said. The total requirement of the project is 340 workers. However, the project expects the highlanders to join the work as the cordyceps season was not good. "We are hopeful that the highlanders will be forthcoming as the cordyceps season was not that good. We expect around 100 workers would turn up there," he said. He said that some of the workers had already worked for the last two years. In 2009, the workers achieved an 86 centimeter reduction while last year they achieved 1.37 meters (7,626,600 cubic meters of water released). This year the set target is 1.4 meters.

Source: Tuesday, July 19, 2011. <http://bhutanandclimatechange.blogspot.com/>

Questions

1. What is the theme of this article?
2. Why is the Lake Thorthormi considered to be the most dangerous lake?
3. What type of disaster might occur if the lake bursts?
4. How would this disaster impact the communities and environment?
5. What actions are taken by the government to reduce the risk?

6. What are the challenges in mitigating the risk?
7. Why is this project important for Bhutan?

ii. Disaster preparedness

During the preparedness phase, government, organizations, and individuals develop plans to save lives, minimize disaster damage, and enhance disaster response operations. Preparedness measures include preparedness plans, simulation exercises, training, warning systems, emergency communication systems, evacuations plans and training, resource inventories, emergency personnel/contact lists, and public information/education. Preparedness actions depend on the incorporation of appropriate measures in national and dzongkhag development plans.

iii. Disaster relief

This is a coordinated multi-agency response and recovery phase to reduce the impact of disaster. It covers measures required in search and rescue of survivors and meeting basic survival needs for shelter, water, food and health care. It also includes provision of assistance or intervention during or immediately after a disaster to meet the life preservation and basic subsistence needs of those people affected. It can be immediate or short term.

iv. Disaster rehabilitation

Once emergency needs have been met and the initial crisis is over, people and communities affected need support as they are still vulnerable. During this phase, dwellings of the victims are repaired, essential services are re-established and economic and social activities are revived.

v. Contingency plan

Disaster can occur suddenly and without warning. Your family may not be together when a disaster strikes, so it is important to plan, how you will get to a safe place; how you will contact one another; how you will get back together; and what you will do in different situations.

Contingency plan is a systematic procedure that clearly details what needs to be done, how, when, and by whom before and after the time an anticipated disastrous event occurs. It helps the communities to reduce hazards, loss of life, property and harm to the environment.

Activity 5.5 Family emergency plan

Instructions

1. In groups, visit nearby houses. Use the check list given in the Table 5.3 to find whether they have a family disaster plan. Interview one of the family members.
2. Write a short report with recommendation to improve the risk factors of your findings and present it to the class. Now, make your own disaster risk reduction plan for your home or hostel.

Table 5.3: Checklist

SI no.	Assessment and planning	Yes	No
1	We hold a family disaster planning meeting every 6 months. We identify our risks and use this checklist for our planning.		
2	We identified exits and alternative exits from our house and building.		
3	We searched for and identified hazards in our home (e.g., furniture or equipment that can fall or slide during earthquake or flood) and our environment (e.g., hazardous materials sites).		
4	We know our emergency persons contact number(s). It is		
5	We know that we will only use the telephone in case of physical emergency after a disaster.		
6	We know where we would reunite Inside the house:..... Outside the house:.....		
7	We made our copies of important documents, and key addresses and phone numbers. We keep one in our evacuation bag.		
8	We participate in emergency planning with our community.		
9	We make our expectations known to local, regional and national policy makers.		
SI no.	Physical protection	Yes	No
1	For earthquake: We have fastened tall and heavy furniture, appliances, large electronics, lighting fixtures and other items on the wall which otherwise could kill us or our children. For storm: We have shutters or similar window protection. For flood: We have retention wall, good drainage systems		
2	We know never to light a match, lighter, or any other flame after an earthquake until we are sure there is no danger of escaping gas anywhere around.		
3	Our building has been designed and built according to seismic, wind or flood codes, or it has been inspected by a qualified engineer, and required repair or retrofit has been completed.		
4	We maintain our building, protecting it from damp, and damage.		
5	We have a fire extinguisher and maintain it once a year.		
6	We have secured family heirlooms and items of cultural value that could be lost to future generations.		

7	We have limited, isolated, and secured any hazardous materials to prevent spill or release.		
8	We keep shoes, and flashlights with fresh batteries, by our beds. For flood: We keep flotation device or life-jacket on the highest floor in the building. For fire: We have cleared away fire hazards from around our home. For water and debris flow, we have created channels and are prepared to make sandbags.		
9	We have protected ourselves from breaking glass with heavy curtains, window film or shutters.		
10	We consciously reduce, reuse and recycle.		
SI no.	Response capacity: Skills and supplies	Yes	No
1	We know how to use a fire extinguisher.		
2	We know how to turn off our electricity, water and gas.		
3	For advanced warning: We understand early warning systems and know how to respond. For earthquake: We have practiced "Duck, Cover and Hold" and identified safest places.		
4	We have gathered survival supplies in our home and made up evacuation bags for our home and car. (including 5 litres of water per person per day and food for 3 days, prescription medications, water, high energy food, flashlight, battery, first aid kit, cash, change of clothing, toiletries and special provisions we need for ourselves, including elderly, physically challenged, small children, and animals).		
5	We know principles of incident command systems or similar standard emergency management system for organizing post-disaster self-help in our community.		
6	We have learned first aid, light search and rescue, fire suppression, wireless communication, swimming, or community disaster volunteer skills.		

Questions

1. What is the importance of this checklist?
2. What is the importance of emergency plan?
3. Who should prepare such plan?
4. How should you inform people of the emergency plan?
5. What consideration should people make, while preparing an emergency plan?

Questions

1. Study Figure 5.6 and answer the questions that follow.



Figure 5.6 A Bhutanese village

- i. What are the risks this village is vulnerable to?
 - ii. What forms of disaster will impact this village?
 - iii. What factors do you think will make disaster response operations more challenging in the event of disaster in this village?
 - iv. How can the people become involved in the emergency planning and preparedness process?
 - v. Who should be involved in preparing the plan for emergency preparedness and response in this village?
 - vi. How can village members receive relief services in the event of a disaster?
2. How does disaster management cycle help to reduce the impacts of disaster?
 3. Describe the levels of Disaster Management Plan in your own words?

Summary

- Poorly managed environment can lead to exposure and vulnerability to natural hazards, such as pollutions, landslides, forest fires or floods.
- Environmental degradation is a significant factor that reduces a country's ability to deal with risk of natural disasters.
- The primary causes of environmental degradation are triggered by human behaviour and activities through unsustainable patterns of natural resource consumptions.
- The department of Disaster Management under the MoHCA is responsible for coordinating the disaster risk management plans at the national level in Bhutan.
- Dzongkhag Disaster Management Committee at the Dzongkhag level coordinates the disaster risk management plans for the local communities.
- A disaster is understood to be a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which are beyond the ability of the affected community to cope with.
- Natural disasters lead to loss of assets, damage of agriculture land and livestock.
- Natural disasters also disrupt the social services and needs, such as water, electricity, transport, communication, etc.
- Information sharing and creating awareness is important in reducing the disaster risk.
- Immediate interventions after a disaster include search and rescue, security, food, water, shelter, sanitation, clothes, medical and trauma care, etc.
- One classification distinguishes two generic disaster groups: natural and technological disasters. The natural disaster category includes six disaster groups, namely biological, geophysical, meteorological, hydrological, climatological and extra-terrestrial.

Exercise

1. Each question in this part is followed by four possible choices of answers. Choose the correct answer.

- a. A flood has occurred and requires sandbags. Obtaining sandbags and volunteers to fill them would be an example of
- A disaster recovery and response.
 - B disaster preparedness and alert.
 - C disaster mitigation.
 - D disaster rehabilitation.
- b. The majority of lives lost in an earthquake is caused by
- A landslides.
 - B fire.
 - C disease.
 - D building collapse.
- c. Pre-disaster planning will make the following possible
- A the prevention of the disaster.
 - B the effective application of aid where prevention is not possible.
 - C self-sufficiency in dealing with natural hazards.
 - D all of the above.
- d. Which one of the statement is FALSE on disaster.
- A A disaster may be national or international.
 - B A disaster may be caused by nature or have human origins.
 - C A disaster always receives widespread media coverage.
 - D A disaster may have a known and gradual onset.

- e. An area's susceptibility to desertification is
 - A a function of climatic cycles.
 - B a function of land-use pressure.
 - C a function of the soil-water energy use.
 - D the result of inadequate irrigation systems.

2. Write TRUE or FALSE for the following statements. Correct the false statements and write them down.

- a. Warning about disaster is important as it allows people to take measures for protection.
- b. The rapid rate of deforestation is a prime force in the yearly increase of flood disasters.
- c. Earthquake is a geophysical disaster.
- d. Epidemic diseases are major threats after disasters.
- e. Environmental impacts differ greatly depending on the type of disaster.

3. Fill in the blanks with the correct word(s).

- a. The major human-made cause of deforestation is
- b. Long-term drought can cause changes in social and living patterns.
- c. Terracing is a method used to combat
- d. The primary causes of glacial lake outbursts are and
.....
- e. Educating people of the disaster is an example of phase of the disaster management cycle.

4. Match the word or phrase numbered (a) to (e) in Column A with the appropriate word or phrase numbered (i) to (viii) in Column B.

Column A	Column B
a. mudslide	i. a small earthquake after a larger one.
b. blizzard	ii. a big wave that can destroy towns near the sea.
c. tsunami	iii. a very bad snowstorm
d. aftershock	iv. a small earthquake after a larger one
e. avalanche	v. a lot of water
	vi. a disaster in which snow and ice move quickly down a mountain.
	vii. a disaster in which hills become too wet and the soil moves.

5. Answer the following questions.

- What are the differences between natural disaster and technological disaster?
- Which is the worst natural disaster Bhutan has ever experienced? What were the causes?
- Complete the table.

Disasters	What are they?	Why do they happen?	Where do they happen?	How do they affect people?	What can people do?
Flood					
Earthquake					
Windstorm					
GLOF					

- d. Study the abstract and answer the questions that follow.

Wangari Maathai's Green Belt Movement

By the early 1970s, Wangari Muta Maathai, a Kenyan woman, witnessed a numerous overarching and negative effects of the Kenyan government's deforestation efforts. By converting forests into land for agricultural and residential uses, the government deforestation program only worsened Kenya's environmental decline, leading to severe droughts, soil erosion, and the natural conversion of farmland into arid desert-like soil. These changes deprived countless communities of the resources they needed



to survive. Kenyan women, whose traditional role has always been to find firewood and water, were greatly affected by the destruction of these natural resources. As a result, Maathai founded the Green Belt Movement, a grassroots environmental non-governmental organization, on Earth Day in 1977. With the founding of the Green Belt Movement, Maathai launched a life-long campaign to put a stop to Kenya's environmental catastrophe and its attendant infringement on the right of all people to live healthy and sustainable lives.

Maathai's goal at first was simply to preserve the environment, but she also sought to bring hope and empowerment to women, providing them with the confidence they would need to fight back against violations of their ways of life and their natural environments. In the movement's early stages, Maathai encouraged farmers, 70% of whom are women, to plant "greenbelts", or lines of trees, to fight soil erosion and help restore natural resources.

The Green Belt Movement's work has not been limited to tree planting alone; it has also been working to empower women within Kenya. Working in cooperation with the National Council of Women of Kenya, Maathai's group has provided services to Kenyan women and villages that include lessons on family planning, nutrition, and leadership skills. The Green Belt Movement has educated thousands of low-income women about forestry and created nearly 3,000 jobs.

In 2004, Wangari Maathai was awarded the Nobel Peace Prize for her Green Belt Movement and became internationally famous.

Source: <https://tavaana.org/en/content/tree-mother-africa-and-her-green-belt-movement-1>

Chapter 5

Answer the following questions

- a. What does the situation in the abstract make you think about the impact of deforestation on people and the environment?
- b. What could have happened to the people of Kenya, if Wangari Maathai had not started the movement?
- c. Will you support such movement in our country? Support your view with reasons.
- d. Why are developing countries vulnerable to disasters?
- e. Why are people living in rural areas affected differently than those of urban areas even though hit by the same disaster?
- f. Explain some of the ways by which disaster risk can be reduced.
- g. What are some of the measures taken by government to reduce disaster risk in our country?
- h. How are disasters and poverty linked?

Pollution & Climate Change



Natural events and human activities contribute to the pollution of soil, water, and air. The polluted air is generally composed of dust particles, gases and water particles. Some of these gases, such as carbon dioxide, nitrous oxide, chlorofluorocarbons, methane are greenhouse gases. These gases in the atmosphere deplete the ozone layer, and cause global warming. Global warming causes the global temperature to rise which brings changes in weather and climate patterns. Climate change has significant influence on the life cycles of plants and animals, and also bring challenges to our environment.

1. Global warming

Learning objectives

On completion of this topic, you should be able to:

- *relate enhanced greenhouse effect to global warming.*
- *explain the relationship between the global warming and the climate change.*
- *explain the effects of GHG on ozone layer using chemical equations.*

Developmental activities, such as construction, transportation and manufacturing not only deplete the natural resources, but also produce large amount of wastes that lead to pollution of air, water and soil. Some of the pollutants affecting air, water and soil disturb the natural composition of greenhouse gases resulting in ozone layer depletion and a major alteration of global climatic conditions.

A. Ozone layer depletion and its effects

Ozone is a gas composed of oxygen atoms (O_3). It is found mainly in stratosphere layer. Thus, stratospheric ozone is commonly known as the **ozone layer**. Some amount of ozone is also present in the troposphere.

Chapter 6

Ozone layer is vital to all forms of life as it protects the Earth from the harmful ultraviolet(UV) rays of the Sun. Since the ozone layer influences the temperature distribution of the atmosphere, it plays important role in regulating the Earth's climate. However, increased human activities have led to the addition of Greenhouse Gases (GHGs) in the atmosphere which deplete the ozone layer. GHGs like chlorofluorocarbons (CFCs) in the presence of ultraviolet rays produce highly reactive chlorine radicals that deplete the ozone layer as shown in Figure 6.2.

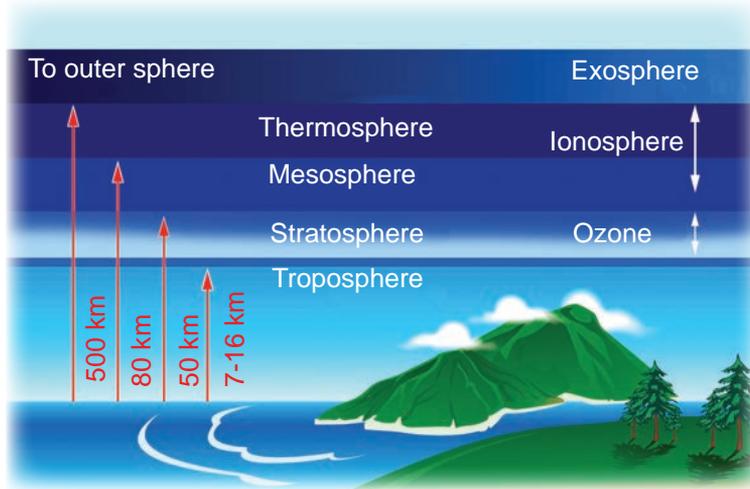


Figure 6.1 The layer of atmosphere

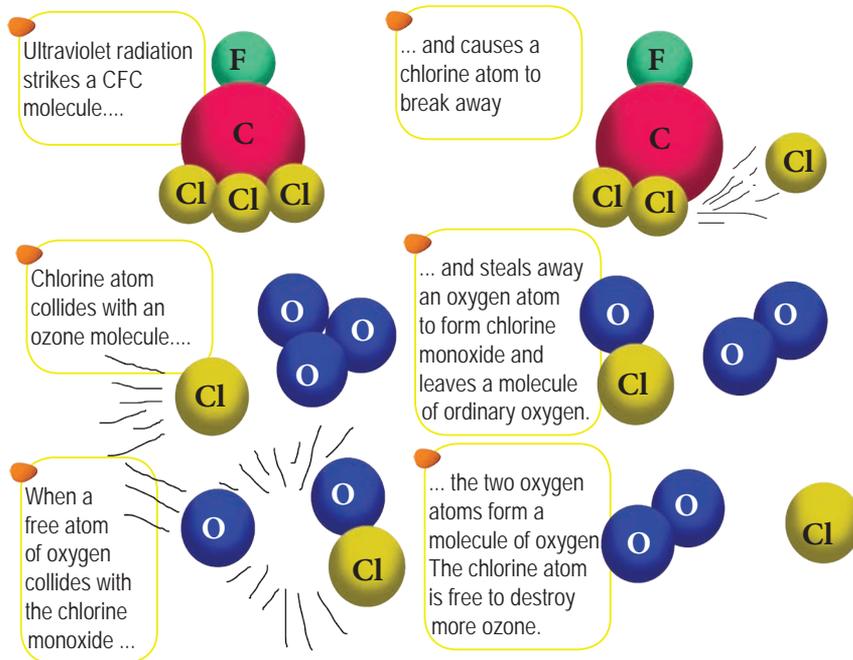
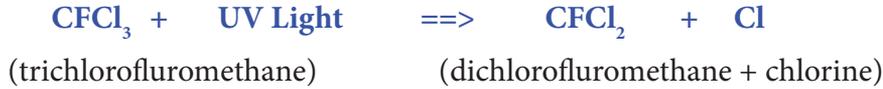


Figure 6.2 Process of Ozone depletion by CFCs

The chemical reactions involved in the process are as follows.



The free chlorine atom reacts with an ozone molecule, forming chlorine monoxide



The free chlorine atom further breaks down other ozone molecules into chlorine monoxide and oxygen molecules, and continues the cycle resulting in the destruction of thousand molecules of ozone.

Ozone layer depletion has several potential environmental effects as shown in the Figure 6.3.

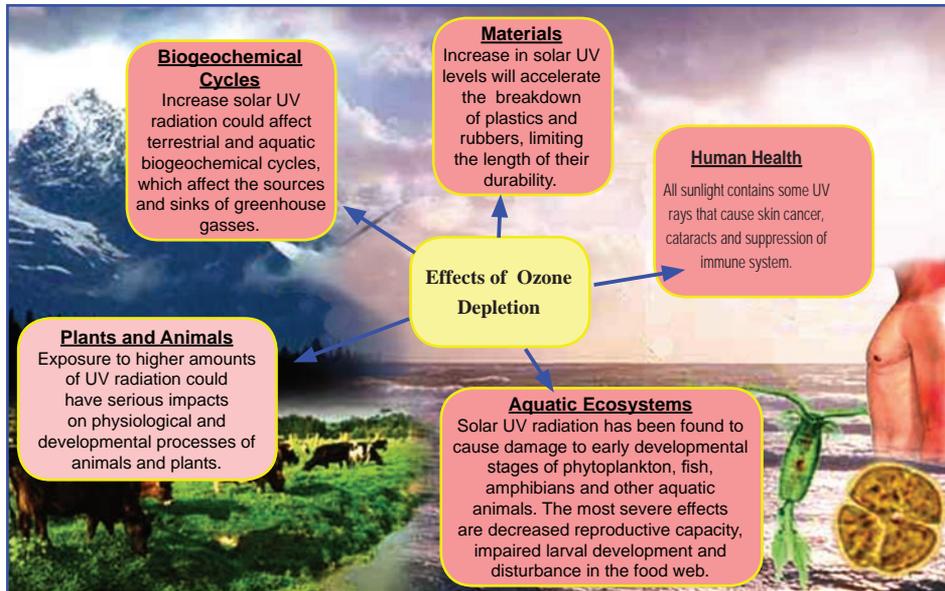


Figure 6.3 Effects of ozone depletion

Do you know? In 1994, the UN General Assembly proclaimed 16 September the International Day for the Preservation of the Ozone Layer, commemorating the date of the signing in 1987 of the Montreal Protocol on Substances that deplete the Ozone Layer.

B. Greenhouse effects and global warming

The greenhouse gases, such as water vapour, carbon dioxide, methane, nitrous oxide and fluorinated gases in the atmosphere are capable of trapping the infrared radiation radiated from the Earth surface that help to maintain the average temperature of the Earth. This phenomenon is known as greenhouse effect. Without greenhouse effect, there would be no weather on the Earth. The temperature of the Earth would be about -18°C instead of its present 15°C .

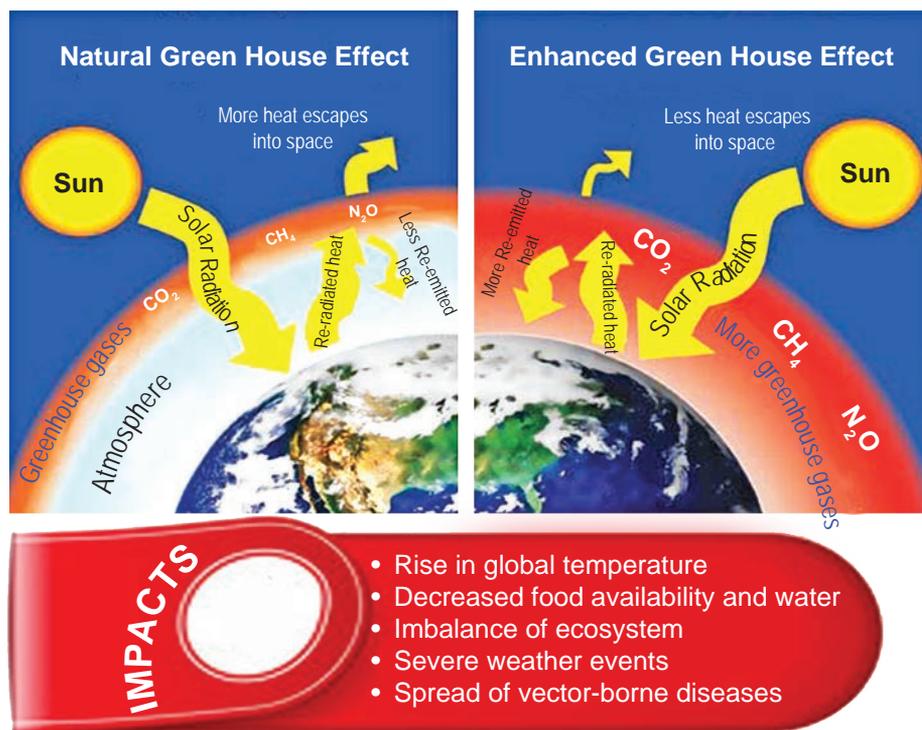


Figure 6.4 Greenhouse effects and impacts

With the modern urbanization and industrialization, humans have been releasing more quantities of greenhouse gases into the atmosphere, thus contributing to enhanced greenhouse effects. The Figure 6.4 illustrates some of the activities which contribute to enhanced greenhouse effects.

The enhanced greenhouse effects trap more heat and gradually increases the average temperature of the Earth. This phenomenon is called global warming. Some of the effects of the global warming on the Earth are:

- increase in the rate of evapotranspiration of water from soil, plants and water bodies. Greater rate of evapotranspiration leads to frequent, severe and prolonged droughts in many places.

- increase in the risk of extreme rainfall events in many places as warmer atmosphere can hold more water vapour. The atmosphere now holds 4% more water vapour than it did 40 years ago as a result of increased temperature.
- formation of geophysical phenomena, such as storms, cyclones, tornados, particularly in the tropics because of change in land and on sea-surface temperature by global warming.

Activity 6.1: Assessing the impact of global warming

Tuvalu: Rising Sea, sinking Island.

Instruction: Read the text and answer the questions that follow.

Tuvalu is the chain of nine coral islands in the South Pacific with a total area of 25 sq km and a population of 11,000. It is one of the smallest and most remote countries, halfway between Hawaii and Australia. It is now a paradise with chalk-white beaches and coconut palms. Soon, however, it will be a paradise lost!



Sea level rise, caused by global warming, is already a fact in Tuvalu. The islands are made of porous fossil coral and water has started flowing up through holes in the ground. The tides are higher and the storms are more frequent and severe.

Waves wash over the island's main roads. Coconut trees stand partly submerged. Small patches of croplands have been rendered unusable because of encroaching saltwater.

Thousands of journalists, researchers, and curious onlookers come to Tuvalu during high-tide months to see the big waves. These visitors bring valuable income to the country. They also spread awareness about global warming when they return to their countries.

The people of Tuvalu, who survive on agriculture and fishing, are not giving up yet.

They may, however, be forced to evacuate the islands within the next 50 years. While Australia does not want them, New Zealand is ready to take half the population and give them farm jobs.

Tuvalu is not alone. Rising sea level threatens also the other Pacific island nations, such as Kiribati, Vanuatu, the Marshall Islands, the Cook Islands, Fiji and the Solomon Islands. They have larger populations, where will they go?

Tuvaluans feel that they are being punished



for no fault of theirs. The reckless burning of fossil fuels by the rich countries has resulted in global warming and sea level rise. They have even threatened to file cases against countries, such as the US and Australia at the International Court of Justice.

Tuvalu may well become the first nation in the world to disappear due to global warming. When the Tuvaluans leave their homes, who will compensate them for the loss of their culture, language, and way of life?

Adapted from: <http://www.moyak.com/papers/tuvalu-climate-change.html>

Questions:

1. What are the effects of global warming on the Tuvalu Island?
2. "Tuvaluans feel that they are being punished for no fault of theirs." Justify the statement.
3. Why are researchers and journalists interested on the Tuvalu Island?
4. What are the effects of global warming on the other parts of the world?
5. What should the world learn from the story of Tuvalu?

Questions

1. Greenhouse effects are important in sustaining life on earth. Justify.
2. List the ways by which the greenhouse effects are enhanced?
3. Explain how the ozone layer is depleted.
4. How does ozone depletion affect the environment and people?

2. Climate Change

Learning objectives

On completion of this topic, you should be able to

- *explain the concept of climate change.*
- *identify the factors which contribute to climate change.*
- *explain the effects of climate change – global and country level.*

Climate change refers to the change of weather patterns over the periods of time that may range from decades to millions of years. The changing climate constantly affects people and the environment in many ways. People experience effects of climate change, such as stronger hurricanes, severe heat waves, heavy precipitation and droughts. Some of these effects of climate change are life threatening. On the other hand, longer growing seasons for crops can be good. However, as the Earth keeps getting warmer, the negative effects are expected to outweigh the positive ones.

The Earth's climate is dynamic and always changes through natural cycle. Such changes have occurred for millions of years that always cause changes in the weather and climatic patterns. However, today the climate change that we are concerned about is primarily caused by human activities.

A. Causes of climate change

The weather and climatic patterns of the Earth have changed over the years. These changes can occur due to a variety of influences, both natural and human-induced factors.

i. Natural causes of climate change

The Earth's climate is influenced and brought to changes due to natural causes like volcanic eruptions, ocean current, tilt of the Earth's axis and solar intensity variations.

a. Volcanic eruptions

When a volcano erupts, it throws out large volumes of sulphur dioxide (SO₂), water vapour, dust, and ash into the atmosphere. Large volumes of gases and ash, and tiny particles called aerosols from volcanoes reflect solar energy back into the space, causing atmospheric cooling. Volcanoes also add greenhouse gases like carbon dioxide and methane, which cause global warming, and hence, climate change.

b. Ocean current

Oceans cover about 71 percent of the Earth and absorb about twice as much of the Sun's radiation as the atmosphere or the land surface, making oceans a major component of the climate system. Ocean currents move vast amounts of heat across the planet - roughly the same amount as the atmosphere does. This indicates that, there is an intense interaction between oceans, atmosphere and ice.

