ENVIRONMENTAL SCIENCE

CLASS NINE

Department of Curriculum and Professional Development
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Royal Government of Bhutan
Ministry of Education
Cultivating the Grace of Our Mind

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January 4, 2015

FOREWORD

In education, we continue to aspire to create a truly wholesome education that develops knowledge, skills and qualities in our children to help them excel in the schools and appropriately equip them for the world of work by focusing on skills like problem solving, communication and collaboration, endowed with our rich spiritual and cultural values. The purpose of school education should therefore be to continuously strive to equip the students with appropriate knowledge and skills and right attitude to life and the environment in which they live in.

As envisioned in the Bhutan Vision 2020 document, environmental science was introduced in our schools as a subject and formed major part of the curriculum diversification initiative. It introduces students to career opportunities in the areas of environmental and natural resources; and provide opportunities to both teachers and learners to incorporate effective educational approaches such as utilizing current issues, connecting with community resources and engaging themselves in research and project-based learning.

One of the challenges of the 21st century is going to be the issue of sustainability of natural resources. Students as future leaders need to learn how to balance the varied needs of human population while at the same time protecting the capacity of the earth to sustain all forms of life; and recognizing that the quality of the environment determines the long-term economic and social health of a country.

This textbook for class IX pioneers series of subsequent textbooks to be developed for introduction in classes X, XI and XII as one of the optional or elective subjects in our schools.

The Ministry of Education dedicates the launch of this Environmental Science series to His Majesty the 4th King for his immense contributions to national and global sustainable development.

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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.

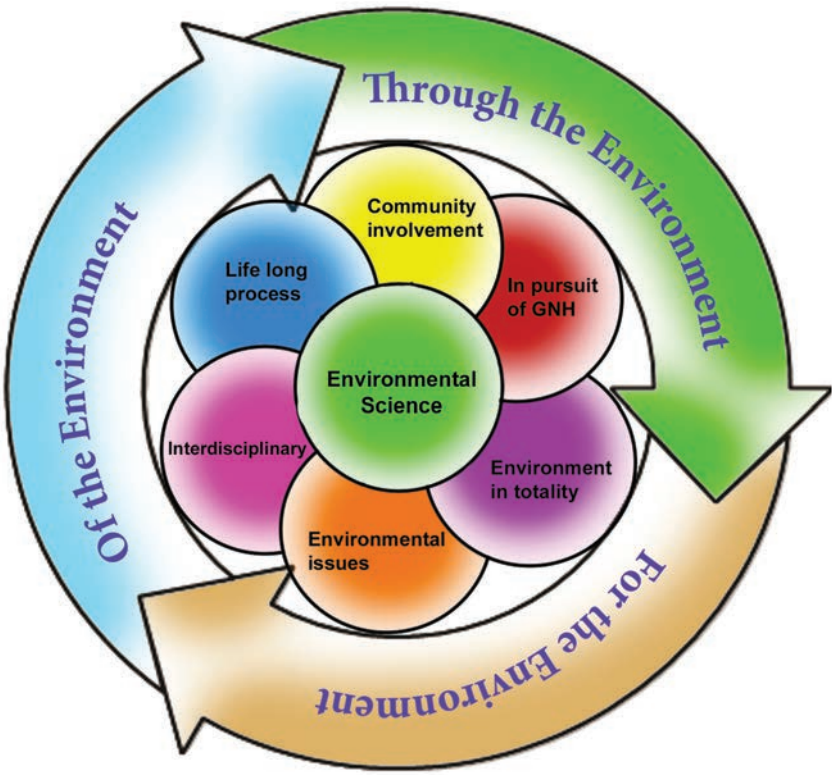

Figure. 1. Principles of Environmental Science Curriculum

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**

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 ecosystems, types of ecosystems, 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 ecosystems 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 feel 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 also are 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 realise that they need to change their consumption pattern.

Strand 4: Sustainable Development

Students after learning the conservation and management methods, will now 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 realize that human resources are also very important in the growth of the country. Finally, they move to the concept of sustainable development understanding the fact that environment , economics and society are the three major pillars needed to sustain any development and they must see them 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; 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 Case Files 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 Case Files 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 Case Files 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 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. assess 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. *assess student's ability to respect others views and opinions.*
iv. *assess 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. *assess progress in students' learning and to provide immediate feedback.*
ii. *assess 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. *assess the display of environmental science ideas and concepts of students in the form of models, charts and posters.*
ii. *assess 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. *assess 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. assess student's level of participation in learning activities.
ii. assess student's behavioural conduct with teacher, friends and community.
iii. assess 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. assess 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. assess 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. assess 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: Key: √- Yes X- No Learning objectives Name:	Content knowledge (CK) Topic: Ecosystem - organisation and types					
		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
1	Tshering						
2	Wangmo						

Sample checklists: Environmental Processes(EP)

No.	Class: Key: √- Yes X- No Learning objectives Name:	Environmental processes (EP) Topic: Ecosystem - organisation and types							
		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
1	Choeki								
2	Jigme								

Sample checklists: Environmental science values and attitudes (EV)

No.	Class : Key: √- Yes X- No Learning Objectives Name:	Scientific values and attitudes (SV) Topic: Ecosystem - organisation and types						
		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
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 profiles 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 profiles 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 have relevance to environmental science that you have heard or watched, in news, radio, or read in books, Internet, journals or magazines. Such as, 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 profiles 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 a 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 a environmental science project

The first step in doing a 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	Introduction to Environmental Science	90	2
Chapter 2	Ecosystem Earth	540	11
Chapter 3	Balance of Nature – Interaction and Resilience	450	9
Chapter 4	People and Environment	585	10
Chapter 5	Natural Resources Degradation	450	10
Chapter 6	Environmental Pollution	450	9
Chapter 7	Understanding Disaster Risk and Environment	450	10
Chapter 8	Biodiversity	450	10
Chapter 9	Fundamentals for Watershed Management	540	11
Chapter 10	Energy Resources	450	9
Chapter 11	Environment and Development	405	9
Total		4860	100

The total time required to complete the topics is 4860 minutes or 97 periods of 50 minutes in a period.

Table of Content

Introduction to Environmental Science

Environmental science is a multi-disciplinary subject. It comprises aspects from various branches of studies like chemistry, physics, medical science, life science, agriculture, public health, social science, etc. It studies about the sources of natural resources and physical events; interactions and relationships amongst the biological and abiotic worlds; roles of biogeochemical events in sustaining the life forms on the Earth; anthropogenic activities and their effects in the environment; and human initiatives and strategies in sustaining the carrying capacity and natural resources of the Earth for future generations. The multidisciplinary nature of the study of integrating physical, chemical, biological and social sciences, peppered with cultural and spiritual belief of human societies provides a holistic perspectives of the subject. It connects the concepts and principles of various sciences to the real life situations, and promotes environment friendly practices amongst learners. This makes the subject unique and interesting among the widely taught school courses.

1. Definition of environmental science

Environment, as defined by Boring is, '**A person's environment consists of the sum total of the stimulation, which he receives from his conception until his death.**' From the definition, environment comprises various types of forces such as physical, intellectual, economic, political, cultural, social, moral and emotional. Therefore, the environment is the sum total of all the external forces, influences and conditions, which affect the life, nature, behaviour and the growth, development and maturation of living organisms.

The word '**science**' come from Latin word '**scientia**', which means '**knowledge**'. Thus, "**environmental science**" is the systematic, scientific study of the environment in combination with living organisms, and their interactions that influence the life forms on the Earth.

2. Element of environment

Environment is everything that surrounds us, both natural and human-made, and the interacting systems of physical, biological and cultural elements that are inter-related in various ways, individually as well as collectively. Therefore, the major elements of the environment include:

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i. Physical elements

Physical elements include space, landforms, water bodies, climate soils, rocks and minerals. They determine the variable character of the human habitat, its opportunities, as well as limitations.

ii. Biological elements

Biological elements such as plants, animals, microorganisms and men constitute the biosphere. The physical and biogeochemical processes are the culminations of interactions and relationships amongst the biotic and abiotic elements that sustain the life on the Earth.

iii. Cultural elements

Cultural elements such as economic, spiritual, social and political elements are essentially man-made features, which constitute the cultural environment. The bond of environment with its cultural elements is inherent for the health of the environment and all life forms.

3. Scope of Environment

The environmental science draws heavily on aspects of the life and Earth sciences. Therefore, the study of environment deals with the following four segments of the Earth.

i. Atmosphere

The atmosphere implies the protective blanket of gases that surround the Earth. It sustains life on the Earth and saves the life forms from the hostile environment of outer space. It absorbs most of the cosmic rays from the outer space and a major portion of the electromagnetic radiation from the sun.

ii. Hydrosphere

The hydrosphere consists of all types of water resources, which include oceans, seas, lakes, rivers, streams, reservoir, polar icecaps, glaciers, and ground water. It is the source of water, essential for all life forms on the Earth.

iii. Lithosphere

The lithosphere is the outer mantle of the Earth, which consists of minerals occurring in the Earth's crusts and the soil. It is vital to support the terrestrial life forms.

iv. Biosphere

The biosphere comprises all of the living forms and their interactions with the environment, such as atmosphere, hydrosphere and lithosphere. The varieties of life forms and their interactions govern the health of the environment, and the universe at large.

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4. Importance of Environmental Science

The environmental science is a means to inform people of the importance of protection and conservation of our environment. The following reasons justify the importance of the environmental science:

i. Environmental concerns

The environmental issues are growing in size and complexity day by day, threatening the survival of life forms on the Earth, including the humans. Issues like global warming and ozone depletion, acid rain, marine pollution and biodiversity are national issues, as well as global concerns.

ii. Environment versus development

The increase in urbanisation, industrial growth, transportation systems, agriculture and housing leads to excessive use and exploitation of environment and its natural resources. The unscientific ways of extraction and use of natural resources jeopardize the sustainability of the environment. The disturbance in the balance in nature , generally, culminates to natural disasters and degradation of the environment.

iii. Enhancing pollution

The increased human population stimulates the growth of urbanisation, industrial growth, transportation systems, agriculture, and housing. Unscientific agricultural practices aggravate the soil quality due to deficiency of micronutrients and organic matter, soil salinity and the damage of soil structures. The developmental processes lead to generation of wastes of all types, leading to pollution of all four elements of the environment.

iv. Need for prudent planning of development

Humans' survival and sustenance depend on the health of the environment. The synchronization of extraction of resources with the ecological cycles is crucial for the sustenance of the environment and the development. The in-depth understanding of how the elements of environment interact and affect all life forms can lead to wise planning of developmental processes.

v. The Constitution of the Kingdom of Bhutan

The natural world is the source of way of life for every Bhutanese. It is embedded in the religion, culture, values and beliefs that they follow, and is integral to the spiritual well-being and happiness of people. The importance of the environment is evident in the three clauses of the Constitution of the Kingdom of Bhutan, wherein:

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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.

-The constitution of the Kingdom of Bhutan, Article 5, section 1 and 2 (pp-11)

The field of environmental sciences is of global importance. People worldwide are realising it as they are able to smell a polluted and degraded tomorrow. This stimulates people towards careful handling of today's environment in order to pass the healthy environment as a legacy for tomorrow's generation.

Exercise

1. Define environment.
2. Explain environmental science in your own words.
3. Describe the importance of environmental science.
4. "The need for public awareness about environment is of vital importance." Discuss.
5. Explain the roles of government towards the conservation of environment.
6. Why is environmental science important for Bhutanese children?

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Ecosystem Earth

An ecosystem consists of communities of species and the physical environment. Ecosystem is defined by a network of interactions among organisms and with their environment. The ecosystem can be as small as a pond, or as big as a sea; as simple as a group of mosses growing on a rock, or as complex as a forest. A series of connected ecosystem blends with each other forming a biome. Different types of biomes extend over a large biogeographical zones of the Earth having distinctive climatic conditions, flora and fauna. Technically, this makes the Earth a huge ecosystem in itself.

The Earth is categorized into four different subsystems which interact with each other, which influence the climate, geological processes and life on the Earth.

1. The Earth System

Learning Objectives

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

- *recognise the subsystems of the Earth.*
- *describe different layers of atmosphere.*
- *recognise the interactions amongst the subsystems of the Earth.*

A system is an interacting network of components, working together as a whole to perform one or more important functions. For instance, in the circulatory system of the human body, its network of organs works together as a whole to transport blood, provide the various organs with food and help get rid of the waste generated in the body. Similarly, the components such as land, oceans, air and life forms interact physically, chemically and biologically to sustain life on the Earth. Hence, the Earth can be considered as a system.

A. Subsystems of the Earth

The Earth consists of four subsystems also known as the spheres of the Earth: Lithosphere (land), Hydrosphere (water), Atmosphere (air), and Biosphere (life forms).

i. Lithosphere

Lithosphere is the outermost layer of the Earth. It includes the Earth's crust (continental crust and oceanic crust) and a small portion below the crust, which is referred to as upper mantle as shown in Figure 2.1. Lithosphere is hard annd rigid, and contains mainly rocks, minerals and soil.

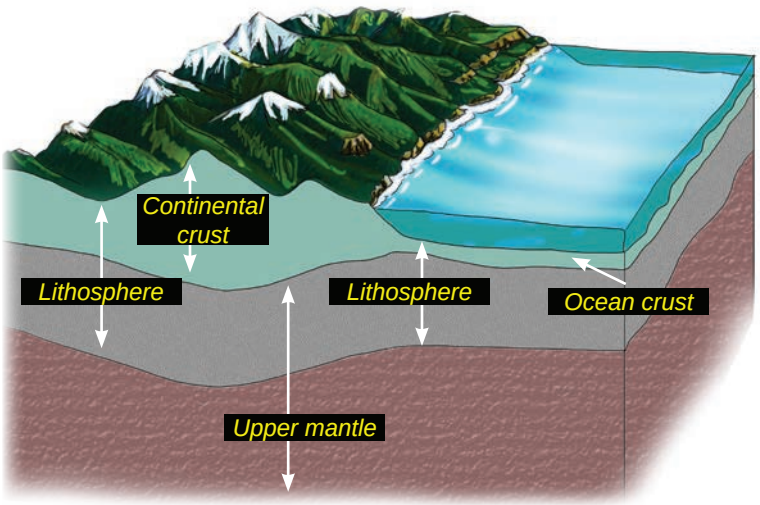

Figure 2.1 Cross section of lithosphere

Lithosphere is broken into large plate-like sections called tectonic plates (Figure 2.2). The enormous heat produced at the center of the Earth makes the tectonic plates move. This is believed to be the reason for the formation of continents, diverse habitats and life forms.

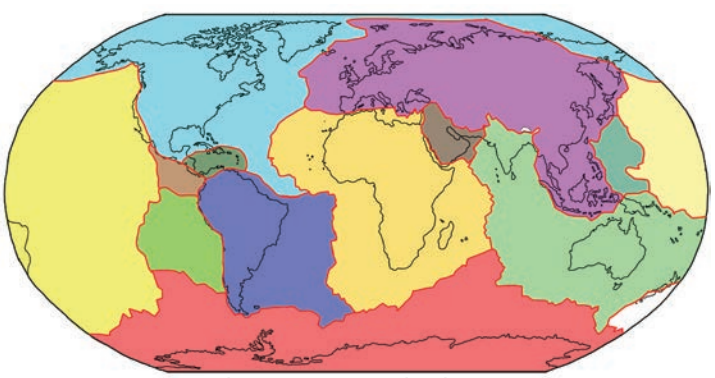

Figure 2.2 Tectonic plates

Rocks of the lithosphere form soil by the process of weathering. Soil formation is a long and complex natural process. It takes around a hundred to thousand years for the formation of one centimetre of soil. Organic materials are added to the soil due to the growth and decay of plants, animals and microorganisms. The soil thus formed is rich in organic matter. The depth of the soil varies from place to place.

Hence, lithosphere is an important part of the Earth that helps to provide food, shelter, and other requirements for organisms to survive.

ii. Hydrosphere

Hydrosphere includes all forms of water found on the planet. It includes water in solid, liquid and gaseous forms: solid form, such as glaciers, snow and polar ice caps; liquid form as water found in oceans, lakes, rivers, streams, ponds and, ground water; and gaseous form as moisture in air. Figure 2.3 shows the forms of fresh water available to life forms on the Earth, including humans.

Hydrosphere covers more than 70 percent of the surface of the Earth. Life is believed to have originated and evolved in water. It is the lifeline for all the life forms on the Earth. Oceans, lakes, rivers, streams and ponds provide shelter to diverse life forms. Water cycle (also called the hydrological cycle) maintains the balance of water on the Earth (Figure 2.3). Can we imagine this planet without water? Earth is also known as the blue planet. Can you find out, why it is called so?

iii. Atmosphere

Atmosphere is a layer of gases surrounding the Earth. Depending on the temperature, pressure and the type and volume of gases, four layers can be identified in the atmosphere.

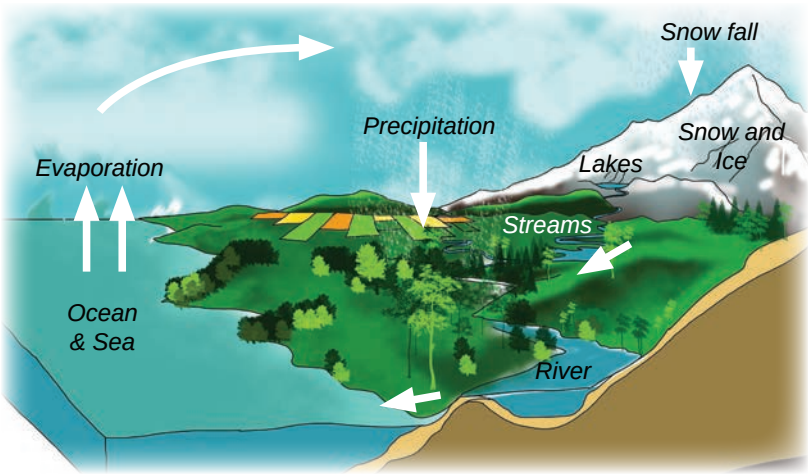

Figure 2.3 Hydrosphere and its cycle

Activity 2.1: Understanding the composition of atmosphere

Instruction:

Study Figure 2.4 and answer the questions that follows:

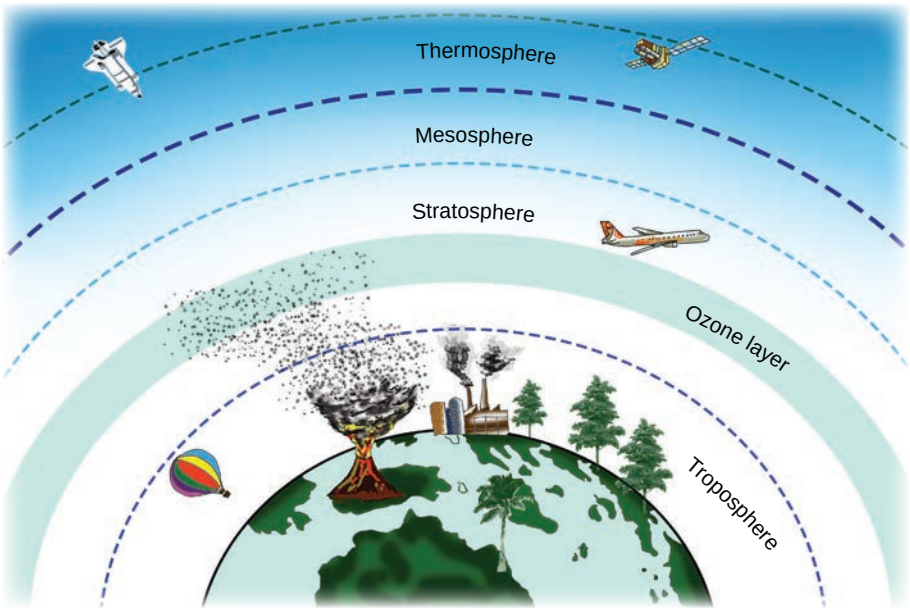

Figure 2.4

1. Match the atmosphere layers in the first column with the corresponding descriptions in the second column in Table 2.1, with reference to Figure 2.4.

Table 2.1

Stratosphere	is the lowest layer of the atmosphere, extending from the surface of the Earth to around 12 km above. It contains oxygen, nitrogen and other gases like carbon dioxide, water vapour, which are vital to life forms. Water vapour is an important component of this layer that controls all the weather related processes and activities like cloud formation, rain and wind circulation.
Troposphere	is the layer that extends from 50 km to around 80 km, and is the coldest layer of the atmosphere with an average temperature of minus 85° C.
Mesosphere	extends from 12 km to around 50 km. It contains the gas ozone, and hence, is also referred to as the ozone layer. This layer absorbs the ultraviolet (UV) radiation that enters the Earth from the Sun.
Thermosphere	is the outermost layer of the atmosphere. Satellites and spacecraft are placed in this layer.

2. Which layer of the atmosphere can support life forms? Why?
3. Why is ozone layer important?
4. List down some of the human activities that deplete the ozone layer?
5. How would the absence of atmosphere affect the Earth?

iv. The Biosphere

Biosphere is that zone of the Earth, where life thrives. Since life can be found in water, on land and in air, biosphere consists of parts of the hydrosphere, lithosphere and atmosphere, as shown in Figure 2.5. Life in its numerous forms exists in various sizes and shapes, and is found in almost all parts of the Earth; from the icy poles to the scorching deserts, and from the mountain tops to the depths of the ocean.

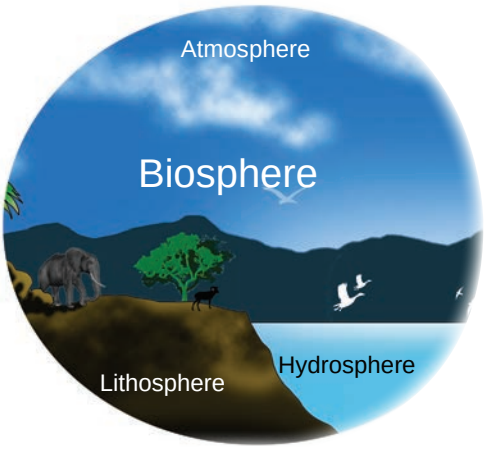

Figure 2.5 Biosphere

Biosphere interacts with the abiotic components of all other subsystems of the Earth. For instance, plants growing on a rock influence the process of soil formation through biological processes. The soil, in turn, influences the plant and its growth. Similarly, plants absorb carbon dioxide from the air to prepare food and release oxygen back into the atmosphere. Animals, on the other hand, breathe in oxygen and breathe out carbon dioxide releasing it in the atmosphere. Therefore, all these processes and interactions between the subsystems work towards maintaining an ecological balance on the Earth.

Questions

1. Why do you think that the Earth is a system?
2. Illustrate and name the subsystems of the Earth.
3. Explain with example the interaction of spheres of the Earth to create a functioning system.?

2. Biogeographical zones and biomes

Learning Objectives

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

- *describe the biogeographical zone(s) and the biomes of the world.*
- *illustrate the biomes on the world map.*
- *identify the biogeographical zone(s) that Bhutan belongs to.*
- *name the predominant biomes of Bhutan and their salient features.*

The biosphere is a major subsystem that consists of several biogeographical zones and biomes. The geographical distribution of plants and animals is determined by the ecological factors (biotic and abiotic) of the Earth, and the movements of the tectonic plates (continental movements). On the basis of distinctive features of plants and animals that exist, eight biogeographical zones or ecozones have been identified around the world, as shown in Figure 2.6.

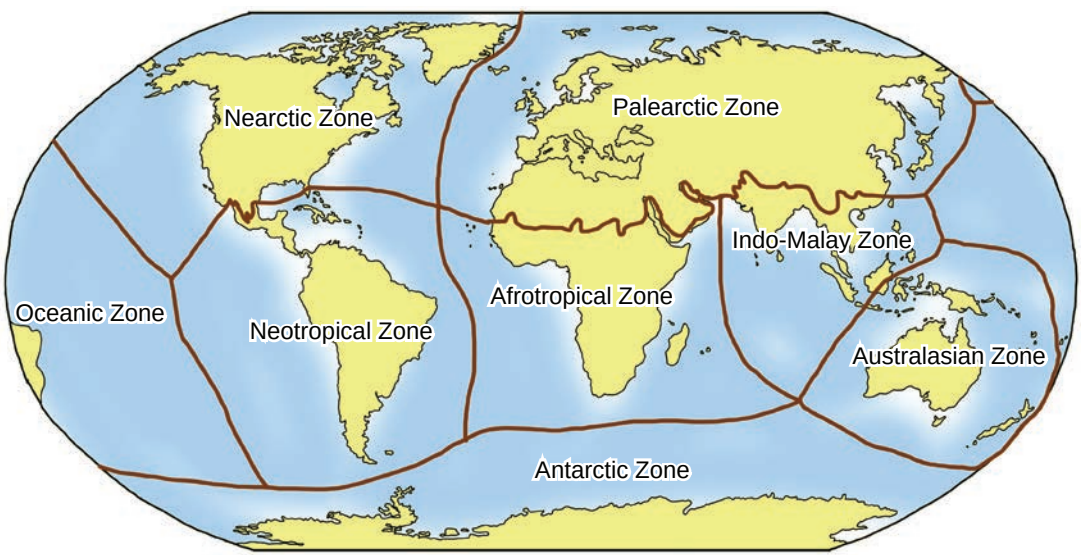

Figure 2.6 Biogeographical zones of the World

These zones, mainly represent the continental zones. Each of these biogeographical zones support several biomes. For instance, in the Indo-Malay zone, the major biomes identified are tropical forest, coniferous forest, desert and the Tundra. Can you identify the biogeographical zone to which Bhutan belong?

Biomes are part of the biogeographic zones, and have distinct sets of climatic regimes and plants and animals. Different ecologists classify biomes in several ways, based on factors such as climate, habitat, plants, animals, and even human activity. Hence, the number of biomes varies from five to fourteen depending on the type and number of factors considered in the classification. Some have considered only terrestrial biomes, while others have taken aquatic biomes in the classification. According to Eugene Pleasants Odum, who is considered as the father of modern ecology, ten major biomes are identified as shown in Figure 2.7. Biomes are generally named after their predominant vegetation type.

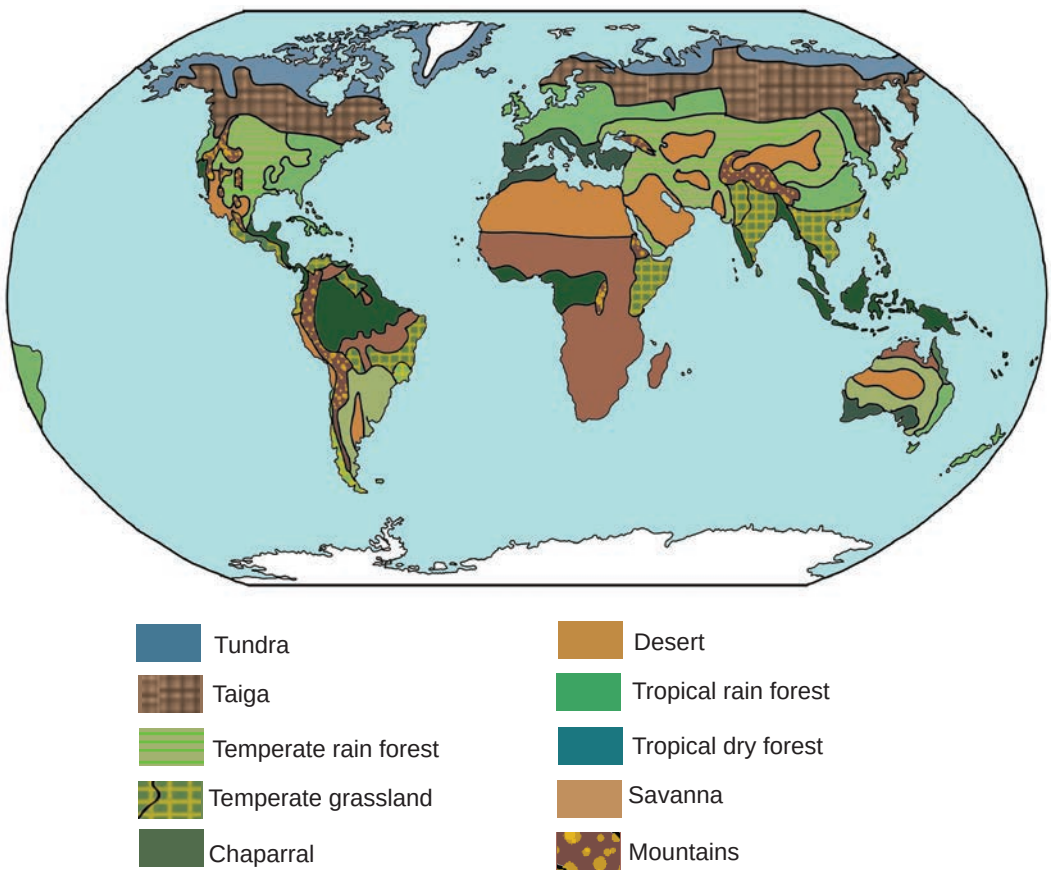

Figure 2.7 Distributions of Biomes

The distribution of the biomes depends on the altitude and precipitation (Table 2.2).

Table 2.2 Terrestrial Biomes of the World

Major Biomes	Climate	Predominant plants and animals
Desert (hot)	Receive less than 25 cm (10 inches) of precipitation (rain) per year. Arid climate.	Specialized plants, which can cope with water scarcity. Example Cactus. Examples of animals include insects, lizards, snakes, small mammals, grazing animals and birds.
Temperate Grassland (Prairies/ Steppes)	Receive between 25 and 75 cm (10 to 30 inches) of precipitation per year. Freezing winters and hot summers are typical.	Grasses make up 60 to 90 percent of the vegetation. Primary consumers are herbivores, including horses and bison. Many kinds of insects are also present.
Savanna	Receive 50 to 150 cm (20 to 60 inches) of rain per year, not distributed evenly. Climate with a long dry season is prevalent.	Grassland with tall scattered trees. Major mammals are grazers like zebras, elephants, antelope. Carnivores like lions, hyenas, leopards are also present.
Mediterranean Shrub lands (Chaparral)	Wet, cool winters and hot, dry summers. Rainfall is 40 to 100 cm (15 to 40 inches) per year.	Vegetation dominated by woody shrubs that are adapted to withstand hot, dry summers. Plants often dormant during the summer. Many species of insects, reptiles, birds and mammals are found.
Tropical Dry Forest	Monsoon climate with several months of heavy rainfall followed by extensive dry periods. Rainfall may be as low as 50 cm (20 inches) or as high as 200 cm (80 inches).	With seasonal rainfall, several species of plants show adaptations for drought. Trees drop their leaves during the dry period. Insects, birds, climbing mammals, lizards and tree frogs are common.
Tropical Rainforest	Warm temperature which is relatively constant. Rains nearly every day. Most areas receive more than 200 cm (80 inches) of rain per year. Some receive 500 cm (200 inches) or more.	Greater diversity of species than any other biome. Balsa, teak wood and many other woods form tropical trees. Insects, birds, climbing mammals, lizards, and tree frogs are common. Since flowers and fruits are available throughout the year, there are many species of fruit-feeding birds and mammals. Animals found in tropical dry forests are also found in these forests.

Major Biomes	Climate	Predominant plants and animals
Temperate Deciduous Forest and Temperate Rainforest	Receive 75 to 100 cm (30 to 50 inches) of evenly distributed precipitation in deciduous regions, and 130 cm to 300 cm (50-120 inches) of rain in rainforest each year.	Beetles, moth larvae, wasps and ants and many migrant birds live in these forests. Major predators include foxes, coyotes and birds of prey. In rain forests, Sitka spruce, Douglas fir and western hemlock are typical ever green coniferous trees. A wide variety of animals include insects, birds such as woodpeckers, chickadees, juncos, warblers; larger animals such as back tail deer, bears, beavers, and owls.
Taiga (Northern Coniferous Forest or Boreal Forest)	Short, cool summers and long winters with abundant snowfall. Precipitation ranges between 25 and 100 cm (10 to 40 inches) per year.	Conifers such as spruces, firs, and larches are the most common trees specifically adapted to winter conditions. Most birds are migratory and feed on the abundant insect population. Typical mammals are deer, weasels, snowshoe hares, and squirrels. A few reptiles and amphibians also live in this biome because of the cold climate.
Tundra (cold desert)	Extremely cold and windy climate. Precipitation is less than 25 cm (10 inches) per year. Short summers are generally wet, due to the melting of winter snow. Temperatures are usually less than 10°C (50°F) in spring and summer, which reduce the evaporation rate.	Many small plants and lichens, such as reindeer moss grow here. Several species of insects serve as food for migratory birds during the summer. Artic foxes, wolves and owls are the primary predators.
Mountains	This is a complex zonation. Mountains are generally considered as part of the other biomes. Some ecologists consider mountains as separate biomes because of the vertical altitudinal zones.	Complex plants and animal communities. Scattered patches of tundra-like communities are also found on several mountain tops throughout the world. These are known as alpine tundra. Although the general appearance of the alpine tundra is similar to true tundra, many of the species of plants are different.

As one proceeds from sea level to the top of mountains in a biogeographical zone, series of biomes can be found as shown in Figure 2.8.

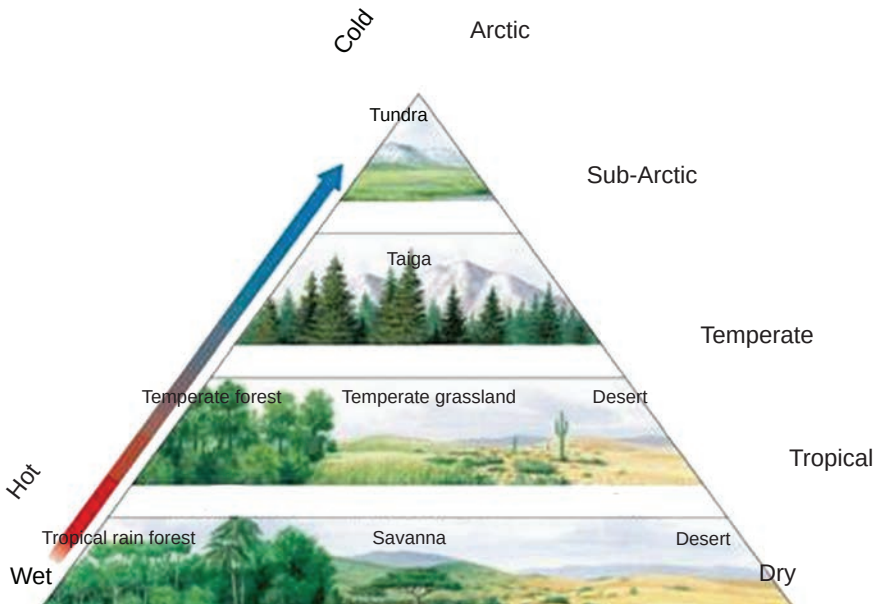

Figure 2.8 Biomes

Activity 2.2: Understanding biogeographical zones of the World

Materials required: Outline map of the world, tracing paper, crayons, colored pen, sello-tape or pins

Procedure

1. Trace out the biogeographical zones on the outline map, using tracing paper, sellotape or pins.
2. Trace the biomes of the world on the outline map in different colour.
3. Make suitable legends for steps one and two.
4. Locate and mark the outline of the continents on the map.

Bhutan with a geographical area of 38,394 square km, situated in the Eastern Himalayas with altitudes ranging from 97 m to 7570 m, falls in the Indo-Malay and Paleartic zones. While a large part of Northern Bhutan is located in the Paleartic zone, the Southern part falls in the Indo-Malay zone. The Paleartic zone harbours

temperate coniferous forests and temperate grasslands. The major biomes of Indo-Malay zone are tropical forests, temperate forests and savanna (Table 2.3).

Table 2.3 Biomes of Bhutan

Biogeographical Zone	Biome	Place
Indo - Malay	Tropical and subtropical moist broadleaf forests.	Bumthang, Chukha, Dagana, Mongar, Pemagatshel, Samdrup Jongkhar, Sarpang, Trashigang, Tsirang, Zhemgang..
Indo – Malay	Temperate broadleaf and mixed forests.	Chukha, Dagana, Gasa, Haa, Lhuentse, Mongar, Paro, Punakha, Samdrup, Jongkhar, Samtse,Sarpang, Thimphu,Trashigang,Trashiyangse, Tsirang, Wangdue Phodrang, Zhemgang.
Indo – Malay	Tropical and subtropical moist broadleaf forests.	Bumthang, Chukha, Dagana, Mongar, Pemagatshel, Samdrup Jongkhar, Samtse, Sarpang, Tsirang, Zhemgang.
Indo – Malay	Tropical and subtropical coniferous forests.	Dagana, Trongsa, Tsirang, Wangdue, Phodrang, Zhemgang.
Indo – Malay	Tropical and subtropical grasslands, savannas, and shrub lands.	Chukha, Dagana, Samtse.
Palearctic	Montane grasslands and shrub lands.	Bumthang, Gasa, Haa, Lhuentse, Paro, Punakha, Thimphu, Trashiyangse, Trongsa, Wangdue Phodrang.
Palearctic	Temperate coniferous forests.	Trashigang.

Activity 2.3: My land - My biome

Materials required: Outline map of Bhutan, crayons and pencil.

Procedure

In the outline map (with dzongkhag borders) of Bhutan, shade the biogeographical zones, and identify the biomes using different colours.

Answer the following questions

1. Identify the biome(s) of your Dzongkhag.
2. List down predominant types of vegetation, plants and animals species found in these biomes.

Questions

1. How many biogeographical zones are found in the world?
2. What are the major factors considered to classify biomes?
3. Name the major biomes of Bhutan?
4. How do the different biogeographical zones affect the agricultural practices?

3. Ecosystem - Organisation and Types

Learning Objectives

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

- *distinguish between biome and ecosystem.*
- *explain the levels of organisation in ecosystems.*
- *describe ecological niche.*
- *identify the types of ecosystems.*
- *recognise the roles of components and interactions in an ecosystem.*

An ecosystem is the structural and the functional unit of the biosphere. A biome consists of several ecosystems. For instance, a tropical forest biome may have rain forest, deciduous forest, water bodies and patches of grass land ecosystems. The scientific study of the ecosystems is called ecology. The word ecology ("Ökologie") was derived from Greek , (meaning: oikos = house; logos = study). The word was coined in 1866 by the German scientist Ernst Haeckel. It deals with the study of interactions amongst living organisms, and organisms with their abiotic components.

A. Ecosystem and its organisation

An ecosystem encompasses the communities of organisms together with the physical environment. A community consists of groups of interacting populations of several species. A population is a group of same species that live together in the same area at the same time. A species is a group of several interbreeding individuals. The physical environment that sustains the communities in an ecosystem is a habitat. An ecosystem may harbour one or several habitats. For instance, a stream ecosystem (Figure 2.9) may consist of rocks, sand, water plants, animal shells, and others. Each one of these habitats provides a different physical environment and, therefore, supports different types of organisms or species.

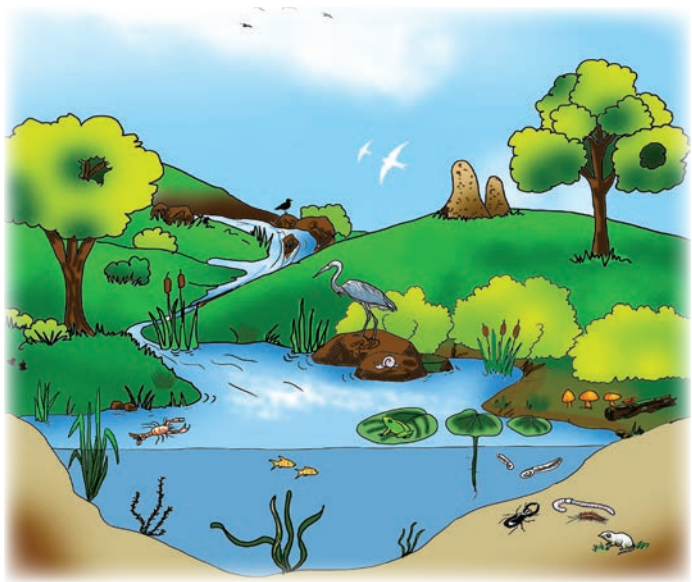

Figure 2.9 Stream Ecosystem

A species is suited to live in a particular place within a habitat and carry out roles that best suit the habitat and the species themselves. 'Ecological niche' is the term used to define the role, or the position of an organism in the habitat. It is the sum total of all attributes needed by an organism or species to live, grow and reproduce. A niche may include the living space; physical components like temperature, humidity; food; time and method of reproduction. Niche is specific to species. Two species with the same needs cannot live in one niche, since they compete with each other for these resources. For example, two species of crabs live on sand, which is their habitat. However, if one species is active during the day and the other during the night, the niche is said to be different for these two species. This is because the conditions, such as temperature, humidity, types of food (worms, snails), and the nature of sand habitat are different during the night and the day. In the Figure 2.10, different birds depend on different parts of the river bank.

An ecosystem, therefore, is a numerous complex interactions among organisms and their physical environment. Biotic components interact for food (nutrients and energy), space, shelter and other needs. These interactions may lead to various adaptations in organisms.

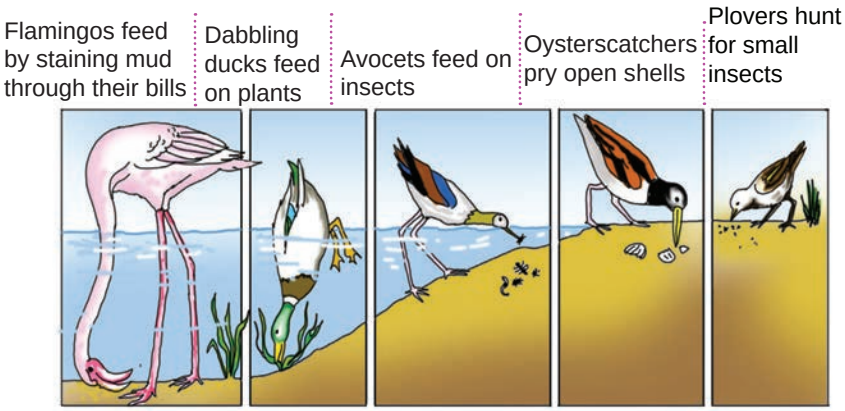

Figure 2.10 Niche of birds

The interactions in the ecosystem may lead to competition, predation, succession and other processes. Evolution and extinction of species are also part of these interactions. These interactions keep the ecosystem in balance. If any thread in the interaction gets damaged, the ecosystem has capacity to mend it and restore the balance. However, if the damage is severe, nature cannot mend the damage. This leads to imbalance in the ecosystem.

Ecosystems are controlled by both internal and external factors like climate and solar radiation. At times, certain biotic and abiotic factors may limit the success or growth of organisms. For instance, plant shows stunted growth in the absence of adequate sunlight. Here, sunlight becomes the limiting factor.

B. Types of Ecosystems

Ecosystems can be generally classified into two types: natural and human made ecosystem. Human made ecosystems are natural regions affected by human interference. Some examples include agricultural systems, urban systems and industrial systems. Natural ecosystem is broadly classified into two major types: aquatic ecosystem and terrestrial ecosystem. Figure 2.11 shows the types of natural ecosystem.

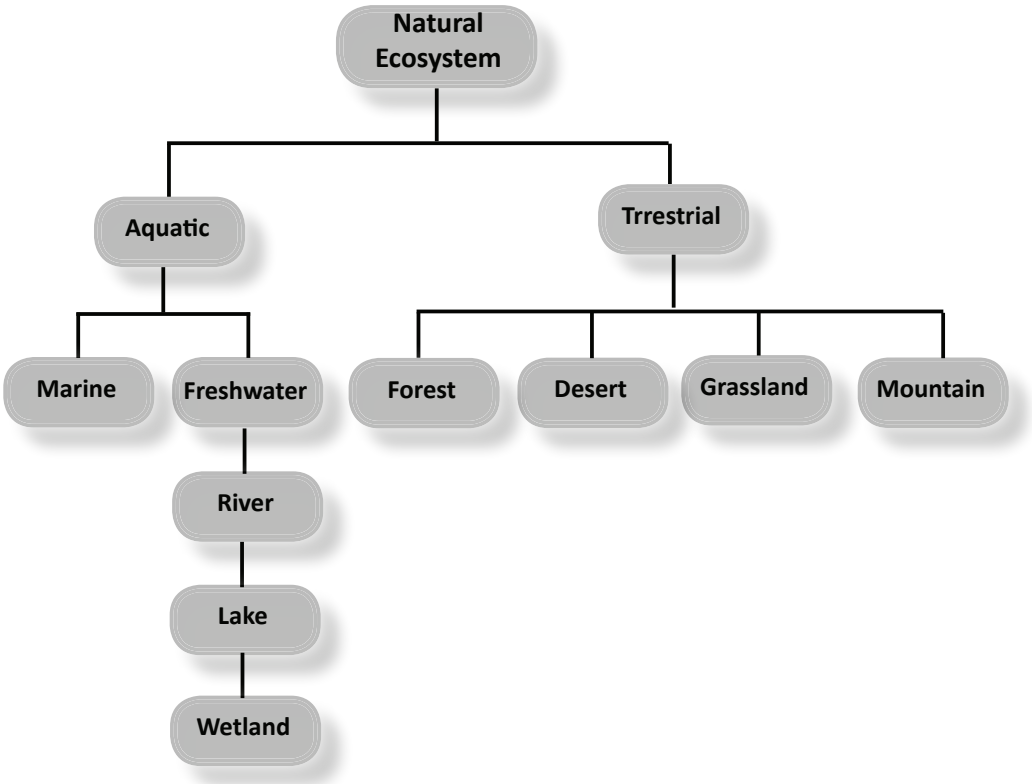

Figure 2.11

In Bhutan, forest is the predominant ecosystem. The aquatic ecosystem is dominated by fresh water, lakes, rivers, wetland and hot springs. The major human altered natural ecosystem in our country is the agricultural ecosystem.

Activity 2.4: Exploring ecosystem.

Materials required: Writing materials like notebook, camera and a pen.

Procedure

1. Visit a nearby ecosystem.
2. Observe and note down all the biotic and abiotic components that are found in the ecosystem.
3. Take photographs and make notes of the habitats, dominant plants and animals.
4. Prepare a presentation using the photographs and the notes. You may even prepare a power point presentation and share your findings with the class. Ensure that your presentation addresses the following points sufficiently.
   - The type of ecosystem that you have visited.
   - Biotic and abiotic components.

- Major habitats.
- Interactions in the ecosystem.
- Levels of organisation in the ecosystem.

Questions

1. Differentiate between environment and ecology.
2. Compare habitat and niche.
3. List some of the major ecosystems in Bhutan.
4. How does the Forest Act of Bhutan contribute towards ecosystem conservation?

Summary

- Everything in the Earth's system can be placed into one of the four major subsystems: land, water, living things, or air.
- There are two types of lithosphere: oceanic lithosphere and continental lithosphere.
- Atmosphere protects life on the Earth by providing vital gases like oxygen for the survival of life, maintaining the temperature of the Earth, and absorbing a large part of the ultraviolet radiation from the Sun.
- Biosphere is also known as ecosphere and it is the worldwide sum of all ecosystems.
- An ecosystem is a community of living organisms (biotic) together with the non living components (abiotic) like air, soil, and water interacting as a system.
- Ecosystem is dynamic with changes occurring due to the influence of external and, or internal factors.
- The geographical distribution of plants and animals is determined by the ecological factors (biotic and abiotic) of the Earth, and the history connected with the tectonic plate (continental) movements.
- Biomes are community of plants and animals that share common characteristics for the environment they thrive in.

Exercise

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

a. The term given to a group of populations of different species living in a given area is _____.

b. The outermost layer of the lithosphere is _____.

c. The two most abundant atmospheric gases are _____ and _____.

d. The two biogeographical zones of Bhutan are _____ and _____.

e. The role and position of an organism in a habitat is _____.

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

a. The subsystem that includes all other spheres where life exits is called

A. Atmosphere.
B. Lithosphere.
C. Hydrosphere.
D. Biosphere.

b. The scientific study of the ecosystems is

A. Zoology.
B. Biology.
C. Ecology.
D. Sociology.

c. A set of ecosystem is called

A. Biome
B. Biogeographical zone
C. Community
D. Subsystem

d. Which of the following determines a biogeographical zone?
   A. Altitude.
   B. Leaf types.
   C. Climatic conditions.
   D. Plant and animals.

e. The major human altered ecosystem in Bhutan is
   A. forest.
   B. agriculture.
   C. industries.
   D. dams.

3. Write TRUE or FALSE for the following statements. Rewrite the false statements in the correct forms.

a. Temperature, precipitation and sunlight are classified as abiotic factors.

b. A single organism can occupy more than one type of niche.

c. An ecosystem is the basic unit of ecology.

d. All individuals of the same species that can interact are known as a community.

e. A population is all the individuals of the different species that can interact.

4. Explain the following .

a. Natural ecosystem

b. Structure of atmosphere

c. Niche of a Takin

5. Answer the following questions.

a. State some human activities that alter a natural ecosystem.

b. 'Clouds are parts of hydrosphere' Justify.

c. Study Figure 2.12 and answer the following questions.

Figure 2.12

i. Identify as many ecosystems as possible from the Figure 2.12.
ii. List different forms of habitats.
iii. Relate the environmental significance of this structure..

d. The following Protected Areas in Bhutan are wide spread across the country.

1. Jigme Khesar Strict Nature Reserve
2. Jigme Dorji National Park
3. Jigme Singye Wangchuck National Park
4. Phibsoo Wildlife Sanctuary
5. Royal Manas National Park
6. Phrumsengla National Park
7. Bumdeling Wildlife Sanctuary
8. Sakteng Wildlife Sanctuary
9. Jomotshangkha Wildlife Sanctuary

i. Why are the protected areas spread across the country?
ii. How does protection of areas benefit the ecosystem in Bhutan?

Balance in Nature - Interaction and Resilience

Balance in nature is the stable state of natural ecosystems in which the communities of plants and animals, interact with each other and with their non living components and coexist in harmony. They interact for resources like food, space and water which lead to interdependence. The interactions steer the changes in the ecosystem, and help to keep the ecosystem stable. The changes in the ecosystem are caused by both external and internal factors.

Solar radiation plays an important role in sustaining life on the Earth and maintaining the balance of nature. The Earth retains solar radiation and maintains the temperature at an average of 15°C. This phenomenon is vital for the survival of life on Earth.

This chapter also explains the nature of interdependence among living organisms, and between living and non living components, the green house effect and the balance of nature.

1. Interdependence in Nature

Learning Objectives

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

- *explain various interactions among living organisms, and between living and non living components.*
- *recognise the interdependence of biotic and abiotic components, arising out of such interactions.*
- *appreciate various forms of interdependence.*

Organism Interactions

Organisms within an ecosystem interact with one another in many different ways. These interactions play an important role in the survival of the organisms and the stability of the ecosystem.

Food chains or food webs describe the feeding relationships between species, and represent the flow of energy through an ecosystem. These types of interactions occur between organisms at different trophic levels.

Besides the interdependence for food, living and non living components depend on one another for water and shelter. For instance, organisms that live in the soil, such as rodents and termites burrow the soil. These animals get shelter, while the soil gets aerated, which is important for plants and other soil organisms to survive.

Symbiosis is a close interaction between individuals of different biological species. One of the organisms benefits from the interaction. The other organism either benefits, gets harmed, or is not affected. There are three main kinds of symbiotic relationships: **commensalism, mutualism, and parasitism.**

Commensalism is a kind of symbiotic relationship, where one of the organisms benefits and the other is not harmed, or helped by the interaction. Often the organism that benefits can either find food more easily, or get protection because of the interaction.

Figure 3.1 Commensalism- Cattle and egrets

For example, in Figure 3.1, egrets often follow grazing herbivores and eat the insects that are stirred up; thereby, help them find their food easily. The grazing herbivores are not affected by the presence of the egrets.

Mutualism is a kind of symbiotic relationship, in which, both organisms benefit. Flowers and their pollinators are one of the most common forms of mutualism. Many kinds of plants depend on insects, such as moths, bees, wasps, and beetles, for pollination as shown in Figure 3.2. The pollinator gets nectar or pollen as food from the flower. The plant in the process gets pollinated.

Parasitism is a symbiotic relationship in which, one organism benefits and the other organism is harmed by the interaction. The organism that benefits is known as parasite, while the other that is harmed by the interaction as host as shown in Figure 3.3. The host is usually impaired slowly over a period of time. Parasites can live either inside or on the body of the host. Fleas and mosquitoes are external parasites that feed on the blood of their hosts. Internal parasites, such as tapeworms and round worms, live inside the body of their host and absorb nutrients from it. In both the cases, the host is affected.

Figure 3.2 Mutualism- Plant and bee

Figure 3.3 Parasitism- Mosquito on the host

Activity 3.1: Interdependence nature

Instruction: Read the story narrated below.

Ap Karpola is a farmer, who lives in a cosy log house in a remote village in Lhuentse. His closest companions are a cat and a dog.

He had three cows. One of the cows felled prey to a leopard last year while grazing in the grass land of the village. Usually, leopards do not enter the village. But due to a severe drought last year, forage plants did not grow well. The population of herbivores, deer in particular, was reduced drastically. The leopard, not getting enough food from the forest, prowled into the village and attacked Karpola's cow.

This year, Ap Karpola is happy. Timely adequate rainfall has improved the forage situation. His cows are getting enough feed and are producing good quantity of milk.

Every morning, Ap Karpola collects cow dung from his cowshed and heaps them in a corner of his kitchen garden for composting. He needs the compost for his kitchen garden. Compost also harbours a host of earthworms, insects and other micro and

macro organisms, especially in summer when it is warm and moist.

In his kitchen garden, Ap Karpola grows different species of vegetables like potatoes, cabbages, broccolis, beans, and chillies. These vegetables demand special care. During summer, he removes weeds at least once a week, and waters his vegetables when there is no rain. Cutworms (caterpillars) attack his cabbages once in a while, and aphides the broccolis. Sometimes, potatoes rot. The Agriculture Extension staff have told him that potato rot is because of bacterial attack.

Ap Karpola also rears some chickens, but they are often taken away by falcons and martens.

Yet, Ap Karpola seems to be happy with his life. His only complaint is that the fleas disturb his sleep at night, and the rats often eat his grains. “At least my cat keeps the rats under control,” he says smiling gaily.

Answer the following questions.

1. Identify and explain different kinds of symbiotic relationships in the story.
2. Why did one of Ap Karpola’s cows fall prey to a leopard?
3. Explain why Ap Karpola removed weeds from his kitchen garden?
4. Evaluate Ap Karpola’s farmyard as an example of “balance in nature”.

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Questions

1. Can an organism be both a consumer and a decomposer? If yes, give reasons citing an example.
2. Explain the roles of animal droppings and farm yard manure in an ecosystem.
3. The action of the decomposers leads to loss of food items. Explain, how nature benefits from the same action.
4. The action of rat eating grains and the cat eating the rats sound like disharmony in nature. But they actually bring harmony in nature. Justify the statements.
5. Study Figure 3.4, and answer the following questions.

Figure 3.4

i. Describe various examples of interdependence of organisms on the tree.

ii. Can the tree be called an ecosystem? Why?

iii. What will happen, if trees are removed from our surroundings?

2. The Greenhouse Effect

Learning Objectives

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

- *explain the phenomenon of greenhouse effect.*
- *list the natural greenhouse gases and their sources.*
- *illustrate the role of greenhouse effect on the temperature of the Earth.*

Energy is necessary for all interactions on the Earth. The Sun is the primary source of energy. Energy is not only important for the preparation of food and other life processes, but it is also crucial for maintaining the temperature on the Earth. Favourable temperature is important for all the ecosystem processes and interactions, including the biochemical reactions in organisms. The greenhouse effect is one of the factors that control the temperature of the Earth.