The ocean surface water at higher latitudes like in Atlantic is denser than ocean water at the equator. The denser water, mainly due to cold and salinity, in Atlantic sinks

deep down into the ocean decreasing the sea level temporarily. This makes the warm and less saline water from the equator flow to Atlantic, where it cools and sinks as illustrated in Figure 6.5. The whole cycle then repeats itself. This system of heating, cooling and circulation of water is called the global thermohaline circulation system. The term thermohaline circulation describes the driving forces: the temperature (thermo) and salinity (haline) of seawater. The water density differences ultimately drive the flow of ocean water. The primary influence of the thermohaline is to transfer heat from the equator to the higher latitudes. The El Niño event in the Pacific Ocean demonstrates the change in regional ocean currents (e.g. Humboldt current), which affect the climatic conditions around the world.

c. Earth's axial obliquity

The Earth is inclined on its axis at an angle of 23.5° . The amount of sunlight received by the surface of the Earth varies with latitude. The poles receive lesser amount of the sunlight. The tilt of the Earth changes between 22.1° and 24.5° within a cycle of about 41,000 years. This axial variation is the planet's obliquity (Figure 6.6). The planet's obliquity causes difference in the intensity of sunlight received by the Northern and Southern Hemispheres. For instance, when the tilt is greater, the seasons are extreme. When the tilt is less, summers are cooler and winters milder.

Days are longer and the nights are shorter during summer, and the days are shorter

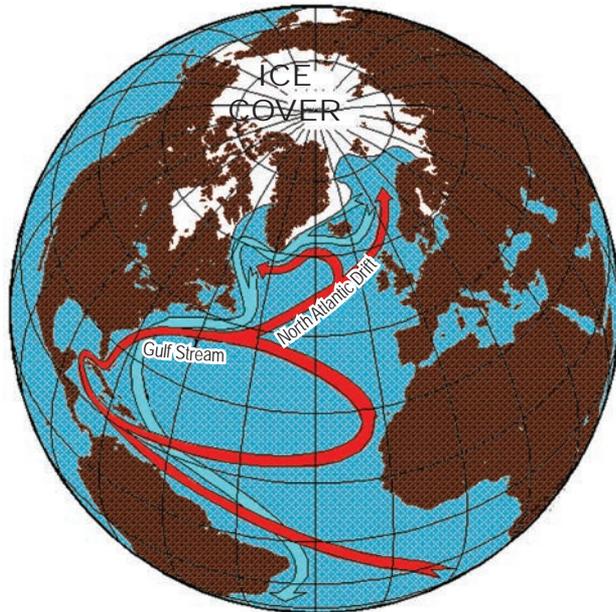


Figure 6.5 Europe's heating system.

and nights are longer in winter. If there is no tilt of the Earth, the day and night would be of same length all the year round. In the Equatorial regions, the length of the day and night are almost equal. Therefore, Equatorial regions have single season as they have same climatic condition throughout the year. On the other hand, the two hemispheres have seasons due to varying amount of sunlight received at different times of the year.

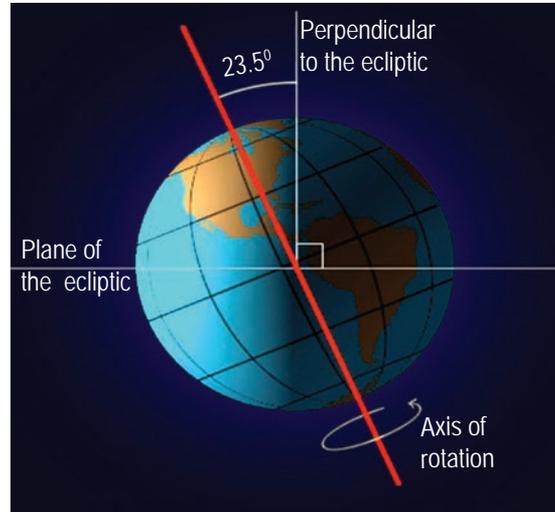


Figure 6.6 Variation of axial obliquity

The recurrent cool summers over the years builds up massive ice sheets and glaciers at high altitude. Snows reflect significant amount of sun's energy into the space, further dropping the temperature. The drop in temperature causes additional accumulation of snows and glaciers.

d. Solar variations

Solar variation is the change in the amount of radiation emitted from the solar activities in the Sun (Figure 6.7). Variations in the ultraviolet component in the radiation and other cosmic rays change the Earth's cloud cover. When the cloud cover is low, more heat reaches the Earth and escapes to the space. This change results to variation of temperature causing warming and cooling effects of the Earth's surface. The solar radiation also affects the planetary wind pattern which affects the ocean current.

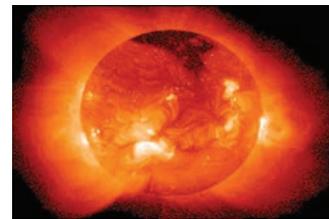


Figure 6.7 Solar variations

ii. Human induced factors:

Climate change is mainly of anthropogenic origin caused by human activities, which include burning of fossil fuels, waste generation, deforestation, agricultural practices, and increasing industries.

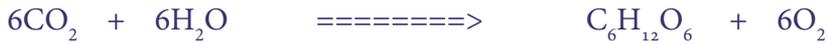
a. Agriculture

Agricultural activities produce significant effects on the climate change, primarily through the production and release of greenhouse gases. The use of fossil fuel-based fertilizers, burning of biomass, forest fire, cultivation of wetland and addition of chemicals through fertilizers; and wastes from domestic animals produce greenhouse gases like carbon dioxide, methane and nitrous oxides. They contribute to air, land and water pollution that cause global warming resulting to climate change.

Agriculture also alters the Earth's land cover, which can change its ability to absorb or reflect heat and light. Cleared land surface reflects more solar radiations than rough or forested lands. Therefore, all of these have direct effects on global temperature.

b. Deforestation

Forest acts as carbon sink as it absorbs and converts carbon dioxide to carbon during photosynthesis which is stored in the form of wood and vegetation.



Forest, thus helps to maintain the balance of carbon dioxide in the atmosphere. Cutting down of forest increases the concentration of the carbon dioxide in the atmosphere resulting to greenhouse gas effects, and hence the climate change.

Deforestation also dramatically reduces rainfall rates, both locally and regionally. This drop occurs because deforestation reduces the natural recycling of moisture from soil and vegetation into the atmosphere. Figure 6.8 depicts some of the causes of climate change.

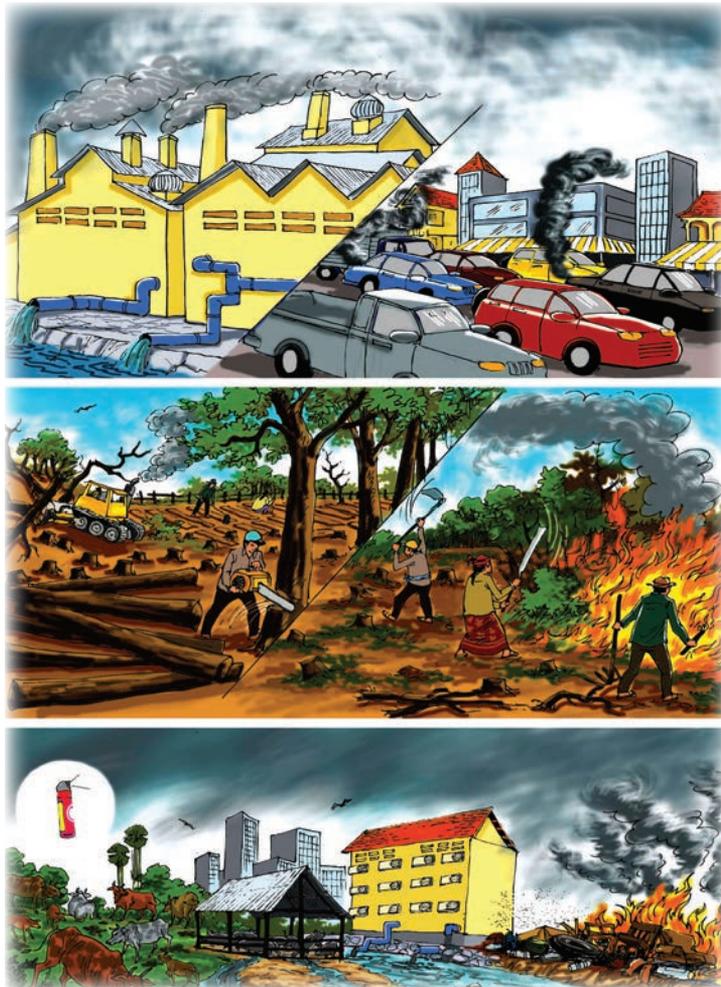


Figure 6.8 Causes of climate change

c. Industries

Industries emit greenhouse gases like carbon dioxide, sulphur dioxide, methane and nitrous oxide. Industries also produce aerosols which cause the Earth surface and atmosphere to cool or warm. For instance, black carbon aerosols (soot) absorb solar radiation and warm up the atmosphere. These emissions from the industries contribute to global warming and climate change. On the other hand, sulphate aerosols reflect sunlight and contribute to cloud formation resulting to cooling effect on the Earth.

B. Impacts of climate change

Many global issues are related to short supplies of, and meeting the basic needs, such as food, water, health, and shelter. The production and resource availability for all the living things depend on natural resources and the climatic conditions. For instance, changes in climate, such as increasing temperature, rising sea level, changing precipitation rate, and more frequent or extreme weather events influence the survival of living organisms and their habitats.

Though the climate change is an inherently global issue, the impacts are not felt equally across the planet. Impacts differ in both magnitude and rate of change across continents, countries, and regions.

a. Impacts on Agriculture and Food

Changes in climate have significant impacts on biogeochemical cycle, thereby, affecting the food production around the world. Heat stress, droughts, and precipitation affects the growth of the plant; intensity of sun shine and water availability affect the flowering and fruiting of the plants; and weather conditions affect the cycling of nutrients in the environment.

Warmer temperature makes many crops grow more quickly, reducing the amount of time that seeds need to grow and mature. This reduces the yield of the crop because the time required by seeds to germinate is shortened, not all the seeds can germinate at the same pace. Hence, only few seeds grow to be matured plants to produce crops. Many pests and weeds thrive at warmer temperature and affect the production of food. Heavy precipitation results in flooding and water clogging which damages the crop plants. On the other hand, lack of rainfall for prolonged period causes droughts, which make the land unsuitable for crop production. Higher carbon dioxide concentration due to enhanced greenhouse gases can increase the yields of crops like corns, wheat, and soya beans.

Increased frequency and intensity of heat waves and droughts due to climatic changes are known to kill livestock in many regions. Climate change increases the prevalence of parasites and diseases, which further aggravates the survival of the livestock.

Increasing ocean temperatures and conditions of the ocean have direct effect on the migratory patterns of the marine animals. This increases the competition for food and survival amongst the marine lives. In addition, enhanced carbon dioxide in the atmosphere makes the ocean more acidic and affect the survival of shell fishes and life cycle of many other marine organisms.

b. Impacts on water supply and quality

We need clean drinking water to sustain our health. Water is also needed for agriculture, energy production, navigation, recreation, and manufacturing. These uses put pressure on the water resources. However, the increasing temperature of the Earth due to climate change causes water from water bodies to evaporate. Streams, lakes, marsh land start to dry resulting in lesser outflow of water from the sources.

Snow and glacial ice are important sources of streams, rivers, lakes, seas and oceans. Due to climate change, extensive volume of glaciers melt. This increases the water supply to rivers and lakes, which causes streams and rivers to flood (GLOF); thereby, affecting the agriculture activities and livelihoods of people. On the contrary, once these glaciers have melted, the water supply to water bodies decreases.

Global warming makes air warmer than before and can hold more amount of moisture. This moisture is due to the enhanced rate of evaporation of water from land and water bodies. Consequently, the precipitation of the moisture results in heavy downpour. Heavy downpours can increase the amount of runoff into rivers and lakes, washing sediment, nutrients, and pollutants into water supplies, making them unsafe for use.

Due to the melting of glaciers and heavy downpours, levels of oceans and seas are raised, endangering the islands, costal lands and people inhabiting them. The quality of fresh water supply in coastal and island regions is also at risk due to the rising sea level and occurrence of droughts, which increases the salinity of both surface water and ground water through salt water intrusion.

With the climate change, there are significant changes in terms of frequency and pattern of precipitation. For example, precipitation becomes unpredictable and prolonged in certain regions. This further affects other biogeochemical cycles.

c. Impacts on Human Health

Climate change and shifts in ecological conditions have impact on the human health. Warmer average temperature leads to hotter days and more frequent and longer heat waves. This increases the number of heat related illnesses and deaths. For example, people dying from heat stroke, which involves severe headache caused by high temperature and humidity in the air. Warmer temperature can increase the concentration of unhealthy air and water pollutants, which may cause health related problems to respiratory system and skin.

Further, increased temperature and rainfall enhances the spread of mosquito-borne diseases such as malaria and dengue fever. Drought often creates a lack of clean water for drinking, sanitation and personal hygiene, which lead to wide range of life threatening diseases. Extreme weather events, such as cyclones, storms also can cause flooding and high winds and other direct threats to people and property.

d. Impacts on Ecosystem

The climate change has significant influence on the biotic and abiotic components and their interactions in an ecosystem. Some of the significant impacts include:

i. Biogeochemical cycle reduction: The biogeochemical cycles, such as nitrogen cycle, water cycle, mineral cycle, carbon cycle and life cycle are responsible for the health and ecological balance in an ecosystem. These cycles are dependent on the climatic conditions of the ecosystem. Extreme climatic conditions have adverse effects on the biogeochemical cycles, thus, reducing the efficiency of the bioproductive areas in an ecosystem.

ii. Adaptive inability: Prolonged and extreme change in climate demands organisms to adapt to new environmental situations. In the process, some species are endangered, while those that cannot adapt to this situation become extinct. For instance, microbes responsible for decay and nitrogen fixation in carbon and nitrogen cycles may not survive under extreme condition; plants cannot photosynthesize; and water cannot evaporate; consequently affecting the physical and biological cycles. Thus, causing disturbances to food chain, food webs and other interactions in the ecosystem.

iii. Habitat reduction: Warming and changing composition of the Earth's oceans affect the habitat and food supplies for many kinds of marine life. For instance, an increase in acidity of ocean water degrades the coral reefs that are important habitat and food sources for many marine organisms. On the land, though some forests benefit from an extended growing season, longer periods of hot weather can make them more susceptible to wildfires, pest infestation, damages, and diseases.

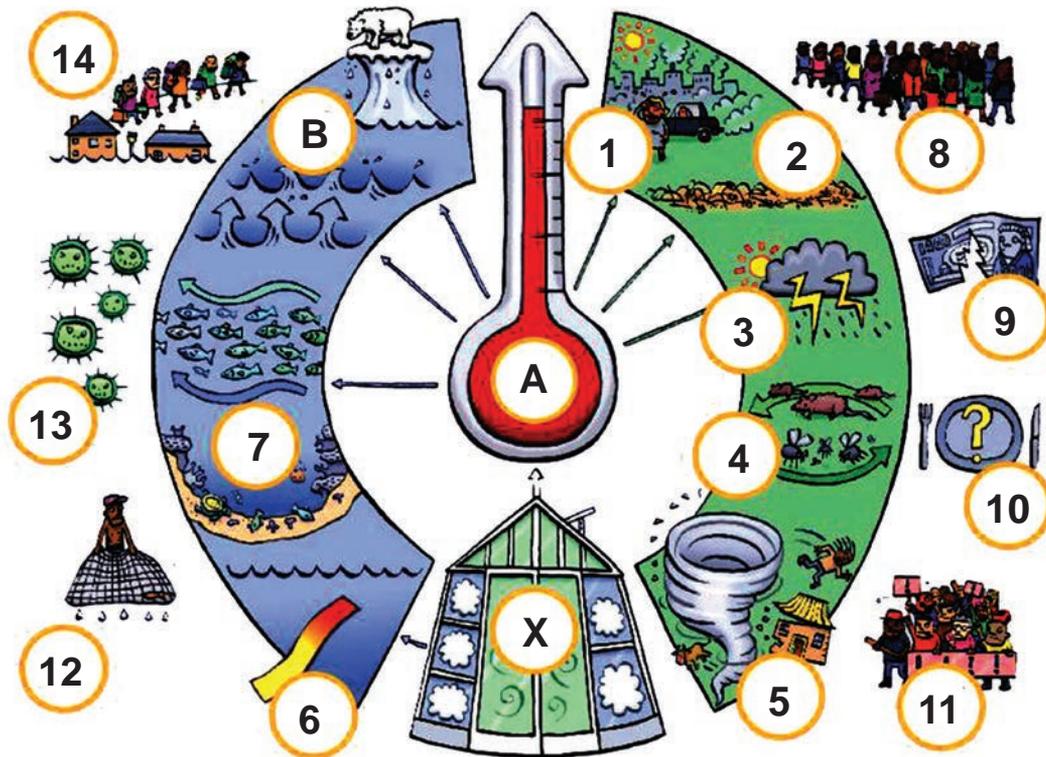
For example, melting sea ice is eliminating an important habitat for several Arctic species. Mangroves and other coastal wetlands, which are critical to many species, are at risk of disappearing because of rising sea level. Some species adapt to changing habitats, for example, by shifting their range to higher altitudes to adjust the rising temperature. Others, however, might not be able to adapt fast enough to keep pace with the rate of climate change. All these events disturb the ecosystem composition and make ecosystem unstable.

iv. Biological process disruption: The timing of many natural events, such as flower blooms and animal migrations, is linked to climatic factors, such as temperature, moisture availability, and the amount of daylight. Changes in weather patterns and extreme events associated with climate disrupt natural biological processes. These

disruptions, in turn, affect seasonal behavior and interactions among species. For example, if birds migrate and lay eggs too early, hatchlings might not have an adequate food supply. If organisms are not able to adapt, they may not even survive.

e. Impacts on National Security

Climate change impacts productions and availability of resources for survival of people and socio-economic development. With increasing population and developmental activities, many countries experience scarcity of resources. The constraint of resources in the country intensifies the national security issues, and increases the number of international conflicts. For instance, food, water and land shortages can increase the human conflicts and the risk of humanitarian crises. Many times, such dire situations trigger population migration across national boundaries, and even stimulate political and social instability.



X. Rising greenhouse gas levels, which lead to:

A. Temperature rise, which leads to:

1. Higher temperatures
2. Crop failure
3. Altered weather patterns
4. Injury
5. Homelessness
6. Ocean acidification
7. Marine ecosystem shift

B. Sea level rise, these changes in turn lead to:

8. Mass migration
9. Economic disruption
10. Malnutrition
11. Social unrest
12. Aquaculture failure
13. Infectious disease spread
14. Displacement

Activity 6.2: To identify the indicators of climate change.

Instruction

Study the Figure 6.10 and answer the following questions.

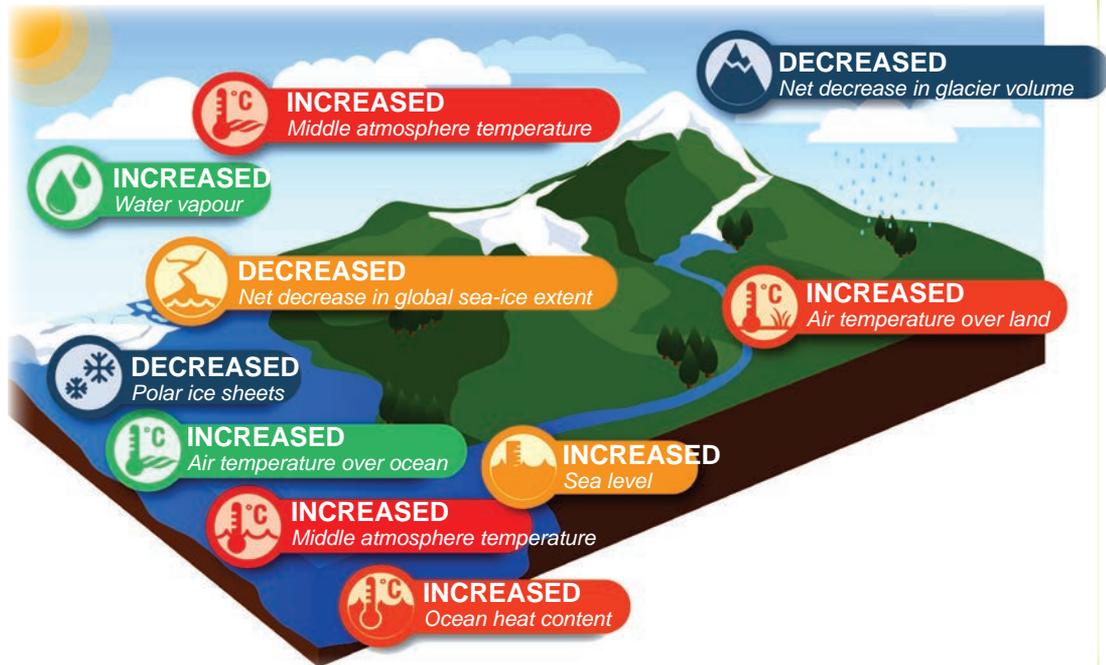


Figure 6.10 Indicators of a warming world.

Questions

1. Describe the scenario shown by Figure 6.10.
2. List down the indicators of the climate change.
3. Explain the cause for the increase or decrease in the indicators shown in the diagram.
4. Does the situation depicted by Figure 6.10 have connections to Bhutan? If so, in what ways is Bhutan affected?

From the activity, we can understand that indicators are observations or calculations that can be used to track conditions and trends. The indicators of climate change can communicate key aspects of the changing environment, point out vulnerabilities, and guide in policy, planning, and resource management. The information can be used by farmers to plan their agricultural activities, and by policy makers to conceptualise the national developmental plans and activities.

Questions

1. Define climate change.
2. How will global climate change influence ecosystems?
3. How can a change in global average temperatures impact our lives?
4. Rising of sea level affects the mountainous country like Bhutan. Justify.
5. Explain global warming by using the Figure 6.11.
6. What are the objectives of Bhutan's initiative to remain carbon negative?

Earth's temperature has risen about 1 degree Fahrenheit in the last century. The past 50 years of warming has been attributed to human activity.

During the past 100 years global sea levels have risen 4 to 8 inches.



Figure 6.11

3. Phenology

Learning objectives:

On completion of topic, you should be able to:

- *define phenology.*
- *identify factors effecting phenology of plants and animals.*
- *explain the importance of phenology.*
- *justify the roles of phenology as a sensitive biological indicator of climate change.*

The environment is a changing world under the influence of various factors and conditions. The biotic components of an ecosystem respond to these changes in order to survive and reproduce. Organisms demonstrate morphological and physiological changes with the changing physical conditions of the environment.

A. What is phenology?

Phenology is one of the earliest fields of science, studied by humans for millennia to predict the availability of food through the comings and goings of seasons. Early humans depended largely on their ability to locate, identify, and protect edible plants during all times of the growing season. The word phenology is derived from the Greek words, *phaino*, which means “to appear or to come into view”, *logos*, which means “study”. Phenology is a science to measure the timing of life cycle events (phenophases) for plants, animals, and microbes, and infer how the environment influences the timing of those events. Periodic biological phenomena, such as sprouting and flowering of plants in the spring; changing of colour of plants in the fall; birds migrating; insect hatching and animals hibernating, are examples of phenological events (Figure 6.12).

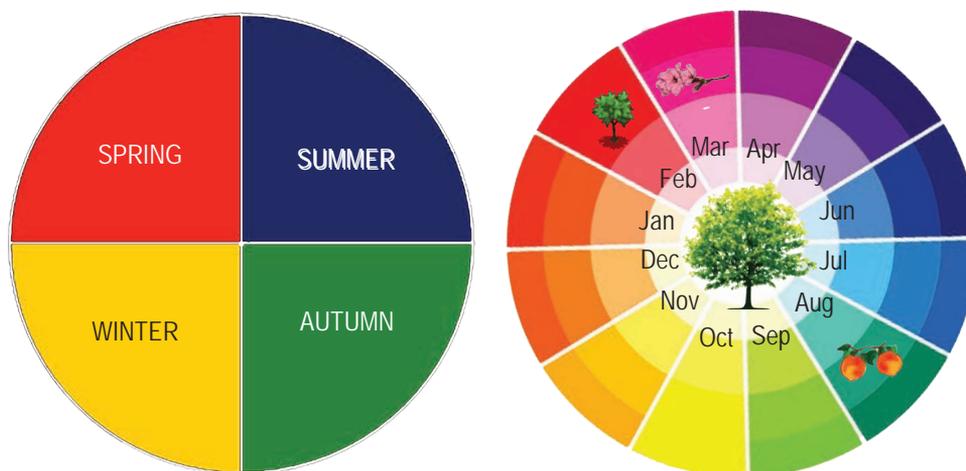


Figure 6.12 Phenology wheelscape

The timing of phenological events is sensitive to environmental conditions. For example, in a particularly warm and dry spring, leaf bud bursts and first flower occurs weeks earlier than usual; whereas, in an exceptionally cool and wet spring, they are delayed. As a result, the timing of phenophases tends to vary in between years based on patterns of weather, climate and resource availability. Phenological observations are therefore integrative measures of the condition of the physical, chemical, and biological environment. Since the phenological studies are based on the environmental sensitivity, they are simple and cost-effective ways to measure the environmental changes, including climate change over the long-term.

As part of citizen science initiative, Bhutan's Phenology Network(BPN) was initiated in 2014. BPN is schools and communities based program for monitoring the impact of climate change on phenology of plants, animals and landscape. Schools across different ecological zones in Bhutan are implementing the program. Since its implementation in 2014, phenology study has been found to be viable and an engaging citizen science program that stimulates significant interest and support from public and schools. It provides insightful information about the impacts of the climate change on the phenology of plants and animals. Besides generating yearly phenological records, it also promotes broad understanding and appreciation of nature among younger generation and citizens.

B. Phenology factors

Phenological dynamic is determined by complex interrelation of genetics and environment like weather pattern, climate, and resource availability.

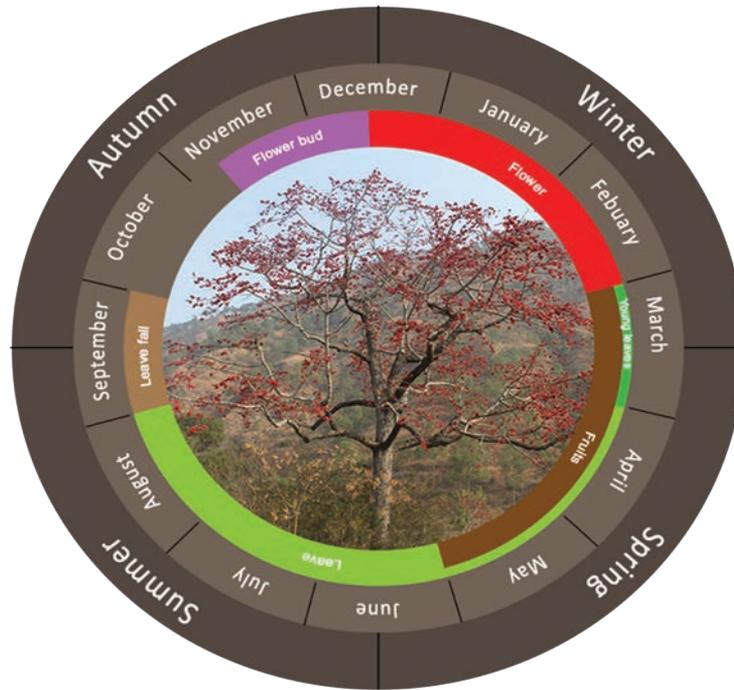


Figure 6.13 Seasonal changes observed in Semal (*Bombax ceiba*)

i. Environmental factor

Plants and animals take cues from yearly changes in climate to commence the phenological events. For example, as the days get warmer in the spring, semal (*Bombax ceiba*) exhibits spectacular display of flowers. As summer progresses, leaves of semal sprout and fruits ripen. In winter, as weather cools and day-length shortens, leaves change colour and fall. This cycle repeats every year. Similarly, birds migrate to their breeding place during spring using cues of available sunlight. As spring approaches, the length of the day increases, the amount of sunlight increases, which is a sign that the summer is around the corner and it is time to migrate.

ii. Resources factor

The phenological attributes of living systems influence ecological interactions, and therefore the probability of persistence in the future. For example, if species that depend on each other, mutualists, such as a plant species and its pollinator, do not

thrive at the same time in “synchrony” then both species may suffer. The timing of an organism’s phenophases can change dramatically as a direct response to environmental conditions, and this can have larger effects in the community. For example, warmer weather at the onset of spring can cause the seeds of many species to germinate earlier than they generally do. This mismatch of timing results to “asynchrony”, which can have cascading effects in the community. The productivity and sustainability of ecological communities, whether wild or farmed, can be greatly diminished when the phenophases of interdependent populations or species become asynchronous.