The Greenhouse

The biochemical processes need a suitable temperature for germination of seed, or growth of plants. In cold countries, seeds do not germinate or plants do not grow well due to low temperature. For this purpose, shelters are made with transparent materials, like plastic or glass covering on all the sides. Such a structure is called greenhouse.

Solar radiation that enters the greenhouse warms the objects inside the greenhouse and radiates energy back into the surroundings in the form of thermal radiation. Plastic or glass does not allow the radiation to escape from the greenhouse. Therefore, the temperature inside the greenhouse remains higher than the outside. This

Figure 3.5 Plastic greenhouse

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effect of the actual greenhouse is similar to the phenomenon of temperature regulation on the Earth by its atmosphere; and thus, the term greenhouse effect. While the actual greenhouse warming is due to convection process, the warming of the Earth is due to radiation process. However, the effects are similar.

The gases responsible for the greenhouse effect are called greenhouse gases. The major natural greenhouse gases are carbon dioxide (CO_2), water vapour (H_2O), methane (CH_4), nitrous oxide (N_2O) and ozone (O_3).

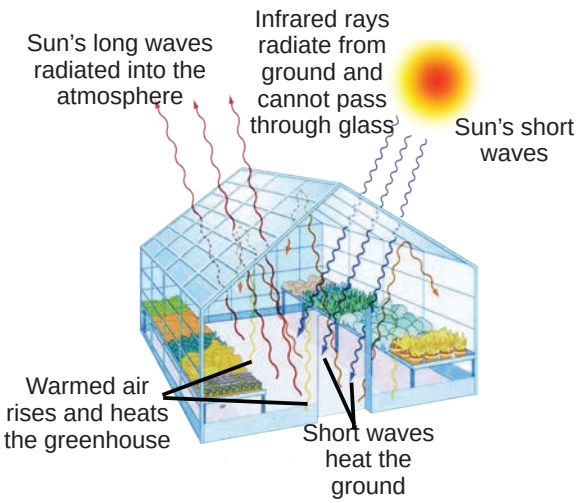

Figure 3.6 Glass greenhouse

Activity 3.2: Identifying sources of greenhouse gases

Instruction: Discuss, copy and complete Table 3.1.

Table 3.1

Greenhouse gases	Sources
Carbon dioxide (CO_2)	
Water vapour (H_2O)	
Methane (CH_4)	
Nitrous Oxide (N_2O)	
Ozone (O_3)	Action of solar radiation

Table 2.1

Answer the following questions

1. Identify two greenhouse gases from the table that are produced in your locality.
2. Why are greenhouse gases, a global concern?
3. Discuss the trend of emission of greenhouse gases in Bhutan?

Human activities, especially burning of fossil fuels, increase the amount of greenhouse gases in the atmosphere. Use of refrigerators, air conditioners, and fire extinguishers produce greenhouse gases like chlorofluorocarbons (CFCs), which are not natural components of the atmosphere. These gases enhance the greenhouse effect, which increase the average global temperature; thus, leading to the phenomenon of global warming.

Questions

1. Define greenhouse effect.
2. Name some greenhouse gases produced at home.
3. Human activities enhance the green house effect. Justify this statement.
4. Analyze the roles of greenhouse effect in the agriculture sector in Bhutan.
5. Why is "green tax" levied on the fuel for cars?

3. Ecological Resilience

Learning objectives:

By the end of the topic, you should be able to:

- *explain homeostasis.*
- *identify the external and internal factors responsible for the changes in ecosystem.*
- *appreciate the dynamic nature and resilience of the Earth's ecosystem.*

Ecosystem is dynamic in nature. Its characteristics, components and composition constantly change due to the influence of both external factors like sunlight, and internal factors like water and nutrients. The increase in temperature, which is an external factor, affects the water availability and soil status. This in turn affects the biological processes in living organisms. For example, during winter, deciduous plants like apple and oak tree shed their leaves in order to reduce loss of water through transpiration. Similarly, animals make certain physiological modifications like sweating, to reduce the heat and maintain constant body temperature.

Depending on the factors, variations in the ecosystem can be slow or rapid. The ecosystem responds to these changes by regulating or adapting to the influencing factors. For instance, temperature is regulated through the greenhouse effect; water balance through the water cycle; and population explosion or dominance of any species through the food chain, essentially by prey-predator relationship.

Activity 3.3: Operation air drop

Instruction: Read the following story.

In the early 1950s, the World Health Organization (WHO) took up a major malaria eradication programme following an outbreak of malaria in Borneo in Indonesia. Large amounts of DDT - a pesticide - were sprayed to kill the mosquitoes that spread malaria. With this, malaria was brought under control, but the roofs of several houses collapsed! It was shocking to learn that DDT was killing not just the mosquitoes, but also a species of wasp that fed on thatch-eating caterpillars. As the number of wasps came down due to DDT, the thatch-eating caterpillars increased. It did not stop here - DDT also killed several other species of insects like cockroaches. These dead and poisoned insects were eaten by house lizards (gecko), which in turn were food for cats. The cats started to die after consuming these DDT stuffed lizards. With the number of cats decreasing, the rat population flourished. World Health Organization, threatened by the possibility of an outbreak of plague and typhus, which the rats would carry, had to parachute live cats into Borneo. This story illustrates, how the introduction of a chemical into a system, that was not originally a part of the system, disturbed the system and its balance. Eventually, several such impact studies led to the declaration of DDT as a hazardous chemical.

Figure 3.7 Live cats parachute into Borneo

Answer the following questions.

1. Draw a flow chart of the events in the above story.
2. What are the advantages and disadvantages of use of DDT?
3. Evaluate the actions taken to restore the balance.
4. What conclusion can you draw from the story?

Balance in nature is a feature of ecology which states that, the ecosystem maintains a status of stability or equilibrium despite the changes. The ability of nature or ecosystem to maintain the stable state is called homeostasis (Greek "homoios" = similar ; "stasis" = standing still). Figure 3.8 illustrates the mechanism of balance in nature.

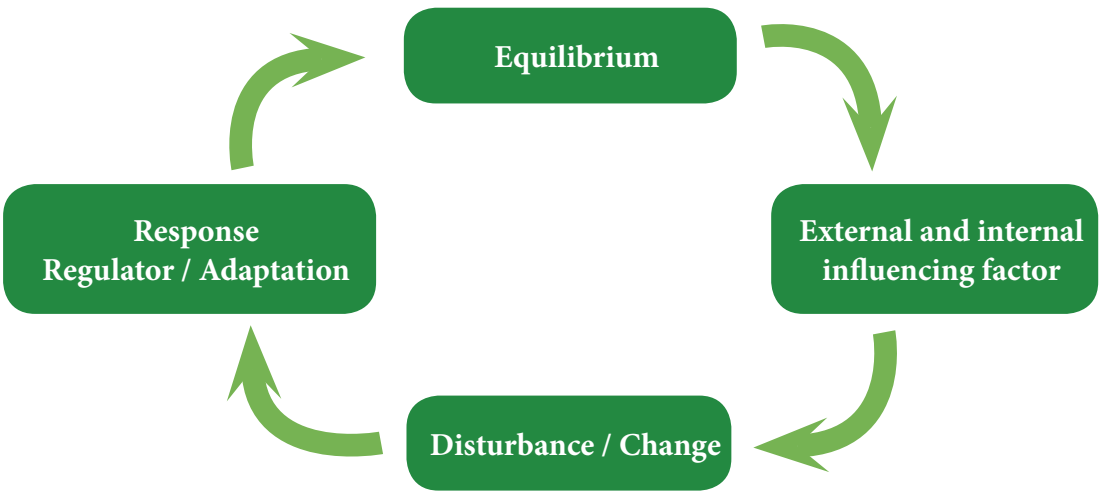

Figure 3.8 Balance in nature

Sometimes changes or disturbances in an ecosystem may lead to ecological resilience, whereby, the ecosystem responds to disturbances and recovers quickly. For instance, when the forest ecosystem is rapidly lost due to forest fire, it receives more sunlight. This may increase the evaporation rates, leading to dry conditions as shown in Figure 3.9. This condition enhances the growth of shrub vegetation. Sunlight interacts constantly with several factors like water and soil. The system then transforms itself from forest coverage into shrub vegetation. Thus, with a new set of components, a new equilibrium emerges in the ecosystem.

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Figure 3.9 Ecological resilience

Ecological resilience occurs in all types of ecosystems. For example, organic waste, thrown into an aquatic ecosystem, is decomposed by bacteria present in water. The decomposed materials, essentially nutrients, are used by a range of aquatic plants and animals, such as protozoa, algae, fungi, crustaceans, snails, water birds, etc. These organisms use dissolved oxygen for respiration. Aquatic plants release oxygen back into the water as part of the process of photosynthesis. All these activities maintain balance in the aquatic ecosystem naturally as shown in Figure 3.10.

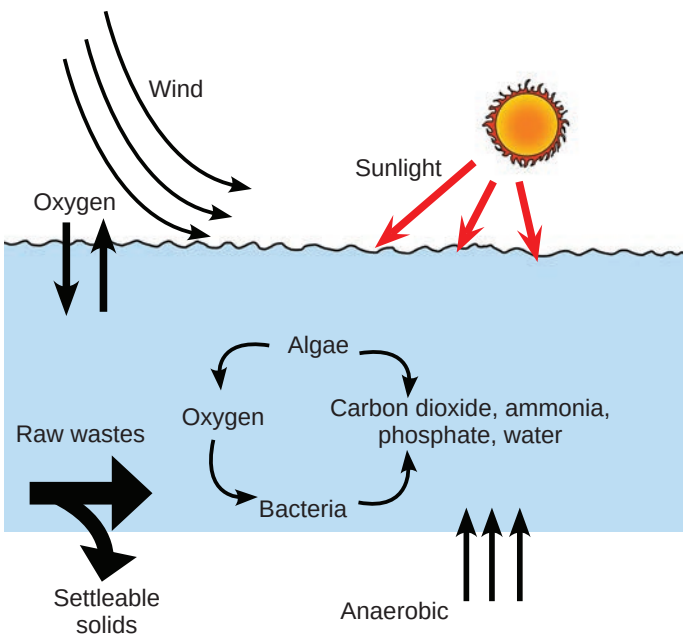

Figure 3.10 Balance in aquatic ecosystem

Activity 3.4: Working together with Nature

Instruction: Study the flowchart below and answer the questions that follow

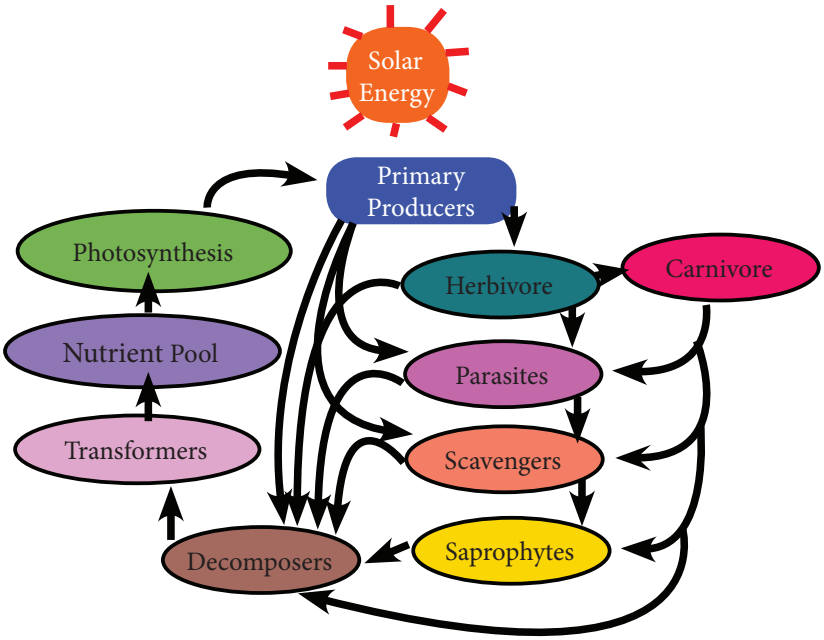

Figure 3.11 Energy flow chart

Questions

1. Relate the flow chart to maintaining balance in nature..
2. If the carnivore link is removed from the chart, what impact would this bring to the ecosystem?

Questions

1. Explain, how homeostasis is achieved in nature.
2. List the external and internal factors responsible for the changes in an ecosystem.
3. Narrate one or two incidences of imbalance in nature, which affected the lives of people in Bhutan.
4. Describe some of the initiatives taken by our government to maintain the balance in nature.

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Summary

- Producers, consumers and decomposers, plays an important role in the food chain and energy flow in nature and are interdependent.
- Interaction of biotic and abiotic factors and their interdependence bring about the balance in nature.
- Symbiosis is a close interaction between individuals of different biological species.
- The three main kinds of symbiosis includes - commensalism, mutualism and parasitism.
- It is because of the greenhouse gases that the Earth is able to maintain an average temperature of 15°C. Otherwise, its average temperature would be minus 18°C, and life on the Earth would be almost non-existent.
- While the Earth cannot support life without the natural greenhouse effect, the enhanced greenhouse effect may cause global warming.
- Ecosystems are dynamic in nature.
- Balance in nature is a feature of ecology which states that the ecosystem maintains a status of stability or equilibrium despite the changes.

Exercise

1. Fill in the blanks with the correct form of word/s.

a. Organisms that live on dead material are called .....

b. The glass or plastic in a greenhouse retains …….

c. Enhanced..... contributes to global warming.

d. The changes caused by …….. always have consequences for the biotic and abiotic part of ecosystem.

e. Interactions between individuals of different biological species is called ……

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

a. Which of the following is not a greenhouse gas?

A. Carbon dioxide
B. Nitrous Oxide
C. Water Vapour
D. Oxygen

b. A mutually beneficial association necessary for survival of both partners is

A. mutualism.
B. commensalism.
C. parasitiem.
D. predation.

c. Oceans and seas are major sources of

A. ozone.
B. carbon dioxide.
C. nitrous oxide.
D. water vapour.

d. The solar radiation that the Earth's surface reflects back is

A. 20%
B. 90%
C. 4%
D. 30%

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e. The organisms that break down the dead remains of plants and animals and release energy are

A. consumers.

B. decomposers.

C. scavengers.

D. producers.

3. Write TRUE or FALSE for the following statements. Rewrite the false statements in the correct forms.

a. A pitcher plant is a primary consumer.

b. A tick that survives on cattle can survive without plants on the Earth.

c. Earth cannot support life without greenhouse gas.

d. The ability of natural ecosystem to regain its normal state after disturbance is called ecological resilience.

e. Earthworm is a decomposer.

4. Write short answers.

a. Describe the role of food chain in the balance of nature.

b. What would happen, if herbivores are removed from an ecosystem?

c. Write any three articles from the Constitution of Bhutan, that relate to balance in nature

d. The Earth's average temperature would be about 33°C lower than what the greenhouse effect can maintain. What would be the temperature of the Earth without the greenhouse effect? Would life be possible at that temperature? Justify.

e. Fill in the blanks

Interaction	Species A	Species B	Examples
.....	Receives benefits	Not affected	.....
Mutualism	.....	Receives benefits	.....
Parasitism	Receives benefits	.....	.....

5. Answer the following questions

a. Taking example of how a carnivore interacts with biotic and abiotic factors, explain about the balance in nature.

b. Explain why farmers use a greenhouse shed to grow seedlings or vegetables?

c. What is the ecological importance of earthworms?

d. Explain the statement, "The natural greenhouse effect is not responsible for global warming."

e. Fill in Table 3.2 by selecting three consequences for each human activity from the list below.

i. Surface soil is removed, killing soil organisms and plants.

ii. The courses of rivers and streams are changed, so that water will flow to the specific place chosen for the dam.

iii. The shape or slope of the land is changed, resulting in different patterns for drainage of rainwater.

iv. Soil and plant life are removed to make space to build factories.

v. Huge numbers of living things are killed or displaced, and must find new places to live. This includes humans, too.

vi. Farmland that is taken over to build roads and buildings, and no longer available to grow crops and livestock.

vii. The packaging, transportation, and consumption of goods generate waste and green house gases.

viii. Land is flooded to create lakes in places where none existed before.

ix. Production process creates wastes that can enter and pollute air, water, and soil.

Table 3.2

Human activity	Possible Abiotic and Biotic Consequences
1. Construction of roads and buildings 	

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2. Dam-building 	
3. Manufacturing and consumption of goods 	

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People & Environment

Chapter

The environment includes all the biotic and abiotic components, along with the human built social, cultural, economic and political attributes, influencing the organism. There are various natural resources found or produced in the environment, such as plants and animals, their products, water, rocks, minerals, etc. Natural resources are vital to human survival and well being. They provide food, fodder, clothing and shelter for human sustenance. They also satisfy the other socio-economic needs of human societies by providing raw materials like wood, fibre, fuel, minerals and other requirements for agriculture, industry, health care and others. Natural resources also play a significant role in the cultural and spiritual life of the people.

Human societies have been interacting with the natural resources since their evolution. In the process, human societies have influenced natural resources and vice versa. As a result, throughout history, major changes occurred in human civilization, as well as natural resources, at different stages of development. As human civilization started taking major strides towards development, there has been a quantum leap in the use of natural resources. What are the consequences of this increased harvest and use of natural resources? Are natural resources everlasting? Can we go on extracting natural resources? This chapter discusses the human dependency and interaction with natural resources, and their impacts on the environment

1. Environment and Natural Resources

Learning Objectives

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

- *list natural resources.*
- *classify natural resources.*
- *discuss the significance of natural resources for Bhutan.*

Natural resources are materials supplied by the earth and its processes, and includes things in the physical environment used for housing, clothing, heating, cooling, transportation and to meet other human wants and needs. For example, trees are used for construction, animals for food, clothing and medicine, minerals and fossils for power, transportation, heating and cooling. These resources include soil, air, water, forest, wildlife, fish, fossil fuels, metals and minerals.

A. Classification of Natural Resources

The biotic and abiotic components that occur or produced naturally in the environment are all natural resources. Several of them, like water, plants and soil are essential for the survival of humans, while others like gold are not. Human societies use some of the natural resources, such as water directly. However, several other resources are used as raw materials to produce other goods and resources. For instance, fossil fuels are processed to get petroleum; iron ores are processed to manufacture steel; and wood is used to produce paper. Every human-made product is composed of one or several natural resources.

Natural resources are classified in various ways, based on their origin or source, development process, availability and their uses.

Activity 4. 1: Organise your resources

Instructions:

1. Table 4.1 represents the classification of natural resources based on their characteristics. Column A contains the classification and column B is the characteristics for classification.
2. Discuss and match the type of category with the corresponding criteria.
3. Share your work to the class.

Table 4.1 : Natural resources and their classification

(A) Classification	(B) Characteristics
1. Biotic and abiotic resources	Resources that can be renewed in one human life cycle. Examples: plants, animals (also known as biomass), water Resources that cannot be renewed in one human life cycle. Example: fossil fuels
2. Renewable and non-renewable resources	Living Resources. Examples: plants, animals, microbes Non living resources. Examples: soil, water

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(A) Classification	(B) Characteristics
3. Exhaustible and non exhaustible resources	Resources which have been in use for a long time. Examples: minerals, petroleum, water Those resources that are recently developed/recognised or still in the process of development like some of the plant and animal products, wind, tide.
4. Conventional and non-conventional resources	Resources that do not run out upon use in the foreseeable future. These are infinite resources. Examples: sunlight, water The vast majority of natural resources deplete upon continuous use in the foreseeable future. These are finite sources. Examples: coal, oil
5. Potential and actual resources	Resources that are found everywhere (omnipresent). Example: Sunlight, air Resources that occur in pockets, restricted to only some locations.
6. Ubiquitous and localised resources	Resources that are available for future use. Example: Mineral resources, coal Resources that are available for present

B. Types of natural resources

Some of the commonly used natural resources are as follows:

Forest resource

Figure 4.1 Forest Resource

Forest is a complex combination of natural resources, including land, soil, water, plants, animals, and microbes. Roughly 30 percent of the land area across the world is covered by various types of forests. The World Wide Fund for Nature (WWF) estimates that three hundred million people worldwide live in forests, and 1.6 billion depend on them for their livelihoods. The major forest related activities are hunting, lumbering, herding, and gathering of natural products like fuel wood, fodder, gum, resin, wax, and medicinal herbs. The vegetation of the forests produce oxygen, absorb carbon-

dioxide, retain ground water, check soil erosion, protect biodiversity, all of which are vital ecosystem services.

Water resources

Figure 4.2 Hydro power

As one of the valuable natural resources that support life on Earth, water covers 70 percent of the earth's surface. Like land and forest, water is also a complex combination of rich resources, harbouring millions of life forms and minerals. Besides their survival, human societies use water for the production of food and goods, including electricity. The major water based activities related to livelihood are hydropower, irrigation, fishing, extraction of minerals, transport, tourism and sports.

Mineral resources

Figure 4.3 Mineral (coal)

Minerals, both metals and non metals, form the key raw material for an array of activities, like construction, manufacturing, agriculture, and cosmetic industries. Mineral resources are processed further for obtaining products like steel, copper, petroleum, etc. These products are used in our daily lives for electricity, housing, automobiles, machines, computers, and other household items.

Land resource

Land is a major resource. It covers almost 149 million square km of the Earth's surface. Land is utilised for various purposes like forest, settlement, agriculture, industries and so on. The most important and direct use of land, in Bhutan, is for agriculture. Soil, minerals and rocks are all integral parts of the land resource, which influence the growth of plants.

Activity 4.2: Eco-friendly planning

Instruction:

1. Ask students to close their eyes and picture the community where they live.
2. Once they are done, ask them to picture what the area might have looked like before the community was built in the area. Tell them to picture the kind of animals, plants, water resources, landscape, etc., before the settlement.
3. Ask for about five student volunteers who would be responsible to carry out a simple research to find out more precisely what the land, vegetation, wildlife, water, etc., was like before the community was built.
4. The volunteers will report to the rest of the students about their findings, so that they are able to picture clearly of how it was like before.
5. Divide the class into groups, making sure that there is at least one volunteer student researcher in each group.
6. Once the groups are formed, tell the groups to design a community where people live and work with least negative effect on the natural resources, while still meeting the needs of the people.
7. The groups after having developed the community plan sit with your teacher and review the plan.
8. After the review, students in their groups build a model of the community that they have designed.
9. After all the groups have finished developing their model, exhibit the models to rest of the students in the school, explaining the features of the community, keeping in mind the environmental concerns.

Answer the following questions:

1. Make a list of natural resources the early settlers used to build the community.
2. Make a list of ways, people in your community directly or indirectly contribute to environmental problems.
3. Describe ways to lessen activities in your community, which contribute to environmental problems.

Questions

1. Water covers 70 percent of the earth's surface and supports life on the Earth. Explain the statement.
2. Why do we need to manage our resources?

2. Human Dependence on Natural Resources

Learning Objectives

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

- *explain the socio-economic provisions of natural resources.*
- *list the natural resource based livelihoods.*
- *explain the cultural and spiritual significance of natural resources.*

Natural resources are the basis for human survival and growth. Humans depend on natural resources for their sustenance and their wants and desires. Human migration and settlement have been regulated by the availability and abundance of natural resources. If you trace the human history, settlements have always been along the river valleys. Water sources have always been the centre of production for agriculture and industrial growth.

Natural resources such as air, water, biodiversity are essential for survival, while other resources, like petroleum are used for non essential purposes such as transportation. Natural resources are also processed into goods and services for various essential and non-essential purposes. For instance, land is cultivated to produce crops and minerals are processed to manufacture a variety of goods like steel and electricity.

Dependence of human beings on the natural resources can be studied under the following provisions.

A. Socio-economic provisions

Natural resources provide a means of livelihood to human societies. Besides securing the basic necessities like food, water, shelter and clothing, natural resources also help generate income, which is much needed for improving the social conditions of human societies, such as health and education. Thus, natural resources provide a means of making a healthy and happy living.

Figure 4.4 Bamboo Weaving

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People who live very close to natural resource bases are directly dependent for their livelihoods through collection and sale of fruits, seeds, fuel wood, honey and medicinal herbs. For instance, in Bhutan, majority of the population depend on forest resources for their livelihoods, like basket weaving, wild mushroom, and medicinal plant collection.

Figure 4.5 Cinchona tree and its bark

People who live away from natural resource bases, indirectly depend for raw materials for agriculture, industry, trade, tourism, medicines and others. For example, quinine, a malarial drug, is extracted from cinchona tree bark.

Figure 4.6 Lemon grass

The availability and use of natural resources directly contribute to the growth of human societies and countries as a whole. In fact, the availability of natural resources is considered as one of the important socio–economic indicators of development of a country. Therefore, natural resources are referred to as natural capital, and their economic values are calculated and included in the national growth.

In case of Bhutan, the rich forest resources are the major contributing factor to the national economy. Hydropower, tourism, forest based industries, forest produce, all add to the national economy. It is reported that the livelihood earned from these natural resources support majority of the Bhutan's population.

Figure 4.7 Ophiocordyceps sinensis

Health care needs a special mention here, since nature provides different raw materials, which can be directly used, or processed to make medicines contributing to health care. In developing countries, majority of the population depends on indigenous medicines for primary health care, which are almost entirely extracted from plants. In Bhutan, for instance, Ophiocordyceps sinensis (a sac fungi) and lemon grass are highly valued medicinal plants. More than 600 plant species are being used in traditional medicines. Hot springs in Bhutan, with their diverse mineral content, are believed to possess curative powers for skin diseases and other ailments.

Activity 4.3: Exploring the use of traditional medicines in the locality

Instructions:

1. Talk to your parents, neighbours and elders in the locality, and ask about the home remedies used for various treatments.
2. If your neighbourhood/locality/society has traditional health care providers, discuss with them about the most common diseases and their treatments, status of the source for medicines, etc.
3. Document your findings in the following format for each medicine

Table 4.2

Plant or animal part used	Disease/problem for which it is used	Source	Process involved in preparing the medicines

Answer the following questions

1. Which plant or animal parts are commonly used in your locality?
2. What is the general habitat of medicinal plants?
3. What are the common diseases healed by indigenous medicines in your locality?
4. What are the challenges faced in accessing the resources for indigenous medicine?
5. What are the changing attitudes towards the indigenous medicines? Based on this, predict the future scenario as you see it.
6. Discuss the advantages and disadvantages of indigenous and allopathic treatments.

B. Cultural and spiritual provisions

Culture is a way of life shared by a group of people adapted to their physical environment, patterned by nature and natural resources. The type, availability, and the ways of utilisation of natural resources have shaped the culture of human societies, since time immemorial. For instance, people in the higher altitude of Bhutan, lead nomadic life. They live in tents made from yak hair. Their livelihood depends on yak and their products, like meat and milk. Their life is woven around those resources, which are available to them. Thus, coexisting with nature, human societies have developed unique cultures, traditional practices, and rich knowledge of natural resources.

Nature and natural resources have been the spiritual means of connecting people with nature, society and their religious belief. Communities revere natural resources like mountains, water bodies, and forest as a source of spiritual inspiration and beliefs. Many societies across the globe attach spiritual meaning to nature, and believe several

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natural features as sacred. Linking nature with spiritual practices has strengthened the attempts to preserve natural ecosystems.

Figure 4.9 Tang Membar Tsho

In Bhutan, communities consider all forms of life and the environment sacred. They see forests as a valuable source of spiritual health. Resource harvest is prohibited in places, where deities are worshipped. The belief that forests, rivers, lakes and mountains contain spirits, and are guarded by protective deities has helped to preserve the country's natural resources.

Besides the cultural and spiritual framework, natural resources are an unparalleled source of beauty, peace and inspiration for human societies. This is apparent in the religion, tradition, art, including nature photography, film-making and nature watch.