The ways in which phenophases are exhibited by organisms, play a key role in determining the structure and function of an ecosystem. Many birds time their nestling, so that their eggs hatch when insects are available as feed for their nestling. In turn, insects synchronize their emergence with leafing out of host plants. For most people, allergy seasons starts with onset of flowering of some plants. Knowing when does the flowers of particular plants bloom help to avoid going out when allergen is high in the air.

iii. Genetic factors

The timing of phenophases in plants and animals is subject to evolution by natural selection. If the climate changes gradually, and if populations contain enough genetic variation in phenological traits, like the date of first flower, they will be able to adapt as natural selection favors those phenophases that perform well under the new environmental conditions. However, if climate change progresses too rapidly, many populations will not be able to adapt because they lack the genetic variants that perform well under the new conditions. Therefore, the phenophases of individual organism are determined by its genetic composition. For instance, the flowering curves of siblings or other closely related individuals tend to be more similar than the flowering curves of more distantly related individuals. This variation is also affected by environmental factor.

The climatic warming hence has impact on the phenological sequences. If phenological records are continued over a sufficient length of time throughout the world, they may reflect the occurrence of climate change of the Earth.

C. Importance of phenology?

Phenology, like all other sciences, uses quantitative methods to measure and describe the occurrence of events and patterns in the natural world. Phenology study provides information and fundamental knowledge about patterns and processes in nature. Based on the knowledge of phenology derived from series of studies, phenology has various importance for environment and humans. The timing of phenological events, such as flowering of plants and arrival of birds are intricately linked to climatic

variables. Increasingly, a long term phenological records are used to detect climate change and its impact.

The success of an ecosystem or food chain depends on the timing of phenological events. Many animals rely on leaves, buds, flowers and fruit for their food. If the timing of the emergence of leaves, buds, and flowers is greatly changed, it can result in fewer seeds and insects which would impact the animals that depend on insects for their food. Phenology also indicate the timing and duration of resource availability in ecological communities, such as, when pollen and nectar are available to pollinators; when fruits are available to fruit-eating animals; when leaves are available for herbivorous insects and mammals; and whether plants must compete with each other for the services of pollinators and seed dispersers.

Phenological studies help to inform in agricultural planning, disease and pest control, and eco-tourism industries, as well as the anticipation of allergy seasons. They can also describe how populations, species, communities, and biomes respond to changes in the regional and global climate.

Phenology also has significance in the human culture around the world. For example, people in Bhutan, Indonesia and other Asian countries celebrate the harvesting of paddy as 'rice harvesting festival'. Similarly, Black necked crane festival is celebrated in Bhutan.

Activity 6.3: Understanding the importance of phenology

Instruction: Study the Figure 6.14 and answer the questions that follow. The diagram 'A' represent life cycle of a bee and the diagram 'B' represents life cycle of a peach tree.

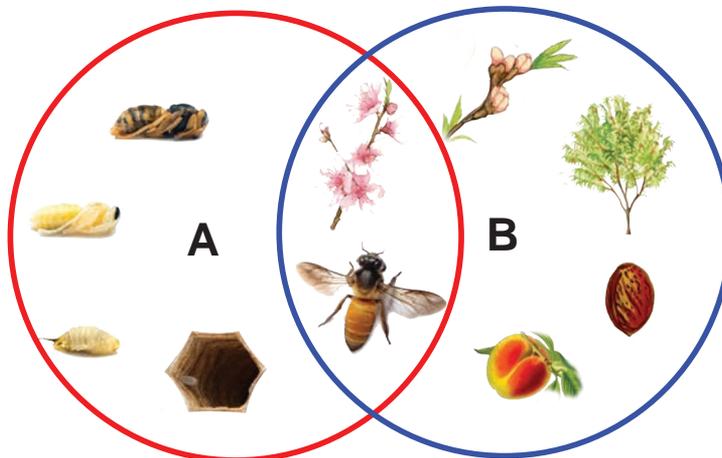


Figure 6.14

Questions

1. Fill in blanks.

A: Life cycle of a bee:

1.
2.
3.
4.
5.

B: Life cycle of a peach tree

- 1.....
- 2.....
- 3.....
- 4.....
- 5.....

2. How does the delay of phenophase of the bee affect the life cycle of the peach tree?
3. What are the factors influencing the phenophases in this example?
4. What does an area of overlap of two circles, A and B represent? Justify.

Questions

1. Define phenology.
2. What are the factors that influence the phenology?
3. Every winter, black necked cranes migrate to Bhutan from Tibet. What are the cues that the cranes use to start their migration?
4. How do people use the knowledge of phenology for anthropogenic activities?

4. Initiatives on Climate Change

Learning objectives

On completion of this topic, you should be able to

- *describe the significance of global and national initiatives on climate change.*
- *familiarise with the prevailing rules and policies on climate change of Bhutan.*
- *suggest ways to minimise the causes of climate change.*

In recent years, Bhutan, like other Himalayan countries, has experienced an increase in landslides due to heavy rains, and some glacial lake outburst floods (GLOFs). The GLOF threat is one of Bhutan's most dangerous threats brought about by climate change. There has been a rise in temperature of about 1°C in summer and 2°C in winter since 2000; reduction in irrigation water availability in some areas and other global warming effects; shifting precipitation patterns; changing growing zones; more severe weather; and worsening of air and water pollution and water scarcity.

Since the climate change is a global concern, various measures to combat and mitigate the causes of climate change are initiated at global, regional and national levels.

A. Global initiatives

The United Nations Environment Programme (UNEP) stimulates worldwide awareness on the environment and enhances political attentions and actions through World Environment Day, commemorated each year on 5th June. Recognizing that climate change is becoming the defining issue of our era, UNEP enforces countries, companies and communities to focus on Greenhouse Gas emissions, and how to reduce them by promoting low carbon economies and lifestyles, such as improved energy efficiency, alternative energy sources, forest conservation, and eco-friendly consumption.

The followings are some of the examples of global initiatives towards mitigating the climate change.

i. Earth Summit

The Earth Summit is an international environmental treaty which was negotiated at the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro, Brazil in 1992. The objective of the treaty is to “stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous

anthropogenic interference with the climate system.” The treaty provides a framework for negotiating specific international treaties (called “protocols”) in setting targets to minimise the global Greenhouse Gases emissions. The parties to the convention meet annually at the Conferences of the Parties (COP) to assess progress in dealing with the climate change.

ii. Kyoto Protocol

The Kyoto Protocol strengthens the United Nations Framework Convention on Climate Change by establishing a framework for the direct implementation of actions in reducing Greenhouse Gases (GHGs) emissions. The protocol was adopted in 1997 and entered into force in February 2005. Abiding with the Kyoto Protocol, countries have committed themselves to reducing their GHGs emissions throughout 2008-2012 by 5.2% compared to the year 1990. National targets vary across Kyoto countries, the European community having committed itself to an 8% target, while Canada and Japan have a 6% target.

Activity 6.4: Case study on UN framework convention on climate change.

Instruction: Read the two Articles on UNFCCC and answer the questions.

Article 2 OBJECTIVE

The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

Article 3 PRINCIPLES

In their actions to achieve the objective of the Convention and to implement its provisions, the Parties shall be guided, inter alia, by the following:

1. The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof.
2. The specific needs and special circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change, and of those Parties, especially developing country Parties, that would have to bear a disproportionate or abnormal burden under the Convention, should be given full consideration.

- The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost. To achieve this, such policies and measures should take into account different socio-economic contexts, be comprehensive, cover all relevant sources, sinks and reservoirs of greenhouse gases and adaptation, and comprise all economic sectors. Efforts to address climate change may be carried out cooperatively by interested Parties.



Figure 6.15 UN Framework Convention on Climate Change

- The Parties have a right to, and should, promote sustainable development. Policies and measures to protect the climate system against human-induced change should be appropriate for the specific conditions of each Party and should be integrated with national development programmes, taking into account that economic development is essential for adopting measures to address climate change.
- The Parties should cooperate to promote a supportive and open international economic system that would lead to sustainable economic growth and development in all Parties, particularly developing country Parties, thus enabling them better to address the problems of climate change. Measures taken to combat climate change, including unilateral ones, should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade.

Source: <http://unfccc.int/resource/docs/convkp/conveng.pdf>

Questions

- What is the overarching goal of the Article 2 of UNFCCC?
- Why has this convention been instituted?
- What are the benefits of this convention for the developing countries?
- How are the developed countries contributing towards the implementation of UNFCCC mandates?
- List down the strategies suggested in this convention towards the climate change.
- How is this convention relevant to Bhutan?

B. Bhutan's initiatives

Bhutan's policies and action plans are geared towards low carbon production and climate resilient development. Some of the prevailing action plans and strategies adopted to combat climate change are discussed below.

In 2009, Bhutan committed itself to remain carbon neutral for all times to come during the 15th Conference of Parties to the United Nations Framework Convention on Climate Change.

Towards this, the Carbon Neutral Policy of the National Environment Commission (NEC) is to guide the country on how to remain carbon neutral.

Some of the identified strategies include,

- declaration of another 4954 square kilometres of land as national park bringing the total area under protected areas to 19,750 km² (around 51% of land area), of which, close to 10% consists of biological corridors. It is important for the local communities to get involved in helping Bhutan remain carbon neutral. Therefore, strategies include empowerment of local communities to take ownership and responsibility for managing natural resources through community forestry schemes.
- adoption of the code of management and use of forest for the protection and conservation of forest. It banned the export of timber, restricted burning of forest for pasture or agriculture.
- enhancing the capacity to monitor air and water qualities and to enforce environmental standards on industries. Bhutan has also prioritized sectors for economic development and these are eco-friendly hydropower generation, green tourism and organic agriculture.
- adoption of watershed and climate change management and sustainable land management practices to address land degradation.
- adoption of a policy to plough back 1% royalty on hydroelectricity to watershed management and adoption of a Green or Full Cost Accounting system to make agencies and individuals responsible and accountable for adopting proper environmental standards and ethics.

Activity 6.5: Exploring the ways to minimise the climate change.

Instructions:

1. In a group, discuss and complete Table 6.1 .
2. Present your findings to the class.

Table 6.1:

How do Bhutanese people contribute to the climate change?	Ways to minimise the causes of climate change.

Questions

1. What human activities emit GHG the most?
2. Why should people minimize the GHG emission?
3. Among the ways, which one can you address through your daily activities?

Questions

1. What are the reasons for instituting initiatives on climate change?
2. Explain one of the global initiatives on climate change.
3. Explain the Carbon Neutral Policy strategies of Bhutan.
4. How does large forest coverage help in preventing climate change?
5. In what ways as an individual can you contribute to towards preventing climate change?

Summary

- The greenhouse effect is the rise in temperature of the Earth due to the emission of green house gases in the atmosphere.
- Greenhouse effect is enhanced by the addition of extra-greenhouse gases into the atmosphere by various anthropogenic activities.
- An enhanced greenhouse effect leads to global warming, enhancing the global climate change.
- Global surface temperatures have increased roughly by 0.74°C (1.33°F) between the start and the end of the 20th century.
- The depletion of ozone layer is due to the reaction of chlorine atom from the CFC with the ozone molecule, by which ozone is depleted to oxygen.
- Depletion of ozone has an adverse effect, directly or indirectly, on human and the environment.
- CO₂ is the most significant and prevalent greenhouse gas released by human activities, and emitted mostly from the burning of fossil fuels like coal, oil, and natural gas.
- Phenological dynamic is determined by complex interrelation of genetics and environment like weather pattern, climate, and resource availability.
- Climate change is already apparent as evidenced by increasing temperatures, rising sea levels, extremities in weather patterns, and glacier and polar ice melt.
- The potential consequences of global climate change pose threats to worldwide countries; their citizens face significant challenges in food and water resources, health, and living standards.
- The Earth Summit and Kyoto Protocols are examples of global initiatives towards the global climate change.
- The Carbon Neutral Policy of Bhutan is one of its initiatives towards mitigating the climate change.
- Global and national initiatives are put in place to minimize the causes of climate change.
- The causes of climate change include natural factors: solar variation, axial obliquity of the Earth, ocean current, volcanoes; human induced factor: agriculture, deforestation, industry.

Exercise

1. Fill in the blanks with the correct word(s).

- a. The weather over a long period of time is called
- b. Ozone layer is vital for all the living organisms on the Earth because it absorbs rays.
- c. While is the most important greenhouse gas, humans have very little control over it.
- d. The heavy down pour of rain is because the warm air can hold more , which is an indicator of climate change.
- e. Climatic influence in the life cycle of organisms is known as

2. Write TRUE or FALSE for the following statements. Correct the false statements and write them down.

- a. Our planet is getting warmer because of various human activities that add extra greenhouse gases into the atmosphere.
- b. Ozone depletion will increase if more CO₂ is released into the atmosphere.
- c. Deforestation reduces the Earth's ability to absorb carbon dioxide from the atmosphere.
- d. The greenhouse gases are like glass panes, which let the heat in but not out.
- e. Climate change has no influence over phenological events in plants and animals.

3. Each question in this part is followed by four possible choices of answers. Choose the correct answer.

- a. Which of the following is most likely to occur because of the decreasing levels of ozone in the stratospheric ozone?
 - A. A decrease in the level of smoke in cities.
 - B. A decrease in the rate of global warming.
 - C. An increase in the occurrence of skin cancer in humans.
 - D. An increase in photosynthetic activities of phytoplankton.

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- b. Since 1901, global surface temperatures have risen at an average rate of 17.7°C every ten years. Which of the following phenomenon is the impact due to increase in global temperatures of the Earth?
- A. Rising of sea levels.
 - B. Frequent occurrence of earthquake.
 - C. Decreasing erosion within coastal areas.
 - D. Increasing the formation of ice in the Polar Regions.
- c. The objective of Earth Summit is to
- A. conserve the biodiversity composition.
 - B. protect the degradation of natural resources.
 - C. preserve and promote the culture of different countries.
 - D. stabilize the greenhouse gas concentration in the atmosphere.
- e. Which of the following event depicts phenology?
- A. Migration of birds to escape cold winter.
 - B. Melting of polar ice due to global warming.
 - C. Depletion of ozone due to excess greenhouse gases.
 - D. Celebration of Black necked crane festival in Bhutan.
- e. Methane is a greenhouse gas most likely produced by
- A. burning of organic in incinerators.
 - B. decomposition of organic materials in landfills
 - C. heating of organic materials in high atmosphere.
 - D. recycling of organic materials in recycling plants.

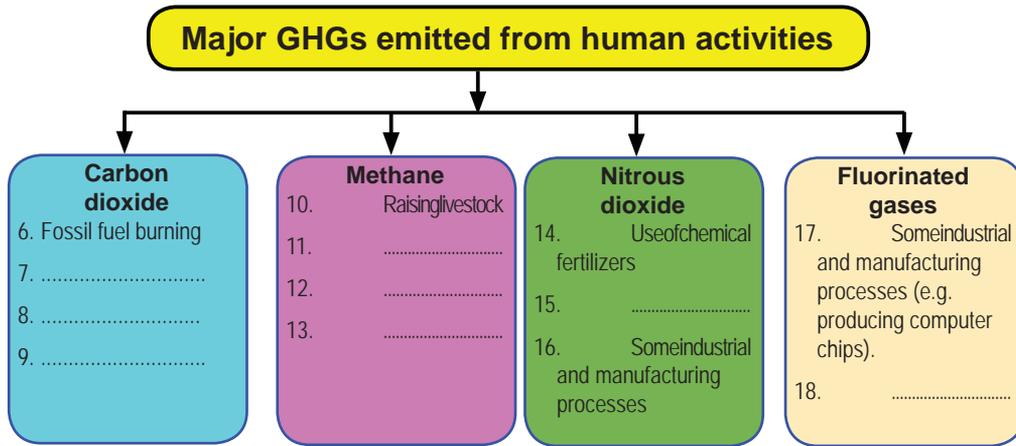
5. Match the contents of column A with that of column B.

Column A	Column B
1. Global thermohaline circulation system	a. farmers' calendar
2. CFC	b. water cycle is an example of it
3. Phenology	c. shields the ultra violet rays
4. Biogeochemical	d. depletion of ozone
5. Stratosphere	e. transfer heat from the equator to the higher latitudes.

5. Short answer questions

- a. Copy and complete the flowchart with the most appropriate words given in the box.

Word Choices:
 Burning gasoline; sewage plants; use of chemical fertilizers; landfills; cutting down trees;
 using coal for fuel; natural gas pipe leak; leakage of coolants from refrigerators and air
 conditioners.



- b. Interpret Figure 6.16 in terms of the climate change.



Figure 6.16: UN Framework Convention on Climate Change

- c. What are the causes of global warming?
- d. Climate change may benefit some communities. Support this statement with appropriate examples.

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- e. Human desire is the root cause of ozone depletion. Explain. In what ways, is ozone depletion different from the global warming?
- f. How does the global climate change influence biodiversity and the extinction of species?
- g. How does environmental factor influence the phenophases of plants and animals?

Biodiversity and its Conservation



“Throughout the centuries, the Bhutanese have treasured their natural environment and have looked upon it as the source of all life. This traditional reverence for nature has delivered us into the twentieth century with our environment still richly intact. We wish to continue living in harmony with nature and to pass on this rich heritage to our future generations.” - *His Majesty the King Jigme Singye Wangchuck*

Conservation of biological diversity is important for the survival of all life forms. Without a healthy biodiversity, there will be adverse effects on livelihoods, ecosystem services, natural habitats, and food security.

Biodiversity is under threat as a result of human activities, such as population growth and resource consumption; climate change and global warming; habitat conversion and urbanisation; and introducing invasive alien species. To conserve and enrich biodiversity, government has initiated various conservation efforts like in-situ and ex-situ, including the implementation of stringent legislations and policies. Traditional conservation practices also contribute to conservation of the biodiversity. Through the efforts for the conservation of biodiversity, the survival of many species and habitats threatened by human activities is ensured.

1. Biodiversity

Learning Objectives

On completion of this topic, you should be able to:

- explain biodiversity, including endemism.
- distinguish levels of biodiversity with examples.
- list the endemic species of Bhutan.
- evaluate the species richness in your local area.

An ecosystem is a community of living organisms, together with the physical environment they occupy at any given time. Our planet as a whole is an ecosystem, but it contains many others: forests, deserts and rivers which are themselves made of smaller ecosystems.

Different kinds of plants, animals and microorganisms live and interact in an ecosystem. Different organisms are collectively known as biodiversity. It varies from one ecosystem to another. A rich biodiversity is very important for maintaining the stability of an ecosystem. How does this happen?

A. Threat to biodiversity

Biodiversity is generally studied at three levels: Genetic, Species and Ecosystem diversity as shown by Figure 7.1.

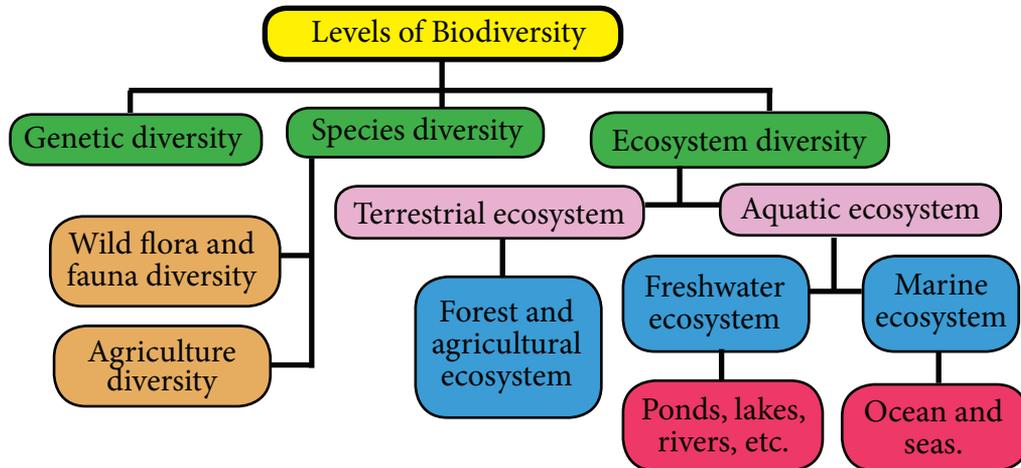


Figure 7. 1 Different levels of Biodiversity

i. Genetic diversity

Genetic diversity refers to the differences in genetic make-up between distinct species, as well as the genetic variations within a single species. Greater the genetic diversity within a species, greater is the chances of long-term survival. Figure 7.2 shows genetic diversity in maize seeds.



Figure 7.2 Genetic diversity in maize

ii. Species diversity

Species diversity refers to the variety of living species within a given region or area. Species diversity considers species richness, species evenness and species dominance. The number of species in a given area is a measure of richness. Evenness is a measure of the relative abundance of the different species making up the richness of an area.

a. Species dominance

Species dominance is the degree to which a species is more numerous than other species in an ecosystem, or makes up more of the biomass in the ecosystem. Species that are more in number as compared to other species are known as dominant species. For example, kangaroo in Figure 7.3 is a dominant species on the Australian savanna, Reindeer is a dominant species on the Tundra, and Huasai palm is one of the dominant trees in the Amazon rainforest.



Figure 7.3 Kangaroo in Australian savanna

b. Species richness

Species richness refers to the total number of species living in an ecosystem. For example, the species richness of an ecosystem is 15, if 15 different species of organisms are found. Species richness is not uniform throughout the Earth as it is influenced by many factors, such as latitude, ecological conditions, natural processes, etc. Disturbances, such as fires, hurricanes, and floods, can also affect species richness. Species richness of an ecosystem changes over time due to speciation and extinction.

c. Species evenness

Species evenness refers to how close in numbers each species in an environment are. For example, in ecosystems A and B in Table 7.1, ecosystem A shows more species evenness than in ecosystem B.

Both ecosystems have same species richness (5 species) each and equal number of individuals (100). However, ecosystem A has more evenness than ecosystem B. This is because the total number of individuals in ecosystem A is quite evenly distributed amongst the five species. In the ecosystem B, most of the individuals are rabbits with only a few of the other species.

Table 7.1 Species evenness in two ecosystems

Species	Ecosystem A	Ecosystem B
Rabbit	25	50
Deer	15	15
Tiger	10	5
Wild Boar	20	10
Squirrel	30	2
Total	100	100

Biodiversity of a habitat is quantified by taking into account the number of species present, as well as the abundance of each species. As species richness and evenness increase, so diversity increases. Simpson's Index of Diversity is a measure of diversity which takes into account both richness and evenness.

Simpson's Index of Diversity

Simpson's index of Diversity is calculated in the following ways

Calculation of Simpson's Index (D)

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

where, n = *The total number of organisms of a particular species* and N = *The total number of organisms of all species.*

The value of this index D ranges between 0 and 1. Greater the value, lower is the species diversity.

For example, for a single quadrat sample of ground vegetation, the following data was collected as shown in Table 7.2. Sampling only one quadrat would not give you a reliable estimate of the diversity of the ground flora. Several samples would have to be taken and the data pooled to give a better estimate of the overall diversity.

Table 7.2 Plant species in a single quadrat

Species	Ecosystem A	Ecosystem B
Woodrush	2	2
Holly (Seedling)	8	56
Bramble	1	0
Yokshire Fog	1	0
Sedge	3	6
Total	N=15	$\Sigma n(n-1) = 64$

Putting the figures into the formula for Simpson's Index.

$$D = \frac{\Sigma n(n-1)}{N(N-1)}$$

$$D = \frac{64}{15(14)}$$

$$D=0.3$$

1. Calculation of Simpson's index of Diversity

Simpson's Index of Diversity = 1-D

$$= 1 - 0.3$$

$$= 0.7$$

In this case, Simpson's Index of Diversity is 0.7, which is closer to 1, therefore, the diversity of species is high.

Activity 7.1 Measuring species diversity in a local ecosystem

Materials required: pencil, paper, record sheets, hand lens, plant identification book. 4 Meter sticks, String, 4 - wooden stakes, 2 - Metric rulers, 3 - 1 m x 1 m quadrat squares

Procedure:

1. Follow quadrat sampling method to collect and record the data of various species of plants in your study area as follows:
 - a. Locate an area with a variety of grass and shrubs around the school yard that is of at least 100 square meter.
 - b. Place the wooden stakes in the ground at the corners and "rope off" your square with the string. This is a 100 m² (100 square meter) quadrat.
 - c. Randomly place the 1 m x 1 m quadrat square (Location 1) somewhere within the larger quadrat.
 - d. Count the number of each type of plants within Location 1. Record your answer in the Data collection table.

- e. Repeat steps "d" at another two other random locations (Location 2 & Location 3) within the large quadrat.

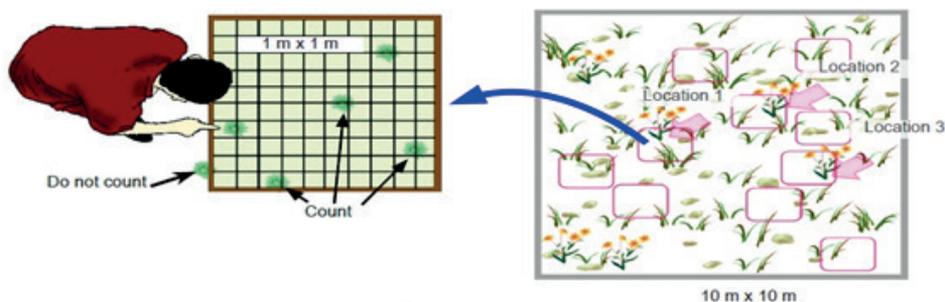


Figure 7.4

Table 7.3 Data collection table

Sl no.	Name of the plant	Number of plant in 1m x 1m quadrat Square (location 1)	Number of plant in 1m x 1m quadrat Square (location 2)	Number of plant in 1m x 1m quadrat Square (location 3)	Average number of the plant in three locations
1					
2					
3					

2. You have obtained a representative average numbers of plants in the 1 m x 1 m square. Now multiply these numbers by 100 to obtain the number of plants (n) in a 100 square meter.

Table 7.4

Name of the plant	Number (n)	n(n-1)
Total	N=	$\Sigma n(n-1)=$

3. Calculate the Simpson's Diversity Index using the following equation.

$$D = \frac{\Sigma n(n-1)}{N(N-1)}$$

4. Calculate Simpson's Index of Diversity (1-D)

Questions

1. How many significant species does the area contain?
2. Identify the dominant species in that area.
3. Compare species evenness among the three selected location in the large quadrat.
4. What conclusion can you draw from Simpson's Index of Diversity?

iii. Ecosystem Diversity

Ecosystems are combinations of communities of living things with their physical environment. An ecosystems can be as simple as a pond, a piece of log, or a stone with lichens growing on it; or, as complex as a tropical rainforest, desert and grassland. Some examples of ecosystems found in Bhutan are forest ecosystem, river ecosystem, lakes, marshlands, hot springs, etc.

B. Flora Diversity in Bhutan

Bhutan has rich species diversity in terms of its flora and fauna. Bhutan has about 5603 species of angiosperms and gymnosperms. About 144 of the plant species recorded are endemic to Bhutan. Endemism refers to those plant or animal species which live only in a particular location, such as a specific island, habitat type, nation or other defined zone and cannot be found anywhere else in the world. Some examples of endemic plant species include *Rhododendron kesangiae*, *Meconopsis superba*, *Pedicularis inconspicua* and *Bhutathera himalaica*.(Figure 7.5).



Rhododendron kesangiae

Meconopsis superba

Figure 7.5 Endemic plant species found in Bhutan

Bhutan, given its wide ranging geo-climatic conditions, is also expected to be rich in insect-fungi, although records are currently limited. Chinese caterpillar fungus *Ophicordyceps sinensis* (Figure 7.6), found in the alpine meadows, is highly valued for its medicinal properties. The National Mushroom Centre has recorded more than 300 species of forest mushrooms in the country. Some examples of mushrooms found in Bhutan are shown in Figure 7.7.



Figure 7.6 *Ophicordyceps sinensis*

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Bhutan also has diverse crops of about 80 species. The main crops include cereals, fruits, vegetables and spices. There are about 350 varieties of rice in the country creating a very valuable and unique gene pool.



Figure 7.7 Some of the mushrooms found in Bhutan

C. Fauna Diversity in Bhutan

Bhutan has close to 200 species of mammals, of which about 27 are globally threatened. Examples of some of the globally threatened mammals found in Bhutan are given in Figure 7.8.



Figure 7.8 Some of the globally endangered animals found in Bhutan

Bhutan is referred to as a Bird’s Paradise on the Earth owing to the rich variety of birds found in the country. About 770 species of birds have been recorded so far. Some of the critically endangered birds are the White Bellied Heron, Black Necked Cranes, Rufous-necked Hornbill, Palla’s Fish Eagle, Yellow-rumped honeyguide, and Tawny Fish Owl.



Figure 7.9 Some of the endangered species of birds found in Bhutan

Bhutan also has rich diversity of livestock. Some dominant livestock breeds are ‘Nublang’, mithun, brown swiss, yak, horse, mule, sheep, pig, goat, etc.

Activity 7.2 Maintaining a biodiversity inventory of your locality

Background information on this activity:

You have so far learnt about the rich biodiversity that we have in our country in terms of flora, fauna and agriculture biodiversity. This activity will help you assess the richness of biodiversity in your own local area by maintaining a biodiversity inventory in your school. The information which you collect could be documented properly as future reference for others interested in the same field of work.

You must try to collect primary information by visiting the local areas and talking to village elders, civil servants who work in the same field of area and your teacher besides seeking information in the library or internet.

Procedure:

1. In groups of 4 to 5, discuss on the type of species that you wish to collect as part of the biodiversity inventory in your local area.
2. Ensure that no two groups are working on the same species. Some suggested species you could take up in groups could be either different vegetables, cereals, fruits, spices grown in the local area or ornamental flowers, wild flowers, medicinal plants, birds, butterflies, insects, domestic animals found in the local area etc.
3. Go around your local area and start collecting the information you need. Follow the format already designed below to collect the information.

Table 7.5 Inventory table

Inventory table for found in Damphu, Tsirang					
Sl no.	Name	Description of species	Uses	Threats identified	Sample or Photo collection sketch drawn
1	Crow or Ola	It is a black bird commonly observed in the area. It has a large beak.	Scavenger which eats the left overs or dead bodies	Small kids stone the birds, dogs try to catch and eat it. Lots of trees being cut down destroying its nesting place.	Photo taken
2					

4. Since the activity involves field work for data collection, it can be completed and submitted with a report within a week. Display the work in one corner of the class and then answer the questions below.
- Which species is most commonly found in your local area?
 - What are some of the threats identified to the least diverse species?
 - What can you say about the biodiversity in your local area? Give specific examples based on the information collected by the class to make your point.
 - Suggest some measures that you can

Questions

- Rich biodiversity maintains the stability and health of an ecosystem. Justify.
- Biodiversity contributes to the economy of our country. Explain.
- Why does Bhutan have rich biodiversity?
- What are the important roles can Bhutan play towards the global conservation of biodiversity?

2. Biodiversity Conservation in Bhutan

Learning Objectives

On completion of this topic, you should be able to:

- *explain the need to conserve biodiversity.*
- *explain various biodiversity conservation initiatives of Bhutan.*
- *interpret the roles of traditional & indigenous practices in biodiversity conservation.*
- *discuss the roles of communities in biodiversity and conservation.*

According to the Convention on Biological Diversity, at least 40 percent of the world's economy and 80 percent of poor people's needs are obtained from the biodiversity. The benefits people derive from the ecosystem are termed as ecosystem services.

Greater biodiversity in ecosystem leads to greater stability of the ecosystem. However, biodiversity is under serious threat due to population growth, which increases the resource consumption and waste generation affecting the climate.

A. Threat to biodiversity

Species with high populations and genetic diversity are more likely to endure disturbances, disease, and climate change. Changes brought about by the destruction of required habitat, introduction of new predators or competitors, direct intervention of humans, usually occur too rapidly to allow most wild species to adjust; consequently, endangering the species or making them extinct. The following are some of the examples which pose threats to the biodiversity:

i. Habitat destruction and fragmentation

Habitat destruction is one of the major threats to biodiversity. Huge tracts of forest are cleared for human settlement, urbanization, industrialization and to meet the growing demand of food. Further, natural disaster, such as flood, landslide and drought also destroy the habitats (Figure 7.10). Habitat fragmentation occurs when ecosystems are divided into smaller components due to human or natural activities. Such fragmentation may cause the disappearance of thousands of species (Figure 7.11).



Figure 7.10 Habitat destruction in a mining area

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Human disturbances could lead to habitat loss for some important flora and fauna species. Owing to this, some examples of the endangered species in Bhutan include tiger, snow leopard, Rufous-necked Hornbill, White-bellied Heron, Black-necked Crane and Blue Poppy, etc. Endangered species are those plants and animals that have become rare and they are at risk of becoming extinct. While, threatened species vulnerable to become endangered in near future.



Figure 7.11 Habitat fragmentation

ii. Climate change and global warming

Climate has significant influence on the biotic and abiotic components and their interactions in an ecosystem. However, the climate changes due to natural and anthropogenic activities. Long-term changes in temperature and rainfall patterns can have serious impacts on biological diversity of ecosystems. For instance, warming could force species to migrate to higher latitudes or higher elevations where temperatures are more conducive to their survival. Similarly, global warming may lead to rise in sea level causing saltwater to intrude into the freshwater system. This will force some key species to relocate or die, thus, removing predators or prey that were critical in the existing food chains.

The climatic conditions influences the phenology of organisms in an ecosystem. Wherein, the life cycles, physiological activities, and behaviour of organisms are affected, prompting them to migrate, bloom and mate in asynchrony with the environment. This leads to the mismatch of the timing of migration and breeding with availability of food. Chances of growth and survival are reduced when migrants arrive at a location before or after the availability of food.

The Himalayan glaciers are receding due to global warming. The growth and life cycle of alpine plants and animals are disrupted because of the lack of snow and snow-melt water. This changes the species composition, structure and functioning of alpine meadows leading to the habitat alteration and disappearance of species.

iii. Invasive species

In an ecosystem, a major threat to native biodiversity is by invasive species. Invasive species are organisms that are not native to a specific location and have a tendency to spread, which may cause damage to the environment, economy and human health. These species may potentially affect native species through competition and breeding

that destroy the unique genetic types, or alter the predator-prey interactions.

Although, there is limited scientific assessment of invasive species and their impacts in Bhutan, some environmental and socio-economic impacts of invasive species are already being felt to some degree. For example, Bhutanese rice farmers are losing crops to the invasive alien waterweeds, such as *Potamogeton distinctus*. Terrestrial weeds like *Lantana camera*, *Parthenium* spp, and *Mikania micrantha* are invading the Bhutanese forests. *Phytophthora capsici*, *Pyricularia oryzae* and *Phytophthora infestans* are invasive species which cause chili blight, rice blast and potato late blight, respectively.



Figure 7.12 Forest infested by *Mikania micrantha* in southern belt of Bhutan

The Bhutan Agriculture and Food Regulatory Authority (BAFRA) and the Department of Revenue and Customs have implemented policies to control the entry of invasive species across the borders.

Activity 7.3 Case study on invasive species

Instruction: Read the case study and answer the following questions.

Report on the APFISN Workshop on ‘Pathways of Biological Invasions into Forests’ organized at Thimphu, Bhutan on 8 & 11 June 2010.

Biological invasions have impacted the economic, ecological and cultural arenas in a highly significant manner than ever before. Invasions by Invasive Alien Species (IAS) are recognized to be much faster than the natural rate of migration of species. The large scale increase in global transport of goods and people is the primary cause of this widening invasion scenario. Among the various worldwide efforts to contain

the invasive species, APFISN, in its period of existence had tried to map the general contours of the problem as a function of sustainable management of natural and planted forests.

The network has been focusing on preparation of country reports on IAS, publication of fact sheets on major invasive species, deliberating on the impact of IAS

on biodiversity and is active in disseminating information on forest invasives across the Asia Pacific. The network realized that the compilation and dissemination of information and establishing direct contact with stakeholders in various countries as an essential and continuing effort and the problems caused by biological invasions warrant urgent action. Efforts to contain biological invasion is an integrated activity which should look into the origin, transport,

arrival, establishment and naturalization of the species that move. Among these various phases of the invasion process, the one with the quickest intervention probability is the transport phase, which can be monitored and checks implemented at the earliest. Considering the immediate need for action in many of the potential invasive species, APFISN workshop at Thimphu, Bhutan focused on the pathways of biological invasion.

Source: Newsletter of the Asia-Pacific Forest Invasive Species Network (APFISN)

Questions

1. Why are invasive species a concern?
2. What is the common mode through which the invasive species spread across the world?
3. What are the initiatives taken by the APFISN towards controlling the global invasive species issues?
4. Why should Bhutan participate in such forum?

B. Conservation initiatives

Biodiversity has significant ecological, cultural and economic roles. Certain natural processes and anthropogenic activities have been threatening the existence of many important species. Owing to the dangers towards biodiversity, numerous conservational initiatives have been implemented for its sustenance.

i. National conservation initiatives

Bhutan's conservation efforts include ex-situ and in-situ approaches. The conservation of species in their natural habitat is called in-situ conservation. For example, Phrumsengla National Park was established for in-situ conservation of rhododendron species. The conservation of species outside their natural habitats is called as ex-situ conservation. The Ministry of Agriculture and Forest has established Royal Botanical Garden and National Gene Bank in Thimphu for ex-situ conservation of plants and animal species that are used for agricultural purposes.

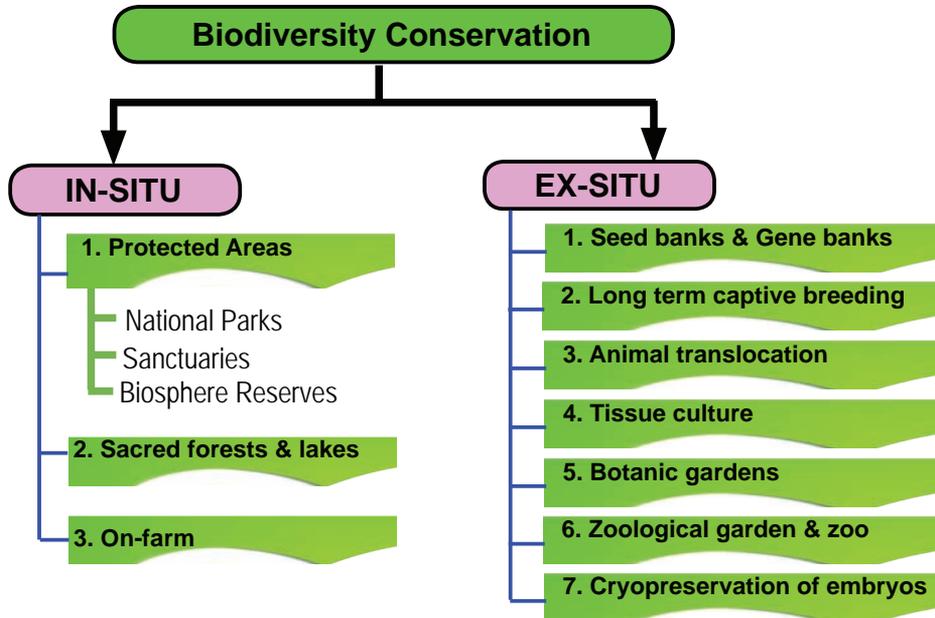


Figure 7.13 In-situ and ex-situ conservation

Several government and non-government agencies are involved in environmental education and awareness programme. Local communities are made aware of the environment related legislations and importance of the biodiversity conservation. Some of the national policies and legislations for biodiversity management in Bhutan are:

a. The Biodiversity Action Plan for Bhutan, 2009

The National Biodiversity Strategy and Action Plan (NBSAP) of Bhutan provides a framework to ensure conservation of biodiversity and promote sustainable development. The plan provides the status of Bhutan's biodiversity and conservation actions taken.

This biodiversity action plan includes the following conservation strategies:

- i.) direct actions for conservation and sustainable use and wild biodiversity resources through the establishment of protected area system, and buffer zones and enclave zone; promotion of in-situ conservation of wild crop relatives and wild plants for food production conservation outside of protected areas.
- ii.) domestic biodiversity resources conservation through in-situ and ex-situ conservation, both plants and animals.
- iii.) essential supporting measures for wild biodiversity resources by conducting periodic scientific research, surveys and monitoring; maintaining databases; and promoting sustainable land use planning.

Chapter 7

- iv.) economic valuation of biodiversity resources by incorporating biodiversity in related sectors' strategy and planning and strengthen the institutional framework relating to biodiversity.
- v.) assure that biodiversity conservation brings benefits to local people; strengthen biodiversity in education and awareness; and establish international cooperation in biodiversity conservation and sustainable use by recognizing the critical importance of population in biodiversity conservation and sustainable use.

b. Biodiversity Act, 2003

This Act was enacted for the following purposes and objectives:

- i.) to ensure national sovereignty of the government over genetic resources in accordance with relevant national and international law.
- ii.) to ensure the conservation and sustainable use of the biochemical and genetic resources through equitable sharing of benefits derived from the genetic resources.
- iii.) to promote technology transfer and capacity building at the national and local levels, including the building of scientific and technological capacity relevant to the conservation and sustainable use of biological diversity.. At the same time, recognize and protect traditional knowledge and practices of local communities associated with biodiversity.
- iv.) to regulate and facilitate the process by which collectors may legally obtain genetic resources, and prevent illegal access to genetic and biochemical resources.
- v.) to recognize and protect the farmers' and breeder's rights by making plant varieties subject to property rights.
- vi.) to promote access to foreign sources of improved plant varieties for Bhutanese farmers.

Other acts and policies related to biodiversity conservation include Forest and Nature Conservation Rules, 2000, The Environment Assessment Act, 2000, etc.

Activity 7.4 Identifying various organisations and their roles in biodiversity conservation

Instruction: Several government organizations are involved in biodiversity conservation. Use library books, internet or ask environmental officials and complete the table 7.1. One is completed as an example

Table 7.6: Organisation involved in biodiversity conservation

Organisation	Conservation roles
1. Department of Forests and Park Services	Protected area management, forest management, etc.
2. National Biodiversity Centre	
3. Department of Livestock	
4. Department of Agriculture	
5. Bhutan Agriculture and Food Regulatory Authority	
6. National Environment Commission	
7. Department of Geology and Mines	
8. National Land Commission	
9. Royal Society for Protection of Nature	
10. Tarayana Foundation	
11. World Wide Fund for Nature (WWF)	
12. Bhutan Trust Fund for Environmental Conservation	
13. United Nations Development Programme	

Questions

1. What are the overarching objectives of all the organizations?
2. What are the common strategies used by the concerned organization?
3. Discuss emerging issues that affect the conservation efforts.
4. How would you contribute to national conservation efforts?

C. Community conservation initiatives

Bhutan has conservation ethics deeply rooted in its people's culture and religion. The association of beliefs and behaviors on the basis of religion and culture strengthened the environment management practices. Some of these practices are still prevalent and effectively promoted by government institutions.

i. Traditional conservation practices

Before forest and environment legislations were enacted, village forests were monitored by nominated 'risups' (village forest guards) to ensure that the local people use the forest sustainably. Even today, government employs 'risups' in villages. Similarly, a nominated 'misups' (Forest Fire Lookouts) monitored the occurrence of forests fire and reported to the concerned authority. In Eastern Bhutan, villagers appointed 'zhingsungpa' (Agriculture Crop Protector) to lookout for crop damages by cattle.

The customary laws or protocols to protect biodiversity, such as 'ladam', 'ridam' and sokdam are still prevalent in many parts of the country. In 'ridam', areas inside forest are restricted for human activities for certain period of time. In 'ladam', mountain passes are blocked for human use. These are usually done in reverence to local deities and sacred places to endow the local residents with good harvest. Similarly, sacred groves, lakes and mountains which are believed to be home to local guardians and deities are protected. Sokdam is observed as law to refrain from killing animals in certain months of the year. Hence, Bhutanese traditions play significant roles in the biodiversity conservation.

Activity 7.5 Exploring the traditional conservation practices in your locality

Instruction

1. Work in groups and carry out the survey on traditional conservation practices in your locality.
2. Collect information on the following areas:
 - a. geographical features of the locality
 - b. lifestyle of the locality.
 - c. different forms of conservation practices, of past and present.
 - d. ways and significance of the practices.
 - e. benefits of these conservation practices.
 - f. implications of practices on the life of the localities.
 - g. personal opinion on the practices.
3. Write a report and present to the class.

Questions

1. Explain the threats to biodiversity.
2. Explain the significance of Biodiversity Action Plan for Bhutan, 2009.
3. How do traditional practices and beliefs contribute to biodiversity conservation?

3. Ecotourism in Bhutan

Learning Objectives

On completion of this topic, you should be able to:

- *describe ecotourism.*
- *explain the benefits of ecotourism.*
- *assess the impacts of ecotourism on biodiversity.*

Many protected areas endowed with rich biodiversity and wilderness in the world generate revenue from tourism activities. It benefits the local communities. Such form of tourism which involves visiting rich biodiversity areas and which benefits the local communities is known as **ecotourism**. The International Ecotourism Society defines **ecotourism** as, “responsible travel to natural areas that protects nature and sustains the well-being of local people”.

Ecotourism covers both the aspects of biodiversity conservation and economic contribution to local people as it:

- contributes to biodiversity conservation through eco-friendly practices.*
- includes local communities in planning, development and operation to contribute to their well-being .*
- respects local culture and traditions.*
- provides positive experience both for hosts and guests.*

Ecotourism, if poorly managed, can have adverse effects to local communities and the biodiversity. Uncontrolled number of tourists can have negative impacts on local culture and damage the biodiversity, for example, destruction of vegetation and littering of places. Erosion of delicate vegetation are associated with the use of horses and yaks during trekking in the high mountains.

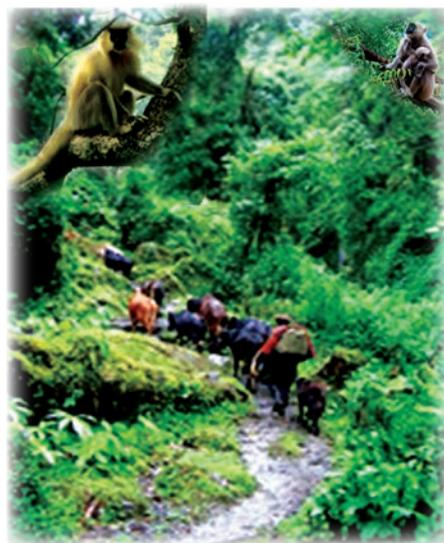


Figure 7.14 Nabji-Korphu community-based ecotourism

Activity 7.6 Exploring the benefits of ecotourism

Instruction: Read the following text and answer the questions

Local people reap benefits from first ecotourism project in the country

Nabji-Korphu community-based ecotourism in Jigme Singye Wangchuck National Park is first of its kind in Bhutan. In 2005, the ecotourism trail was started to combine trekking and cultural activities and benefit the local communities. The Tourism Council of Bhutan and the Association of Bhutanese Tour Operators in collaboration with Ministry of Agriculture supported the project.

To enhance direct benefits to the communities, the project was planned, owned and managed by the communities. Communities were trained in cooking, guiding, campsite management, book keeping and rural enterprise. Campsites were built along 70 km trail of 6-day trek.

Tourists have to use and pay for the campsite facilities, guides and cooks. The Park manager said "Tourists can enjoy both culture and nature along this trek. There are many temples and religious sites along the trek and they can see unique ethnic group. They can also witness village festivals and enjoy local dances. We have wildlife, birds and wonderful viewpoints for them to enjoy".

The local Gup said, "Local people have employed themselves to provide many services to the tourists, such as campsite management, porter and pony, guiding, cooking. We get fees for all these".

He also added that villagers earned revenue through cultural performances, festivals, sale of bamboo and cane products and sale of vegetables. Phurba, a villager said, "My life has improved from the earnings I make

as a village guide". His cousin has started a souvenir shop of bamboo products.

Between 2006 and 2007, about 200 tourists visited the area. The total government earnings through royalty were 4.3 million ngultrums. The tour operators earned about 1.47 million ngultrums. Local communities earned about 230,000 ngultrums from services alone.

According to the local Gup, 10 percent of local earning goes to the Village Development Fund, which they can use for village development. He hopes that ecotourism will help boost local economy through local businesses. "Many people are opening up new businesses to sell to tourists and national visitors", the Gup said.

Aum Pema is happy that she can learn other's culture while sharing Bhutanese culture to them. The Park Manager is happy that ecotourism is having minimum impact on biodiversity because eco-tourists and local communities respect them. But he is worried about the garbage problems. Nature Recreation and Ecotourism Division under the Ministry of Agriculture has been instrumental in assisting the Park and communities in running the ecotourism project. Besides, the Guide Association of Bhutan has also been helpful by providing feedbacks and ideas. The local governments and Dzongkhag Administration ensure that proper policies are implemented.

(Source - NRED, 2011)

Questions

1. Why do tourists visit this community?
2. Explain some of the benefits of the ecotourism for the community.
3. What are some of the negative impact of ecotourism explained in the text?
4. Explain the role of ecotourism on the biodiversity conservation.
5. Explain the roles of community to promote ecotourism in the locality.
6. Relate the ecotourism to the concept of GNH.

Questions

1. Define ecotourism.
2. Discuss the pros and cons of ecotourism in Bhutan.
3. List down some of the good practices crucial to sustain the ecotourism.
4. Justify ecotourism as a sustainable developmental strategy?

Summary

- Biodiversity provides many ecosystem services.
- In Bhutan, importance of biodiversity may be understood at three levels: ethical and cultural values; utilitarian or economical values; and aesthetic and ecological values.
- Greater biodiversity in ecosystem leads to greater stability of the ecosystem.
- Biodiversity is under threat due to population growth with increased resource consumption, decreased in habitats and climate change.
- Invasive species are organisms that are not native to a specific location and have a tendency to spread and affect the environment, economy and human health.
- Traditional and customary practices contribute to biodiversity conservation in different localities.
- Some of the national policies and legislations for biodiversity management in Bhutan are: The Environment Assessment Act, 2000; Forest and Nature Conservation Rules, 2000; The Biodiversity Action Plan for Bhutan, 2009 and Biodiversity Act, 2003.
- Ecotourism covers the aspects of biodiversity conservation and economic contribution to local people. It is a way to balance conservation and development.

Exercise

1. Write TRUE or FALSE for the following statements. Correct the false statements and write them down.

- a. Wild life sanctuary is an in-situ conservation effort.
- b. Agricultural fields decrease natural biodiversity.
- c. Ecotourism is one of the strategies to promote biodiversity.
- d. Both native and exotic species are threats to the biodiversity.
- e. Local traditions help in the conservation of biodiversity.

2. Fill in the blanks with the correct word(s).

- a. The environmental benefits derived from the biodiversity are called services.
- b. Red Panda species may soon be wiped out from the face of the world, and hence it is at the state.
- c. *Ladam* is an example ofconservation practices.
- d. Threatened species are often protected by preserving their functioning ecosystem in a natural setting. This approach is calledconservation.
- e. The organization under the MoAF that controls the entry of invasive species across the border is

3. Match the word or phrase numbered (1) to (5) in Column A with the appropriate word or phrase numbered (i) to (vii) in Column B.

Column A	Column B
1. Royal Botanic Garden	i. Traditional conservation initiative
2. Convention on Biological Diversity	ii. Invasive species
3. Water weed	iii. Global strategic plan for biodiversity.
4. Ecotourism	iv. Form of in-situ conservation.
5. Risup	v. Form of ex-situ conservation .
	vi. Negative impacts on biodiversity
	vii. Threatened species

4. Each question in this part is followed by four possible choices of answers. Choose the correct answer.

- a. The greatest impact on the biodiversity is by the
 - A. introduction of new species.
 - B. pollution of habitat.
 - C. destruction of habitat.
 - D. hunting of animals.
- b. Which of the following is not a form of in-situ conservation?
 - A. National Park.
 - B. Wildlife Sanctuary.
 - C. Botanical Garden.
 - D. Strict Nature Reserve.
- c. Which of the following is not a level of biodiversity?
 - A. Genetic diversity.
 - B. Species diversity.
 - C. Ecosystem diversity.
 - D. Food diversity.
- d. Increased efforts in Bhutan to conserve forests are necessary in order to?
 - A. protect biodiversity.
 - B. promote extinction.
 - C. exploit resources.
 - D. increase industrialisation.
- e. Which of the following is endemic to Bhutan?
 - A. *Meconopsis superba*
 - B. *Ophiocordyceps sinensis*
 - C. *Rhododendron bhutanense*
 - D. *Tricholoma matsutake*

5. Answer the following questions.

- a. How does in-situ promote the biodiversity conservation?
- b. Greater biodiversity increases the stability of the ecosystem. Justify.
- c. How does global warming cause loss of biodiversity?
- d. What are some of the economic benefits of the biodiversity?
- e. Explain the importance of traditional practices in biodiversity conservation?

Land use and Management



Watershed is constituted by land, water and vegetation. They are the basic components of natural resources that support all forms of life on the Earth—for humans, for economy and their livelihood. Among these three components, land forms the lithosphere, a substrate on which other two components exist.

Bhutan is an agrarian country, therefore land is its most important resource. Land resources are used for a variety of purposes, such as farming, afforestation, infrastructure development, water management and ecotourism activities. The ways in which a land is used can be managed to minimise the degradation of forest and watersheds, and enhance the productivity of the land.

In this chapter, you will learn about the land use pattern, its impact on environment and the practices of land management in Bhutan.

1. Land use Pattern

Learning Objectives

On completion of this topic, you should be able to:

- *describe various land use in Bhutan.*
- *identify impacts of different land use.*
- *identify impacts of change in land use on environment.*

In Bhutan, the use of land is broadly categorised into forest, agricultural, settlement, pastures and others, such as wetland, scrubs, rock outcrops, snow covers and degraded areas.

The change in land use is generally influenced by the changing lifestyles of people, type of economy of the society or country, population growth, and the environmental conditions can also lead to the land use change. Different forms of land use and conversion of land from one form to another have various environmental impacts.