Activity 4.4: Community-Based Sustainable Tourism in Phobjikha

Instruction: Read the following extract and answer the questions that follow. The

The Gangtey-Phobjikha valley in Wangduephodrang district of Bhutan is an important wetland conservation area. Besides this significance, Gantey-Phobjikha valley is well known for the winter habitat of Black-necked Crane. An average of over 400 cranes resides in the valley for the winter months, which is the largest winter non-breeding habitat outside China. The valley is also home to about 5000 people, who are dependent on subsistence agriculture, small scale forest management, and livestock rearing. Phobjikha is a place with a classic example of the environmental problems/ challenges, emerging from human livelihood development. As the crane habitat is shared with human land use and developmental activities, potential threats to the stability of the wetland is expected to arise from any change in the land use pattern, and the parallel changes in the social and economic needs of the people.

However, given its unique and picturesque landscape, Gangtey-Phobjikha valley is already a popular tourist destination. Ironically, the local people had benefited very less from the tourism industry as they lacked the capacity to provide either services, or products to cater the needs of the visitors. Most tourism facilities in the valley were owned by people from outside the valley. Therefore, in 2003, the Royal Society for Protection of Nature initiated the Community-based Sustainable Tourism (CBST) project under its conservation

and sustainable livelihood program. It was to develop a tourism program that is environmentally conducive, and favorable to the local economic interests, as it was essential to bring benefits to the local people. This was also expected to lead to community ownership of local resources, and responsibility for the preservation of their cultural and natural heritage, which are crucial for long term conservation.

Since 2011, the community-based sustainable tourism was able to build the capacity and skill of the local community to provide different community tourism services, such as home stays, local guides, local souvenir / handicrafts. The project also contributed to developing and organizing various culture and nature related tourism activities.

A community-based sustainable tourism group that is responsible for management and coordination of the local tourism program and services has been formed in 2012. The group consists members from home stays, local guides, and representatives from the Gangtey-Phobjikha Environment Management Committee (GPEMC). The GPEMC is a local community environment management committee, comprising of representation from the local government, government sectors, local women group and monastic institution.

Currently, the total income of the CBST group members within one year has been, approximately, over Nu. 600000.00. From the total income, 3% is contributed to the Phobjikha Conservation Fund, and 7% is contributed to sustain the management costs of the group, while the rest is distributed to the specific service providers.

Currently the main issue faced is the communication gap of the household members and the guests during the period, when the guides are not with them. This has the risk of creating miscommunication between the host and the guest, leading to unsatisfactory experience. With the community-based sustainable tourism becoming a success story in Gangtey-Phobjikha, there is a risk of other people in the community replicating the similar services without understanding the value of sustainable tourism. In that case, it is very important that the communities are made aware about the sustainable tourism, and how the benefit is connected to preservation of natural and cultural resources. The growing numbers of tourist visits in Gangtey-Phobjikha may even challenge the carrying capacity of the resources and services in the area.

The community-based sustainable tourism project in Gangtey-Phobjikha has been able to develop a demonstrative sustainable tourism practice, which has increased the awareness of the local communities to conserve the Black-necked Crane habitat and other associated species for sustained tourism generated income. Most importantly, Phobjikha valley has a mechanism to empower communities, including women and youth, who will take ownership of their resources and continue to practice conservation through sustainable tourism.

Answer the following questions

1. Describe the importance of Gangtey-Phobjikha valley.
2. What were the challenges faced towards the conservation of ecology?
3. What is the new initiative taken to conserve the ecology?
4. Explain community-based sustainable tourism.
5. How has this initiative benefitted the community of Phobjikha valley?

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6. Discuss the potential future risk to the ecosystem posed by human-wild life conflict.

C. Ecological Provisions

Natural resources are closely linked to ecological services such as providing oxygen, absorbing carbon dioxide, retaining groundwater, preventing soil erosion, decomposition of waste materials, and preservation of biodiversity. Human societies are benefitted by these multitudes of services.

Questions

1. List the livelihoods that are directly linked to natural resources in Bhutan.
2. Name five ecological services of forests.
3. Describe the role of forest cover in retaining the ground water.

3. Natural Resources and Human Societies - The Changing Relations

Learning Objectives

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

- *relate the changes in human societies and the use of natural resources..*
- *explain the impact of human activities on the natural resources.*
- *describe the pattern of migration and its impact on the livelihoods and environment of Bhutan*

Human societies have been interacting with their environment, harvesting and utilising natural resources, since their evolution. Transformation of human societies, from hunter-gatherer to agricultural and industrial societies, has brought in major changes in the resource use pattern. From basic sustenance, human societies are moving towards extracting a range of natural resources and processing them for a wide range of goods and services, which are desirable but not essential. At every stage of human evolution and growth, natural resources have continued to shape our lives and lifestyles, and vice versa.

A. The human societies and natural resources

The hunter-gatherer society directly depended on natural resources for their basic needs like food, clothing and shelter. They hunted wild animals, gathered wild roots and fruits for food; used rocks, stones and wood for shelter; and used fur and leaves for clothing. With domestication of animals for food, clothing and transportation, the pastoral society emerged. Specialised occupations based on natural resources, like agriculture tool making, basket weaving and leather goods production, changed the nomadic lifestyle of human societies. With the growth of agrarian societies, settled life began in the river valleys and plains. The improvement in agriculture led to surplus food production and the settlements grew bigger.

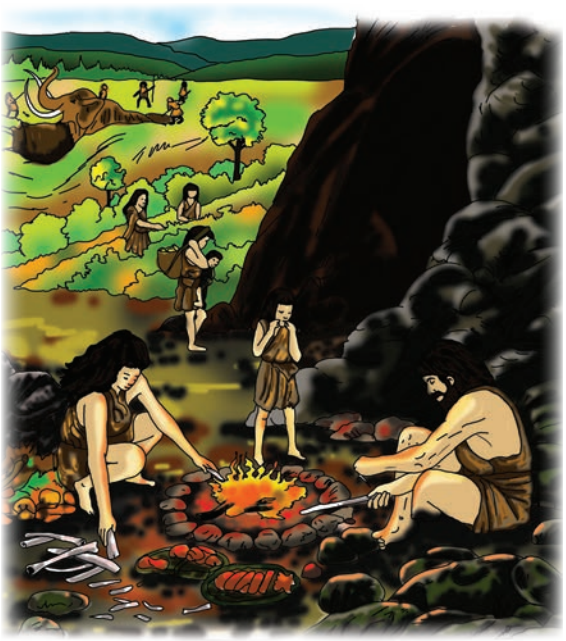

Figure 4.10 Hunter-gatherer society

Trade increased with the onset of the industrial revolution in the 18th century. As a result, urbanisation began and settlements grew bigger. Human societies started exploiting and processing natural resources, such as land, coal, iron-ore, timber, rubber, and so on for goods. Thus, humans started changing the natural environment to their advantage. Masses of people migrated to urban centres as they provided them with new, non agrarian livelihood opportunities, like trade and commerce, construction, and administration. With all this, came the lifestyle changes.

Figure 4.11 Industrial Revolution

The progress of knowledge in science, and the invention of newer technologies have improved the health and the living standard of human society. For instance, the use of fuel-efficient stoves in schools and houses in Bhutan have reduced the use of fuel wood, and minimized the respiratory diseases. However, the advancement in science and technology has contributed to the exploitation of natural resources. The coexisting

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relationship between human societies and the nature, and the perception that nature is central to human survival, are changing.

All of these have impacted both the quantity and quality of the natural resources. Declining forests, biodiversity loss and water shortages have reduced the quantity and availability of resources; land and soil degradation and pollution have reduced the quality of the available resources. The consequences of natural resource degradation are reflected on the economic and social parameters such as reduction in income and in availability of food, health issues and others.

Activity 4.5: Settling of Societies

Instruction:

Find out from the elders, library, folklores, internet, etc. the following information about your locality.

- When did the settlement begin?
- Who were the first settlers?
- What were the factors that influenced the settlement?
- Compare the livelihood practices then, and now? Note down the significant changes in the environment.
- Present the information gathered in a suitable format.

B. Migration and its impact on livelihood and environment

Migration is the movement of living organisms from one place to another. Animals migrate mostly for food, shelter and reproduction. Migration may involve individuals, families or even larger groups of populations. People migrate to improve their livelihood. Nomadic migration in the case of humans is, generally, not considered as migration as it is seasonal. The UN describes migration as 'The movement of a person or a group of persons, either across an international border, or within a State. It is a population movement, encompassing any kind of movement of people, whatever its length, composition and causes; it includes migration of refugees, displaced persons, economic migrants, and persons moving for other purposes, including family reunification'.

Migration has been the way of life, since the beginning of human evolution. Prehistoric human migration, probably, began a million years ago like any other animal, in search of natural resources like food, water, and at times due to climatic variations. Availability of natural resources has often been the reason for migration.

Early human societies have moved from continents to continents. As agriculture developed, human societies started settling in areas rich in natural resources. However, with the industrial revolution in the 18th century, the modern migration began. With this revolution, high levels of urbanisation spread across the world. The pace of migration increased in the 19th century, mostly for work and opportunities that the urban centres offered.

Figure 4.12 Migration

Activity 4.7: Migration in Bhutan

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

Gleaning data from Population and Housing Census (PHCB), 2017, shows the patterns of internal migration by dzongkhags/thromdes and rural/urban migration streams. Internal migration is defined as the change of residence from one geographical unit (place of origin) to the place of destination, crossing defined territorial boundaries or communities within a community. The geographical unit refers to gewog/town, thus internal migration is change in residence across gewog/town. Migrants and non-migrants are classified based on the place of birth. The measure of internal migration with the use of place of birth is referred to as lifetime migration and the individual making the move as lifetime migrants.

Of the total 686,697 person born in Bhutan, 334,185 persons have migrated between gewog/town at some point since their birth. Of these migrants, 51.0% are males and 49.0% are females. The migrant population is largely made up of people in the younger age groups; the maximum are found in the age group 25-29 years where 66% of them changed their place of residence at least once. As the classification of migrants is based on the place of birth, having lesser migrants in the older age groups (50 years and older) is an indication that most people in the past did not change their place of residence and that migration is a more recent phenomenon.

From the total migrant population of 334,185 persons, 273,607 persons have changed their dzongkhag/thromde since birth. This is the total number of lifetime migrants among dzongkhags/thromdes and accounts to 39.8% of the population born in Bhutan. A total of 186,110 persons in the country have migrated across regions. Figure 4.13 shows the intensity of flow of migrants between the four regions. The flow of migration is higher from the three regions (eastern, central western, and central eastern) to the western region

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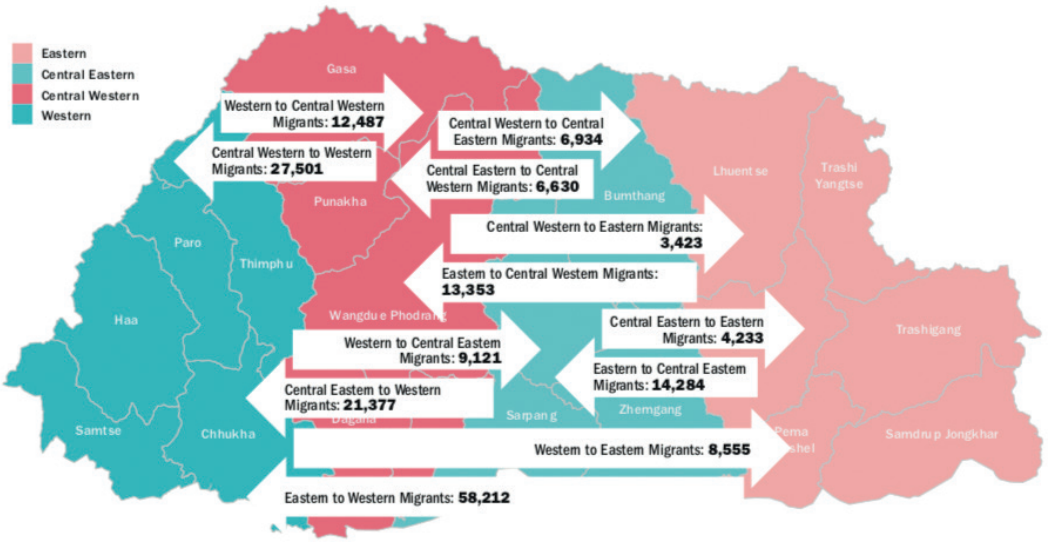

Figure 4.13 Directions of migration by Regions (Source: PHCB, 2017)

Out of 20 dzongkhags and 4 thromdes, 12 dzongkhags have lost their population due to out-migration, while 8 dzongkhags have gained populations due to in-migration. All four thromdes have gained population due to internal migration. In absolute numbers, Thimphu Thromde gained 68,310 persons and lost 20,096 persons, accounting to a net gain of 48,214 persons. Zhemgang, Lhuentse and Trashigang are the top losing dzongkhags with a net loss of about 640, 593, and 547 persons per 1000 population respectively. In absolute numbers, Trashigang Dzongkhag lost 31,930 persons and gained 8,394 persons, accounting to a net loss of 23,536 persons.

Migration stream by urban rural occur between urban and rural area in four streams. The four flows of migration are urban to urban, urban to rural, rural to urban, and rural to rural. The rural to urban flow of migration is the highest accounting to 21.7% of all the population born in Bhutan and 44.2% of all the migrants. Rural to rural makes up the second largest stream with 18.0% of the total population born in Bhutan and 36.6% of the total migrant population.

The most cited reasons for migration are family move, employment, marriage, transfer of workplace, resettlement and education. As migration is mostly a young cohort phenomenon, dzongkhags with high migration rates are found to have higher composition of elderly population of age 65 years and older. Depopulation of educated and young people in the rural villages will continue to accelerate the decline of farming and localized culture, because ancient village-specific culture that took ages to form cannot be replicated in the new cities. An overwhelming level of Bhutanese population residing in, what may finally be a dozen cities, will have major internal security consequences. The internal security challenge will come about because of multiple pressures that the urban population will exert on the State to house, educate, medicate and employ them. The explosive size of urban population, if migration is not tackled, will challenge the State curb down communicable diseases, pollution

of land, air and water. The facilities that have been already created in the villages go waste. Not only so, main asset of the Bhutanese people in the form of common facilities, cropland are fallow and houses back in the villages are empty resulting in gungtongs (empty houses).

The Prime Minister in The State of the Nation report 2017-18 stated that the government has been doing a lot such as construction of farm roads, providing electricity and telecommunication services to villages, initiating programs to support agriculture like distribution of power tillers, installing electric fencing and facilitating rural loans through funding windows like the Rural Enterprise Development Corporation. Additionally, in the 11th Plan, 187 farm shops were established and 200 gewog banks were opened.

Questions

1. What is the general trend of migration according to the 2017 population and housing census?
2. Distinguish between out-migration and in-migration?
3. Distribution of the population is clearly concentrated in the western region. Identify some of the consequences of migration in the region.
4. What are the negative impacts of rural to urban migration on the environment?
5. What are the initiatives taken by the government to discourage rural to urban migration?

Do you know?

It is reported that the biggest mass migration of human history is currently happening in China. It is estimated that around 345 million people will move from the rural China to the cities in the next 25 years creating an urban boom. According to some, this will be the second Industrial Revolution.

Rural to urban migration has both positive as well as negative impacts on livelihoods and the environment. Some of these impacts are listed in Table 4.3.

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Source: http://www.thebhutanese.bt/migration-in-bhutan-to-the-west-and-towns/

Table 4.3 Impact of migration on the environment and livelihoods

Positive Impact	Negative Impact
• Increase in job opportunities. • Availability of different types of jobs.	• Rapid urban growth leading to resource crunch. • Pressure on the urban land and growth of slums.
• Enhancement in household income. • Improvement in social conditions like better health, sanitation, education. • Decrease in direct pressure on the natural resources and the environment.	• Increase in natural resource harvest for commerce and trade. • Natural resource processing for generating new products, to satisfy the human desire and comfort. • Export of natural resources from rural to urban centres. • Decrease in the availability of natural resources for sustenance and livelihood in rural areas. • Decrease in agricultural production due to labour shortage and increase in fallow land. • Changing relationship of human societies with nature and natural resources, and slow death of cultural and spiritual values.

Questions

1. What are the environmental impacts of human dependence on natural resources?
2. Explain migration with an example.
3. Compare the impacts of human migration in Bhutan and in other countries.
4. What are the impacts of migration on natural resource use?

Summary

- The biotic and abiotic components, that occur or produced naturally in the environment, are all natural resources.
- Natural resources are grouped in various ways, based on their origin or source, development process, availability and use.
- Human migration and settlement have been regulated by the availability and abundance of natural resources.
- The availability and use of natural resources directly contribute to the growth of human societies and the countries as a whole; and for this, they are considered as one of the important socio-economic indicators of the development of a country.
- The rich forest resources are the major contributing factor to the national economy of Bhutan, as they support hydropower, tourism, forest based industries, forest produce, etc.
- Coexisting with nature, human societies have developed unique cultures, traditional practices, and rich knowledge of natural resources.
- Besides the cultural and spiritual framework, natural resources are an unparalleled source of beauty, peace and inspiration for human societies. This is apparent in the religion, tradition, art, including nature photography, film-making, nature watch and, so on.

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Exercise

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

a. In which of the following resource classification, time is not a factor?

A. Biotic - abiotic.

B. Renewable – non renewable.

C. Potential - actual.

D. Conventional - non conventional.

b. Everyone is in one way or the other dependent on natural resources. From the choices given below, who is the most dependent on natural resources?

A. Farmer.

B. Painter.

C. Hotelier.

D. Teacher.

c. Resources which can be renewed are called renewable resources. Which of the following is an example of renewable resource?

A. Coal.

B. Petroleum.

C. Iron.

D. Water.

d. Which one of the following does not relate to ecological provision of natural resources?

A. Dwarf bamboos in high altitude prevents soil erosion.

B. Limestone are mined for cement factory.

C. Earthworms till the soil in farmland.

D. Forest is the carbon sink for the Earth.

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

a. Every human made product is composed of ..... at its fundamental.

b. The most important use of land is for .....

c. Resources that can be renewed in one human life cycle are called.....

d. Migration from rural to urban areas happen mainly for .....

e. Culturally, Bhutanese consider all forms of life and the environment .....

3. **Write TRUE or FALSE for the following statements. Rewrite the false statements in the correct forms.**

   a. Hunting and gathering societies consumed the maximum amount of natural resources.

   b. The use of natural resources for spiritual practices helps in the preservation of Nature.

   c. Rural to urban migration increases resource consumption in the context of Bhutan.

   d. The reasons for and patterns of migration have not changed with the evolution of human societies.

4. **Match the items of Column A with the most appropriate items of Column B. Rewrite the correct matching pairs.**

Column A	Column B
a. Socio-economic	i. Waste recycling
b. Cultural	ii. Dipping in hot springs for skin treatment
c. Health care	iii. Forests, lakes and mountains are sacred
d. Spiritual	iv. Bamboo mat weaving

5. **Answer the following questions.**

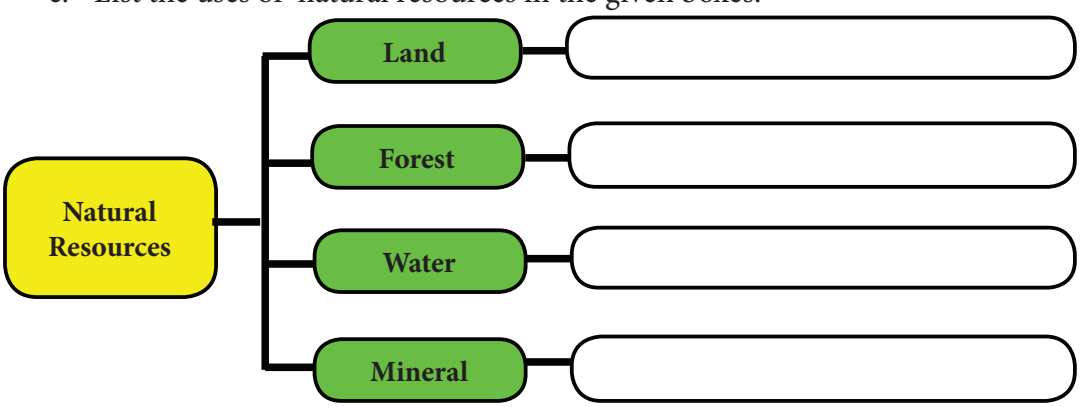
   a. Explain the significance of natural resources.

   b. Summarise the relationship between people and natural resources.

   c. Discuss migration patterns.

   d. Give an account of any of the two major natural resources used by human societies.

   e. List the uses of natural resources in the given boxes.



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f. Describe different ways of classifying the natural resources with example each. Explain the importance of the classification system.

Natural Resources Degradation

Change is a characteristic feature of ecosystems. Change occurs due to the constant dynamic processes and interactions between biotic and abiotic components, and the influence they have on one another. Change disturbs the balance of ecosystems and their functions. However, with time, ecosystems mend these disturbances and, or adapt to these changes to reinstate the homeostasis.

The time taken to re-establish the balance of ecosystem depends on the nature of the disturbance. However, in recent years, human activities have put unprecedented pressure on the natural resources, and disturbed the ecosystems and their functions. The major concern is that the changes in ecosystems brought about by these disturbances are difficult to reverse.

This chapter discusses the causes and impacts of disturbances and pressures on the natural resources and ecosystems.

1. Disturbance of Natural Resources

Learning Objectives

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

- *identify the major causes of disturbance to the natural resources.*
- *differentiate between natural and anthropogenic causes.*

Natural resources that support life on the Earth interact with both internal and external factors. These factors may influence their processes of interactions, which may disturb the natural resources and bring about changes in the ecosystem. Sometimes, changes are so severe that it may take hundreds of years for the ecosystem to regain its original state. At times, the ecosystem as a whole may change. Non-availability of water for several years may change a forest cover into desert vegetation, as in the case of the Thar Desert in India. Several studies indicate that the Thar Desert (Figure 5.1) was once rich in water resources and the Indus Valley Civilisation flourished in this region.

Figure 5.1 Thar desert

The factors that influence natural resources may be natural or human induced. All the human activities influencing the natural resources and ecosystems are anthropogenic factors. In recent years, human activities have significantly changed or permanently damaged the natural resources and ecosystems.

A. Natural causes

Flood

It is the overflow of water that submerges landscapes. Floods occur due to sudden weather or climatic variations. Heavy precipitation, glacial lake outburst, and the change in course of rivers and streams generally cause floods. Floods are responsible for formations of sedimentary rocks, creation of islands, valleys and enrichment of soil through silt deposits.

Figure 5.2 Damages by floods

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Floods disturb life in a region by causing death and migration of organisms. Floods erode fertile soil, cause landslides, and change the quality of water sources by soil deposition. Floods also disturb human life and property (Figure 5.2). For example, the flash flood caused by glacial lake outburst in Lunana in 1994, affected the settlements along the entire river valley.

Drought

Figure 5.3. Drought affected area

Scanty or lack of precipitation reduces the water resources in a region. This prolonged condition leads to drying up of water resources, causing droughts. The drought affected area (Figure 5.3) may become unfit for plant growth, human settlement and survival of life forms. In such situations, living things either adapt to changes or migrate. Severe and prolonged droughts may permanently alter the ecosystem.

Landslides

Landslides are mass movement phenomenon that are generally triggered by an interplay of two or more factors. These includes natural factors such as earthquakes, heavy rainfall, unstable geology, steep terrain and human.

Figure 5.4. Landslide

Activity 5.1: Cause and effect of landslides

Instructions:

Work in groups and recollect the occurrence of landslides in Bhutan. Or, do a library research.

Discuss on the following:

1. Causes of landslides.
2. Effects of landslides on the environment and the people's livelihood.
3. Initiatives of the government and community to prevent landslides.
4. Measures that you would take to minimize landslides in your locality.
5. Share your findings and suggestions with the class.

Windstorms

Windstorms such as cyclone, tornado, gale and hurricane are caused by weather variations. Weather variations are usually caused due to drastic change in atmospheric pressure across the region. Wind speed during a wind storm may exceed 55 km/hr. Bhutan has experienced destructions due to windstorms, snow and hailstorms. In 2013, the storm damaged over 300 houses, several structures, many acres of crops and farm (Figure 5.5).

Figure 5.5. Houses affected by wind storm

Wildfires

Wildfire or forest fire is caused due to lightning, volcanoes, or high atmospheric temperatures in dry weather conditions IFigure 5.6). Forest fires are also caused due to human negligence while cooking in open areas, burning waste, throwing cigarette butts, slash-and-burn farming practices, etc.

Figure 5.6 Forest fire

Wildfires can cause death of life forms, loss of forest vegetation,damage to land, drying up of water resources and damage to human properties.

Forest fires are the major cause of forest degradation in Bhutan. A series of fire outbreak in different parts of Bhutan every year causes social, economic and environmental losses.

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Volcano

Volcanic activities can disturb ecosystems. The hot lava that erupts from the inner earth flows out, and spreads on vast areas of landscape destroying many life forms. The volcanic ash pollutes air, poses threat to air traffic, affects temperature, contributes to acid rain, and destroys ecosystems.

Figure 5.7 Volcano eruption

Plants are destroyed during volcanic eruption; however, volcanic soil is very rich in nutrients, which help plants to regenerate.

Earthquakes

Earthquakes are caused when the energy stored in the Earth's crust is released from the tectonic plate boundaries. It is also triggered by volcanic activity, landslides, mine blasts, and nuclear tests. The branch of science that deals with the study of earthquakes is known as seismology. The magnitude of earthquake of a place is measured in Richter scale.

Figure 5.8 A house damaged by an earthquake

The earthquake can cause landslides, floods and tsunamis, which can bring injury and loss of life as well as damage to properties in a vast area. It also destroys natural resources in the region.

Bhutan is located in one of the most active earthquake zones in the world and, hence, faces a high risk of earthquakes.

Activity 5.2: Identifying natural resource disturbances and their effects

Instructions:

Work in groups.

Discuss and complete Table 5.1 by identifying five natural resources of Bhutan.

B. Anthropogenic causes

Table 5.1

Natural resources	Causes of degradation	Impacts on natural resources (include positive and negative)	Mitigation
1. Forest	Forest fire Land slide Flood		
2.			
3.			
4.			
5.			

Changing lifestyles

From nomadic and semi nomadic pastoral life to the more settled agrarian age, from the industrial and urban age to the technological age, the lifestyles of human societies have changed and continue to change. Food habits, clothing, transportation, housing, domestic appliances are all changing. For instance, domestic appliances like washing machines and mixer grinders have replaced muscle power. Even in transportation, bullocks have been replaced by automobiles. The story of human development and changing lifestyles is closely linked with the extent of dependence and consumption of natural resources. Human societies have manipulated ecosystems, and extracted and processed natural resources to improve their socio-economic status and well being.

Population explosion

A large and rapid increase in the size of the population of any species is referred to as population explosion. In the case of humans, the global population has grown from one billion in 1800 to more than seven billion in 2012. It is expected to reach 11 billion by the end of this century. The current population growth is estimated to be more than 80 million per year.

This rapid growth of population requires enormous natural resources for food, clothing, shelter, transportation and other goods and services, both for sustenance and comfort. In order to meet the increasing demand, natural resources are over-exploited.

Figure 5.9 Extraction of natural resources

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Questions

1. List the causes of natural resource degradation in your locality, and classify them as natural and anthropogenic causes.
2. Can a natural cause be amplified by anthropogenic activities? Explain with an example.
3. Draw a poster to illustrate, how a simple human activity like increased milk consumption leads to environmental degradation?
4. "Development comes at the price of degradation of natural resources". What are your thoughts on this?

2. Pressure on Natural Resources

Learning Objectives

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

- *explain the pressure on the natural resources.*
- *identify the impacts of pressure on natural resources.*
- *identify human activities that lead to natural resource degradation.*
- *discuss the implications of natural resource degradation on human and environmental well-being.*

Rapid urbanization, changing lifestyles and increasing population have led to increased natural resource extractions, thereby increasing pressures on the natural resources. Pressure on natural resources on natural resources may be defined as, any process or activity, natural or anthropogenic that adversely affects the quantity or quality of natural resources.