A. Land use and their impacts

The land use is defined as how humans use the biophysical, or ecological properties of the land. Land-uses include the modification and management of land for agriculture, pasture, settlements, forestry, mineral extraction and nature reserves, etc. However, land use patterns are dictated by its topography, climatic conditions, natural resources availability, population growth, economy of the society or country, etc.

i. Forest

The forest cover has significant influence on hydrological cycle, soil conservation and the climate change. Forest as one of the important elements in the global cycling of carbon (as carbon sink), oxygen and other gases influence the composition of the Earth's atmosphere. The amount of water flow from the watershed is determined by the forest cover. Forest supports the diverse life forms on the land.



Figure 8.1 Forest

Forest is the most dominant land use form in Bhutan, which secures Bhutan the rank as one of the most biodiverse countries. It is one of the countries that harbours the highest species richness per unit area. Therefore, it is part of one of the ten biodiversity hotspots in the world, largely contributed by good percentage of protected areas with declared biological corridors, and community forest.

The forest is one of the main sources of resources for the people of Bhutan. It is used for timber extraction, non-wood forest products (NWFP), fuel wood, fodder, etc. However, the loss of vegetation due to deforestation, unsustainable fuel wood extraction, shifting cultivation, encroachment into forest land, forest fire, over grazing, extension of cultivation onto lands of low potential or high natural hazards, non-adoption of adequate soil conservation measures and improper crop rotation are some of the important factors contributing to deforestation and land degradation in Bhutan.

ii. Agriculture

The majority of population of Bhutan is dependent on subsistent agricultural farming. It is the single largest sector that provides livelihood to more than half of the total

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population of the country.

The agricultural land use consists mainly of 'kamzhing' (dry-land) and 'chuzhing' (wetland). The 'kamzhing' is the most dominant agricultural land use throughout the country. It is either terraced or unterraced agricultural land along the slopes of the hills, generally used to grow crops and cash crops, such as apple, citrus fruits, areca nut, cardamom, etc. The 'chuzhing' is usually terraced wetland where paddy and other crops are cultivated. Much of the wetland is found along or very near the stream, rivers and lakes.

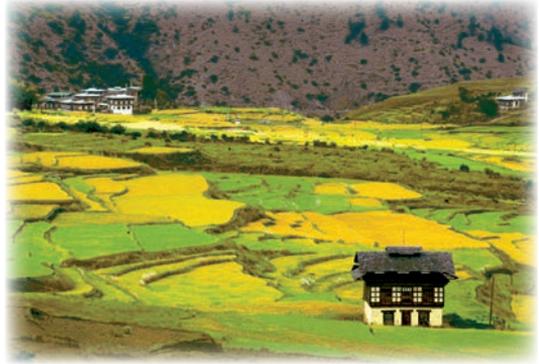


Figure 8.2: Chuzhing

Shifting cultivation is an age-old practice common to several parts of the country. The slash and burn practices in the shifting cultivation is considered to be one of the dominant factors contributing to environmental degradation. Agricultural practices have changed tremendously over the years. Until a decade ago, agriculture was practiced on a subsistence basis. Whatever was produced on the farm was consumed having little or no marketable surplus. With increase in demand for food and the practice of modern farming including the use of pesticides and chemical fertilizers, have resulted in pollution of land and water, even the air. These pollutants upon reaching the water bodies affect the aquatic life and the health of the whole ecosystem. Nitrates from chemical fertilizers and pesticides are soluble and prone to leaching during rainy seasons. Leached nitrates contribute to the eutrophication in an aquatic natural habitat.

In Bhutan, the expansion of arable land is a challenge owing to the nature of the terrain and the difficulty to enhance the productivity of the cultivable land. Most of the land area suitable for agriculture has already been utilised. However, the expansion of agriculture due to increase in population and the recent boom in horticulture is further bringing more land under agriculture land-use, leading to encroachment into forest and degradation of land.

iii. Settlement

This form of land use includes residential, commercial, industrial, institutional and recreational purposes. They are for constructing facilities, such as airport, houses, schools, institutes, factories, hospitals, sewage treatment plants, sports centre, gymnasium complex, theatres, roads, monasteries, bridges, etc., They are also used as waste dump sites, mines, stone quarries, etc.

The nature and extent of the impact by this land form use is determined by the scale of settlement, the level of infrastructure development, the rate of resource consumption, and the type of human and economic activities. The settlement area is being widened and expanded every year owing to increase in population and migration. The boost in economy is also driving the installation of more industries, factories and commercial centres. This form of land use generates wastes and pollutes air, land and water.



Figure 8.3: Settlement

In Bhutan, the urban settlements are increasing steadily changing the forest and arable land into residences, roads and business centres. Mining in Bhutan is changing the topography and is a cause for landslides, disruption of water sources, loss of biodiversity, pollution and soil erosion.

iv. Pasture

The pasture (*tsamdro*) is an open field covered with grass, shrubs and small trees, suitable for grazing. It has been estimated that half of the national fodder requirement comes from natural grassland and forest. According to the Land Act of Bhutan, 2007,

- an individual household or community owning livestock shall be eligible to avail grazing land ('tsamdro') on lease from the government.
- the lease for highlanders (people residing on high altitudes) shall be for a period not less than 30 years with the possibility of extension.
- with the exception of the 'tsamdro' leased to highlanders, there shall be no sub-leasing of 'tsamdro'.
- no permanent infrastructure shall be established on the 'tsamdro' on lease. Unless renewed, upon expiry of lease, the lessee shall not continue with any activities on 'tsamdro' or no infrastructure shall remain on the land.
- there shall be no transaction of 'tsamdro' which is on lease. The lease may however, within the stipulated lease period, be inherited.

Pastures for grazing occupy about 30 percent of the Earth's terrestrial surface, while food crop production occupies about a third of all arable land. Livestock is an integral part in all Bhutanese farming systems. The categories of livestock of farmers include cattle, pigs, poultry, sheep and goats. The livestock sector is the largest anthropogenic user of land. Excessive livestock grazing causes soil erosion, soil infertility, water

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Figure 8.4 Yak herding on pastures and settlement

shortage and depleted organic matter content in the pasture. About 70 percent of all the grazing land is considered degraded, mostly because of overgrazing, compaction and erosion, attributable to livestock activity. Expansion of grazing land for livestock is a key factor in deforestation and environmental degradation.

Some of the challenging and common impacts of the current land use pattern in Bhutan are:

- farming on steep slopes is resulting in soil erosion and decline in the soil fertility;
- limited arable land is limiting the possibility of expansion of agriculture;
- deforestation in the fragile areas is causing soil erosion and sedimentation downstream; and
- indiscriminate use of land for developmental activities is leading to the risk of wasting good arable lands.

Activity 8.1: Analysing the Article on conservation of environment

Instruction: In groups, read and discuss on Article 5 of the Constitution of the Kingdom of Bhutan and answer the following questions.

Article 5 (Environment)

1. Every Bhutanese is a trustee of the Kingdom's natural resources and environment for the benefit of the present and future generations and it is the fundamental duty of every citizen to contribute to the protection of the natural environment, conservation of the rich biodiversity of Bhutan and prevention of all forms of ecological degradation including noise, visual and physical pollution through the adoption and support of environment friendly practices and policies.
2. The Royal Government shall:
 - a. Protect, conserve and improve the pristine environment and safeguard the biodiversity of the country;
 - b. Prevent pollution and ecological degradation;
 - c. Secure ecologically balanced sustainable development while promoting justifiable economic and social development; and
 - d. Ensure a safe and healthy environment.
3. The Government shall ensure that, in order to conserve the country's natural resources and to prevent degradation of the ecosystem, a minimum of sixty percent of Bhutan's total land shall be maintained under forest cover for all time.
4. Parliament may enact environmental legislation to ensure sustainable use of natural resources and maintain intergenerational equity and reaffirm the sovereign rights of the State over its own biological resources.
5. Parliament may, by law, declare any part of the country to be a National Park, Wildlife Reserve, Nature Reserve, Protected Forest, Biosphere Reserve, Critical Watershed and such other categories meriting protection.

(The Constitution of The Kingdom of Bhutan, 2008, pp 11)

Questions:

1. Why is clause 1 of Article 5 important for Bhutan?
2. How does Article 5 contribute to the conservation of our environment?
3. State your plan to accomplish clause 3 of Article 5, in your capacity as
 - a. citizen of the country.
 - b. environmental activist.
 - c. head of the local government.
 - d. policy maker.
4. Explain clause 2b of Article 5 with examples.
5. Explain the type of land use in Bhutan that could be the biggest threat to the environment.

B. Land-use change

The land use continuously changes from one form to another. This change is also called land use transformation. Conversion of forest area to agriculture, pasture or residential area is an example of land use transformation. Similarly, conversion of agriculture, pasture or forest into residential area is also land use transformation.

Major causes of land use change are natural variability, economic and technological factors, demographic factors, institutional factors, cultural factors, and globalization. Some processes of land use change can have ecological gain as in the conversion of waste land into forest or arable land. In most cases, land use changes may be followed by distinct or drastic change in the land quality, including the loss in biodiversity, increased soil compaction, loss of nutrients, etc., resulting in ecological damage.

Activity 8.2: Investigating the impact of change in land use pattern

Analyse the pattern of land use in Bhutan based on the statistics provided, and answer the questions that follow.

Land use	Year					
	1990	1995	2000	2005	2010	2014
Forest	70.60	72.50	72.50	72.50	72.50	70.46
Agriculture	8.80	7.70	7.70	7.80	7.80	2.93
Pasture	0.00	4.00	4.00	3.90	3.90	4.10
Settlement	0.00	0.10	0.10	0.10	0.10	0.18
Others	20.60	15.70	15.70	15.70	15.70	22.33
Total	100.00	100.00	100.00	100.00	100.00	100.00

Adapted: Statistical Yearbook of Bhutan (<http://www.nsb.gov.bt>)

Questions

1. What is the dominant form of land use in our country?
2. Land use for settlement has only slightly increased over the years, but has huge impact on the environment. Justify.
3. List down the possible causes of decrease in agriculture land used for agriculture in the year 2014.
4. Predict the percentage of land use for Bhutan by the year 2020. Give reasons for your prediction on increase or decrease of particular type of land use.
5. The agricultural land use reduced drastically by the year 2014. Explain why this happened and the consequences on the livelihood of people?

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Questions

1. Explain the various land uses and land use patterns in Bhutan.
2. Explain the form of land use represented by the picture.



Figure 8.5

3. Differentiate between land use transformation and shifting cultivation.
4. In what ways does the Land Act of Bhutan benefit highlanders of Bhutan?

2. Farming Practices in Bhutan

Learning Objectives

On completion of this topic, you should be able to:

- *describe farming.*
- *differentiate between traditional and modern farming.*
- *explain the advantages and disadvantages of traditional and modern farming systems.*

Bhutan is a landlocked country and farming is the way of life for majority of its population. Most Bhutanese practice subsistence farming, wherein, they grow enough food for consumption for themselves and their families. Over the decades, farming methods have changed according to the needs and the available technologies. Therefore, the two methods of farming prevalent in Bhutan include the following.

A. Traditional farming

Bhutanese farmers are still practicing traditional farming in many parts of the country. It involves unsophisticated and handmade agricultural tools and oxen for draught power. Since it is labour intensive, it provides more job opportunities to people.

Farm manure, and leaf litters are used for enriching the soil for better yield. Collection of leaf litters help to prevent forest fires, though it deprives the forest floor of the nutrients.

The traditional farming is based on selective breed, in which the best seeds from the previous yield are selected as seeds. Such crops are better adapted to the climatic



condition of that place, but are susceptible to pests and diseases. The use of same seeds for generations will result in loss of their genetic variation and finally result in poorer yield. Despite the low yields, crops are generally of acceptable quality in terms of taste and nutritional values.

Shifting cultivation ('tseri') is one of the common methods in traditional farming practices, mostly in remote places, wherein people slash and burn forest to grow crops. The area is then left fallow for a few years, ideally 10-12 years, to allow the area to recuperate. Once the forest reaches the maturity stage, the area is cleared again to grow crops and the cycle continues. This practice is one of the age-old farming methods practiced in many countries, particularly in the least developed countries. 'Tseri' cultivation is discouraged these days in Bhutan.



Figure 8.7 Shifting cultivation

B. Modern farming

The modern technology was introduced in Bhutan in the recent decades to improve the farming practices and increase the productivity.

In modern farming method, technologies, such as power tiller, tractor, reaper, transplanter, thrasher, transform the traditional farming to lesser labour intensive farming with emphasis on higher yield. To increase the yield, genetically modified high yield seeds and chemical fertilizers are extensively used. Pesticides and biocides are used to protect the crops from pest, diseases and weeds.

Modern farming method compromises the impacts of technologies on the land and the quality of food produced with the higher yield. The yield by this method is very high, but of low quality. The extensive use of artificial fertilizers, without crop rotation, reduces the soil's fertility over the years. About half of the nitrate in the artificial fertilizer used on crops



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Figure 8.8 Use of pesticides



Figure 8.9 Comparison of men ploughing the fields using traditional and modern equipment.

leach into the water bodies and contaminate the water. This contributes significantly to eutrophication in water bodies endangering the life forms in the ecosystem.

The use of machine in cultivation results in deep ploughing, which exposes the ground to heavy rains and erosion of topsoil. Most crops are under the effects of heavy doses of different chemicals, insecticides and weedkillers, before the crops are harvested. Consequently, wild animals and plants which were once a common sight around the farms are deprived of their natural habitat and food. With the process of biomagnification, hazardous chemicals affect all the living organisms in the food chains. Hence, though the modern farming has the advantages in productivity and ease of farming, it has disadvantages in terms of health hazards and degradation of the environment and pollution of land.

Activity 8.3: Understanding farming systems in Bhutan

Instruction: Read the case study and answer the following questions.

Farming systems

In Pemagatshel district, 90 percent of the populations are farmers. Almost all farm households farm at a subsistence level, including both crops and animal husbandry. This subsistence farming system is constrained by the shortage of land, labour and operating capital. Hence, there is practically no room for expansion and there is declining productivity resulting from increased frequency of 'tseri' cultivation. There are shortages of water, compost, fertilizers and pesticides. The growing population has increased the need to produce larger quantities of food from shifting cultivation, which in turn has

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prompted the Royal Government of Bhutan to seek alternatives to shifting cultivation.

Shifting cultivation is viewed not as an exclusive production system, but one integrated with other subsistence activities, such as food gathering from the forest and rearing of livestock, especially cattle. Due to many limitations it has been impossible to commercialize any of these activities. Generally, there is very little surplus in a shifting cultivation system, market facilities in the district are limited and monetization is restricted. Many areas are actually food-deficient, particularly following a crop failure due to weather, pest attacks or other

phenomena. Even the storage of crops, should a surplus occur, is a problem for shifting cultivators.

An estimated 65 percent of households keep cattle, and many of the others have some small stock, such as pigs and poultry. Production of manure for the preparation of

compost is the main objective of keeping cattle. Draught work and dairy products are secondary benefits. Pigs are a principal source of meat, where meat is consumed. Poultry are kept primarily for eggs. Small ruminants (sheep and goats) are rarely kept, and in fact raising them is not encouraged by the government

Source: Upadhyay K.P. 1995. Shifting Cultivation in Bhutan: A Gradual Approach to Modifying Land Use Patterns. A Case Study of PemaGatsel District, Bhutan. FAO, Rome

Questions:

1. What is the type of farming practiced by people in Pemagatshel? Why?
2. List down some of the features of traditional farming as mentioned in the case study.
3. Evaluate the possible environmental impact of shifting cultivation.
4. Why is shifting cultivation discouraged by the government?
5. Describe the purpose of animal husbandry for the farmers of Pemagatshel.
6. What farming methods can be adopted by the farmers of Pemagatshel to improve the production?

Bhutan has witnessed a steady growth rate of the per capita income since the mid 1980s. The government has formulated a policy to modernize the agriculture sector including implementation of various donor supported projects and programs in different regions of the country. Research on crop varieties, extension and manpower development programs in various fields, such as horticulture and market infrastructure development are making a positive impact on the farming systems.

The government is promoting the production of cash crops that has seasonal advantage over other crops in the neighboring countries. The policy is geared towards transforming the agriculture sector from subsistence farming to a market oriented commercial farming.

Questions

1. Critically assess the pros and cons of modern farming.
2. Agricultural farming in Bhutan is predominantly subsistence. Justify.
3. Figure 8.10 is a logo that we often see on the sign posts. Interpret its theme.



Figure 8.10
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3. Waste Management

Learning Objectives:

On completion of this topic, you should be able to:

- *explain the types of waste.*
- *assess the solid waste management in their locality.*
- *draw a solid waste management plan to be implemented in the school.*

A huge amount of waste is produced everyday by humans, and is increasing with changing life styles of people. Traditional Bhutanese lifestyle is environmental friendly as it generates less amount of wastes. This is because people generally use natural and organic materials.

Waste produced may be solid, liquid or gas. The non-degradable wastes pollute our environment posing serious threat to human health and the environment. Understanding the types of waste and its management is important to protect the health of living beings and the environment.

A. Wastes

Globalisation and expanding markets provide us with huge choice of products, which contain both the degradable and the non-degradable materials. While the degradable wastes are easily decomposed and absorbed into the environment, non-degradable wastes pollute the air, land and water.



Figure 8.11 Wastes

The wastes produced from different sources are different in nature and composition. Waste is generally classified into categories on the basis of its physical nature, chemical composition, and biological properties.

i. Biodegradable and non-biodegradable waste

Wastes are classified as biodegradable and non-biodegradable wastes.

- a. Biodegradable wastes: All the wastes that break down safely and quickly by

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biological agents are known as biodegradable wastes. They are generally organic in nature. Some of the examples include saw dust, food wastes, paper and feces of animals.

- b. Non-biodegradable wastes: The wastes that do not decay or cannot be broken down by biological agents easily are known as non-biodegradable wastes. This type of waste is usually in the form of solid waste that accumulates in the environment.

ii. Hazardous waste and Non-hazardous

Wastes can be also classified as hazardous and non-hazardous wastes.

- a. Hazardous wastes: those wastes which are potentially dangerous and can cause diseases, fire, etc. They react explosively with air or water and corrode other materials. They are toxic or radioactive. The radioactive wastes are particularly dangerous as they cause lasting damage, such as change in the genetic structure of individuals (mutation). When released into the environment, these wastes pollute the environment and contribute to bioaccumulation. Acids, petrol, kerosene, paints, solvents, spirit, bases, mercury, ammonia, chlorine, bleach, industrial cleaning agents, pesticides are some of the hazardous liquid wastes. The other common hazardous solid wastes include lead, nickel, arsenic, cadmium, metallic dust, xylene, toluene, ethanol, etc.



Figure 8.12 (a) Hazardous waste



(b) Non-hazardous waste

- b. Non-Hazardous wastes: those wastes which have minimum or no threats to organisms or the environment. This type of waste includes organic and inorganic wastes that are non-flammable, non-reactive, non-corrosive or non-toxic in nature. Examples of such waste are paper, plastics, glass, wood, porcelain, tins, cardboards, clothes, leather, rubber, oil, coal, pulp, sewage sludge, dust and ashes, charcoal and other discarded materials that are non-toxic in nature.

iii. E-wastes

Electronics goods cannot be recycled unlike paper, plastic, and some metals. Discarded electronic equipment are considered e-wastes (electronic wastes). Examples of e-waste are the waste materials generated by the use, or discard of electronic devices and their accessories such as power plugs, batteries, television and computer monitors, refrigerators, air conditioners, washing machines, and microwave ovens, video cameras, DVDs, CDs, floppies, tapes, printing cartridges. Some parts of e-waste can be recycled but most of the components are non-recyclable.

B. Managing of wastes

Waste management is an organized strategy to control generation of wastes by minimizing their quantity and adverse impacts through administrative, financial, legal, planning and engineering functions of storage, collection, transfer and transportation, treatment and disposal. Waste management is usually based in the best principles of public health, economics, engineering, conservation, aesthetics and other environmental considerations.

Managing of wastes has always been a challenge. It is not a responsibility of a single organization, but a collective responsibility of individuals, households, and institutions, business community and policy makers. Good practices of waste management must begin with the individual or the family.

There is no single approach for waste management. Different waste problems require different approaches. Good waste management practices involve integrated approach. For instance, based on sustainability, the hierarchy waste management approach is the preferred approach.

The waste management hierarchy indicates an order of preference for action to reduce and manage waste. This hierarchy is widespread element of national and regional policy and is often considered the most fundamental basis of modern Municipal Solid Waste Management (MSWM) practice. The hierarchy ranks the waste management operations according to their environmental or energy benefits. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste. Proper application of the waste hierarchy can have several benefits such as prevention of emissions of Greenhouse Gases, reduction of pollutants, energy saving, conservation of resources, and stimulation of green technologies development. Virtually, in all countries, the hierarchy is similar to that shown in Figure 8.14.

a. Refuse

Refusing is the way to stop buying items that one may not actually need them, or one may already have. The best example is to refuse of buying a new or latest model mobile

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phones replacing old ones, which can significantly reduce e-waste. One can use the items until they become unusable. Refusing packages and containers like plastics bags and wrappers while shopping can avoid waste and pollution of our environment.

b. Reduce

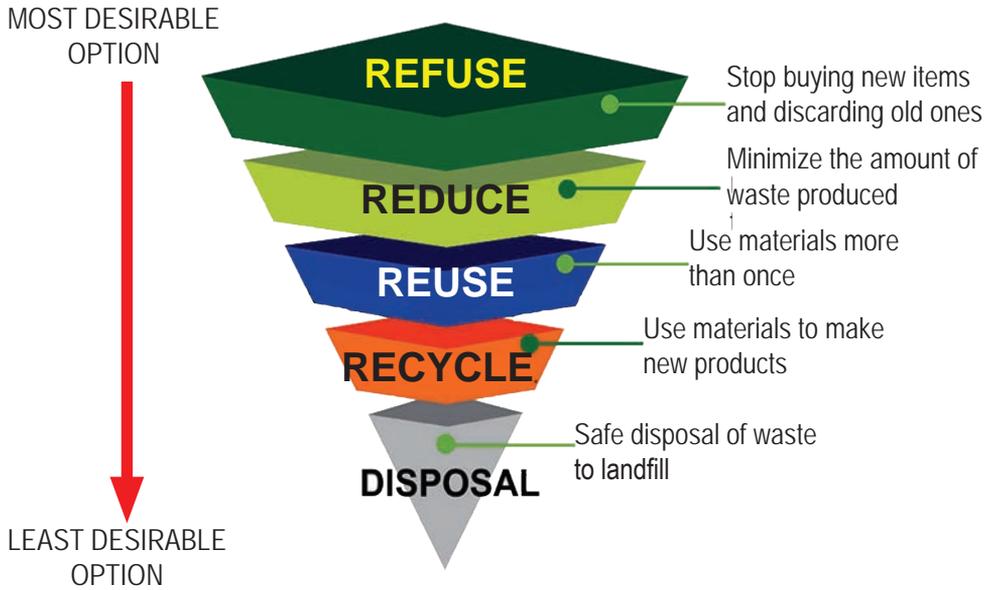


Figure 8.14 The waste management hierarchy

Reducing wastes is usually done at the source from where they are produced. Reducing is to cut the amount of waste before they are disposed off. The use-and-throw away items are generally made from non-recyclable materials like plastics, such as cups, plates, spoons, and also the non-degradable packaging used for food and other items. Reduction of such items reduces the generation of wastes.

Waste reduction also helps conserve resources for future generations and contributes to a cleaner environment. Some of the ways by which we can reduce waste are

- reducing the amount of paper used by double-sided photocopying, printing and using electronic communication.
- choosing products for which refills are available, and avoid using disposables.
- handling and store materials carefully to reduce breakages and spills.
- purchasing goods that use less packaging. Packaging materials make up more than 30 percent of all consumer waste. Buy bulk-packed materials to reduce packaging waste.
- buying only what you need, and buy products made from recycled materials.

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- opening the windows instead of using air fresheners.
- composting your food waste and yard waste.
- walking or riding a bike rather than driving, or taking public transportation rather than driving.

c. Reuse

Reuse is the use of a product for more than one occasion, either for the same purpose or for a different purpose, without the need for reprocessing. Many materials that we throw away, such as bottles, cans, tins, drums and cartons can be reused. Using construction and demolition waste as road aggregates, and using oil jerry cans and drums as buckets or flower pots are some of the ways to reuse discarded objects. The ways by which wastes can be reused are:

- providing separate bins for collecting used packaging, cord binding, envelopes and other materials that can be reused.
- using re-usable cutlery, dishes, cups and coffee filters (e.g. avoid using paper cups and plates).
- reusing packaging materials (e.g. boxes, plastic bags).
- donating old computers, electronic appliances, and furniture to charities.
- reusing equipment parts and fixtures and repair furniture to reduce waste.

d. Recycle and composting

Recycling is an excellent way to reduce the amount of trash going into a disposal site. It involves the treatment or reprocessing of discarded waste material suitable for subsequent re-use, either for its original form or for other purposes. Waste materials can be recycled for use in products similar to their original use, such as paper recycling, or wastes can also be recycled into a product which is different from the original use like the recycling plastic bottles into jackets or toys.

Recycling benefits the environment by reducing the use of resources for making new materials and conserving energy. For example, recycling materials require less energy in their production than the equivalent amount of product made from the raw materials. At a personal level,

- set up a recycling scheme in the office for scrap paper, toner cartridges, plastic bottles, aluminium cans, etc.
- separate scrap metal, wood and plastic from industrial waste for recycling.

Organic waste litters take up lots of space in disposal sites needed for other wastes. Incinerating moist organic waste is inefficient. Therefore, composting organic waste is an effective, and usually less expensive means of managing organic wastes. It enhances the soil fertility and can also be used as manure.

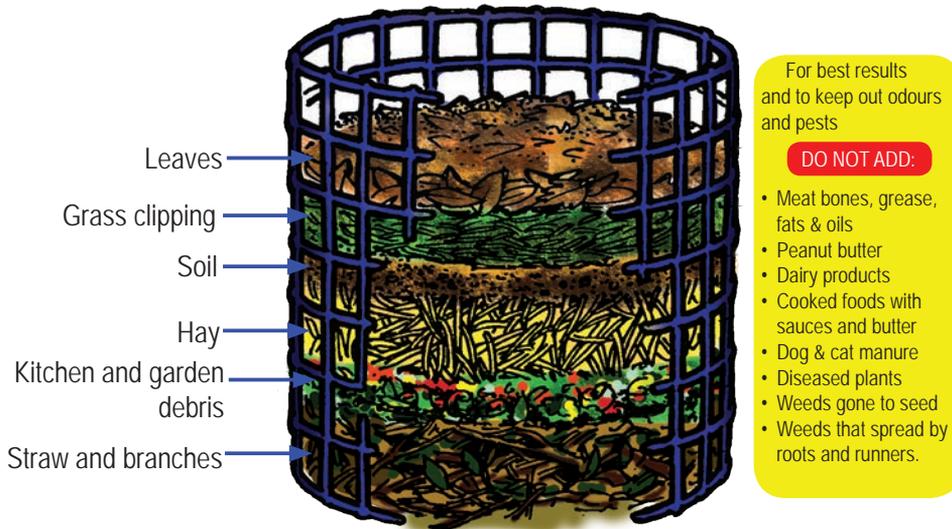


Figure 8.15 Compost pile

e. Disposal

It is important to dispose the wastes safely so that the environment is least affected. There are several ways to dispose the wastes generated.

i. Landfills

Land dumping is a common method of waste disposal. It involves the mass dumping of waste into a designated area, usually a hole or hill sides called landfills. The primary method of dumping is by digging a large hole in the ground in which the garbage is dumped and compressed by large machines. It is then sealed and covered in several feet of dirt, and another layer of waste is dumped and compressed under another layer of dirt. Large amounts of chemical agent to eliminate odour are also sprayed in the air surrounding landfills to dispel the unpleasant smell. This method is popular in Bhutan due to the low operational cost and abundance of unused land.

Many materials that end up as waste contain toxic substances. Over time, these toxins leach into our soil and groundwater, and become environmental hazards for years. Leachate is the liquid formed when waste breaks down in the landfill and water filters through that waste. This liquid is highly toxic and can pollute the land, ground water and water ways. Therefore, landfills cause pollution to the local environment by contaminating the groundwater and aquifers, contaminating the soil, and producing

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methane. Garbage buried in landfill breaks down at a very slow rate and remains a problem for future generations.



Figure 8.16 A typical landfill

ii. Incineration

Incineration or combustion is a type of disposal method in which solid wastes are burned at high temperatures so as to convert them into residue and gaseous products. The biggest advantage of this type of method is that it can reduce the volume of waste to 20 to 30 percent of the original volume, decreases the space they take up and reduces the stress on landfills. The energy produced by incineration are also used for various purposes. This process is also known as thermal treatment and is popular in countries like Japan, where space for landfill is not abundant.



Figure 8.17 Incineration of wastes

However, waste incineration systems produce a wide variety of pollutants, which are detrimental to human health and environment. Such systems are expensive and does not eliminate or adequately control the toxic emissions, such as toxic metals, dioxins, ashes and acid gases.

Activity 8.4: Auditing waste management

Instruction

1. Work in groups.
2. Visit about 5 households in your locality and fill up the questionnaire given in Table 8.1.
3. Analyse the data using appropriate tables and graphs in excel sheet.
4. Interpret the result from your analysis and write a report on your findings.
5. Prepare a waste management programme to be implemented in your locality.
6. Present your report and the plan for waste management programme in the class or community meetings.

Table 8.1

Name of the location:

Household no:

Types	Burn	Bury	Dump				Garbage pickup Trucks	Recycle	Reuse	Compost	Sell to scrap dealer	None	Other (Specify)
			River/Streams	In yard	By road side// Open space	Pit/Landfill							
Foods/ Vegetable Wastes													
Plastics/ PET bottles													
Papers													
Glasses													
Metals													
Rags/ Clothes/ Leather/ Rubber													
Auto parts/ Tyres													
Electric and electronics													
Others(Specify)													
Is garbage segregated for recycling? ____Yes ____No													

Questions

1. Categorise the wastes as hazardous and non-hazardous wastes.
2. What are the types of wastes generated more in the locality?
3. Describe how unmanaged wastes impact the environment of the locality?
4. What are the roles of local government/municipal (thromde) in waste management?

Questions

1. What are the common principles of classifying the wastes?
2. How are the wastes generated?
3. How does waste affect the health of people and the environment?
4. What are some of the simple waste management methods?

Summary

- Land use includes forest, agricultural land, horticulture land, pasture land, settlement and others.
- Forest is the most dominant form of land use in Bhutan.
- Kamzhing is the most dominant agricultural land use form.
- Pasture land includes alpine grasslands, forested lands and other areas where grasses are grown.
- Increasing population and economic advancement lead to expansion of agriculture and settlement.
- Different forms of land use have different impacts on the environment.
- Land use and land use change are dynamic. Land use changes from one form to another as per the requirement of people and climatic conditions.
- Land use change has either positive or negative impacts on the environment.
- Modern farming and traditional farming methods have advantages, but also have negative effects on the environment.
- All the wastes that break down safely and quickly by biological agents are known as biodegradable waste. They are generally organic in nature.
- Wastes which can be reprocessed into new and useful products are known as recyclable wastes.
- Hazardous wastes are those that catch fire easily, react explosively with air or water, corrode other materials.
- Waste is generally classified into categories on the basis of its physical nature, chemical composition, and biological properties.
- The waste management hierarchy indicates an order of preference for action to reduce and manage waste.

Exercise

1. Fill in the blanks with the correct form of word(s).

- a. Food wastes break down within a few days by bacteria and fungus. Food wastes are categorised as
- b. In modern farming, emphasis is solely on
- c. The waste management indicates an order of preference of waste management.
- d. The change in land use is generally brought about by changing lifestyles of the people and population growth, and the change in the conditions.
- e. Preservation of hornbill in Figure 8.19 is supported by the form of land use called



Figure 8.18

2. Each question in this part is followed by four possible choices of answers. Choose the correct answer.

- a. Which one of the following land uses comparatively has more adverse impact on the environment in Bhutan?
 - A. Forest.
 - B. Agriculture.
 - C. Settlement.
 - D. Pasture.
- b. The expansion of arable land is a challenge in Bhutan because
 - A. of unfavourable terrain.
 - B. of county's policy which does not allow conversion of pasture into arable.
 - C. all the land is covered by settlements.

- D. land is covered with forest.
- c. Which is the best farming practice?
 - A. Use of traditional tools, chemical fertiliser, and hybrid seeds.
 - B. Use of machines, manure, and hybrid seeds.
 - C. Use of manure, chemical fertiliser and animal draught.
 - D. Use of machines, chemical fertiliser and same seed.
- d. Forest is the preferred land use form because it
 - A. provides fuel wood.
 - B. provides timber for construction.
 - C. helps to preserve endangered species and biodiversity.
 - D. promotes ecotourism.
- e. Figure 8.20 depicts



Figure 8.19

- A. collection of waste.
 - B. waste management.
 - C. burning all the wastes.
 - D. biodegradable waste.
3. Write **TRUE** or **FALSE** for the following statements. Correct the false statements and write them down.
- a. Land forms the lithosphere of the Earth.
 - b. Vegetable wastes or domestic waste is non-biodegradable waste.
 - c. Dioxin is a hazardous gaseous waste.
 - d. Modern farming in Bhutan, wherein, fertilisers and pesticides are used for higher yield is green farming.
 - e. Leaching of chemical into the water prevents soil pollution.

4. Match the content of column A with the suitable content of column B.

Column A	Column B
A. Bioaccumulation	i. Biodegradable waste
B. Anthropogenic cause	ii. Non biodegradable waste
C. Composting of organic matter	iii. Farming, pasture land, etc
D. Incinerator	iv. Land degradation
E. Land use forms	v. Toxic waste in food chains
	vi. Waste hierarchy

5. Answer the following questions.

- Explain the impact of agriculture on environment.
- What brings about changes in land use?
- How does the change in the land use form affect the ecosystem?
- Why is non-biodegradable waste a concern? Explain with examples.
- Compare the traditional and modern farming considering the features given in the first column.

Features	Traditional farming	Modern farming
Tools/ equipment		
Labour		
Fertilisers		
Pest control		
Use of seed		
Yield		

- What are the ways to reduce waste?
- Read the article provided and answer the following questions.

“A landowner without a house and having only inherited ‘chuzhing’ in his Thram may apply for one plot of 50 decimals in rural area for residential land from such ‘chuzhing’ (The Land Act of Bhutan 2007)

 - Interpret this statement of the Land Act of Bhutan.
 - How does this Act help a farmer?
 - What would happen if the Land Act of Bhutan 2007 did not have restriction on ‘chuzhing’ conversion?

h. Categorise the following objects into hazardous or non-hazardous wastes:

rubber, glues, paint, pesticides, batteries, books, slipper, vegetable, glass, plastic, pet bottles, disinfectants, glass, shirt, steel cans, broken wooden desk, acids, electronic gadgets.	
Hazardous	Non-hazardous



Energy Resources

Energy is one of the most fundamental components, which is responsible for the functioning of the universe. There are many sources of energy which are classified as renewable and non-renewable. The use of some energy resources pollute the environment, while others do not. The energy derived from the later is considered 'green' or 'clean'. Green energy sources are considered clean since the use of such energy resources does not emit pollutants, or produce any kind of hazardous wastes. These energy sources are readily accessible all over the world.

Green energy is harnessed from renewable resources such as sunlight, wind, river water, ocean tides, plants, algae and hotspots. On the other hand, fossil fuels are non-renewable because it takes millions of years to replenish.

1. Hydro-energy in Bhutan

Learning Objectives

On completion of this topic, you should be able to:

- *explain the advantages of hydropower development in Bhutan.*
- *explain the generation of electricity from a hydropower plant.*
- *investigate the impacts of hydropower on the environment.*

A. Hydro-energy

Hydro-energy is one of the oldest sources of energy in the world. More than 2000 years ago, it was first used by Greeks to turn water wheels for grinding wheat into flour. Today, hydropower is the main source of electricity and the national revenue source in Bhutan. The first hydropower plant was built in 1967 at Samteling, Thimphu. It is the 360 kW capacity hydropower plant that generates power even today.

The hydropower plants generate electrical energy. Figure 9.1 illustrates generation of electricity by a hydropower plant.

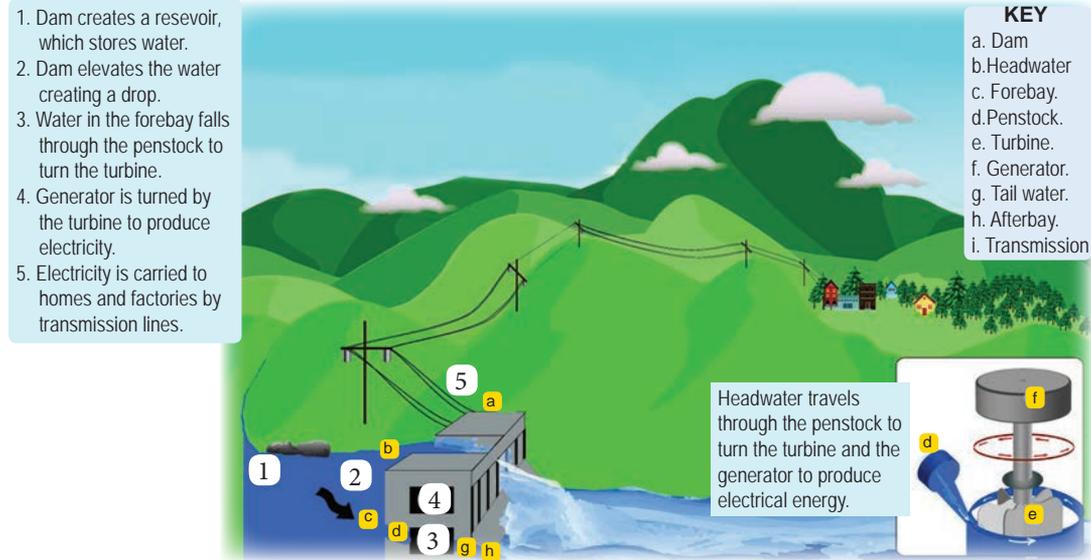


Figure 9.1: Generation of hydropower

Hydropower as a renewable resource has two important roles to play in the socio-economic development of Bhutan.

- i. to provide safe, reliable, sufficient and affordable electricity for domestic consumption and industrial use.
- ii. to generate revenue from export of hydroelectricity, thereby providing capital to finance social projects, and achieve economic self-reliance.

Today, the Royal Government has prioritized electricity network expansion in the country. Eventually, electricity is to be made accessible to the entire country.

i. Hydropower and its impact on the environment

Although the hydropower is one of the cleanest sources of energy, harvesting hydropower has impacts on the river system and the human settlement. While large-scale hydropower can provide large quantity of reliable, relatively inexpensive electricity, there are significant environmental and social consequences, namely:

a. Ecosystem damage and loss of land

The damming of rivers and creation of reservoirs disturbs large areas of vegetation and soil. This disrupts stream ecosystem habitats and breeding cycles of fish species. Migratory patterns of aquatic animals are also affected. It can affect drinking water supplies. New access roads to hydroelectric dams can induce major land use changes, particularly deforestation resulting in loss of biodiversity and accelerated soil erosion.

b. Siltation and flow shortage

In nature, as the river flows, it carries silt which is transported downstream and deposited once the river slows. However, when rivers are dammed, this process is disrupted and silt is deposited in the reservoir instead of downstream. The erratic control of water in the dam also hampers the flow of river, causing disturbances to the biodiversity downstream.

c. Involuntary displacement of people

Involuntary displacement of any people who work or live near the site of hydropower projects is a common adverse social impact. It may also result in other environmental implications, such as the conversion of natural habitats to settlements, thus, bringing change in life styles and customs of the people. Sometimes, it may also cause emotional scarring.

d. Loss of cultural properties

Cultural values and properties, including archaeological, historical, paleontological, and religious sites and objects, can be inundated by reservoirs, or destroyed by associated quarries, borrow pits, roads, or other works.

e. Greenhouse gases

Greenhouse gases like carbon dioxide and methane are released into the atmosphere from reservoirs that inundate forests and other biomass. The submerged forest and other biomass decompose releasing greenhouse gases.

All of the above concerns should be taken into consideration when designing and implementing new hydropower plants to minimize environmental damages and impact.

Activity 9.1: A case study

Instruction

Read the case study about the Three Gorges Dam Project and answer the questions that follow.

The Three Gorges Dam Project

The world's largest hydropower plant is the Three Gorges Dam in China with a generation capacity of 22,500 MW. The Yangtse River has been dammed up with a 2.3 km long and 181 m high dam with a back flow of 600 km inundating an area of 632 sq.km. This is the world's largest inundated area by a single project in the history of hydropower projects. The construction of the dam forced

the relocation of 1.4 million people in 100 towns and settlements with over 1000 archaeological and historical sites damaged. The dam is expected to provide about 15% of hydropower electricity in China, help in flood control, maintain the scenic beauty of the place and pay back the investment of about \$26 billion in 10 years.

Questions

1. What are the purposes of building the Three Gorges Dam project?
2. List some of the environmental and social impacts of this project.
3. Look at Figure 9.2 of the construction site of Punatsangchhu hydropower project. List some of the environmental issues you observe from the picture.



Figure 9.2: Building a dam

4. Royal Government of Bhutan is targeting to construct numerous power stations around the country. Will you support the government? Why?

Questions

1. Why is hydropower development suitable for Bhutan?
2. Dam constructions involve a lot of concrete and steel work. What will be some of the environmental impacts due to dam constructions?
3. Reservoirs inundate areas with vegetation emitting methane gas when they rot. Why is emission of methane gas not good for the environment?
4. What are the ways to avoid or minimize environmental impacts of hydropower development?

2. Wind Energy in Bhutan

Learning Objectives

On completion of this topic, you should be able to:

- *explain wind energy as a source of green energy.*
- *evaluate the wind potential of Bhutan.*

Wind is the movement of air caused due to difference in atmospheric pressure. Ancient people used sails to capture the wind and explore the world. Some farmers in other countries use windmills to grind grains and pump water. Today, people use wind energy to generate electricity.

Unlike fossil fuels, wind is a clean source of renewable energy. Since the wind is free, the cost of operation is minimal once a wind turbine is installed. However, wind turbines produce a lot of noise disturbing people living around. The rotating blades can also kill migratory birds and affect aerial life.

A. Wind energy potential in Bhutan

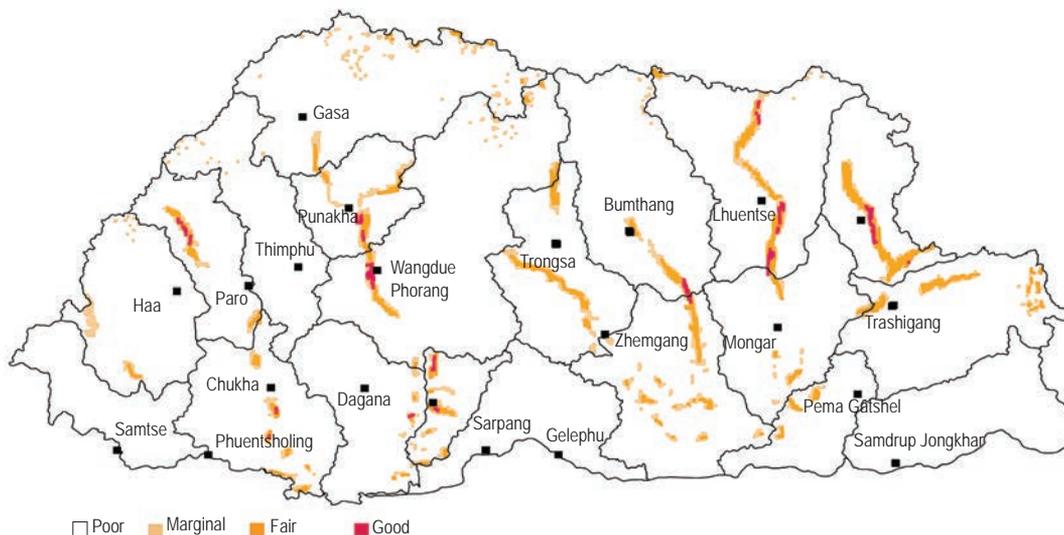


Figure 9.3: Wind resource map of Bhutan

Wind has potential to turn the blades of a wind turbine to generate energy. The amount of electrical energy generated by a wind energy system depends on the velocity of wind, which in turn is dependent on the topographical features, vegetation and infrastructures in and around the wind power plants.

The need to assess wind resource is important before the establishment of wind energy system. Wind resource maps are used for initial site screening and to estimate the regional wind potential. Wind energy project feasibility studies carried out show that the places with the best wind potential in Bhutan are the valleys of Punakha, Wangdue Phodrang, Trongsa, Bumthang, Lhuntse, and Trashiyangtse.

Figure 9.4 illustrates how the wind power is harvested to generate electricity.

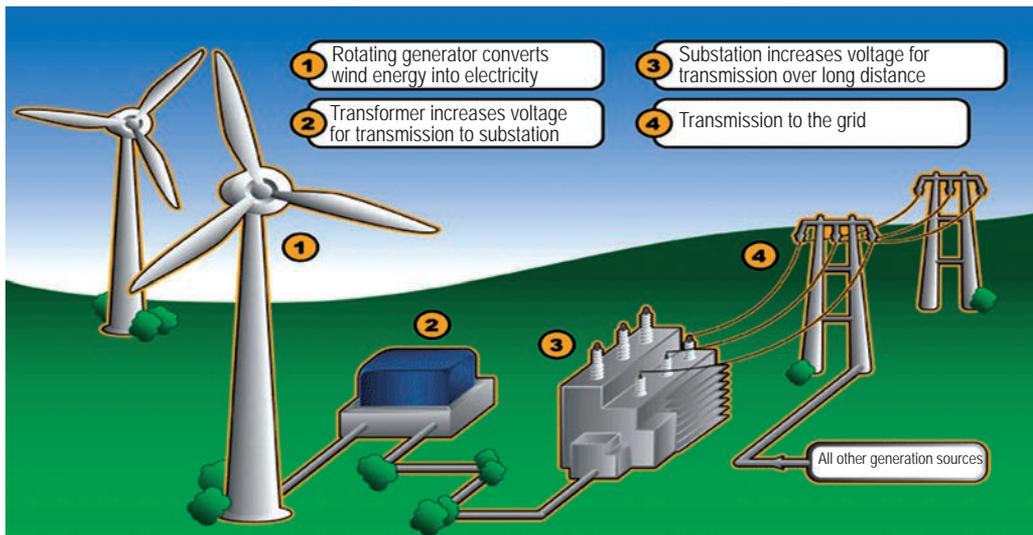


Figure 9.4: Wind energy harvest

Questions

1. Give two examples of how people use wind energy.
2. What are the advantages and disadvantages of harnessing the wind energy?
3. If you were to establish a turbine to capture the wind energy, what are the considerations that you need to make?
4. Refer the map in Figure 9.3 and evaluate the feasibility of establishment of wind energy power station in Bhutan.

3. Solar Energy in Bhutan

Learning Objectives

On completion of this topic, you should be able to:

- state applications of solar energy.
- evaluate the solar energy resource potential of Bhutan.

The Sun emits massive amount of energy in the form of heat and light. The total solar radiation that reaches the Earth's surface every year is more than 10,000 times the world's energy demand, and many times more than other sources of energy. Solar energy is another renewable, non-polluting source of energy. It can be used in remote areas where it is too expensive to extend the electricity power grid.

Solar energy is harnessed during sunny days by using solar panels, as shown in Figure 9.5. The harnessed energy is used to charge batteries. These charged batteries are used to power electrical devices. However, due to the huge size and weight of these batteries, storage and transportation are some of the challenges. They also need timely replacement.

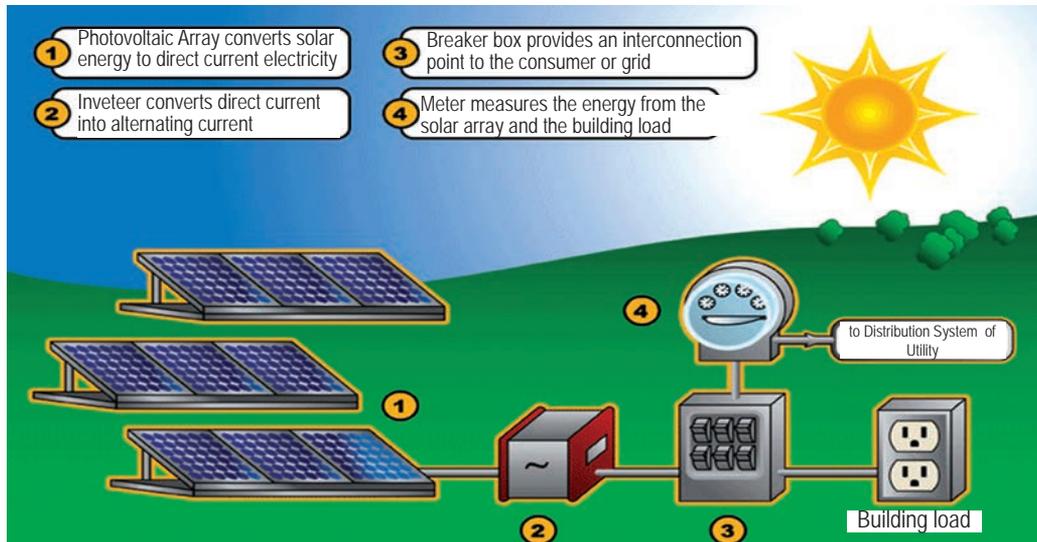


Figure 9.5: Solar energy harvest

A. Applications of solar energy

There are numerous solar energy technologies used these days. Some of them are shown in Figure 9.6.



Figure 9.6 Solar energy applications

i. Solar photovoltaic system

A photovoltaic (PV) module is an interconnected assembly of photovoltaic cells that converts sunlight directly into electricity. In Bhutan, solar PVs have been installed mostly in rural areas for electrification of individual homes. In other countries, PVs are also installed by houses in urban areas and at solar farms to generate electricity.

ii. Solar thermal

Solar thermal system collects and converts solar radiation into usable thermal energy or electricity. In Bhutan, solar water heating systems are installed in few schools, monasteries, hotels, institutes and hospitals.

iii. Solar cookers

Solar cooker collects and converts sunlight into heat energy, which is used for cooking. It is economical and environment friendly.

iv. Solar driers

Bhutanese families use the sunlight to dry everything from vegetables, crops, clothes to meat. Traditionally, goods are left out in the field, rooftop, or on lines which are not very effective and hygienic. Many communities around the world have started using solar driers, as they are quicker and cleaner. Solar driers are devices that use solar energy to dry substances, especially food.

B. Solar energy potential in Bhutan

Solar energy resource is one of the alternative energy sources in Bhutan. The amount of solar energy harnessed depends on the intensity and duration of solar radiation.

The solar energy at a place is stated in kilowatt-hours per square meter per day (kWh/m²-day). This is the quantity of solar energy that strikes the surface of the collector in a day.

The National Renewable Energy Laboratory (NREL), USA has done a solar and wind resource assessment for Bhutan using satellite data. According to the NREL report, it was found that Bhutan has high solar energy potential, as shown in Figure 9.7.

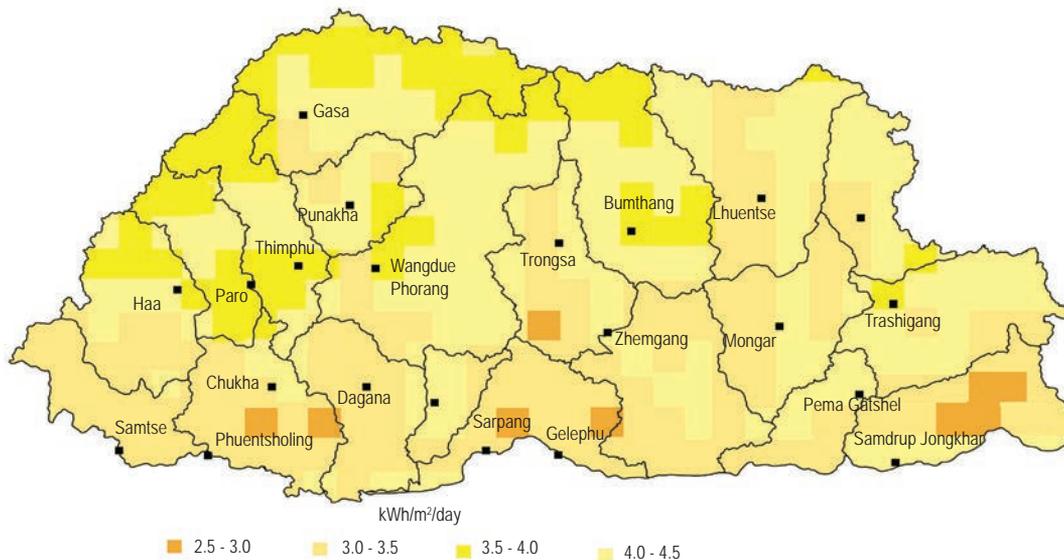


Figure 9.7: Solar resource map of Bhutan

Questions

1. What are some of the solar energy applications?
2. Explain some of the challenges of using solar energy.
3. Mention some benefits of using solar energy.
4. Why should Bhutan promote the use of solar energy?

4. Conservation of Energy

Learning Objectives



On completion of this topic, you should be able to:

- *explain the concept of conservation of energy - describe the purposes of energy conservation.*
- *examine various methods of conserving energy.*

Energy is important for the functioning of all the living organisms and the environment around us. Energy is an indispensable component of industrial product, employment, economic growth, people's lifestyle, and the environment. In the past, the demand for the energy resources was less. However, with the increase in population and rapid economic development, demand for energy increased in every sector, domestic, commercial, industrial, etc.

In Bhutan, owing to its small population and less industrial activities, energy consumption is very low compared to other developed countries. The major sources of energy for Bhutan are hydropower and fuel wood. These sources depend on various factors, such as biomass, climate change, geographical features, and demography. For instance, the changing climate affects the water flow into hydropower stations. Similarly, the biomass, which is the source of fuel wood, is affected by the availability of water and climatic conditions. Thus, with the changing climatic conditions and decreasing biomass, the energy sources are getting depleted.

A. What is energy conservation?

Energy conservation is the efficient use of energy, by reducing energy consumption and wastage.

i. Purposes of energy conservation

The purposes of energy conservation are:

a. Energy security

The International Energy Authority (IEA) defines energy security as “the uninterrupted availability of energy sources at an affordable price”.

Energy security ensures stable supply of energy for economic growth and social benefits.

Lack of energy security is linked to the negative economic and social impacts of energy either being unavailable, or prices that are not competitive or are volatile. In order to maintain the supply, it is necessary for countries to increase the domestic energy self-sufficiency ratio. The energy self-sufficiency rate is the ratio between national primary energy output (coal, oil, natural gas, nuclear, hydraulic and renewable energies) and consumption of primary energy in a given year. The energy self-sufficiency ratio is maintained by developing and promoting the use of untapped domestic energy, such as wind and solar energy, and to enhance effective utilization of the existing energies.

b. Measures of the Global Environment

The increasing global demand for energy have brought large scale environmental hazards, such as change in hydrological systems, change in vegetation, climate change, loss of biodiversity and, land degradation.