Human activities are putting enormous pressure on the natural resources. The Earth has enough resources for our need but not for our greed. Exploitation of these resources means that we are using them at a faster rate than that at which they can be produced/replenished.

A. Impact of pressure on natural resources

Natural resource degradation is the deterioration of the natural resources, such as air, water, soil, land, biodiversity, minerals and others, both in terms of quality and availability. The degradation of natural resources has increased poverty, hunger, poor health and sanitation, and reduced the quality of life as a whole. Some of the major impacts of the mounting pressure on the natural resources are:

Pollution

Many human activities pollute the environment by releasing pollutants, which may be physical, chemical or biological in nature. Pollutants alter the nature of natural resources, such as air, water, and land, and threaten the health and survival of humans and other living organisms. Pesticides used in agriculture are a chemical pollutant, which when sprayed on crops, may pollute water bodies. Plants and animals, including humans, in turn are affected by the process of biomagnifications.

Figure 5.10 Water and air pollution due to waste disposal and industrial activities

Degradation of land

Land is said to be degraded, when human activities affect the quality of land, such that the land becomes less productive. Land and soil conditions are affected by clearing the tree cover, poor cultivation practices, mining and construction, industrial establishments, waste disposal and over grazing. Some of these activities also trigger natural factors like landslides, droughts, floods, wildfires; thus, multiplying the impact.

Figure 5.11 Land degradation by mining activity

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In several parts of Bhutan, unscientific agricultural methods, and huge livestock populations have destroyed the land. This has resulted in the loss of fertile soil, reduction in productivity of the land, and also the loss of biodiversity.

Figure 5.12 Deforestation for settlements

Deforestation

Vast areas of natural forest are cleared for agriculture, pasture, industries, mining, and human settlements, including roads and other infrastructure.

Deforestation results in the degradation of land, loss of habitat and biodiversity, and depletion of resources like food, timber, fuel-wood, cane, bamboo, mushrooms, honey, etc. Loss of vegetation affects the water holding capacity of the soil and, thereby, reduces water resources. Figure 5.13 illustrates the causes and impacts of deforestation.

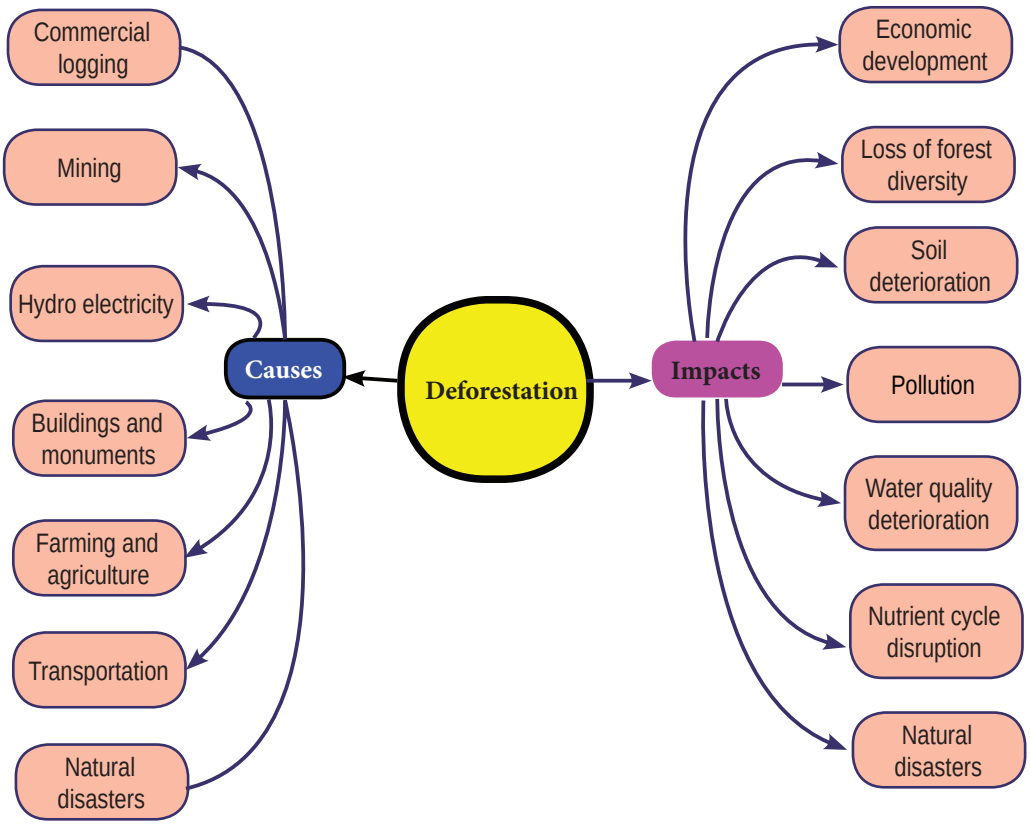

Figure 5.13 Causes and impacts of deforestation

Loss of Biodiversity

Deforestation and degradation of land have fragmented, changed, and even destroyed several habitats. With the habitat loss, the availability of resources like land, water, food and shelter is becoming scarce. As a result, organisms dwindle in population, migrate to other habitats, or disappear completely from their habitats.

Activity 5.3: Where does your shoe come from?

Procedure

1. Look at the pair of shoes that you are wearing.
2. Study the materials used to make the shoe.
3. Copy and complete Table 5.2.

You might need to do some research to find answers.

Table 5.2

Items	Materials used	Sources of natural resource
Packaging materials		
Packaging		
Printing		
Shoe materials		
Lace Body Sole Others		
Transportation		

Answer the following questions

1. From the table, identify the resources that are under maximum pressure for making your shoes.
2. What do you conclude from the above table?
3. State two measures that the industries can take to reduce pressure on the natural resources used for making shoes?
4. Identify measures that you can take, in order to minimize the use of natural resources, while making shoes.

Energy crisis

With the depletion of forests and other vegetation, biomass (biological materials of living organisms) resources are reduced. This may impact people who are directly dependent on forest resources for timber, fuel wood, food, medicine, fossil fuels,

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natural gases, etc. for their survival. Besides, depletion of forests also leads to drying of water resources, and this may reduce the potential of hydropower generation.

Activity 5.4: Mounting pressures

Instructions

1. Study the case.

Thimphu has been developing very fast during the recent years. Consequently, its population has been increasing drastically. The population was 79,185 in 2005 and increased to 99,000 in 2011.

To accommodate its increasing population, the beautiful paddy fields in Chang Gewog, particularly those of Changjiji, Changjalukha and Olakha areas were replaced with various infrastructures like buildings and roads.

An old resident of Thimphu recalls:

"Thimphu is becoming more and more crowded with people, as well as the ever increasing number of motor vehicles now. It is also becoming dirtier. The air smells of smoke from the vehicles throughout the year. Besides, sometimes in winter, Thimphu is covered with dark hazy clouds. Some people say that this is because of the smoke and dust particles that the industries at Pasakha and India let out, while some say that this could be a result of the burning bukharis. There are plastics and papers everywhere. One can no longer drink water directly from the Wangchu the way we used to. People throw rubbish into it. Besides, the runoff water from the town must be carrying a lot of hazardous chemicals, human excreta and other contaminants, while those from the agricultural lands may be contaminated with fertilizers and pesticides."

An environmentalist agrees that the once pristine environment of Thimphu is gradually degrading. Air and water pollutions are on an increase. More and more settlements are cropping up in areas that used to be forest. People are also bringing a lot of forest land under cultivation, since there is great demand for agricultural products. The solid waste disposal is increasingly becoming a challenge, while effluents from automobile workshops along the Olarongchu need stringent monitoring. "We don't want the liquid wastes from these workshops to pollute our rivers, you see," exclaims the concerned environmentalist.

2. Copy and complete Table 5.3

Table 5.3

Sl. No.	Pressure on natural resources	Causes of the pressures	Impacts
1			
2			
3			
4			

Answer the following questions

1. Briefly explain, how industrialisation increases the pressure on air, water and land resources.
2. Briefly explain, how industrialisation increases the pressure on air, water and land resources.
3. Explain the reasons for the excessive use of chemical fertilizers and pesticides by farmers, and its impacts on the following:
   - Soil
   - Water
   - Biodiversity

Do you know?

If there are 100,000,000 different species on the Earth and the extinction rate is just 0.01 percent per year, at least 10,000 species would go extinct every year.

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Questions

1. Discuss the implications of natural resource degradation on the environment.
2. Interpret Figure 5.13.

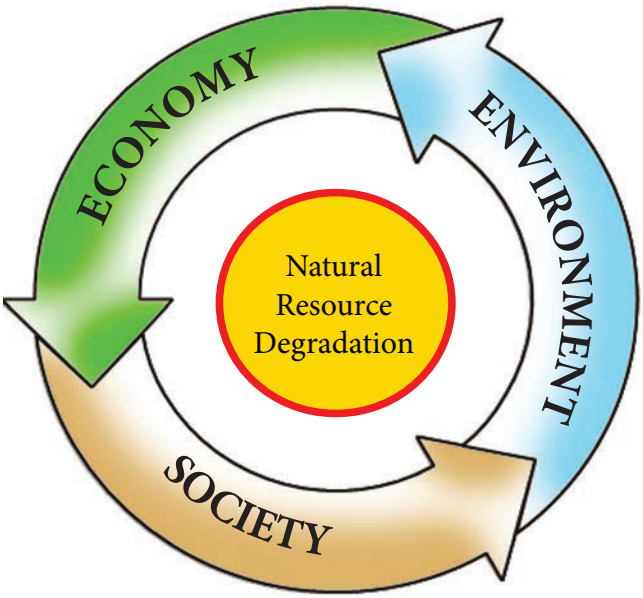

Figure 5.13 Impacts of natural resource degradation

Summary

- The two main causes of pressures on natural resources are natural processes and human activities.
- The main anthropogenic causes of pressures on natural resources are life style change and population explosion.
- Pressures on natural resources are: pollution of air, water and soil, deforestation, land degradation, resources depletion, biodiversity loss.
- The pressures on natural resources may impact the quality and quantity of the available resources.
- As the quality and quantity of the available natural resources decline, the natural resources are degraded leading to environmental degradation.
- Environmental degradation has various implications on human well-being.

Exercise

1. Write TRUE or FALSE for the following statements. Rewrite the false statements in the correct forms.

a. Natural resources can be depleted, but not destroyed.

b. Soil pollution and land degradation have no relationship.

c. Increase in the Earth's temperature may result in desertification in some areas.

d. Since coal is not used by animals as a source of energy, excessive mining of coals will have no effect on their lives at all.

e. The increasing extraction is decreasing the regeneration ability of natural resources.

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

a. Environmental degradation is a result of ..... resource degradation.

b. Floods are responsible for formations of sedimentary rock,.....,valleys and enrichment of soil through silt deposit.

c. Degradation of natural habitat may lead to loss of .....

d. Biological materials of living organisms is called……..

e. Earthquake is caused by…….. movement.

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

a. One of the leading anthropogenic causes of pressures on natural resources is

A. floods due to excessive rainfall.

B. increase in animal population.

C. increase in human population.

D. rise in sea level.

b. If intensive logging is evident in a place, the effect would be

A. increase in biodiversity.

B. loss of biodiversity.

C. increase in water sources.

D. reduction in human settlements.

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c. All of the following contribute to natural resources degradation, EXCEPT
   A. urbanisation.
   B. increase in agriculture products.
   C. increase in the cost of health care.
   D. increase in conflicts.

d. A major decrease in the volume of water in a river that feeds a hydropower plant will
   A. increase its electricity production.
   B. reduce its electricity production.
   C. increase land degradation.
   D. decrease in revenue income.

e. Floods in mountainous regions are generally caused by
   A. heavy rainfall.
   B. forest fire.
   C. deforestation.
   D. earthquake.

4. Match the items of Column A with the most appropriate items of Column B. Rewrite the correct matching pairs.

Column A	Column B
a. Deforestation	i. Flood
b. Pesticides	ii. Desert formation
c. Natural cause of environmental degradation	iii. Changing lifestyles
d. Anthropogenic factor	iv. Chemical pollutants
e. Prolonged drought	

5. Answer the following questions

a. Explain the following terms:
   i. environmental degradation
   ii. deforestation

b. What pressures will be imposed on the natural resources brought about by excessive extraction of sand and boulders from river basins?

c. What will be the impacts of excessive mining of minerals on land resources?

d. Analyse, how urbanisation is both a cause and a solution for natural resources degradation.

e. List down, at least 10 different actions that you can take to reduce natural resources degradation.

f. Describe how a highly populated area in a poor country with limited natural resources may intensify degradation of land, water and air resources. What would be the implications of such a situation on the community?

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ENVIRONMENTAL Pollution

Pollution is mainly as a result of human actions. Almost all human actions generate pollutants. Pollutants are released into air, water and soil, altering the nature of these natural resources. As a result, the quality of these resources degrades. Since all the components of nature are constantly interacting, resource degradation adversely affects the environment as a whole. Environmental degradation, particularly the quality of natural resources on which life depends, threatens the health of living beings, including humans. Resources become unfit for the survival and sustenance of life. Pollution also occurs due to natural phenomena like volcanic eruption, wild fire, and landslide.

Nature has ability to absorb pollutants and thereby maintains the balance. This is the self cleaning capacity of the nature. However, in recent years, human activities are releasing enormous amount of pollutants into the environment. Nature is unable to absorb these huge amounts of pollutant at the rate at which they are being released.

1. What is Pollution?

Learning objectives

On completion of this topic, you should be able to

- *define pollution.*
- *explain pollutants and their forms.*
- *list different forms of pollution.*

A. Pollution

Pollution is the undesirable alteration in the quality of any natural resource such as air, water or soil, which threatens the health and survival of living organisms. For instance, carbon dioxide is a natural constituent of air. Its proportion in the air is 0.03 percent. If the amount of carbon dioxide in the air exceeds this proportion, the air is polluted. Similarly, sulphur dioxide is not a natural constituent of the air, and its introduction contaminates air. Natural phenomena such as volcanic eruption, wildfire, biological decay, landslides, and floods may cause pollution. For instance, volcanic eruption and wildfire may release excess carbon dioxide, sulphur dioxide, and oxides of nitrogen into the air, causing air pollution. Similarly, floods can deposit excess of soil as well as minerals, such as lead and fluorides in water.

B. Pollutants

The factor or the substance that is responsible for pollution is a pollutant. Pollutants can be solid such as vegetable waste, fertilizer; liquid like oil, detergent; or, gaseous like carbon monoxide, carbon dioxide. They can be in physical forms like heat, radiation; chemical forms like pesticides, chemical fertilizers; metal wastes like lead, mercury; or, biological forms like bacteria, virus.

Pollutants are also produced by many natural activities, such as volcanic dust, photo-chemically formed ozone, and methane (CH_4) gas produced during the decay of organic matter and carbon dioxide emitted from the wildfire. Pollutants produced during any human activity are human induced pollutants such as carbon monoxide, and carbon dioxide produced during industrial and vehicular emissions and chemical pesticides used in agriculture.

Based on the nature of sources of pollutants, they are classified as point sources and non-point sources. If a source of pollutant is single and identifiable, it is a point-source pollutant. Examples: sewage pipe, industrial effluent discharge points, and oil leak from oil drill platform. When the sources of a pollutant are scattered and unknown, it is a non point-source pollutant. Examples: pesticides that enter the water sources from farm lands. Generally, these terminologies are used more in relation with water pollution.

Pollutants can be also categorised into primary and secondary pollutants. Primary pollutants are those substances released directly into the environment. Sometimes, primary pollutants react with other components to produce new pollutants. These are secondary pollutants. For example, sulphur dioxide, a primary pollutant reacts with oxygen in the air to form sulphur trioxide, which is a secondary pollutant.

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$2SO_2 + O_2 \rightarrow 2SO_3$

$2CO + O_2 \rightarrow 2CO_2$

$4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$

Numerous human activities are responsible for discharge of pollutants into the atmosphere, hydrosphere, and lithosphere. If all the discharges remain in the specific environmental spheres into which they are emitted, their levels will keep on increasing. However, in spite of the increasing emission, levels have remained fairly constant due to the ability of air, water and soil to undergo self purification. For example, the suspended particles in atmosphere are removed physically by sedimentation. Similarly, the amount of carbon dioxide in the atmosphere does not increase rapidly because plants absorb it for photosynthesis. Further, dead organic matters are decomposed. This phenomenon is known as self cleansing mechanism.

In recent years, the anthropogenic pollution levels have increased so high that the nature's self cleansing process is unable to remove all the pollutants. This is a serious environmental concern today.

C. Forms of Pollution

Generally, three major forms of pollution are identified that are linked with the natural resources. This grouping helps in identifying the type of pollutants, causes, effects, and the possible treatments. The three forms of pollutions are:

- Air pollution
- Water pollution
- Land pollution

Some have identified noise as a major form of pollution. In some texts, thermal pollution and radioactive pollution are seen as separate forms. However, thermal and radioactive pollution do impact air, water and land. Food contamination has been identified as an important form of pollution. Food contaminated with harmful micro-organisms and chemicals, or adulterated with non edible substances and colours affects the human health directly. Some even go to the extent of referring the ugly sightings of bill boards, garbage heaps, hanging telephone and television lines as visual pollution.

Activity 6.1: A peek at pollution

Procedure

1. Study the pictures in Table 6.1.
2. Identify and write the form(s) of pollution and common pollutants in column 2.
3. List their likely health impacts in column 3.
4. Share your notes with other students.

Table 6.1

Picture	Form(s) of pollution and common pollutants	Likely health impact
		
		
		
		

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Picture	Form(s) of pollution and common pollutants	Likely health impact
		

Answer the following questions

1. Classify the sources of above pollutions into point and non point.
2. How have the humans contributed to these pollutions?
3. Suggest some mitigation strategies to minimise each of the above pollutions.

Questions

1. Define pollution.
2. Give examples of any five pollutants, and explain why they are considered as pollutants.
3. Why do you think that anthropogenic activities have increased pollution?
4. Identify the following pollutants as primary or secondary pollutants.

   CO, SO_2, NO, SO_3, HNO_3, CO_2, H_2SO_4, NO_2, O_3

2. Air Pollution

Learning Objectives

On completion of this topic, you should be able to

- *identify the causes and effects of air pollution.*
- *differentiate indoor and outdoor air pollution.*
- *describe the effects of acid rain.*
- *explain measures to control air pollution.*

Air contains gases in a fixed proportion. The change in the composition of natural air occurs due to addition of undesirable substances, resulting in air pollution. Substances that are responsible for air pollution are air pollutants. Air pollutants can be in the form of heat; gases like the oxides of carbon, nitrogen and sulphur; liquid like sulphuric acid droplets; microbes like bacteria and virus; and small particles like dust, ash and pesticide residues that remain suspended in the air for long periods. These suspended particles in the air are generally called Suspended Particulate Matter (SPM).

A. Sources of air pollutants

Air pollution can take place both indoor or outdoor. Indoor air pollution occurs when the air inside a closed habitat like house gets polluted. Outdoor air pollution is air pollution in the open areas of the habitat.

Some of the main causes are: burning of biomass (wood, agro-waste, dung cake, charcoal) for cooking and home heating; refrigerators and air conditioners containing chlorofluorocarbons; building materials, including paints and asbestos; organic compounds like benzo-α-pyrene, para-dichlorobenzene; plastic products and tobacco smoking (Figure 6.1) shows more examples for sources of pollutants. Some living organisms like moulds, bacteria and pollen grains can also add to indoor air pollution.

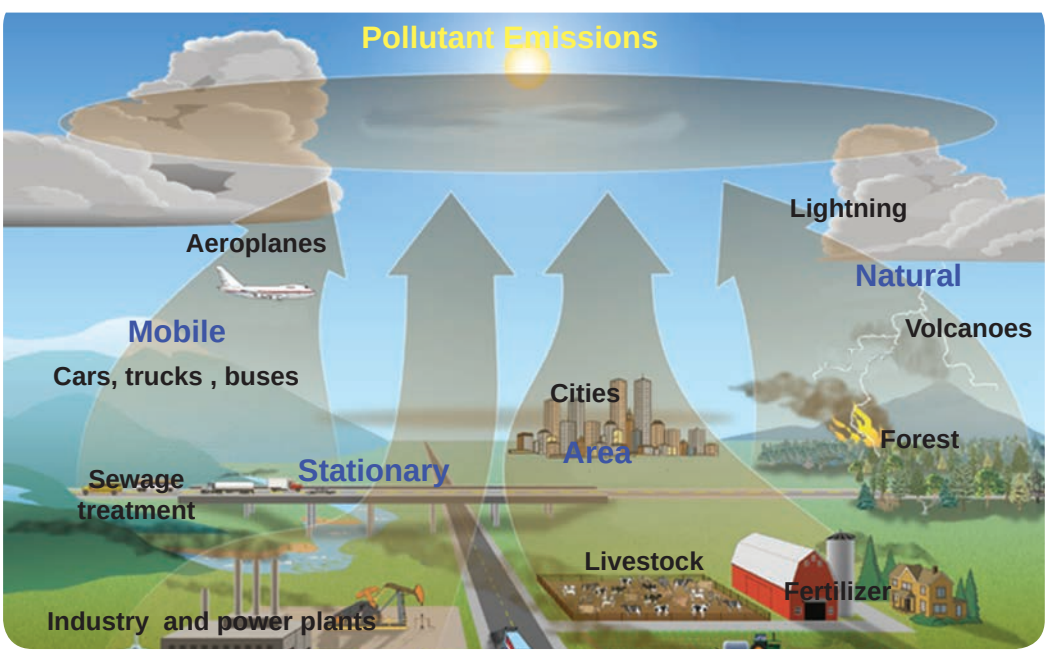

Figure 6.1 Air pollutant emitted from various sources

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While the focus is more on outdoor pollution, indoor air pollution has far more impact on human health than the outdoor pollution. Cooking is the sole major activity in the developing countries responsible for indoor air pollution due to the dependence on fossil fuels for energy. Indoor smoke may contain pollutants hundred times higher than the acceptable levels. High emission levels with a range of pollutants, including soot particles, inefficient stoves and poorly ventilated houses seriously affect human health. According to a 2014 World Health Organization (WHO) study, around 4.3 million people die every year prematurely from health complications due to indoor air pollution, particularly from inefficient biomass burning. Headaches, drowsiness, itchy eyes, cold and asthma are common besides life threatening diseases such as pneumonia, is chemic heart disease, lung cancer and pulmonary disease. Since rural households of Bhutan use large quantities of wood in the domestic sector, health risk is high among women and children. Some of the sources of indoor pollutants are shown in Figure 6.2.

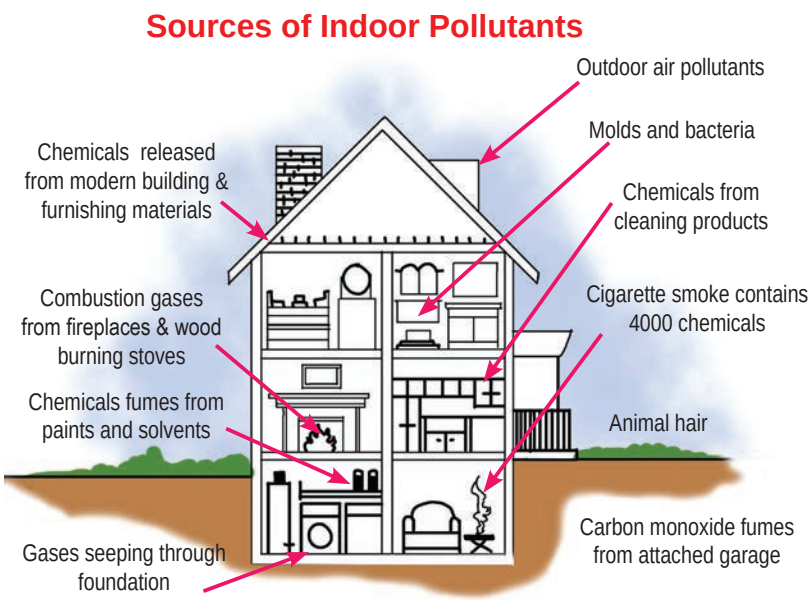

Figure 6.2 Indoor air pollutants and sources

Activity 6.2: The energy ladder

Instruction

Study the energy ladder in Figure 6.3.

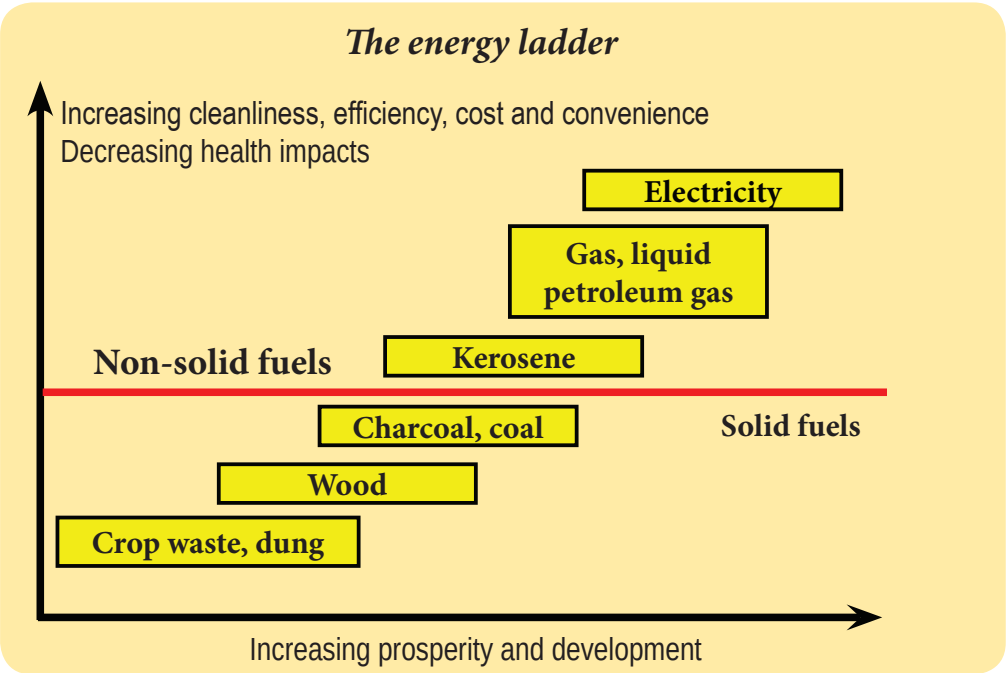

Figure 6.3 Energy ladder

Answer the following questions

1. Explain the graph in Figure 6.3 in your own words.
2. Compare solid fuels with non-solid fuels in terms of health impacts.
3. Explain air pollution at home based on the kind of energy sources used.
4. Mention some health problems that your family members may face.
5. Copy and complete Table 6.2

Table 6.2

Energy source that are used in your home	Suggest alternative source of energy?	Give reasons for your suggestion

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B. Effects of air pollution

1. **Health impact**: Air pollution is the single largest environmental health risk on the Earth. Millions of people die every year due to air pollution. Air pollution affects almost every part of the human body, including eyes, lungs, heart and skin, etc. For Example; The incomplete burning of carbon-containing materials produces carbon monoxide which is highly toxic gas. It reacts with haemoglobin in the red blood cells, and reduces the oxygen carrying capacity of blood. Hence, in high concentrations, carbon monoxide causes headache, nausea, drowsiness, mental impairment, unconsciousness, and even death. It is a colourless and odourless gas and, therefore, difficult to trace, which makes it a very dangerous and silent killer. Major sources are motor vehicle exhaust, forest fire, tobacco smoke, and cooking with inefficient stoves or ovens.

2. **Productivity loss**: Air pollution reduces the yield of food crops. Pollution in Asia alone contributes to 50-60 percent of the worldwide loss of wheat, and more than 90 percent of rice. Pollution in North America is responsible for 60 -70 percent worldwide losses of maize, and 75-85 percent of soya bean.