Global warming is one of the major factors that has great influence on the health of the global environment. Concrete measures are required to regulate the Greenhouse Gas emissions. The energy conservation as one of the measures, limits greenhouse gas emissions, carbon dioxide in particular, by using efficient and sustainable sources of energy. For example, minimizing the use of fossil fuels and natural gas, and using energy saving devices.

c. Income increase or Economic benefits

Improving energy efficiency significantly costs less than investing in new generation and transmission. Energy efficiency can also boost the local economy and create downward pressure on natural gas prices and volatility. Through the implementation of energy conservation, wasteful energy consumption is reduced, and hence income of a household increases equivalent to the amount of the energy consumption reduction. The payments for the utility of electricity and gas decrease and the savings can be utilized to meet the domestic expenditures.

At the business and factory levels, the decrease in energy consumption per unit of production (cost reduction of production) enhances production of goods and stimulates competitiveness in business, while higher income contributes to national economic growth.

The emission trading scheme, a market-based approach to control pollution by providing economic incentives for achieving reductions in the emissions of pollutants based on the Kyoto Protocol Mechanism can contribute to the national economy. For example, Bhutan being “Carbon negative” receives global endowment funds for its environmental friendly developmental activities.

B. Methods to conserve energy

Conserving energy is an important way to reduce strain on the environment. Energy needs to be conserved not only to cut energy costs but also to preserve the resources for longer use. Production and consumption of almost any type of energy have environmental impacts. In rural areas, particularly in developing countries, the use of traditional fuels, such as fuel wood, charcoal and agricultural wastes constitute a major portion of total household energy consumption.

Energy conservation is not about making limited resources last as long as they can, but using technologies that reduce energy demand, protecting and replenishing supplies, developing and using alternative energy sources, and cleaning up the damage from the prior energy processes. Some of the strategies of energy conservations implemented across the world include the following.

i. Institutional initiatives

Some governments and NGOs encourage use of devices with eco-labels that are eco-friendly and energy saving. Energy efficient appliances with Energy Star rating consume less energy and save money.

The enactment and enforcement of energy related policies and regulations at the national levels contribute to judicious and equitable use of energy and conserve energy .

Activity 9.2: Understanding Renewable Energy Policy of Bhutan

Instruction: Read the case study and answer the questions that follow.

The Sustainable Hydro Power Development Policy (2008) and the Economic Development Policy (2010) recognize the need to have Renewable Energy (RE) Policy for promotion of RE sources in order to ensure national energy security. Promotion of RE in Bhutan presents a unique challenge as Bhutan enjoys availability of adequate low cost hydropower resource that is green and clean. RE generation cost is extremely high and would not be competitive with hydropower generation costs.

In view of the rising demand and increasing reliance on a particular energy source, it is critical to broaden the energy mix by means of harnessing other forms of clean renewable energy sources. Further, there is a significant need to supplement the electricity generation in the low river inflow months by other forms of renewable energy sources.

Considering the import levels of the fossil fuels, there is a crucial need to minimize the use of fossil fuels by providing alternatives indigenously. Recognizing the above premise, the long-term and short-term objectives of the Policy have been stipulated as follows:

- a. Long-term objectives:
 - i. enhance energy security and broaden the energy portfolio;
 - ii. conserve the environment and reduce GHG emissions; and
 - iii. enhance socio-economic development.
- b. Short-term objectives:
 - i. support and promote R&D in RE technologies with long term objective of a viable energy resource;
 - ii. harness the potential of RE resources and adoption of RE technologies in the country;
 - iii. design appropriate tariff for various RE technologies to offer secure and stable market to investors and project developers with guaranteed incentives provided by the Government;
 - iv. enable, encourage and facilitate both public and private sector participation for the development RE;
 - v. enable to set realistic target for RE for the energy-mix in line with the principles of GNH; and
 - vi. promote efficient and cost-effective RE systems by providing time-bound incentives.

(Adapted from: <http://www.gnhc.gov.bt/wp-content/uploads/2011/05/RE-Policy-65.pdf>)

Questions:

1. What is the overarching reason for enacting the policy on RE?
2. How does this policy contribute to energy security?
3. How does this RE policy affect the society?

ii. Energy taxes

Some countries levy taxes on energy or carbon emission to discourage the users from increased energy consumption. Taxes on all energy consumption is to reduce energy use, while reducing a broader array of environmental consequences arising from energy production. The energy taxes aim to protect poorer households, while creating a larger tax burden for high energy consumers. This is known as “cap and trade” and it is used as part of the process of regulating and conserving energy consumption and pollution by manufacturing industries.

iii. Building design

The energy conservation in buildings can be improved through an energy audit, an inspection and analysis of energy use and flows for energy conservation in a building, which is a process or system to reduce the amount of energy input into the system without negatively affecting the output. The use of passive solar building design, in which the windows, walls, and floors are made to collect, store, and distribute solar energy in the form of heat in the winter, and reject solar heat in the summer. It is called passive solar design or climatic design because, unlike active solar heating systems, this doesn't involve the use of mechanical and electrical devices.

iv. Consumer products

Consumers are often poorly informed of the savings of energy efficient appliances. A good example of this is the replacement of incandescent light bulbs with more modern alternatives. Many consumers opt for cheap incandescent bulbs, failing to take into account their higher energy costs and lower life spans compared to modern compact fluorescent and LED bulbs.

Questions

1. Explain the term “Energy conservation”.
2. Why should Bhutan conserve energy?
3. What are the components of energy security?
4. How would you contribute in the conservation of energy?
5. Discuss any two strategies for conserving energy.

Summary

- Hydropower is considered a clean source of energy, renewable and having minimum impacts on the environment during its lifetime.
- Hydropower plants in Bhutan are mostly in deep narrow valleys, which help in flood control and motivation for watershed protection.
- There are some negative environmental impacts due to hydropower projects such as fish migration, settlement displacement, inundation, and waste and emission during construction.
- The turning of the turbine blades by the wind generate electricity.
- The best wind potential regions in Bhutan are in the Punakha, Wangdue Phodrang, Trashiyangtse, Chamkhar and Lhuntse valleys.
- The sun is the primary source of all energy and the potential of harvesting solar power globally is more than any other resources.
- Common solar energy systems are solar PV, solar thermal, solar cookers and solar driers.
- Bhutan has a high potential for solar energy that will easily fulfill the country's energy requirement.
- Some governments and NGOs encourage the use of devices with eco-labels that are eco-friendly and energy saving. Energy efficient appliances with Energy Star rating consume less energy and save money.
- The energy taxes aim to protect poorer households, while creating a larger tax burden for high energy consumers.
- The use of passive solar building design, in which the windows, walls, and floors are made to collect, store, and distribute solar energy in the form of heat in winter, and reject solar heat in summer conserving energy.

Exercise

1. **Write TRUE or FALSE for the following statements. Correct the false statements and write them down.**
 - a. Hydropower energy generation depends on the size of the river.
 - b. Wind energy and solar energy are alternative energy sources in the world.

- c. Wind turbines create noise pollution and kill birds.
- d. PV systems are only usable in rural homes.
- e. Green energy is harvested from non-renewable resources..

2. Fill in the blanks with the correct word(s).

- a. The part of solar panel system that converts solar energy into electrical energy is.....
- b. is the structure that stops or diverts the river from its course.
- c. In wind systems, the energy of wind is utilized.
- d. Solar energy systems convert part of the radiation that reaches Earth into usable energy.
- e. The building in which the windows, walls, and floors are made to collect, store, and distribute solar energy in the form of heat in the winter is called design.

3. Match the word or phrase numbered (a) to (e) in Column A with the appropriate word or phrase numbered (i) to (v) in Column B.

Part/component	Characteristics
a. Hydropower reservoirs	i. Does not work if wind speed is too less or too much
b. Penstock	ii. Water heating system
c. Solar PV	iii. GHG Emissions due to submergence of vegetation
d. Solar Thermal Energy	iv. Converts solar energy directly to electricity
e. Wind turbines	v. Carries water to the turbine

4. Each question in this part is followed by four possible choices of answers. Choose the correct answer.

- a. Which of the following is true about hydropower energy?
 - A. no pollution during power generation.
 - B. protects river ecosystem.
 - C. helps in flood control by damming.
 - D. does not change landscape.
- b. Which of the following is not true about solar energy?
 - A. Its potential is more than 10,000 times of global energy demand.
 - B. It can be used for cooking without any emission.
 - C. It is not available everywhere on earth.
 - D. It is possible to set up large on-grid PV solar energy systems.
- c. Which of the is an example of solar energy technology?
 - A. Digital camera.
 - B. Submarines.
 - C. Smokeless stoves.
 - D. Photoelectric cells.
- d. Which of the statements is NOT true for the phenomenon shown in Figure 9.8?

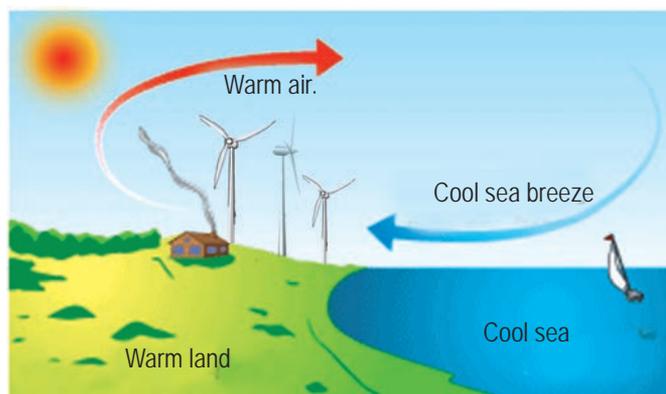


Figure 9.8

- A. The Sun heats land and water.
- B. The pressure difference causes wind.

- C. The Sun's heat facilitates precipitation.
- D. The wind provides mechanical energy
- e. Which one of the following statements characterises the wind energy generation.
 - A. Wind energy generation can be combined with other energy sources.
 - B. Wind energy generation depends on the height of the turbine blades.
 - C. Wind energy generation is possible in all regions of Bhutan.
 - D. Wind energy generation depends on the speed of the wind.

5. Answer the following questions.

- a. What are the ways to increase hydropower energy generation at a plant?
- b. Why is hydropower development important for Bhutan?
- c. Explain the benefits of a solar PV over hydropower electricity?
- d. Why do you think the northern region of Bhutan has better solar potential than other regions?
- e. Study Figure 9.9 and answer the following questions.

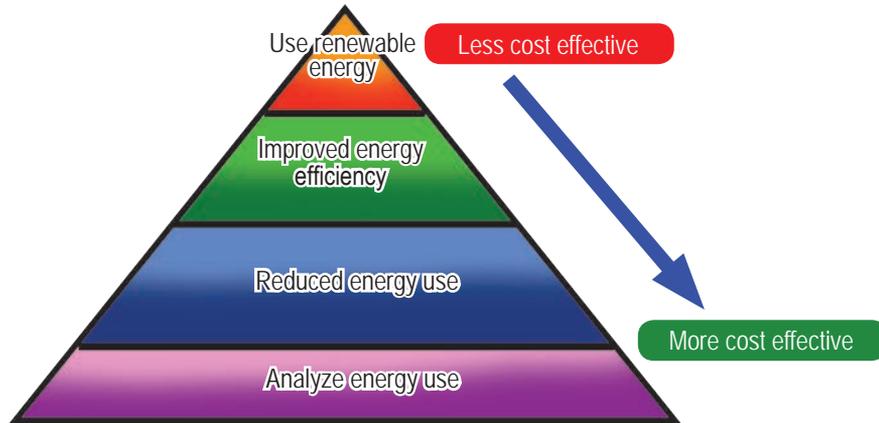


Figure 9.9

- i. What are the strategies for energy conservation in the energy priority pyramid?
- ii. How do these strategies save energy?
- iii. How does the change of energy source save energy?

- f. The National Environment Commission of Bhutan wants you to research and find the impacts of hydropower to the environment. Give seven critical impacts of hydropower on the environment.
- g. Explain with the help of diagram how wind energy is harnessed?
- h. What are some advantages of wind energy and solar energy systems over the hydropower energy?
- i. Your school wants to maximize the use of solar energy. What are the various ways you can use solar energy at your school?

Environment & Development



Chapter

We all depend on the natural environment for our health, wealth and happiness. The everyday decisions that we make about how to live, what to eat and drink, what to wear, how to travel to school and work have strong influences on the environment and the society. To reduce our ecological footprint and to share the Earth's resources more judiciously, individuals and societies need to make conscious lifestyle choices based on the sustainable development principles.

With the advent of modernization, we are faced with numerous challenges to sustain our environment and cultural integrity. Bhutan is a member of various multilateral environmental agreements to pursue sustainable development goals and objectives. The concept of Gross National Happiness enunciated from the throne envisions a way to address such challenges for a balance socio-economic development.

1. Sustainable Development

Learning objectives

On completion of this topic, you should be able to:

- *write the goals of sustainable development.*
- *explain sustainable consumption and production with examples.*
- *describe the developmental change from unsustainable to sustainable.*

We consume goods and avail services everyday to satisfy our needs and desires, but the rate at which we do has a direct impact on the environment and the society. Firstly, these goods and services require natural resources, and the rate at which we consume these materials and services increases with the increasing number of people. This has immense pressure on the Earth's natural resources. Secondly, large amount of waste is generated from the goods and services which pollute our environment. The essence of sustainable development is maintaining a stable relationship between human activities and the natural world. This implies that the economic growth does not deteriorate the

quality of environment and social life in the community. People concerned about sustainable development suggest that meeting the needs of the future depends on how well we balance social, economic, and environmental objectives or needs when making decisions today. Hence, the objective of the sustainable development is to ensure that the sustainable consumption and production are sustainable.

A. Goals of sustainable development

According to World Bank, sustainable development is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” The aim of sustainable development is to balance our economic, environmental and social needs without affecting the prosperity for present and the future generations. Today, sustainable development has become the cornerstone of development planning. It consists of a long-term, integrated approach to development to achieve a healthy community, which includes social progress and equality; environmental protection and conservation of natural resources; and vibrant and stable economic growth. This is in concurrence with ideals of Gross National Happiness in Bhutan. It is a strong element of socio-economic and political development that maintains harmony of society and economy with the environment.

Activity 10.1 Understanding the goals of sustainable development

Instruction: Work in groups.

1. In each group, discuss on one of the goals of sustainable development.

Some of the key goals of sustainable development are:

- i. Making cities and human settlements inclusive, safe, resilient and sustainable.
- ii. Ensuring healthy lives and promote well-being for all at all ages.
- iii. Ensuring availability and sustainable management of water and sanitation for all.
- iv. Ensuring sustainable consumption and production patterns.
- v. Protecting, restoring and promoting sustainable use of terrestrial ecosystems, sustainably manage forests, combating desertification, and halting and reversing land degradation and halting biodiversity loss.
- vi. Achieving gender equality and empowering all women and girls.
- vii. Ending hunger, achieving food security and improving nutrition and promoting sustainable agriculture.
- viii. Ensuring access to affordable, reliable, sustainable and modern energy for all.
- ix. Ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all.

2. Discuss:

- i. how can the goal of sustainable development be achieved?
- ii. how will it improve our socio-economy well-being?
- iii. how will it decrease the impact on the environment?

B. Sustainable consumption and production

Sustainable development is generally defined based on three areas namely:

- *Environmental sustainability* - without damage to natural resources and environment.
- *Economic sustainability* - stable with equitable sharing of resources.
- *Sociopolitical sustainability* - maintaining social harmony and political stability with consideration to environmental protection.

The developmental activity can be sustainable, provided it is dynamic and enables people to realize their potential, improves their quality of life, protects the natural resources and the environment, and enhances the Earth's life support systems. The sustainable consumption and production concept is about the use of services and related products, while minimizing the use of natural resources. Sustainable consumption patterns are practices of consumption that satisfies the basic needs without compromising the Earth's carrying capacity. In most industrialized countries, current consumption patterns are unsustainable as they require large quantity of resources, cause large emissions, and they affect the well-being and happiness of the society. The unsustainable consumption patterns are destroying the environment and depleting the stocks of natural resources.

Some examples of the initiatives taken by Bhutan to attain sustainable development include:

- a. Green Public Procurement (GPP) in Bhutan upscales environmentally and socially preferable goods and services, and infrastructure at affordable prices as sustainable consumption and production habits.
- b. The Environmental Assessment Act (EAA) establishes the procedures for assessment of potential effects of projects on the environment and for social life. Prior to the construction of the project, obtaining an official environmental clearance is mandatory.

Activity 10.2 Model for sustainable development

Instruction: Work in groups. One of the models of sustainable consumption and production is given in Figure 10.1. Study the model and answer the questions.

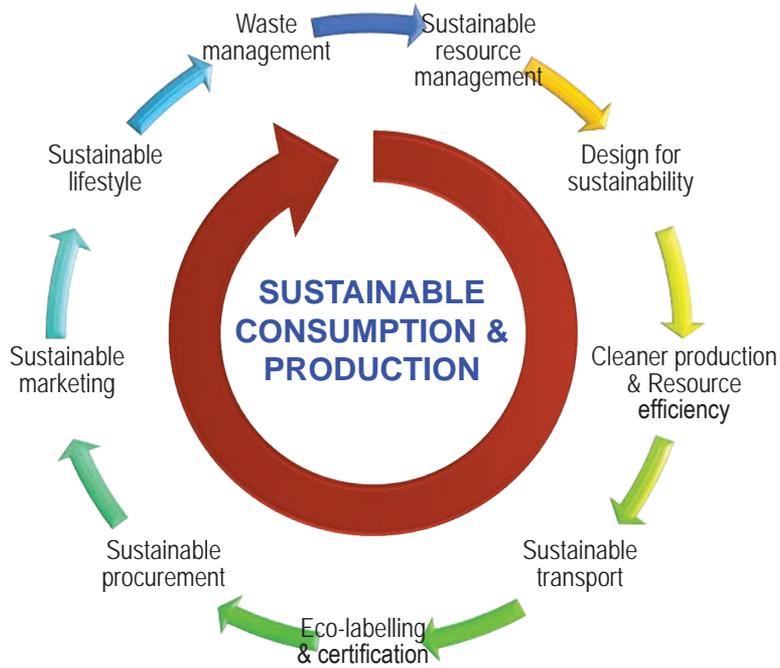


Figure 10.1: Model of sustainable consumption and production

Questions

1. What is sustainable resource management?
2. Why are sustainable lifestyles included in the cycle?
3. Why is eco-labelling and certification stage important in the production process?
4. Think of an item you possess, for example 'dhapa' or your shoes. Discuss in your group, how this particular product has gone through the cycle of this model.
5. Explain sustainable consumption and production in your own words.

C. Unsustainable to sustainable development

During the later half of the 20th century, rapid economic development for a better standard of living became responsible for the degradation of environment by consuming more resources and polluting the Earth with wastes. If the present generation keeps using resources without considering the needs of the future generations, then such practices are termed as unsustainable.

The Earth has everything for each generation, but it depends on its proper use. Everybody has the right to a healthy, clean and safe environment. In order to safeguard the existence of life and future of humanity, we have to change our approach from unsustainable to sustainable. For example, use of non-renewable resources, such as fossil fuels should be made efficient, and the development of alternative sources of energy should be encouraged and promoted. Many development projects, such as dams, mines, roads, industries and tourism have severe consequences on environment. Thus, before the start of any project, a scientific Environment Impact Assessment (EIA) should be carried out. The basic methods of EIA are described in the Activity 10.3.

Activity 10.3 Understanding Environmental Impact Assessment (EIA)

Instruction: Read the text on EIA and answer the questions.

ENVIRONMENTAL IMPACT ASSESSMENT

EIA of Bhutan: The Environmental Assessment Act (EAA) establishes the procedures for assessment of potential effects of projects on the environment and for the determination of measures to reduce adverse effects and to promote environmental benefits. The Act has also established National Environmental Commission (2006) to ensure that environmental concerns are fully taken into account when formulating, renewing and modifying and implementing the project. It has made Environmental Clearance (EC) legally mandatory for projects that may pose adverse impact on the environment.

EIA Methodology

Basic Approach: The basic approach of EIA study includes the study of present environmental scenario like geography, geology, seismology, soil, surface water, meteorology, air quality, ecology and socioeconomics.

Environmental Considerations: The environmental consideration step involves identification of key environmental issues, such as change in land use, impacts of project on the ecosystem, community facilities, etc.

Environmental Management Plan (EMP): After the identification of environmental impacts, the next step involves Environmental Management Plan (EMP), which includes mitigation and control systems in order to minimize the adverse impacts of the project implementation. The EMP also includes a post implementation monitoring activities, which would assist in monitoring the actual effect of commissioning the project.

Report: The report should be presented in accordance with the requirements of the Gross National Happiness Commission and National Environmental Commission.

Questions

1. What is the purpose of EIA?
2. What are the roles of NEC?
3. What are some of the environmental considerations for the issue of Environmental Clearance?
4. What do you understand by the term “Environmental Management Plan”?
5. An industrialist wishes to establish a Brick Factory. What requirements of EIA should he need to fulfill?

Questions

1. How do our lifestyle choices affect the earth globally? Justify.

- ▶ Most religions believe in preserving nature and giving back to the Earth what one has taken. The importance of protecting nature in all its manifestations has infused our consciousness and has become integral to our way of life.
- ▶ Concern about future generations has become a one-sided game that focuses only on harms. In reality, extracting resources also produces huge benefits, such as new ideas and investment in infrastructure that also pass to future generations.
- ▶ Sustainable development is required as it is based on improving the quality of life for all within the carrying capacity of the supporting ecosystems.
- ▶ Sustainable Development is not a major concern for Bhutan as our environment is very healthy and intact.

2. What are the benefits and limitations of sustainable development for farmers?

2. Sustainable Development Initiatives in Bhutan

Learning objectives

On completion of this topic, you should be able to:

- *list the international treaties and conventions on development related to Bhutan.*
- *identify sustainable development initiatives in Bhutan.*
- *describe challenges of sustainable development efforts of Bhutan.*

Sustainable development is fundamental to the global developmental process towards promoting equitable, social and economic well-being of people. Bhutan upholds its commitment to the future generations through the alignment of national developmental priorities with the global sustainable development goals. At the global level, Bhutan is signatory to various international treaties and conventions.

A. Global efforts of sustainable development

International cooperation has provided Bhutan with opportunities and exposure for sustainable development in a wide range of fields, such as access to knowledge, best practices and tools for effective development management. Therefore, Bhutan became member of the following United Nation (UN) environmental conventions over the past years as shown in the flow chart in Figure 10.2.

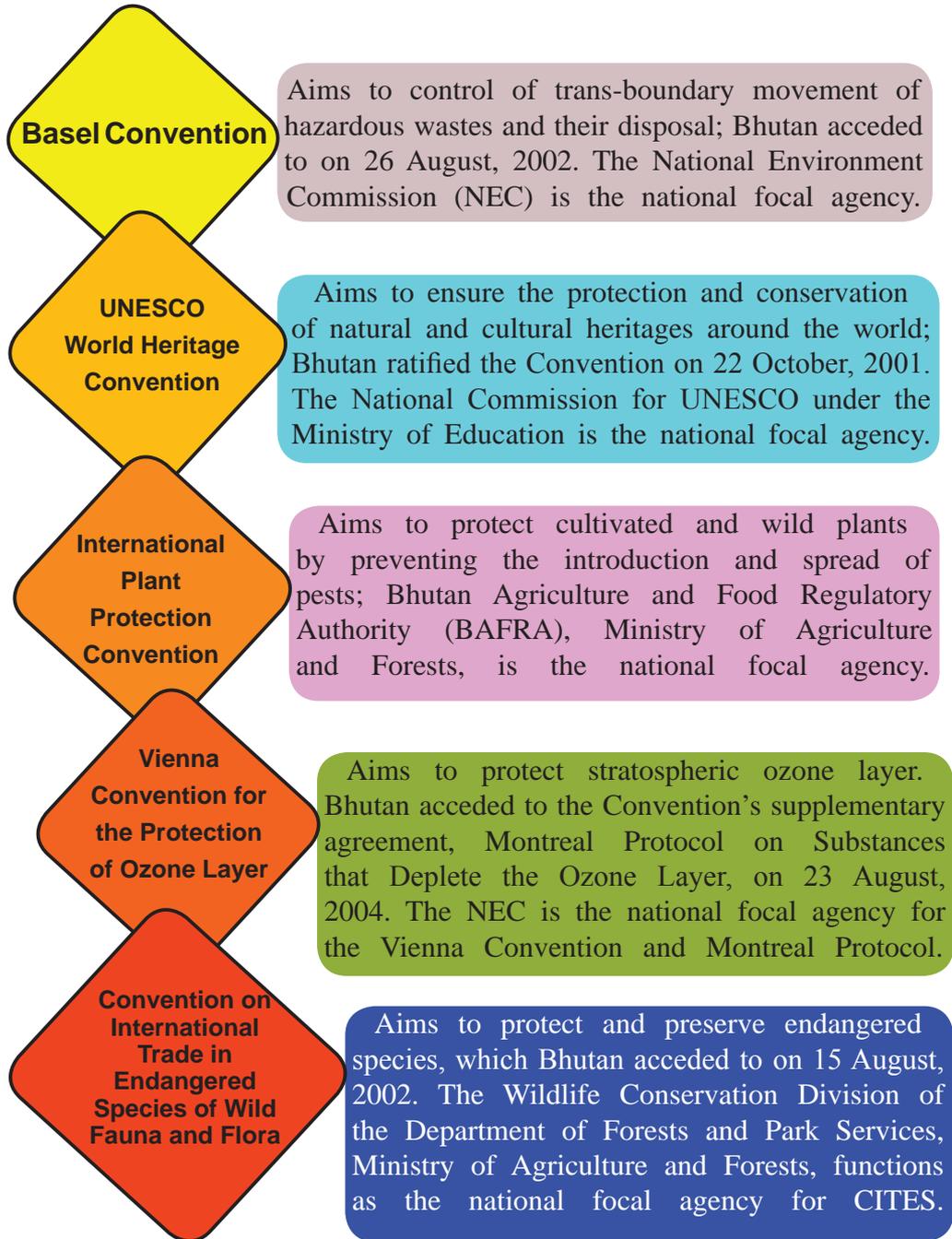


Figure 10.2: United National (UN) environmental conventions

Beside these, Bhutan is also member to three Rio Conventions, such as Convention on Biological Diversity (CBD), United Nations Framework Convention on Climate Change (UNFCCC) and United Nations Convention to Combat Desertification

(UNCCD). As a member to these various multilateral environmental agreements, Bhutan has formulated policies and framework to pursue sustainable development goals and objectives. These includes Biodiversity Action Plans, National Biosafety Framework, National Adaptation Programmes of Action for Climate Change, National Communications to UNFCCC, and National Action Programme to Combat Land Degradation.

Activity 10.4 Understanding treaties and conventions

Instruction: Read the following article and answer the following questions:

Bhutan a Party to Multilateral Environmental Agreements

Bhutan signed the Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC) on 11th June, 1992, at the Rio Summit 1992. Subsequently, Bhutan ratified both these Conventions on 25th August, 1995. The National Environment Conservation serves as the national focal agency for the two Conventions. The third of the Rio Conventions – the United Nations Convention to Combat Desertification (UNCCD) – was acceded to on 20th August, 2003. The Department of Agriculture, Ministry of Agriculture and Forests, is the national focal agency.



As a Party to the CBD, Bhutan has produced three Biodiversity Action Plans – the first in 1998, followed by a second in 2002, and a third in 2009 – progressively reviewing and updating them as living policy documents to address evolving biodiversity conservation circumstances and needs. A key result of the first as an implementing agency of the CBD and for coordinating programmes and projects for the conservation and sustainable use of biological resources.

Bhutan also acceded to the Cartagena Protocol on Biosafety, which is a supplementary agreement of the CBD, on 26 August, 2002. A National Biosafety Framework has been developed in accordance with Cartagena Protocol. In addition, Bhutan signed the recently-formulated Nagoya Protocol on Access and Benefit-sharing on 20th September, 2011.