3. **Global warming**: The increase in gases like carbon dioxide, methane and chlorofluorocarbons enhances the greenhouse effect, and increases the temperature of the Earth. This phenomenon is called global warming. The average temperature of the Earth has been rising over the period of time. For instance, in 1880s, the average temperature was 13.7°C, but by 2013, it increased to 14.6°C. This increase has already led to glacier melting and sea level rise. Figure 6.4 summarises global impact of this phenomenon.

Do you know?

Corals are tiny animals belonging to the phylum coelenterate. A species of algae (zooxanthelle) that grows in coral reefs impart colour to coral reefs. This species of algae cannot survive in warmer water. When water becomes warm due to global warming, the algae dies and coral reefs lose their colour.

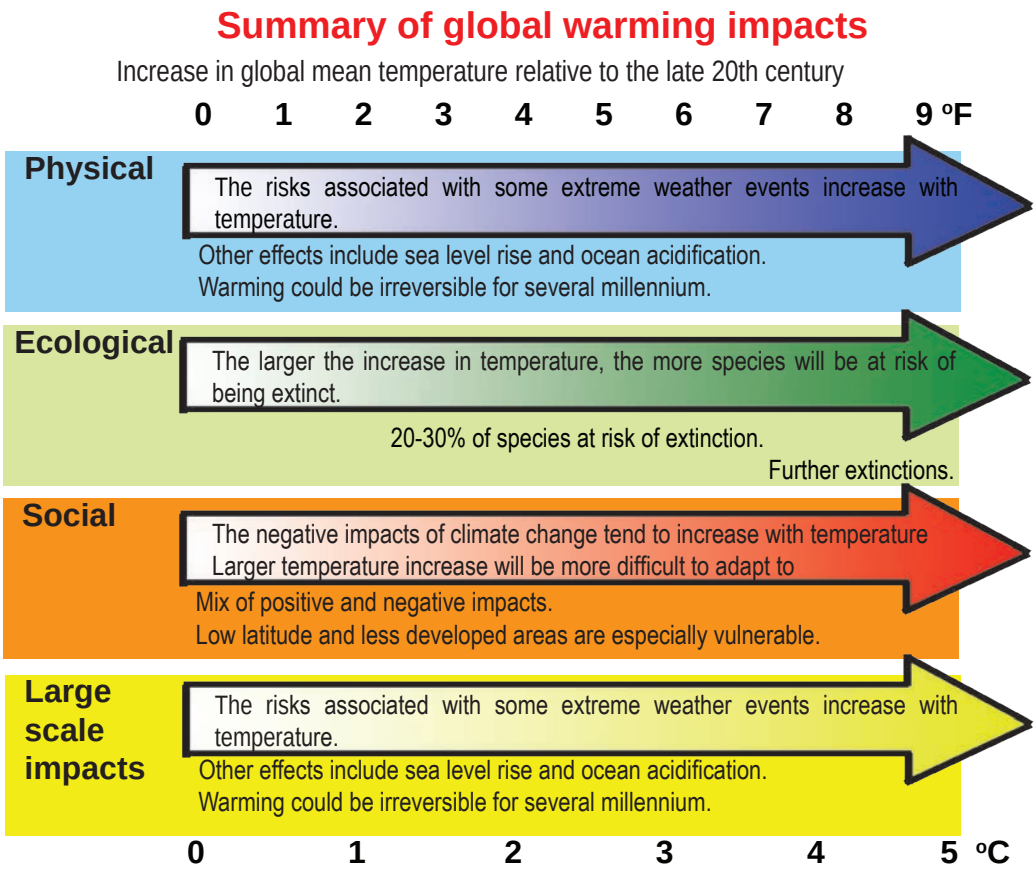

Figure 6.4 Impacts of global warming

4. **Depletion of ozone layer**: The ozone layer blocks most of the ultraviolet radiation from the Sun. Air pollutants like chlorofluorocarbons in particular, react with the ozone in the stratosphere, and convert it to oxygen as shown in Figure 6.5. With the depletion of the ozone, the ultra violet (UV) radiation enters the Earth's surface, causing health problems like skin cancer, eye problems (cataract), and damage to the immune system. It also affects photosynthesis in plants, by which the crop yields are severely affected.

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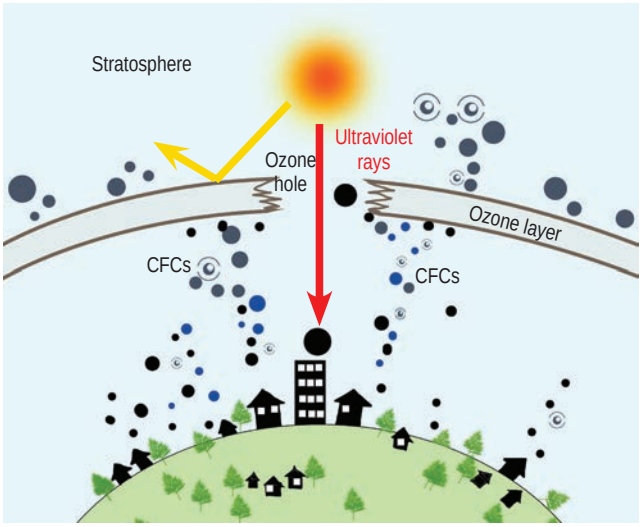

Figure 6.5 Depletion of ozone layer

5. **Acid rain**: The oxides of carbon, sulphur and nitrogen released during the burning of fossil fuels react with water vapour and form acids like, carbonic acid, sulphuric acid and nitric acid.

Formation of carbonic acid

$CO_2 + H_2O \rightarrow H_2CO_3$

Formation of sulphuric acid

$SO_2 + H_2O \rightarrow H_2SO_3$

$2H_2SO_3 + O_2 \rightarrow 2H_2SO_4$

Formation of nitric acid

2NO + O2 - 2NO2

2NO + H2O - - HNO2 +HNO3

2HNO2 + O2 --2HN03

The rain that contains high acid content is called acid rain. Acids may also reach the ground with any form of precipitation like, fog, mist, dew drops, snow or hail stones. Acids in the form of vapour can travel long distances before they fall on land along with the rain. Hence, heavy pollution in one region can affect far off regions.

Acid rain pollutes land, air and water (Figure 6.6). As a result, it harms life, affects growth of plants, reduces soil fertility, slows decay process, kills aquatic life, and affects reproduction of living organisms. Acid rain also bleaches coral, corrodes buildings and monuments.

In Bhutan, air pollution has become a matter of concern in recent years. Industrial activities like manufacturing of cement, mining and chemical processing, increasing number of automobiles, burning of wood and solid waste, and rapid urbanisation contribute to pollution.

A 2013 NEC (National Environment Commission) report titled 'Air Quality Status Over 2011-2012' indicated that the pollution level in Thimphu has doubled from 2007 to 2012.

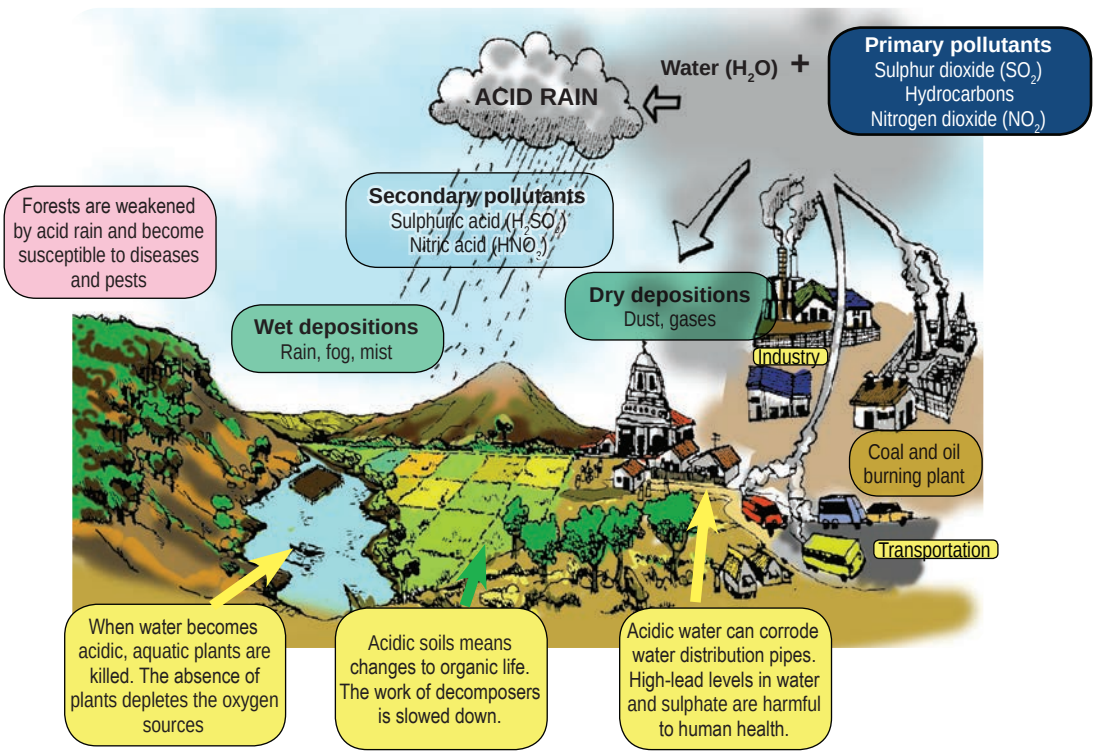

Figure 6.6 Acid Rain

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Activity 6.3: Pollution solution

Instructions

1. Work in groups.
2. In Table 6.3, three major human activities, which cause pollutions with corresponding suggested solutions to reduce air pollution are given. For each human activity, rank the solutions from the highest to the least priority.

Table 6.3

Human activity	Suggested solutions
	• Using less polluting fuels like natural gas. • Keeping the automobile engines clean with regular emission checks. • Switching off vehicle engines during long waits. • Car pooling. • Increasing the use of public transport services. • Walking or cycling. • Enforcing laws. • Creating awareness on pollution and its mitigation.
	• Promoting cleaner fuels like natural gas and efficient technologies in industries to reduce emissions. • Locating all the industries and factories at one place. • Treating or filtering emissions to reduce the release of particulate matters and noxious gases. • Making strict legislation.
	• Using cleaner fuels like LPG. • Encouraging use of fuel wood efficient stoves. • Creating awareness on use of fuel efficient technologies. • Involving people in awareness programmes and trainings.

Answer the following questions

1. What criteria did you consider, while ranking the suggested solutions?
2. Why do we need multiple solutions?
3. Which solution will work best in your locality? Why?

Questions

1. Why is the ozone layer depletion harmful to life forms?
2. Explain the formation of acid rain.
3. Justify air pollution as one of the main killers of living organisms.
4. Copy and complete the Table 6.4.

Table 6.4

(A) Activity or source	(B) Air pollutants
Refrigeration and sprays	Chlorofluorocarbons
Indoor activities like cooking, painting	
Burning of Biomass	
Industrial emissions	
Livestock rearing	
Mining and construction	

3. Water Pollution

Learning Objectives

On completion of this topic, you should be able to

- *identify the causes and effects of water pollution.*
- *describe eutrophication and biomagnifications.*
- *explain measures to control water pollution.*
- *adopt measures to control water pollution in your daily life.*

Water gets polluted when any undesirable substance, which is not a natural component of water, is discharged into water bodies. This causes dissolved oxygen depletion, and other undesirable changes in water, making it unfit for use.

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A. Water pollutants

Water is polluted by different types of pollutants as shown in Figure 6.7.

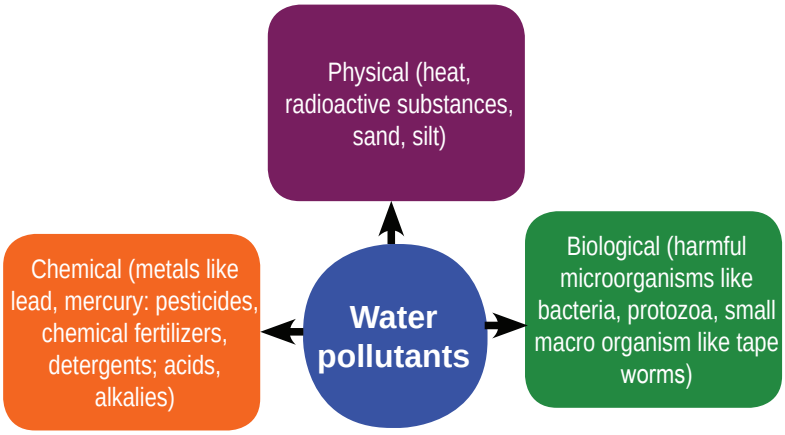

Figure 6.7 Water pollutants

Activity 6.4: Sorrowful stream

Instruction: Study Figure 6.8 and discuss in groups to answer the following questions.

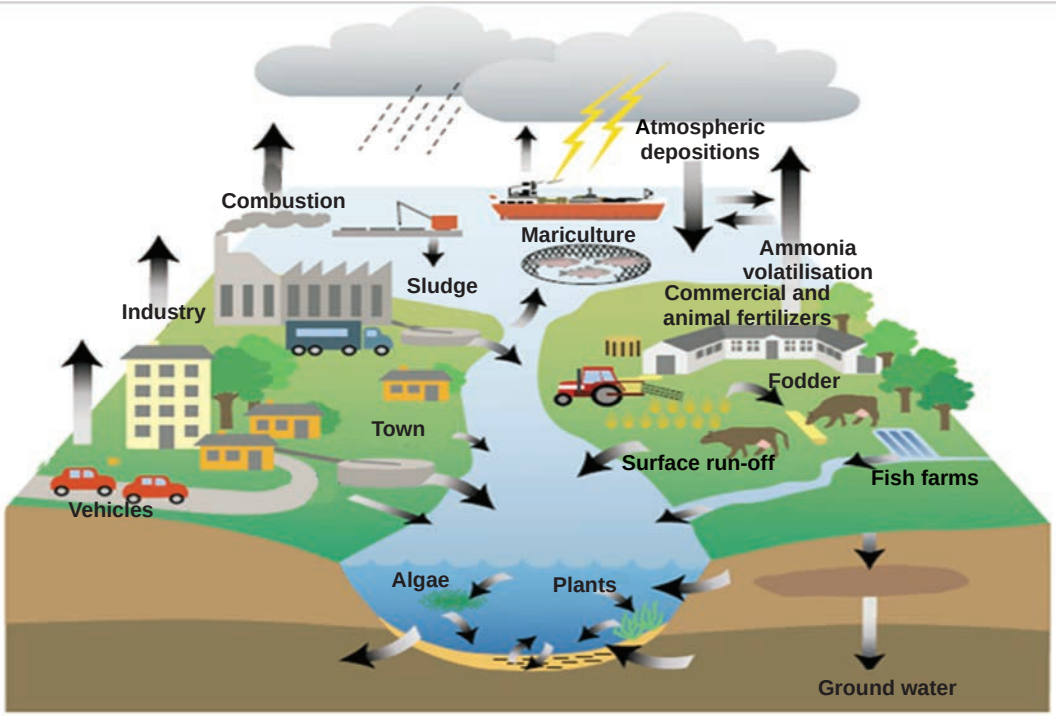

Figure 6.8 Water pollution

1. Study Figure 6.8 and complete the table

Table 6.5

Pollutant	Source	Point / nonpoint source
heat		
radioactive substances		
sand and silt		
lead and mercury		
pesticides and chemical		
fertilizers		
detergents		
acids and alkali		
bacteria		
protozoa		
tape worms		

2. Suggest ways to prevent water pollution.
3. Identify the sources of water pollution in your locality and illustrate them with similar drawing.
4. Suggest some ways to prevent water pollution in your locality.

B. Effects of water pollution

1. Health impact

Several pollutants lend the water a stinking odour and an unpleasant colour; thus, depreciating the quality of water. Dangerous microorganisms, or pathogens discharged into water from sewage, especially faecal matter, cause life threatening diseases like cholera, typhoid, hepatitis, diarrhoea, and other gastro intestinal problems.

2. Biomagnification

Biomagnification is the increasing concentration of a substance, such as a toxic chemical, in the tissues of organisms at successive levels in a food chain Figure 6.9. The increase in the concentration of the substance is because it takes a longer time to break down and is transferred to higher trophic level through food chain. Biomagnification of pollutants can harm the health of organisms at every trophic level.

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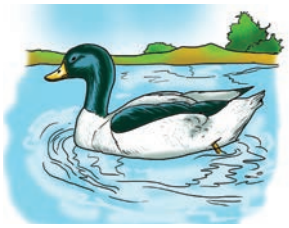

Duck 1600 ppm (parts per million)

Fish 200 ppm

Plankton 5 ppm

Water 2 ppm

Figure 6.9 Biomagnification

Activity 6.5: The noxious chain

Instructions

Study the case of biomagnifications in Japan.

Minamata disease is a typical example of biomagnification. It was first discovered in Minamata Bay in Japan in 1956, as a result of the biomagnification of mercury in the food chain. Methyl mercury released in the bay through industrial waste water got accumulated in the shellfish. The local people who ate the shellfish had difficulty in walking and speaking and suffered from convulsions. Animals died and human deaths continued for several years.

Answer the following questions

1. If 5 ppm of mercury is accumulated in each plankton, calculate the amount of mercury accumulated in a fish eating 100 such planktons.
2. Calculate the amount of mercury accumulated in the duck, eating 10 such fishes.
3. What can you conclude from the calculations?
4. How does this phenomenon affect humans?

3. Eutrophication

Eutrophication is a process, wherein, water bodies are enriched with nutrients like nitrates and phosphates leading to excessive plant growths Figure 6.10. In recent years, the enrichment of nutrients in water sources is occurring at a greater speed due to agricultural run-off containing chemical fertilizers applied to farms and untreated sewage. With the increase in nutrients, the water plants, particularly algae, undergo

rapid growth leading to sudden algal bloom. This decreases the amount of sunlight reaching the plants under the water. Thus, the rate of photosynthesis is reduced. This results in death and decay of aquatic plants. The decaying process demands oxygen. Microorganisms like bacteria responsible for the decaying process, break down the organic matter. Dissolved oxygen is used by these organisms for the decomposition process. With this, oxygen in the water is depleted and becomes unfit for the survival of aquatic organisms.

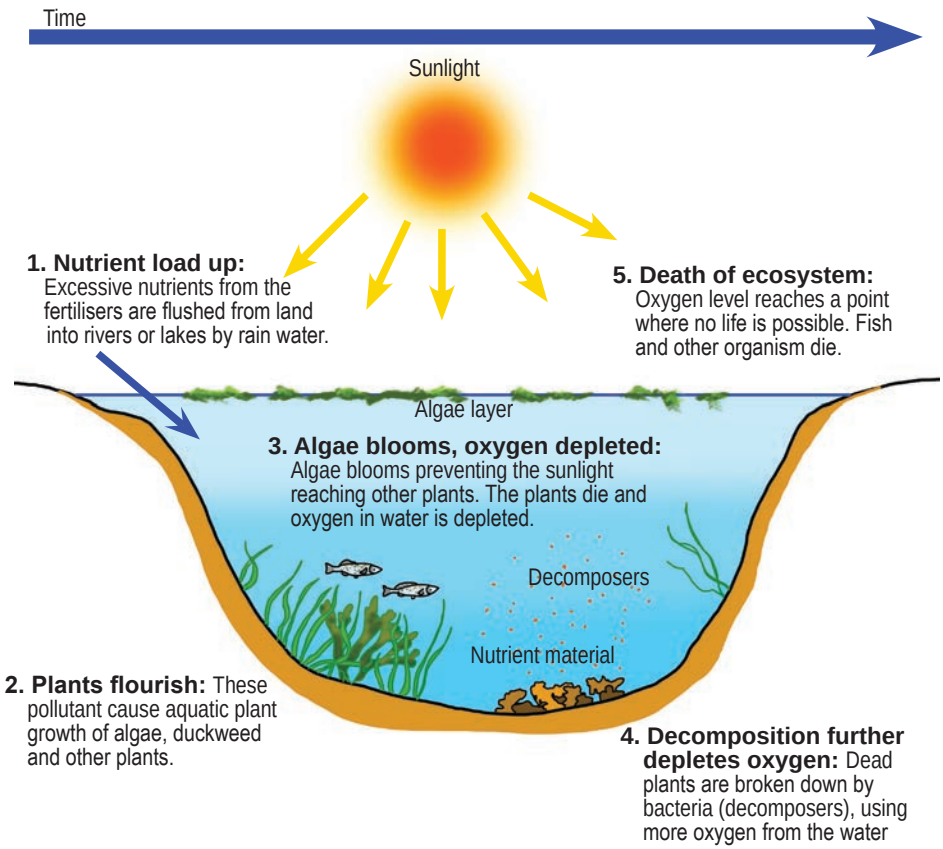

Figure 6.10 Eutrophication

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Questions

1. List the sources of water pollution.
2. Differentiate between eutrophication and biomagnification.
3. How are you affected by biomagnification?
4. Suggest at-least four things that you will do to control water pollution?
5. How is air pollution related to water pollution?
6. A detailed study was undertaken in 2008 and 2009 on the assessment of water quality of Talung Chhu, which flows through Talung city. The water temperature, pH, turbidity, nitrate, phosphate, chloride, total coliform bacteria and biological oxygen demand were found high in the river water. At the same time, pollution tolerant benthic macro-invertebrates were found in abundance. Benthic macro-invertebrates are used as biological indicators.

    i. Describe the quality of Talung Chhu.

    ii. Talung city is violating the 'right to clean water' for communities living downstream. Justify.

    iii. Suggest a water resource management plan for the city to ensure cleaner water for downstream communities.

4. Land Pollution

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

- *discuss the causes and effects of land pollution.*
- *relate land pollution to biomagnification.*
- *debate measures to control land pollution.*

Land or soil pollution is the undesirable change in the composition of soil. This change can occur due to changes in the natural components of the soil like air, water and temperature, or when any substance, which is not a natural component like pesticide gets into the soil.

A. Causes of land pollution

Agricultural activities

With the increase in human population, demand for food has increased considerably. This has led to excessive use of fertilizers and pesticides to increase the yield. Such practices result in contamination and poisoning of soil. The other wastes like plants and livestock can also cause land pollution, if not managed properly.

Industrial activities

Large quantities of wastes from industries are dumped over the surface of soil Figure 6.11. These wastes may change the chemical and physical nature of soil and pollute underground water. The rain also often leaches harmful substances into the ground, which harm the organisms living in the soil, animals, and humans living near the contaminated land.

In certain industrial activities, in particular, nuclear electricity generation, radioactive wastes are produced. These wastes continuously give off dangerous radioactive particles and rays, which affect the living things around. Infrastructure development and mining also produce large amount of wastes and damage the landscapes.

Figure 6.11 Wastes

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Domestic wastes

Each household produces tonnes of garbage each year. Garbage like aluminum, plastic, paper, cloth, wood becomes a part of landfills. Although, most of the waste can be recycled, due to the lack of efficient waste management system in most countries, household waste becomes a major land pollutant. Improper sewage system can also lead to land pollution by infesting the area with harmful microorganisms and other chemical substances.

Degradable and non degradable wastes are disposed off in large areas of land. The harmful metals, chemicals and biological substances gradually get into the soil and pollute it.

In most developing countries, the methods of waste disposal, like segregation into wet, dry and hazardous waste, are not scientifically managed. Solid waste disposal is an emerging issue in Bhutan. The magnitude of the problem is growing, particularly in urban areas.

Activity 6.6: Lurking danger!

Materials required

Camera, notebook and pen

Procedure

1. Take pictures of polluted areas in your locality.
2. Copy and complete the Table 6.6.

Table 6.6

Sl.No.	Type of waste	Yes / No	Quantity		
			Abundant	Less abundant	Scanty
1	Vegetable and fruits				
2	Paper				
3	Plastic				
4	Pet bottles				
5	Cloth				
6	Glass				
7	Metal				
8	Chemical				
9	Leather				
10	Wood				
11	Others				

3. Organise a photo exhibition.

Answer the following questions

1. Which types of waste are found in abundance? Suggest possible reasons for it.
2. Describe the effects of these wastes on the environment.
3. Discuss and suggest better ways of waste disposal methods for different types of wastes.

B. Effects of land pollution

1. **Effects on human health**: The toxic materials that pollute soil can get into the human body through the process of biomagnifications. The toxic materials can cause skin cancer, pulmonary diseases, deformities, suppression of immune system, disruption of hormonal system, cellular damage and damage to genetic material and reproductive inhibition or failure.

2. **Effect on the environment**: Land pollution can affect the fertility of soil. The soil organisms that help plants to grow die due to the toxic chemicals, thereby affecting their growth and yield. Besides, land pollution also affects water and air, which in turn affect the biological diversity at large.

Activity 6.7: Path of pesticide

Instruction

Read the case given below and observe the Figure 6.12 carefully.

Endosulfan, one of the most toxic pesticides used in agriculture, is responsible for many fatal poisoning incidents in the world. It is released in air, water, and soil during its production and when sprayed on crops. Endosulfan in the air may travel long distances before it settles on crops, soil or water. Animals living in endosulfan contaminated waters can accumulate large amounts of the pesticide in their bodies.

Endosulfan is highly toxic to the nervous system of animals, including humans. Its manufacture and use have been banned globally due to its ill effects on human health and environment. Reproductive problems, paralysis, cancer risks and nervous disorders linked to endosulfan due to its bioaccumulation, came to light around 2001. Its production, storage, sale and use were banned globally in 2011.

Answer the following questions

1. Why do we use pesticides?
2. Trace the journey of pesticides in Figure 6.12.
3. Illustrate biomagnification using the pesticide path.

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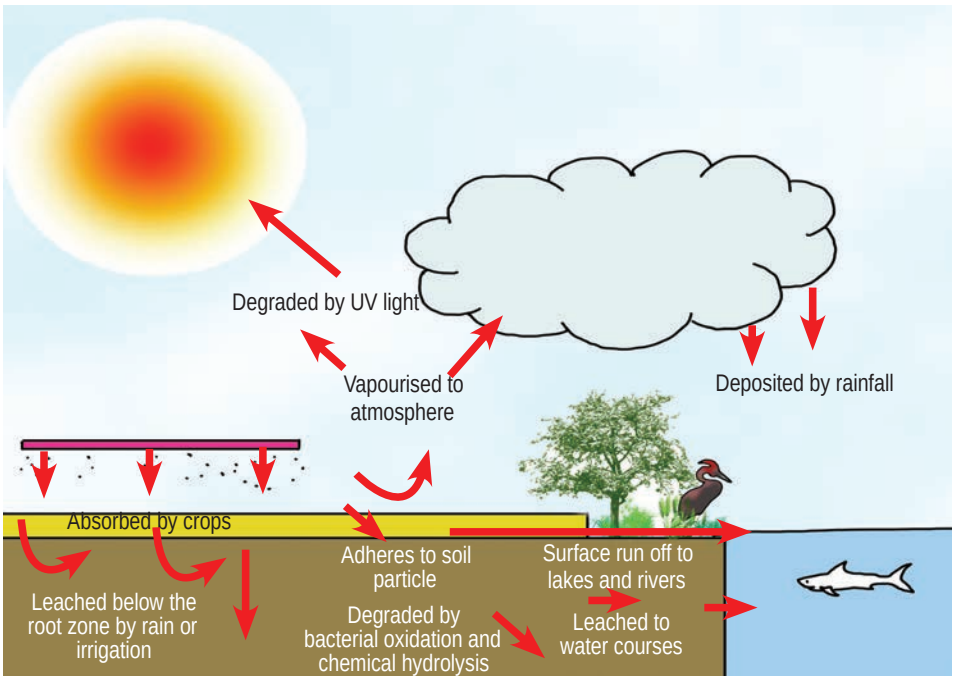

Figure 6.14 Pesticide cycle

C. Measures to control land pollution

The following are some of the measures to control land pollution.