As a Party to the UNFCCC, Bhutan submitted its Initial National Communication in 2000. The Initial National Communication enabled the country for the very first time to establish an inventory of Green House Gas (GHG) emissions by sources and sequestration by sinks, and identify climate change vulnerabilities and adaptation measures. The Second National Communication, submitted in 2011, presents an updated GHG inventory, and describes mitigation measures, climate change vulnerabilities and a wide range of adaptation options across the various development sectors. A National Adaptation Programme of Action for Climate Change (NAPA) was produced in 2006, outlining among other things priority projects for adaptation to climate change. Based on NAPA, the Royal Government formulated and implemented a number of key climate change adaptation projects including a massive and arduous project on the reduction of climate change-induced risks and vulnerabilities from glacial lake

outburst floods in Punakha-Wangdi and Chamkhar valleys.

Bhutan has also acceded to Kyoto Protocol on 26 August, 2002, which sets binding targets for industrialized countries and the European community for reducing GHG emissions.

Bhutan became a member of the International Union for Conservation of Nature (IUCN), the world's first and largest global environmental organization, in November of 2011 and designated the Ministry of Agriculture and Forests as the focal agency.

Source: Bhutan: In pursuit of sustainable development, national report for the United Nations Conference on sustainable development, 2012.

Questions

1. State one main objective of National Adaptation Programme of Action for Climate Change (NAPA).
2. Give two examples of Bhutan's initiatives after acceding to NAPA.
3. What were the reasons for Bhutan to accede to Kyoto Protocol on 26 August 2002?
4. What are the advantages and disadvantages of agreeing to international treaties and conventions for Bhutan?

B. National efforts of sustainable development

The government of Bhutan has adopted the philosophy of Gross National Happiness (GNH), as a holistic approach to sustainable development. GNH is an approach to responsible development, characterized by the right balance between equitable and sustainable livelihood, ecological conservation, good governance, and dynamic and thriving culture. This fosters a sense of sufficiency and contentment, which promotes harmony and connectedness with nature, others and self. The GNH policy is based on the nine precepts or domains. In accordance to nine domains of GNH, 72 indicators are used to define and analyze the sustainable development and to assess impacts of any policy and project.

The Gross National Happiness Commission (GNHC) ensures that its principles are mainstreamed into the planning, policy making and implementation process of developmental activities. All the projects and initiatives within Bhutan are evaluated based on their relevance to the GNH framework. The framework includes developing a dynamic economy as the foundation for a vibrant democracy, living in harmony with tradition and nature, effective and good governance and our people investing in the nation's greatest asset.

Some of the initiatives and projects towards sustainable development include:

- i. Human settlement policy and planning:** It includes enhancement of energy-efficient housing and climate change adaptation through land use zoning based on the levels of vulnerability to climate induced natural disasters.
- ii. Green construction industry:** Promoting design and production of eco-friendly housing materials for insulation, roofing, lighting, water storage, rainwater run-off management, and so on. Green architecture and landscaping also have great potential in minimizing the causes of climate change.
- iii. Integrated rural-urban planning and regionally-balanced urban development:** The population pressure in any area has adverse effects on the ecosystems and the social infrastructure or a community. Creating regional urban hubs and providing markets for adjoining rural areas disperses the urban population by providing economic opportunities equitably across the country, whilst alleviating the population pressures on urban areas.
- iv. Solid waste management enterprises:** Using recycling methods with affirmative action creates opportunities for gainful employment and poverty reduction, whilst reducing pressure on landfills and other disposal facilities. There are encouraging examples of how some business enterprises have innovatively linked waste management, philanthropy and livelihoods.
- v. Entertainment industry:** It is nascent as an economic sector in the country, but has shown vast potential to create employment. Besides generating economic and cultural benefits, the entertainment industry, specifically music and movie production, can be an excellent avenue to disseminate, promote and popularize the Bhutanese values of GNH. This type of industry has immense potential for the economic development with limited resource and has minimum adverse impacts on the environment.
- vi. Partnership with civil society:** Bhutan has put in place institutional development framework for sustainable development at all levels with particular impetus on local government institutions at the grassroot levels. One of the strategies of the government is to continue to strengthen partnerships with the civil society organizations and the private sectors to increase the public outreach of its development programmes and services. For example, community forest, farmer's cooperatives, civil society organization (CSO), support the local communities with varying services.

C. Challenges of sustainable development efforts in Bhutan

Although Bhutan has made historical development progress in the past few decades, it is confronted with numerous challenges. As a small nation, it is a challenge for Bhutan to maintain its identity, sovereignty and security in the highly populated and globalized world. Some of the key issues and challenges faced by Bhutan in achieving sustainable development are described in Activity 10.5.

Activity 10.5 Identifying challenges of Sustainable Development Initiatives (SDI)

Instruction: Work in groups. Study Figure 10.3 and answer the following questions.

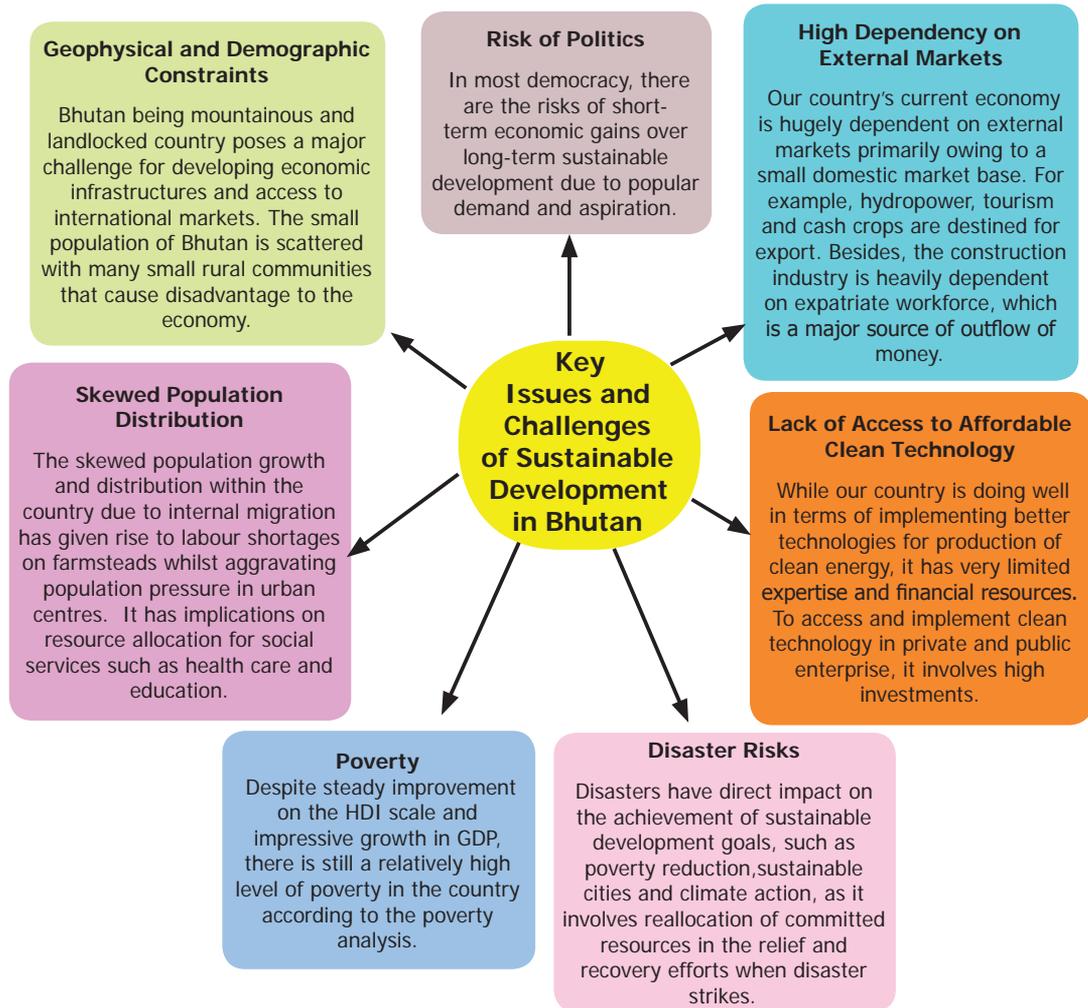


Figure 10.3 Challenges of sustainable development

Questions

5. How does Bhutan's geographical location impact SDI?
6. How does the skewed population of Bhutan affect the SDI?
7. Which of the challenges are not relevant to Bhutan? Why?
8. Identify the benefits and limitations of Bhutan's dependency on the global markets.
9. Which of the challenges will directly impact your community? Explain.

Questions

1. Name the treaties which Bhutan signed to uphold environmental and sustainable developments.
2. The government of Bhutan has taken up several strategies to ensure environmental conservation. List them down.
3. How do the treaties and conventions contribute to the process of sustainable development in Bhutan?

Summary

- Sustainable development involves maintaining a stable relationship between human activities and the natural world, upholding the quality of environment.
- Sustainable consumption is the consumption of goods and services that have minimal impact on the environment, and are socially equitable and economically viable.
- In the pursuit of sustainable development under GNHC, many noble initiatives are being taken up by various private and public agencies of the country.
- Under sustainable development effort, Bhutan has become party member to many unilateral and multilateral treaties and conventions.
- Although there are many success stories of sustainable development initiatives, there are many challenges to be addressed in the due course of development.
- GNH is the sustainable development philosophy of Bhutan.

Exercise

1. Each question is followed by four possible choices of answers. Choose the correct answer.

- a. Social sustainability refers to
 - A. increase in forest cover and shelter for animals.
 - B. protection of indigenous people and building their homes.
 - C. concept of the providing jobs and generating income in the long term.
 - D. sharing benefits fairly and equitably, and respecting the quality of life of communities and of human beings.
- b. Which factor best explains the inception of sustainable development?
 - A. Human population growth
 - B. Humans decreased their reliance on natural resources
 - C. Humans increased resource consumption beyond the Earth's carrying capacity
 - D. All nations in the world pollutes the environment.
- c. Which of the following are the challenges in achieving sustainable development goals in Bhutan?
 - I. Small size of population.
 - II. High dependency on external market.
 - III. Developing economic infrastructure due to steep mountain terrain.
 - IV. Internal migration leading to unequal distribution of social services.
 - A. I, II and III
 - B. I, III and IV
 - C. II, III and IV
 - D. I, II and IV
- d. Projects are unsustainable, if they are
 - A. financially unaffordable.
 - B. environmentally invasive.
 - C. socially intrusive.
 - D. all of the above.



Figure 10.4

- e. Rio Convention best benefitted Bhutan in
 - A. promoting Gross National Happiness.
 - B. conserving the pristine environment.
 - C. becoming a member of the global community.
 - D. strengthening the policy and programmatic framework to pursue sustainable development goals and objectives.

2. Fill in the blanks with the correct word(s).

- a. The is the national focal agency for Montreal Protocol.
- b. The establishes the procedures for assessment of potential effects of projects on the environment.
- c. The key economic sectors of Bhutan are and
- d. It is mandatory for any hydropower project to carry out to measure impact on environment .
- e. is the international organization that ensures the protection and conservation of culture around the world.

3. Write TRUE or FALSE for the following statements. Correct the false statements and write them down.

- a. Change in consumption pattern and production has posed a challenge to sustainable development.
- b. Gross National Happiness and sustainable development are two different concepts in Bhutan.
- c. Skewed population distribution supports sustainable development efforts in Bhutan.
- d. Traditional and local beliefs do not protect and preserve our environment.
- e. Constructing hydropower plant is always a sustainable development practice.

4. Match the word or phrase numbered (1) to (5) in Column A with the appropriate word or phrase numbered (a) to (e) in Column B.

Column A		Column B	
1	Highest policy making body in Bhutan which emphasizes the integration of environmental consideration into plan, policy and programs.	a	Civil Society Organization
2	Ensures that environmental concerns are fully taken into account when formulating, renewing and modifying and implementing the project.	b	Sustainable Development
3	Operates in constructive partnership with the Government to advance public interest socioeconomically, culturally and environmentally.	c	Gross National Happiness Commission
4	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.	d	National Biodiversity Centre
5	A guiding policy document for conservation and sustainable use of biological resources of the country.	e	National Environment Commission

5. Answer the following questions.

a. Study Figure 10.5 and answer the following questions.



Figure 10.5

- i. How do you think that this project would impact our economy?
- ii. How would these project impact the social lives of the community?
- iii. What environmental threats can you foresee in this project?
- iv. Do you think that this project is sustainable? Justify.

- b. Organic farming is one of the means for sustainable development. Justify.
- c. Which three sustainable development goals are the most important ones for your community? Give reasons.
- d. Why is sustainable development process very crucial for Bhutan?
- e. Practicing sustainable consumption can ensure that the environment has resources available for the future. How do the following contribute to sustainable development?
 - i. carpooling.
 - ii. practising refuse, reduce, reuse and recycle .
 - iii. developing alternative fuel sources, such as biofuel.
 - iv. using renewable energy sources, such as solar or wind power.

MODEL QUESTION

Environmental Science

Class: X

Time: 2 hours

Directions

- The first 15 minutes of the examination are for reading the paper only. Students must **NOT** start writing during this time.
- This paper has two sections A and B.
- **Section A** contains objective questions and all questions are compulsory.
- **Section B** contains extended response questions, wherein you have to answer **any five** out of six questions.
- The intended marks for questions are given in brackets ().

Section A (50 Marks)

Compulsory: Attempt all questions.

1. Each question in this part is followed by four possible choices of answers. Choose the correct answer. (25 marks)

- i. Carbon is processed through biogeochemical cycle into the biosphere. Which of the processes is not related to this?
- B. photosynthesis
 - C. transpiration
 - D. burning of fossil fuels
 - E. decomposition of plants and animals

- ii. Study Figure 1 which shows varieties of the potatoes.

It shows an example of

- A. genetic diversity
- B. species richness
- C. species composition
- D. genetic evenness



Figure 1

Model Question

- iii. What is the symbiotic relationship called in which one organism is benefited and the other organism is harmed?
- A. mutualism
 - B. parasitism
 - C. commensalism
 - D. consumer

- iv. Figure 2 shows a food web in an ecosystem. If a disease reduced the number of frogs in the food web, then the number of:

- A. foxes would remain the same.
- B. snakes would be reduced.
- C. grasses would increase.
- D. beetles would drop.

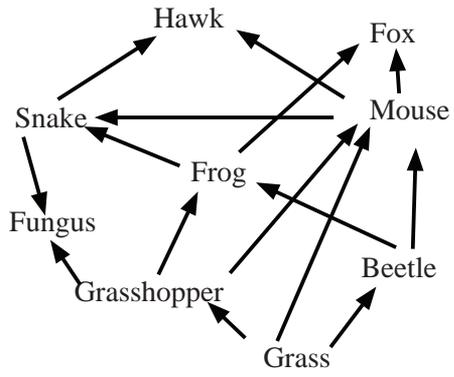


Figure 2

- v. The graph in Figure 3 shows the change in the stability of an ecosystem over a period of time.

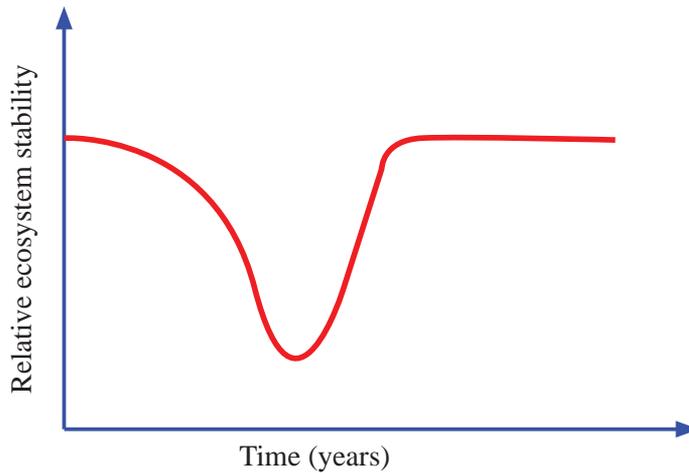


Figure 3

Which statement best describes the change in ecosystem stability shown in the graph?

- A. A stable ecosystem can be altered, and then it can recover to a point of stability.
- B. An ecosystem remains unchanged as its stability decreases.

- C. The stability of an ecosystem remains unchanged but its biodiversity decreases.
 - D. A stable ecosystem cannot recover after it is altered.
- vi. People use land for many purposes, such as extracting minerals, ecotourism, harvesting and rearing domestic animals. Which one of these purposes is the bio-productive area for production of food?
- A. cropland
 - B. forest
 - C. ocean
 - D. rock
- vii. Ecology is under constant threat due to excessive use of natural resources and generation of waste and pollutants into the environment. The ecological status is better measured by
- A. built-up land.
 - B. forest land.
 - C. grazing land.
 - D. carbon footprint.
- viii. An ecosystem is easily damaged but recovers after some time when the damaging effect stops. Such an ecosystem has
- A. high stability and high resilience.
 - B. low stability and low resilience.
 - C. high stability and low resilience.
 - D. low stability and high resilience.
- ix. The natural resources are exploited extensively and over harvested to meet the economic developmental needs. Measures are taken at various levels to mitigate the overharvesting. Which one of the following is an example of mitigation measure at the national level?
- A. Enactment of the Global Biodiversity Conservation Convention
 - B. Bhutan's Carbon Neutral Policy
 - C. Demarcation of Nature Reserves, Wildlife Sanctuaries, and National Parks in the country
 - D. The Green Economy Policy of Bhutan

Model Question

- x. Malthus describes that an unchecked population growth is exponential, while the growth of the food supply is arithmetical. This phenomenon is related to the carrying capacity of an ecosystem, because it describes about the
 - A. balance between biotic potential and environmental resistance where a population can be supported indefinitely.
 - B. situation wherein the resources increase proportionately with population.
 - C. force generated by finite resources and competition.
 - D. maximum rate of growth of any population under ideal conditions.

- xi. Which one of the following is NOT a limiting factor of an ecosystem?
 - A. the amount of resources available in the ecosystem.
 - B. the size of population.
 - C. amount of resources each individual is consuming
 - D. type of ecosystem

- xii. A virus has rapidly spread in a village. It has impacted the health of the people living there and wiped out the whole population from the village. The above scenario best describes the:
 - A. climatological disasters
 - B. geophysical disasters
 - C. biological disasters
 - D. hydro-meteorological disasters

- xiii. After an earthquake, there are activities like rescue, relocation, providing food and water. The multi agency provides these facilities to
 - A. meet the basic needs of people.
 - B. restore the telecommunications facilities.
 - C. improve transportation facilities.
 - D. warn aftershock of an earthquake.

- xiv. A greenhouse gas that is entirely anthropogenic in origin is
- A. CFCs
 - B. methane.
 - C. nitrous oxide
 - D. water vapour
- xv. Select the best example that describes the impact of climate change on the ecosystem.
- A. Hibernation of animals during winter.
 - B. Flowering of apple trees during spring season.
 - C. Decrease in the habitat of plants and animals due to urbanization.
 - D. Decrease in the habitat of plants and animals due to floods and droughts.
- xvi. Which one of the following would NOT be affected by the depletion of the ozone layer?
- A. biogeochemical cycles.
 - B. the rate of skin cancer.
 - C. amount of greenhouse gases.
 - D. amount of UV rays reaching the Earth.
- xvii. Consumption is the use of goods and services by an individual, while production is the rate of generation of resources. The availability of resources influences the consumption, and therefore affects the
- A. resources people consume daily.
 - B. spiritual wellbeing of the people.
 - C. wealth of the people.
 - D. lifestyle of people.
- xviii. The populations of organisms such as insects grow logistically when
- A. resources are limited.
 - B. standards of living are high.
 - C. resources are unlimited.
 - D. standards of living are low.

Model Question

- xix. An example of in-situ conservation effort of Bhutan is
- A. establishment of zoo
 - B. creating of national conservation park
 - C. establishment of gene bank
 - D. practice of tissue culture
- xx. Both modern and traditional farming have some disadvantages. We can integrate the two types of farming to produce quality crops and reduce the impacts on environment. Which one of the following would be the best method of integrated farming?
- A. Using modern tools, seeds from previous yield and manure.
 - B. Using modern tools, seeds from previous yield and chemical fertilizers.
 - C. Using modern tools, hybrid seeds yield and chemical fertilizers.
 - D. Using modern tools, hybrid seeds and manure.
- xxi. The energy derived from water and wind is considered as “Clean Energy”. It is because,
- A. there is minimum impact on the river system.
 - B. there is minimum pollution.
 - C. it is derived from natural resources.
 - D. energy sources are unlimited.
- xxii. The hydropower system is one of the sources of greenhouse gases. Which of the following statement justifies this claim?
- A. Forest is destroyed while constructing the dam.
 - B. The dam collects wastes from the upstream.
 - C. The electromagnetic radiation affects the environment.
 - D. The decaying plants in the dam produce gas.
- xxiii. The developmental policy of Bhutan is based on the concept of “Middle Path”, targeting for a sustainable society with the ability to
- A. return to a more primitive style of living.

- B. curtail all further development.
- C. continue as always as assumes that things will work out for the best.
- D. meet the needs of the present without compromising those of the future.

xxiv. Which of the following is related to Basel Convention?

- A. Ensuring the protection and conservation of natural and cultural heritages around the world.
- B. Controlling of trans-boundary movement of hazardous wastes and their disposal.
- C. Protecting cultivated and wild plants by preventing the introduction and spread of pests.
- D. Protection and preservation of endangered species.

xxv. All of the following are effective strategies adopted by Bhutan to maintain carbon neutral for all times, EXCEPT

- A. adoption of watershed management.
- B. increasing protected areas and sanctuaries.
- C. increasing the production of wind generated electricity
- D. enhancing the capacity to monitor the air and water qualities

2. Fill in the blanks. (5 marks)

- i. Bhutan protects the biodiversity of critically endangered species by the establishment of
- ii. In an ecosystem, the deer population overshoots the carrying capacity. This may lead to collapse of the
- iii. The systematic approach to identify, assess and reduce the risks of disaster is known as
- iv. The difference in the density of sea water that varies with temperature and salinity causes
- v. The bottlebrush plant was introduced into Bhutan for its beauty and fragrance. It thrives exceptionally well in Bhutan, but it affects some of the native species. Such an organism is called species.

3. Match the items of Column A with the most appropriate items of Column B. Rewrite the correct matching pairs. (5 marks)

Column A	Column B
i. Pandemic	a. Solar and wind energy.
ii. Biodiversity act, 2003	b. To ensure the conservation and sustainable use of the biochemical and genetic resources.
iii. Sustainable development	c. Natural cause of climate change
iv. Energy conservation	d. Maintaining a stable relationship between human activities and the natural world upholding the quality of environment.
v. Earth obliquity	e. Efficient use of energy
	f. Ex-situ conservation
	g. Biological disasters

6. Write TRUE or FALSE against the following statements. Rewrite the false statements in the correct forms. (5 marks)

- i. Competition occurs when the niche of two organisms overlap.
- ii. In a sedimentary biogeochemical cycle, the element in question is withdrawn from the atmosphere and then returned to the soil.
- iii. Wetlands support a wide variety of plants and animals; this means that they have great biodiversity.
- iv. One of the disadvantages of recycling waste is that the energy used during recycling process is more than the energy used to produce products from the raw materials.
- v. Bhutan has adopted the philosophy of Gross National Happiness as a holistic approach to sustainable development.

7. Short answer questions (10 marks)

- i. Why is Bhutan considered to be 'Carbon negative?'
- ii. How does the carrying capacity for a population change overtime?
- iii. What is endemism? Name two plant species endemic to Bhutan?
- iv. How is phosphorus cycle different from the carbon and nitrogen cycles?
- v. Describe the importance of phenology with regard to climate change?

Section B (50 marks)
Answer any five questions.

Question 1 **(10 Marks)**

1. Define the biogeochemical cycle. (1)
2. The table below shows the data collected while documenting the biodiversity of three dzongkhags. Which dzongkhag should be categorized as the one with the highest species biodiversity? Justify. (3)

Paro	40 species	650 individuals
Thimphu	32 species	1200 individuals
Punakha	12 species	1250 individuals

3. How do the extrinsic factors impact the ecosystem's ability of resistance and resilience? (2)
4. What is meant by sustainable lifestyle? (1)
5. How does the ecological footprint relate to carrying capacity? (3)

Question 2 **(10 Marks)**

1. What does the statement, 'Living within the limits of an ecosystem,' mean? (1)
2. What is GLOF? (1)
3. Distinguish between climatological and geophysical disasters. (2)
4. Give two examples to explain that humans benefit from diversity of life. (2)
5. How does the invasion of an alien species reduces the species diversity of an area? (2)
6. Society is looking for alternate energy sources that are renewable due to the negative effects of burning fossil fuel on the environment, . Other than this fact, state two advantages of using this renewable energy sources. (2)

Question 3 **(10 Marks)**

1. Why is sustainable development policy important for Bhutan? (2)
2. What can you as an individual, do for making development of the country more sustainable? (2)

Model Question

3. Describe the basic principles, advantages and limitations of different waste management systems. (2)
4. State two effects of wastes on the human health. (1)
5. Complete the Waste Hierarchy given in Figure 4, in order of priority. (3)

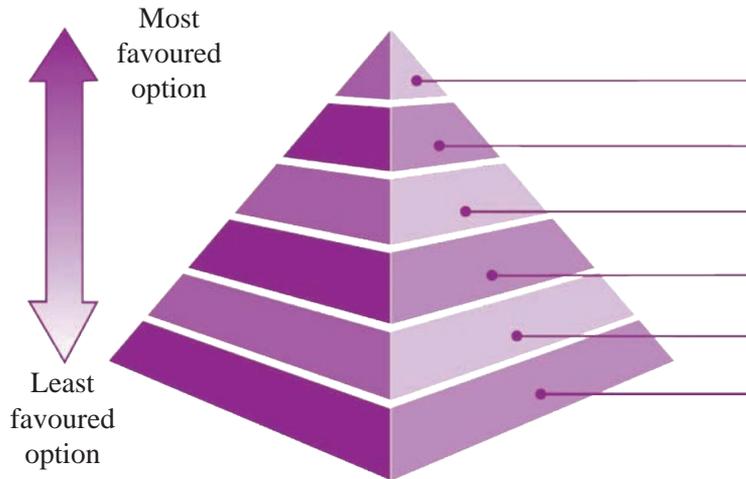


Figure 4

Question 4

(10 Marks)

1. How does ecotourism as a community based enterprise exemplify the sustainable use of natural resources? What are the benefits of ecotourism? (3)
2. How does thermohaline circulation influence climate? (2)
3. How does the increase in industrialization and urbanization affect the global climate? (2)
4. How does Kyoto Protocol contribute to curb climate change? (3)

Question 5

(10 Marks)

1. The temperature of Earth's atmosphere depends on the greenhouse gases emitted into it over a long period. Explain with the help of clearly labeled diagram(s) how this happens? (4)
2. Explain the differences between the natural greenhouse effects and enhanced greenhouse effects, including the implications of each on human life. (2)
3. Why is Gross National Happiness (GNH) considered as the sustainable development philosophy of Bhutan? (4)

Question 6

(10 Marks)

1. Explain the TWO prominent initiatives of Bhutan towards the biodiversity conservation. (4)
2. Explain how chlorofluorocarbons destroy ozone molecules. Write its chemical equation? (3)
3. Study Figure 5 that shows plants which are common in the Southern belt in Bhutan, and answer the questions that follow.
 - a. Name the type of species. (1)
 - b. How does this species affect other species in the area? (1)



Figure 5

4. Explain one compelling mandate of the Earth Summit. (1)