1. Management of solid waste.

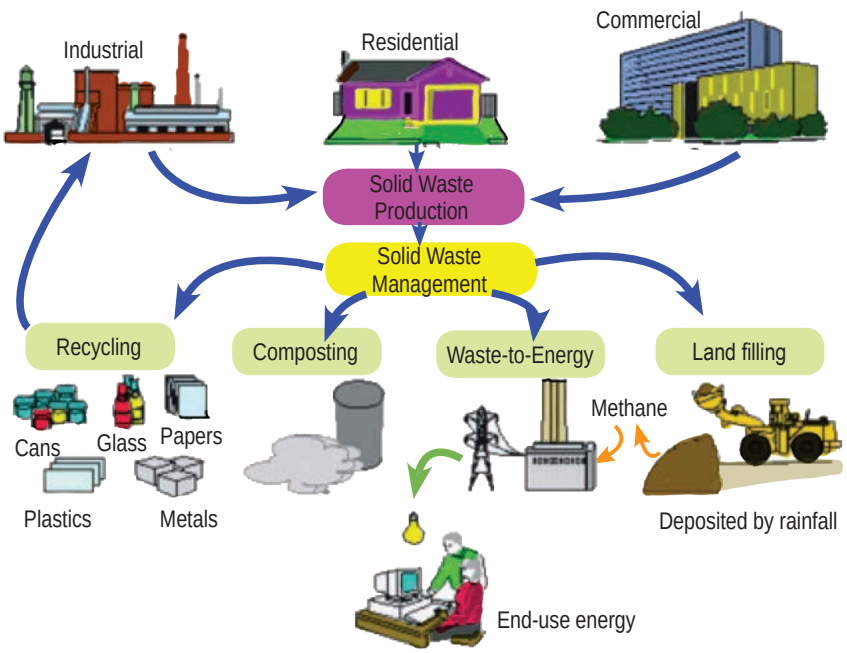

Figure 6.15 Solid waste management pathways

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2. Treating the sewage before releasing it into the soil.
3. Minimising the use of chemical fertilizers and pesticides.
4. Careful disposal of the radioactive waste from nuclear power plants.
5. Awareness on land and soil pollution and management, particularly the 3'R's -, reduce, reuse, recycle - of the solid waste, and segregation of waste at source.
6. Encourage people to participate in solid waste management campaigns.

Activity 6.8: Spreading the message

Instruction

1. Identify the various ways in which pollution occurs in your locality.
2. Discuss with other students, teachers and community members and chalk out measures to control pollution.
3. Carry out an awareness campaign to reduce pollution.
4. Evaluate the impact of campaign, and list the challenges faced.
5. Interpret the logo given below.

Questions

1. Why is garbage problem more serious in urban areas than in rural areas?
2. Why do toxic chemicals accumulate at higher trophic levels?
3. What are some of the health problems caused by land pollution?

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Summary

- Pollution is the undesirable alteration in the quality of any natural resource, such as air, water or soil, triggered by physical, chemical or biological factors, which threatens the health and the survival of living organisms, including humans.
- Indoor air pollution is the contamination of air by smoke, burning of wood and fossil fuels, heating appliances, paint, etc.
- The presence of pollutants in outdoor air that impacts on human health and the environment is called outdoor air pollution.
- Acid rain is formed due to chemical reaction of water with the oxides of carbon, sulphur and nitrogen in the air.
- Air pollution causes global warming, acid rain, and ozone layer depletion.
- Water pollution is the contamination of water bodies.
- Water pollution is caused by excessive use of pesticides, chemical fertilizers, industrial wastes, household wastes, heavy metals, etc.
- Water pollution increases the biological oxygen demand (BOD), and leads to eutrophication.
- The undesirable change in the land that harms life forms is called land pollution.
- The process in which toxic substances become concentrated in the tissues of living things as they move up the food chain is known as biomagnification.
- Eutrophication is the phenomenon in which aquatic organisms are deprived of sunlight and oxygen due to algal bloom and decomposition of organic matter in the water body.
- Solid waste is a serious problem in many countries, and is an emerging issue in Bhutan.

Exercise

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

a. Treat the _____ before it is released into the water body.

b. Reduce temperature of _____effluents before releasing them in the water bodies.

c. A person suffering from food poisoning from fish meal can be due to _____ in the food chain.

d. Provide education to_____ about harmful effect of chemical fertilizers and pesticides.

e. Reaction of oxygen with carbon is an example of _____ source of acid rain.

2. Write TRUE or FALSE for the following statements. Rewrite the false statements in the correct forms.

a. Pollution can travel great distances, often across national boundaries.

b. Ozone layer filters out harmful ultraviolet rays.

c. Bacteria and fungal spores can contribute to indoor air pollution only.

d. Indoor pollution can become more hazardous than outdoor pollution.

e. Improperly managed sewage outlets and chemical fertilizers can lead to oxygen depletion in the water bodies.

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

a. The dark lake is heaven for duckweeds and spirogyra, a strong pungent smell pervades the air, and aquatic animals are hardly seen. This is an example of.

A. biomagnification.

B. eutrophication.

C. water pollution.

D. greenhouse effect in water.

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b. Demand of oxygen in water does not increase with increase in

A. concentration of solid waste.

B. number of aquatic plants.

C. number of aquatic animals.

D. rapid flow of water.

c. Fine organic or inorganic particles suspended in air is called

A. particulate pollutants.

B. gaseous pollutant.

C. aerosol.

D. suspended particulate matter.

d. Which of the following is a secondary pollutant?

A. CO_2

B. CO

C. O_3

D. SO_2

e. Which one of the following source is not an example of point source.

A. Sewage pipe .

B. Industrial effluent discharge.

C. Oil leak from oil drill platform.

D. Pesticides that enter the water sources from farm lands.

4. Answer the following questions.

a. Define the following:

i. Pollution.

ii. Biomagnification .

iii. Global warming.

iv. Eutrophication.

b. What are some of the pollutants produced by your daily life styles?

c. What are the sources of water pollution in Bhutan?

d. Air pollution is a transboundary issue. Illustrate this with an example.

e. Why is it important to educate the farmer about the use of pesticide and chemical fertilizer?

f. Pollution is a global concern. Discuss.

g. What humans produce as waste comes back to us. Explain this statement with an example each in terms of air, water and land pollutions.

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Disaster Risk & Environment

Chapter 7

The Earth is the only planet which is known to support life. Life will continue on the Earth as long as all the natural processes of the Earth are undisturbed, or continue to remain in their normal conditions. Any disturbances and abnormalities in these natural processes can lead to disasters. A disaster means a calamity affecting a region due to natural or human induced causes. Both natural and human induced disasters have an impact on the society, economics, environment, and disturb every aspects of life. The geographical location of our country protects it from certain types of disasters like tsunami, but it is vulnerable to several other disasters such as earthquakes, glacial lake outburst floods, forest fires, landslides and flash floods. Human's developmental activities have magnified the frequency and extent of disasters, causing more loss of life and property. Natural disasters such as earthquakes and volcanic eruptions cannot be controlled, but loss of life and property can be prevented by being prepared for disasters.

This chapter provides a basic understanding of natural disasters and the human interventions to reduce and prevent disasters.

2. Disaster

Learning Objectives

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

- *explain major causes and the impacts of disasters.*
- *identify natural and human induced disasters.*
- *describe disasters that are common in Bhutan.*
- *identify the causes and effects of disasters in Bhutan.*

Disaster is an event that causes serious disruption to life, and may cause economic losses beyond the coping capacity of a given society.

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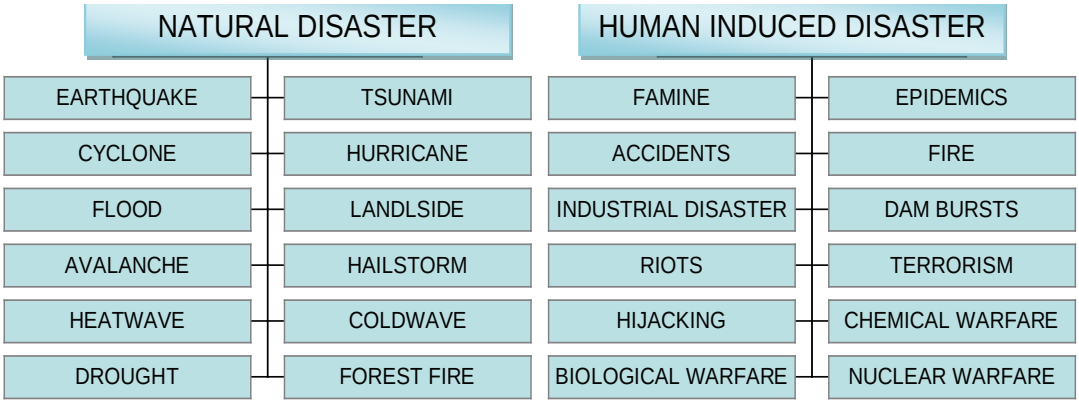
Disasters can be classified based on the nature and origin of the disaster as in the Figure 7.1.

(a) Classification based on nature



(b) Classification based on origin

Geophysical	Earthquakes, volcanoes, tsunami, dry mass movements
Hydrometeorological	floods, storm, cyclones
Climatological	Drought, extreme temperatures, wildfire
Biological	Epidemics, insect infestations, animal attacks

Figure 7.1 Classification of disaster

Activity 7.1: Understanding Disaster

Instruction

1. Discuss on any recent disaster that you have experienced or observed. Prepare a comprehensive report and present it to your class using methods such as, power point presentation, skit, street play, etc. Visit the school library for necessary references. Your discussion can include the following aspects.
   - Name of disaster.
   - Time, Date, Month and Year of occurrence.
   - Place of occurrence.
   - Impact on the environment and community.
   - coping capacity of the community.
   - Future preparedness.

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Geophysical disasters

These disasters are caused due to natural Earth related processes and phenomena. Examples are earthquake, volcanic eruption and tsunami.

(a) Earthquake

Earthquake is caused by the sudden movement of the tectonic plates. When the tectonic plates move, the boundaries slide against each other creating frictional pressure on the edges of the plates. When this pressure is released, seismic waves are formed, and the tremors are felt. The point in the region where the earthquake starts is called epicenter (Figure 7.1). Volcanic eruption and underground mining also trigger earthquakes.

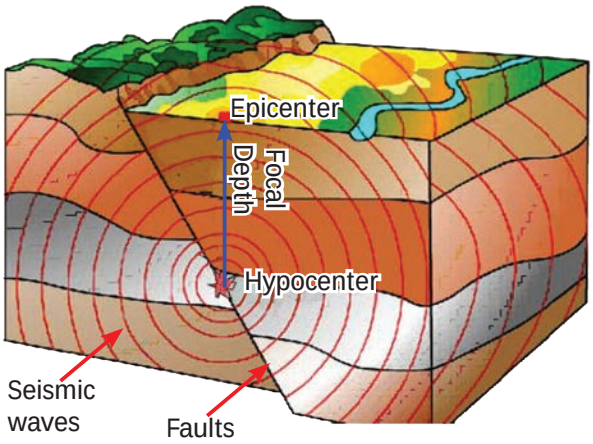

Figure 7.1 Epicentre

Bhutan is vulnerable to earthquakes due to its location in the eastern Himalayas, which is one of the most seismically active regions in the world. The entire country lies near the major fault line that divides the Indian tectonic plate from the Eurasian plate.

Earthquakes damage infrastructure like, buildings, streetlights, bridges, roads, etc. It also triggers other disasters like tsunami and landslides.

The seismic waves generated by an earthquake can be detected with an instrument called a seismograph. The severity or magnitude of the earthquake is measured on the Richter Scale, a unit devised by Charles F. Richter, an American seismologist, in 1935.

Figure 7.2 Tsunami

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(b) Tsunami

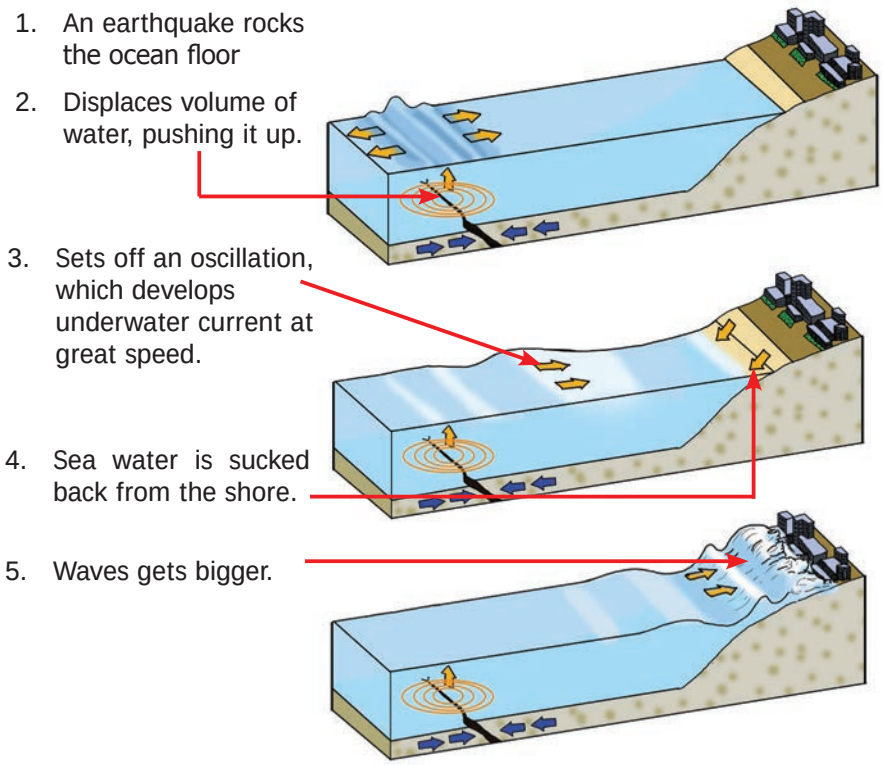

Figure 7.3 Tsunami Formation

Tsunami, meaning the 'harbour wave' in Japanese, develops generally on the ocean floor when triggered by an earthquake or volcanic eruption. Large scale disturbance in sea or ocean due to underwater explosions, or nuclear weapon explosions also may create powerful surge of water beneath the surface of the ocean that travels with a high speed towards the shore. These high speed waves manifest into tsunami and damage lives and properties along the coastal areas as shown in Figure 7.2.

(c) Volcanic eruption

Volcanic eruption is the ejection of hot, molten rock (lava), ash and gases from the depths of the Earth through the openings or ruptures on the Earth's crust.

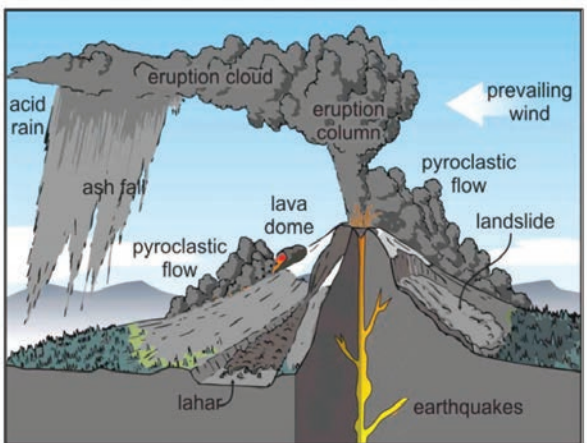

Figure 7.4 Volcanic eruption and its impacts

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Generally, volcanoes are classified as active, dormant and extinct. Active volcanoes are the ones that frequently erupt. Dormant volcanoes are inactive volcanoes that remain dormant for long periods and have potential to erupt in future. Extinct volcanoes have a record of eruption in the past, and are highly unlikely to erupt again. Volcanic eruptions are known to cause environmental pollution, loss of life, and damage forest, farms and homes.

Hydro-meteorological disasters

These disasters occur due to disturbances and imbalance in atmospheric, hydrological and oceanographic phenomena. Examples are cyclones, floods, landslides and avalanches.

(a) Cyclones and Windstorms

Cyclones are developed over the seas due to low atmospheric pressure and high humidity over warm waters. They are characterized by inward spiraling winds that rotate counterclockwise in the northern hemisphere, and clockwise in the southern hemisphere. Cyclones are named depending on their regions of occurrence like tropical cyclones in the Tropical regions; hurricane in the Atlantic region; and typhoon in East and Southeast Asia.

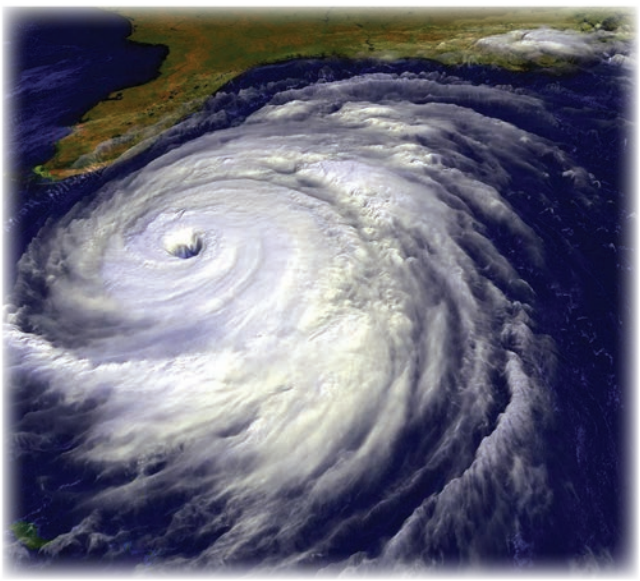

Figure 7.5 Cyclone

A severe cyclone will have a wind speed of over 120 km/h. As the cyclone moves towards land from the sea, it brings thunder showers, heavy rain and storm surges which destroy and damage human settlements.

Wind speeds exceeding 55 km/h is windstorms. Every year, wind storms blow the roofs of many Bhutanese houses, damage crops, disrupt power and water supplies. It also damages roads, irrigation channels and bridges, and other infrastructure, including schools and hospitals across the country.

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(b) Flood

Flood is an overflow of water that submerges the land. Floods occur when the river changes its course, or the volume of water exceeds the water holding capacity of the river or streams. Floods are generally caused by heavy precipitation. Floods are quite common in Bhutan. Some of the major causes of floods in Bhutan are heavy rainfall, natural dam formation, landslides blocking the flow of the stream, heavy siltation of the river bed leading to a reduction in its water carrying capacity, and construction of dams and reservoirs.

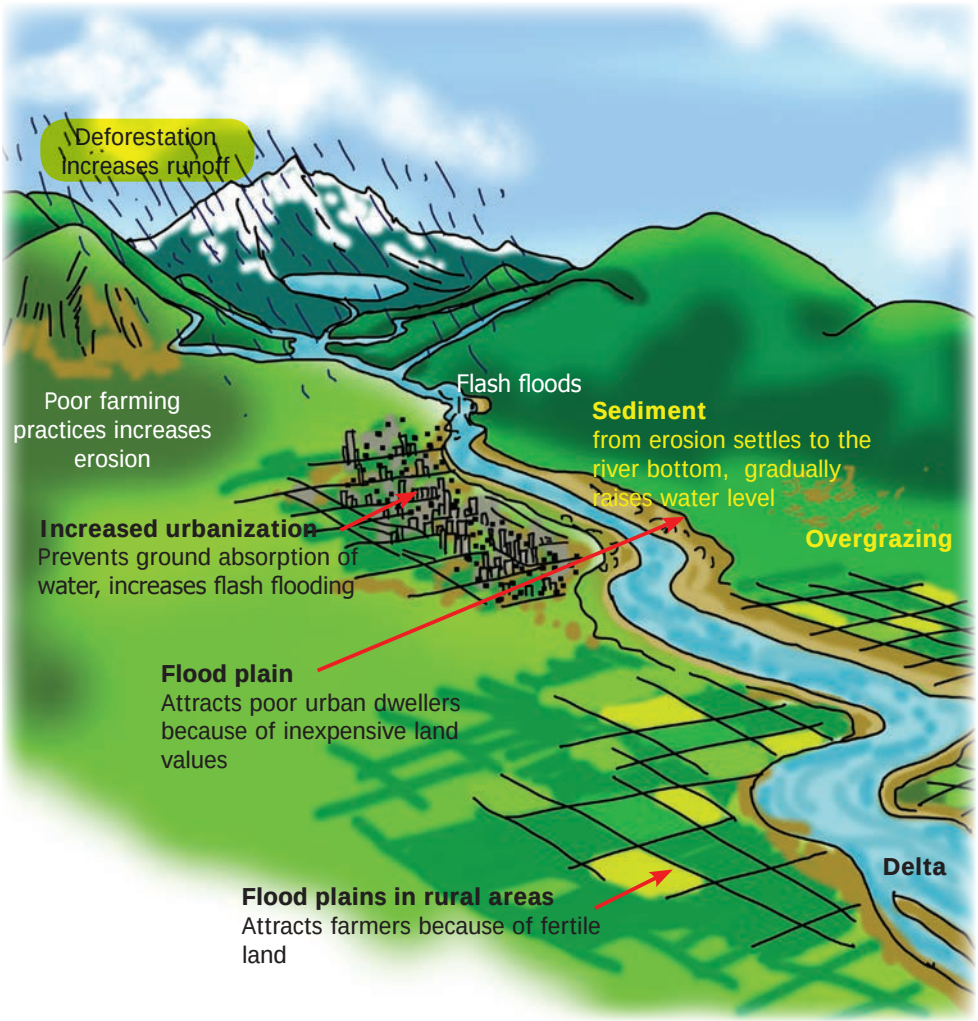

Figure 7.6 Causes and impacts of floods

Coastal flooding can result from a variety of different causes, including storm surges created by storms like hurricanes and tropical cyclones, rising sea levels due to climate

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change and by tsunamis. Flood engulfs large areas of land causing damage to life and property.

(c) Glacial Lake Outburst Flood (GLOF)

Earthquakes can trigger Glacial Lake Outburst Floods (GLOF) by breaking natural dams formed and its outbrust could be taken under floood. A large amount of water gushes out when a glacial lake bursts. This floods valleys and low lying areas. Glacial Lake Outburst Floods are among the most potential natural disasters in Bhutan. Source 2,674 glacial lakes in Bhutan, of which 25 are potentially dangerous in terms of GLOF.

The regions at risk from GLOF are the basins of Chamkhar Chhu, Mangde Chhu, Kuri Chhu, Mo Chhu and Pho Chhu. GLOF may claim lives and cause massive property and livestock damages, including the damage of hydropower plants, agricultural lands and human settlements.

(d) Landslide

Landslide is the sudden movement of mass of earth (rock, earth, or debris) down a slope.

Landslides are very common in Bhutan because of its geographical location. The contributing factors are the loose soil, heavy rainfall, rapid flow of rivers and streams, construction of roads and deforestation.

Landslides cause property damage, injury and death, and adversely affect a variety of natural resources. For example, water supplies, fisheries, sewage disposal systems, forests, dams and roadways.

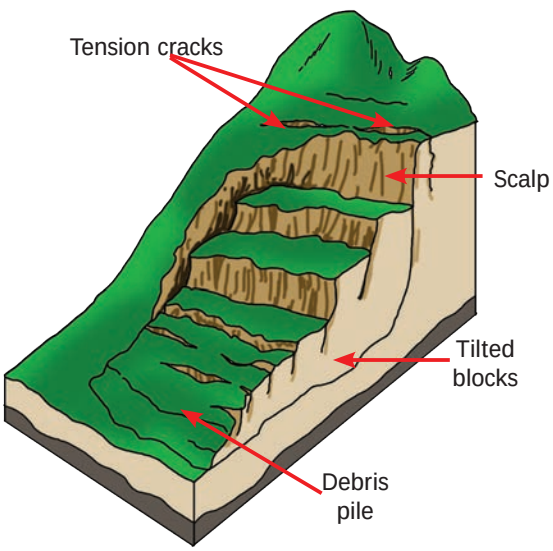

Figure 7.7 Landslides

(e) Avalanche

Avalanche is the rapid slipping of snow down the snowy mountain slopes.

An avalanche may constitute snow, ice, rock or soil, or debris containing all these materials. Major causes of avalanche are wind, heavy snowfall, and earthquakes. Human activities, like skiing, mountain climbing and loud sounds, also trigger

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avalanche. Avalanches usually bury people, animals, vegetation, and cause power and water supply disruptions.

Figure 7.8 Avalanche

Climatological disasters

Climatological disasters are the result of prolonged extreme climatic or weather conditions, such as extreme winter conditions and drought. It is also a result of heat wave, cold wave or wild fires.

(a) Drought

Drought occurs when the water resources are reduced, or become dry due to low rainfall or snowfall. Severe and prolonged droughts may permanently alter the ecosystem, cause severe food scarcity leading to famine. Famine is considered as one of the worst natural disasters.

Figure 7.9 Drought

(b) Wildfires

Wildfires are caused by lightning and high atmospheric temperature in dry weather conditions. Forest fires are also caused by human negligence while farming, hiking, and trekking. It ferociously destroys forest, vegetation and living organisms. This leads to an unbalanced ecosystem.

Figure 7.10 Wild fires

Forest fire is a regular feature in Bhutan and occurs almost every year, causing damage to wildlife, including humans. They generally occur during dry seasons. In Bhutan, forest fires are mostly caused by human activities like cooking near or inside the forest, careless disposal of cigarette butts, or deliberate burning of forest to clear land for cattle grazing and farming.

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Bhutan is vulnerable to wildfire outbreaks, both in settlements and forest. The rugged terrain, highly combustible forest trees, erratic wind conditions and shortage of trained fire fighters make the containment of wildfires difficult.

Biological disasters

Biological disasters are caused by pathogenic organisms, toxins secreted by living organisms, and other bioactive substances such as antibiotic, enzymes, and vitamins. Major biological disasters include epidemics and insect infestations.

Figure 7.11 Pest infection

Epidemic diseases are infectious diseases which spread to a large population. Infectious diseases among humans account for more than one fourth of the deaths worldwide. The major epidemics are cholera, dysentery, meningitis, encephalitis, gastrointestinal infections and measles. Bird flu, foot and mouth disease, swine flu, rabies are also known to wipe out the cattle stocks and other animals. Plants and crops are also affected by diseases like potato scab, apple scab, brown rot, club root, etc. A pest is any living organism such as grasshopper, locust or worms, which damages plants and animals. Epidemic pest infestations and plant diseases affect crops and reduce food productivity.

Questions

1. What are the differences between natural disaster and the human induced disaster?
2. Which disaster is the most dangerous? Why?
3. Describe the natural disasters that frequently occur in Bhutan.
4. Write a report on any one disease or pest that affects crops or cattle in your village.
5. The poorest areas are the ones that suffer the most during and after a natural disaster. Justify the statement.
6. Why is natural dam formation a threat?
7. List the main causes of fires in forests and human settlements, and suggest ways to prevent them.
8. How can the damages caused by wind storm in Bhutan be minimized?

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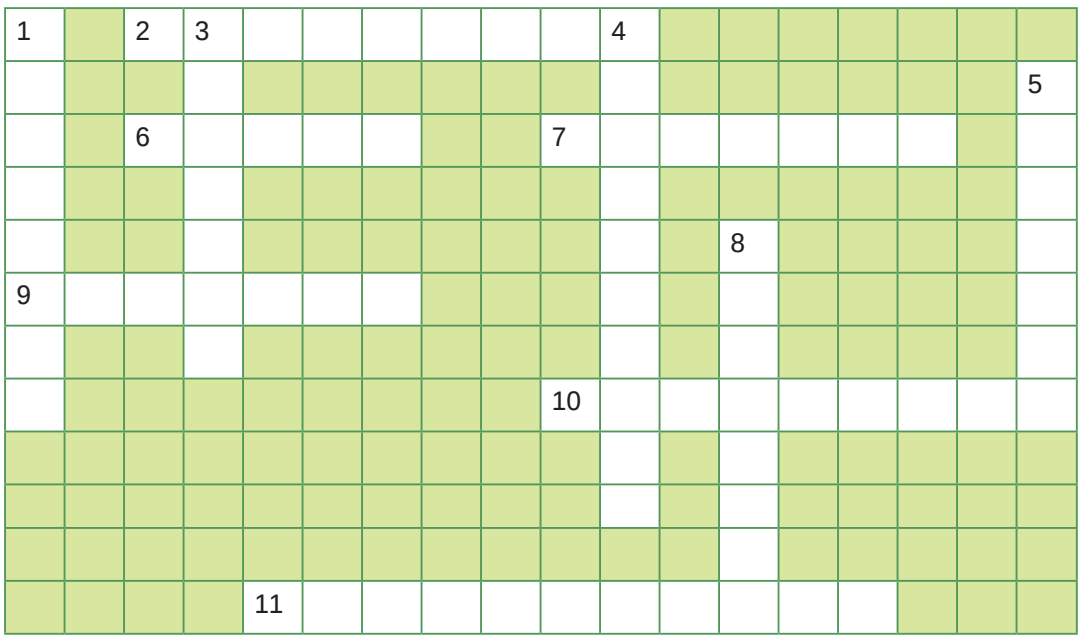
9. Complete the crossword given below by answering the following questions.

1. Cyclonic storms, floods, earthquakes, etc., are various types of .....
2. This disaster occurs when the snow cover on a slope slips down because of gravity.
3. This eruption spews out molten rock and ash from deep below the Earth's surface.
4. This disaster shakes the Earth's surface and causes damage to buildings.
5. This has spiraling high speed winds accompanied by heavy rainfall.
6. This occurs when overflowing water from a river, or a lake submerges the surrounding land.
7. This disaster results by the lack of rainfall for several years.
8. Disaster of biological origin.
9. The name of this disaster originated from a Japanese word.
10. Deforestation, construction of roads, mining, etc., are responsible for this disaster.
11. Earthquakes, volcanic eruptions and tsunami are categorized under this disaster type.



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1. Hazard, Vulnerability and Risk

Learning Objectives

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

- *explain the terms hazard, vulnerability, risk and response capacity.*
- *generate the relationship among disaster, hazard, vulnerability and risk.*
- *alert the community about disasters.*
- *assess the preparedness for the hazards.*

Hazard is an environmental event, physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption, and environmental degradation. Hazards are the sources of danger. A physical event, like earthquake that occurs in an inhabited region which does not affect human beings and properties is a natural phenomenon, but it is hazardous event if it damages the populated area.

The hazard that cause widespread damage to livelihood and property or unacceptably large number of loss of life is a natural disaster.

It is necessary to identify the type of hazard in a given region to determine the threat of disaster. Information like how frequently the hazard occurs, how far it spreads, and how severe are its impacts, helps in determining the probability of a disaster. Each hazard is characterized by its location. For example, earthquakes generally happen along the tectonic plate boundaries, which is the reason for Bhutan being vulnerable to earthquake.

Vulnerability is a condition of not being protected and safe. Vulnerability is the extent to which a community, property, services or geographic area is likely to be damaged by the impact of a hazard.

Vulnerability is determined by the physical, social, economic and environmental factors, which reduce people's ability to cope with and respond to the impact of an extreme event. For instance, a multi storied housing has greater chances of causing more death than a single storied house during an earthquake. Hence, during an earthquake, communities living in multi-storied buildings are more vulnerable.

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Housing is just one of the several factors, which contribute to the vulnerability of communities. A combination of several factors determines the vulnerability of a community.

Table 7.1 shows the various factors contributing to vulnerability. These factors have been grouped under broad categories for better understanding.

Table 7.1: Vulnerability factors

Categories	Vulnerability factors
Geographical	Physiographic characteristics of coasts like slope, elevation, shoreline features.
Climatic	Temperature increase.
Social	Demographic features (population, gender, age, density), literacy and education, insurance, health.
Economic	Livelihood and other economic indicators like property, vehicles, communication systems.
Physical	Houses, roads, bridges, cyclone shelters, transport and communication systems, and other infrastructure.
Environmental	Access to natural resources, availability and quality of natural resources, quality of ecosystem services.
Development related	Type of developmental activity, location, adherence to policies.

The degree of vulnerability varies for different hazards, and so do the responses. Vulnerability assessment is the methodology to determine the nature and extent of vulnerability. Information on various factors of vulnerability is collected and analyzed to arrive at the factors that make people vulnerable to disasters. The understanding of these factors helps in mitigating the risks of disasters.

Risk is the probability of harmful consequences of disasters such as deaths, injuries, property loss, livelihood loss, economic activity disruption or environmental damage, resulting from the hazards and vulnerable conditions. Risk is expressed as a function of hazard and vulnerability.

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Risk = Hazard x Vulnerability

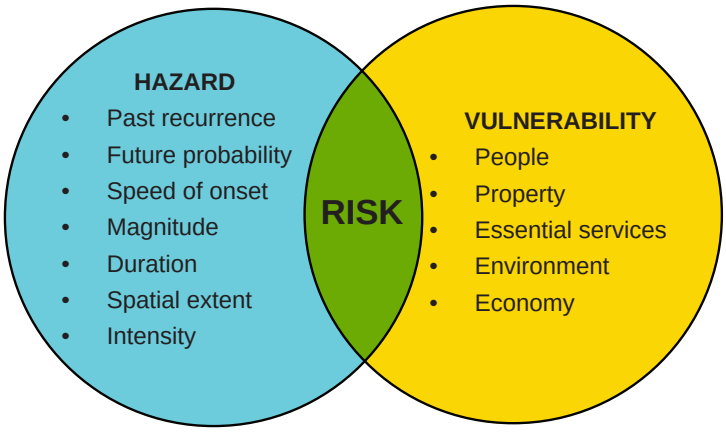

Figure 7.13 Risk, hazard and vulnerability

Risk is also defined as a function of hazard, vulnerability and response capacity. Response capacity refers to the availability of food, water, medicines, shelter, sanitation, etc., in the event of a disaster. The response (adaptive) capacity reduces the risk of spread of diseases, malnutrition, and displacement of communities. Therefore, risk is reduced by installment of response capacity.

Risk = Hazards x (Vulnerability - Response or Adaptive Capacity).

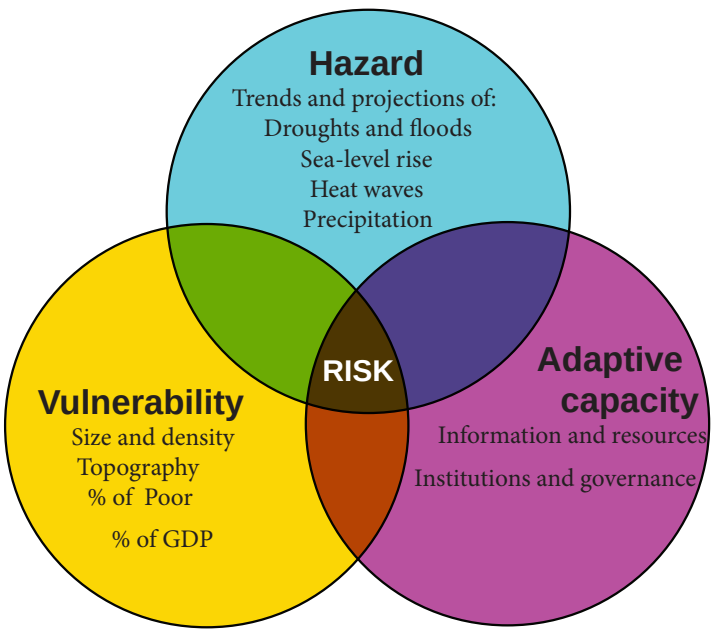

Figure 7.14 Risk, hazard, vulnerability and adaptive capacity

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Risk assessment is a methodology to determine the nature and extent of risk by analyzing hazards, conditions of vulnerability, exposure and coping capacity. Risk assessment is carried out for each hazard. It is important to recognize the type and frequency of hazards, and the magnitude of damage to make preparedness plans and to take necessary action.

Activity 7.2: Assess your locality

Materials required: Plain paper and pencil

Instructions

1. Observe the landscapes of your locality carefully.
2. Sketch it in a plain paper with all the details. Include slope, rocks, electric poles, road, cliff, infrastructure, stream, trees, etc.
3. Complete the Table 7.3 based on your sketch.

Table 7.2

Hazard	Secondary Hazard (Those hazards triggered by primary hazards)	Elements at Risk	Why they are at Risk?	
			Physical / Material	Social / Organisational
Earthquake	Fire, land slide, GLOF	School Buildings, Students, teachers	Location of the school/no evacuation site.....	No insurance, lack of community vitality, weak community leadership

1. What are the natural and human induced hazards in your locality?
2. Who are at the highest risk in your locality in case of an earthquake?
3. Who are the most vulnerable in case of windstorm? Give reasons.
4. Write a report that includes your observation, findings and recommendations.
5. How can you reduce the risks evident in your findings?

Answer the following questions

1. Explain the terms hazard, vulnerability and risk with suitable example in your own words.
2. Explain adaptive capacity.
3. A landslide in an uninhabited area is not a disaster. Justify.

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Activity 7.3: Check your preparedness

Instructions

1. Form groups and discuss the following hazards in your school.

   Hazards

   Earthquake, flash flood, wildfire, wind storm, landslide, epidemic, glacial lake burst, any other

4. Follow the instruction for filling information in Table 7.3.

Table 7.3.

Sl. No.	A Hazards	B Hazard likelihood 1 = low : 5 = high	C Impact Severity (Vulnerability) 1 = low : 5= high	D Risk Score =B x C	E Priority

- In column A, enter all the hazards from the list above that may affect your locality or your school.
- In column B, indicate the likelihood of occurrence of this event.
- You may need to interview the school disaster management committee, and, or local disaster management committee for hazards and likelihoods.
- Rate the likelihood on a scale of 1 to 5.

Hazards Likelihood	1 Very Low	2 Low	3 Medium	4 High	5 Very High

- In column C, rate the severity of impact for each of these hazards on a scale of 1 to 5. When rating the impact severity, consider the wide range of losses that your school and community may face such as:
  - Human- deaths, injuries, disabilities;
  - Physical – damage to buildings, equipment, services;
  - Economic- cost of repair and replacement, cost to students and families of delayed or incomplete education, loss of food;
  - Environmental- loss of water resources, debris accumulation, tree fall

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Vulnerabilities	1	2	3	4	5
Impact severity	Minor	Controllable	Critical	Devastating	Terminal

- In column D, find out the relative risk score by multiplying the hazard likelihood by impact severity scores.

Risk Score	3-1	8-4	14-9	19-15	25-20
Description	Very Low	Low	Medium	High	Very High

- In column E, enter the priority scores: low (1- 8 risk score), medium (9 to 14 risk score), high (15 to 25 risk score).

Risk Score	1-8	9-14	15-20
Priority Level	Low	Medium	High

5. Fill up the Table 7.5 in consultation with your school disaster focal person to find out the response capacity of your school.

Table 7.4.

Name of school:		No. of students:		No. of staff:
School status (Boarding/Day school):				No. of structures:
Sl. No.	**Items and activities**	**Available (Yes/No)**	**Quantity**	**Preparedness (Adequate/ Inadequate)**
1	First Aid Boxes			
2	Ladders			
3	Fire extinguishers			
4	Sand bags/buckets			
5	Electric torch			
6	Trained personnel			
7	Emergency contact Nos.			
8	Map showing clear exits route for every structure			
9	Rope			
10	Safety helmets			
11	Sirens/Alarms			
12	Disaster awareness campaign and notice board			
13	Mock drill sessions per year			

Answer the following questions

1. Which hazard(s) pose the highest risk to your school?
2. What steps would you take to reduce the risk(s)?

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3. Based on the information collected in Table 7.4 and Table 7.5, do you think that your school is prepared for any kind of disaster? Why?
4. Write a report to the school administration, or Gewog administrator on the preparedness status of your school and the help and support you require.

Summary

- Disaster is an event that causes serious disruption to life, and may cause economic losses beyond the coping capacity of a given society.
- Disaster can be broadly classified into two categories: natural, and human induced.
- Hydro-meteorological disasters occur due to disturbances and imbalance in atmospheric, hydrological and oceanographic phenomena.
- Geophysical disasters are caused due to natural Earth related processes and phenomena. Climatological disasters are the result of prolonged extreme climatic or weather conditions, such as extreme winter conditions and drought.
- Biological disasters are caused by pathogenic organisms, toxins secreted by living organisms, and other bioactive substances such as antibiotic, enzymes, and vitamins.
- Vulnerability is the extent to which a community, property, services or geographic area is likely to be damaged by the impact of a hazard.
- Risk is the probability of harmful consequences of disasters such as deaths, injuries, property loss, livelihood loss, economic activity disruption or environmental damage, resulting from interactions between hazards and vulnerable conditions. Risk is also related to the response capacity and preparedness of the people and the system.
- Risk assessment is a methodology to determine the nature and extent of risk by analysing hazards, conditions of vulnerability, exposure and coping capacity.
- Bhutan is vulnerable to disasters because of its geographical location. The disasters common in Bhutan are earthquake, glacial lake outburst flood, landslide, flash flood, forest fire, dam burst and windstorm.
- The various causes that amplify the risk are environmental degradation, unsafe construction practices, lack of awareness, and lack of disaster risk reduction initiatives.

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Exercise

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

i. Hazards generally lead to _____.

ii. The melting glacier in the Himalayas forms lakes that may cause _____.

iii. Earthquakes that occur under water usually triggers _____.

iv. Risk is expressed as a function of hazard and ……...

v. ……. disasters are the result of prolonged extreme climatic or weather conditions.

2. Match the items of Column A with the most appropriate items of Column B. Rewrite the correct matching pairs.

Column A	Column B
a. Instability of a slope	i. Cyclone
b. Lightening and dry weather	ii. Earthquake
c. Outbreak of disease	iii. Forest fire
d. High wind speed and heavy rainfall	iv. Flood
e. Movement of plates due to stress	v. Landslide
	vi. Epidemic

3. Write TRUE or FALSE for the following statements. Rewrite the false statements in the correct forms.

i. Human activities influence the frequency of natural disasters.

ii. A disaster mock drill session helps us to prepare against hazards.

iii. Severe Acute Respiratory Syndrome (SARS), a global pandemic, is a climatological disaster.

iv. Natural disasters can occur at any time without giving any warning or a signal.

v. A hazard becomes a disaster only when there is high vulnerability and high response capacity.

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4. Answer the following questions.

a. Define the following terms:

i. Disaster
ii. Vulnerability
iii. Epicenter
iv. Risk
v. Typhoon

b. Refer Figure 7.15 to answer the following questions

Figure 7.15

i. Identify and name the hazards 1to 10.
ii. Which hazards are not common in Bhutan
iii. Explain the cause and impact of hazards 3 and 7.
iv. Do you think hazard 4 will happen in Bhutan? Give reasons.
v. Differentiate between the causes of hazards 5 and 8.

c. What are the causes of earthquake? How do anthropogenic activities increase the risk?

d. What are glacier lake outburst floods? List down the major causes of glacier lake outburst floods in Bhutan?

e. How are forest fire, flood and landslide related to each other? Describe the root cause of these disasters in Bhutan.

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f. Study Figure 7.16 and answer the questions i to iv.

Figure 7.16

i. Name the hazard in the in Figure 7.16.

ii. Identify and list any three vulnerability factors that might have contributed to the disaster.

iii. What are some of the risks of this kind of disaster?

iv. Suggest some ways to prevent such hazards in other towns in Bhutan.

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Biodiversity

Biodiversity is an integral part of our day-to-day lives. The distribution of plants, animals and microorganisms varies among different geographical locations depending on the environmental factors. All organisms have relationships with the environment that they live in.

A range of studies have been undertaken to understand the various aspects of life, and volumes of information have been collected in the past two centuries. Despite this, we still do not have definite answers to several marvels of life, such as, how many species exist on the Earth? Why do zebras or tigers have stripes?

1. What is Biodiversity?

Learning Objectives

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

- *define the term biodiversity.*
- *explain the levels of biodiversity.*
- *trace the role of evolution in formation of diverse life forms.*
- *appreciate various adaptations and vital relations*

Biodiversity or biological diversity refers to the variety of life forms in a particular area or earth. It consists of plants, animals and other microorganisms living in wide range of habitats. Biodiversity determines the health of an ecosystem. .

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A. Levels of biodiversity

There are three levels of biodiversity. They are genetic diversity, species diversity and ecosystem diversity.

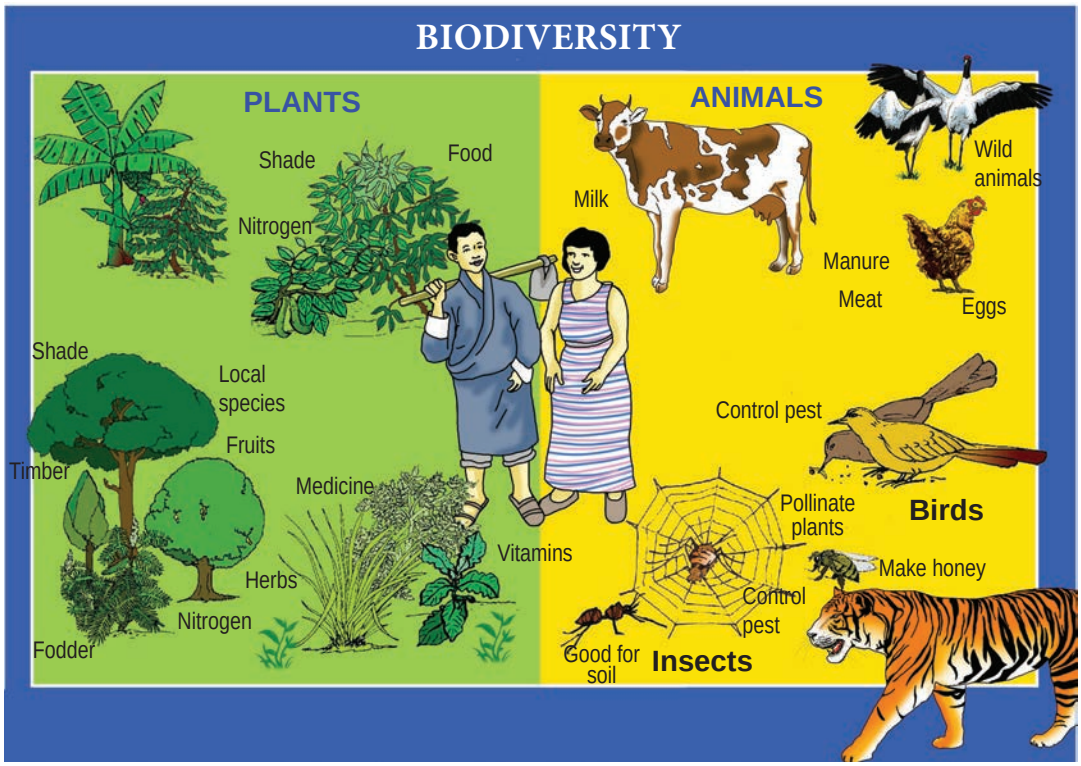

Figure 8.1 Biodiversity

Genetic diversity: Genetic diversity refers to the variation of genes within a species. The individuals of the same species differ in their genetic makeup, hence they exhibit unique characteristic features.

Figure 8.2 Variety of rice

For instance, there are more than 40,000 varieties of rice (*Oryza sativa*) worldwide. It is easy to identify some of the varieties by their size, colour and taste (Figure 8.2).

Species diversity: Species diversity refers to the variety of species within a given habitat or ecosystem (Figure 8.3). In nature, individuals of one species do not, generally, breed with individuals of another species. Each species is distinct from the

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other. Species diversity is measured as the total number of species in a given area. It is also called species richness. Species diversity is most commonly used to describe the biodiversity of a region. The global biodiversity is estimated to be about 10 to 50 million, however, biologists have classified only about 1.7 million species so far.

A majority of the species not described or identified are insectsand tiny creatures, including microscopic organisms. Less than five percent of the species identified are large mammals, birds and vascular plants.

Figure 8.3 Species diversity of animals

Ecosystem diversity: Ecosystem diversity refers to the occurrence of different types of ecosystems in a geographical area (Figure 8.4). Ecosystems show variation in terms of biotic composition and abiotic factors.

Even within a single ecosystem, species vary because of different habitats. For instance, a forest ecosystem may contain different habitats like tropical forest, deciduous forest and scrub. Similarly in a river, the surface water habitat varies from the habitat at the bottom because of differences in the physical, chemical and biological factors.

Figure 8.4 Different types of ecosystem

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B. Origin of life on Earth

According to big bang theory, the solar system was formed as a result of explosion of a single mass of matter called singularity. The primitive earth formed was a ball of hot gases It underwent gradual cooling and formed present earth.

Figure 8.5 Prokaryotes

As the planet Earth cooled, water vapour condensed and poured down as rain. This led to the formation of water bodies. Organic substances like nucleic acids, proteins, fats, and carbohydrates were formed in those water bodies. Early life forms such as, prokaryotes (Figure 8.5) are said to have formed by condensation of these organic substances. The prokaryotes gradually evolved to unicellular and multicellular eukaryotes.

Thus, life from oceans could have branched out into the millions of species that we know today.

C. What caused life to diversify?

Charles Robert Darwin, a British naturalist, put forth the most important theories of the origin of species in 1859. On his great voyage to Galapagos archipelago in the Pacific Ocean, he studied the life forms there, and drew theory of evolution that explained the origin of species. According to Darwin, organisms produce large number of offspring. This may lead to competition or struggle between various individuals for food, space, mate and other resources, and control the growth of the population. Therefore, struggle for existence is not just a physical battle between two life forms, but it is also for dependence of one organism on the other for food, shelter and reproduction.

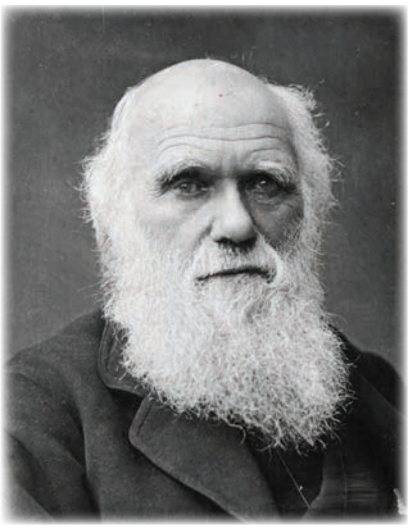

Figure 8.6 Charles Robert Darwin

Some organisms show changes induced by competition and changing physical conditions, thus adapting to the situation to survive and produce healthy offspring. This change is called 'adaptation leading to variation'. Most suited adaptations are passed on to the next generation. This phenomenon of survival by organisms by adaptation is called natural selection or selection by nature.

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Likewise, populations of a species, when separated and isolated by geographical barriers, try to adapt themselves to a new environment and survive. While adapting, changes occur in the gene pool of the isolated population. Over a period of time, this isolated population with the genetic variations may not be able to breed with their ancestral population. The isolated population becomes a new species by natural selection.

The process of evolution of new species by natural selection is called speciation.

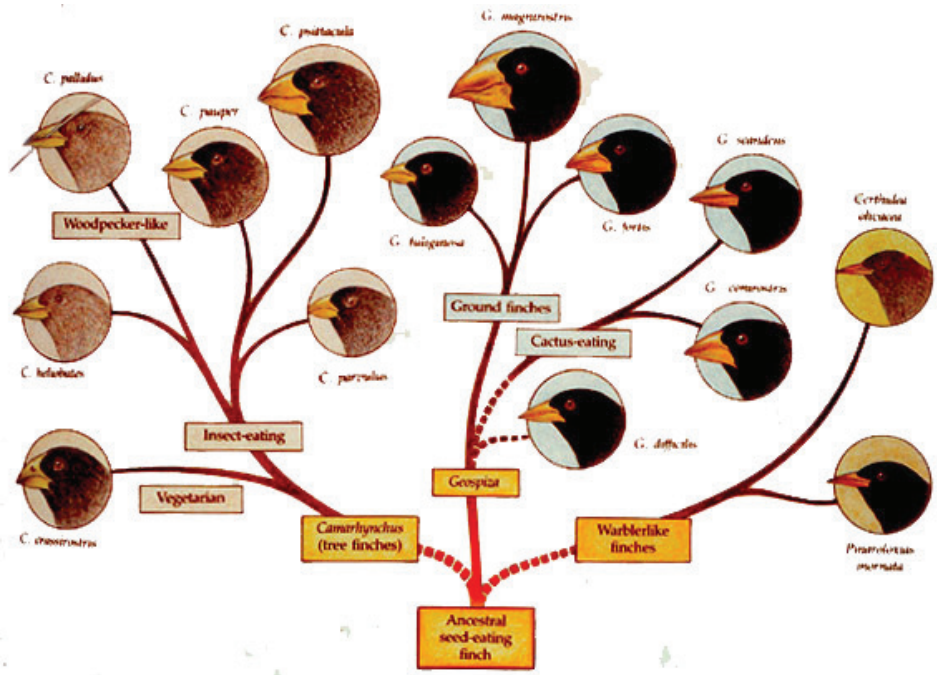

Figure 8.7 Darwin finches

For instance, Darwin's finches found in Galapagos islands evolved from a species of native finches that lived in the mainland. Initially there was only one species of finch in mainland, however, when the mainland fragmented into several islands, the native finch population broke into smaller populations that occupied separate islands. Due to geographic isolation, the finches occupying different islands gradually evolved to about 13 new species of finches (Figure 8.7).

D. What is adaptation?

Adaptation is the modification that an organism makes in response to changing environmental conditions to survive. Adaptations help organisms to escape from predators, find food, survive in various climatic conditions, and find mates or rear young ones. Adaptations have increased specializations, complex structures and

functions resulting in increase in the diversity in organisms. Adaptations may be structural, physiological and behavioral.

Viceroy butterfly Monarch butterfly

Figure 8.8 Batesian Mimicry

Structural adaptations are changes that organisms make in their structures. For instance, in fast running animals like deer, the structure of the body is adapted to enable swift movement. Fish and birds also show structural adaptations.

Sharp structures like thorns and spines in some plants help to ward off the herbivores. Webbed feet in aquatic animals help them swim with ease. Some orchids mimic the shape of insects. This attracts other insects resulting in pollination.

Colour is one of the interesting survival strategies. Organisms display interesting colours to hide themselves from predators or prey. Some animals like chameleon change colour to camouflage themselves.

In physiological adaptation, organisms like snake, scorpions and some frogs secrete certain chemicals or venoms, which are poisonous to organisms, including human beings. Some plant species also secrete certain chemicals and latex that are poisonous to herbivores.

Figure 8.9 Behavioural adaptation (Mimosa pudica)

Behavioural adaptation refers to behavioural changes in response to various stimuli. Some species of snakes suddenly hiss and spit, or display bright coloured body parts to frighten predators. Some animals like chameleon remain motionless giving the impression of being dead, while others, like deer, flee at high speed.

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Some species of lizards break off their tails when attacked . Wriggling tails leave the predator confused, while the animal escapes. Leaves of *Mimosa pudica* (Figure 8.9) (touch me not) plant fold when touched.

Activity 8.1: Animal adaptation

Materials required: 6 clay balls of different colours

Instruction:

1. Divide the class into groups.
2. Tell the students they will play a game in which they all are predators.
3. Inform them that there are six coloured balls hidden outside the classroom.
4. Ask all the students to find the coloured balls.
5. Ask students to move in their group to find the coloured balls. The coloured balls are to be considered as prey.
6. Each group is to be given one minute to find the ball.
7. After a minute, all groups will gather back in the class.
8. Reveal the ball they have found.

Answer the following questions

1. Which coloured clay balls were difficult to find?
2. Why was it difficult to find the coloured balls?
3. What implication does the colour have on animals in their habitat?
4. What are the two prominent conclusions about survival of organism in a habitat that you can draw from the activity?

The vital relations: Interaction between organisms is vital for their existence. There are interesting interactions between species for food, space and mate. There are also other interactions like prey-predator relation, competition and cooperation.

Cooperation is when organisms live in close physical association. It is also called symbiotic relationship. The most common forms of symbiotic relationships are mutualism, commensalism and parasitism.

Predation is an interaction, where one species is eaten by the other. The one which eats is the predator, and the one that is eaten is the prey. Predation is seen almost in every interaction. Herbivory is a type of predation, where the plant is eaten by a herbivore. Carnivory is an animal eating another animal. Predation leads to diverse adaptations like defence structures, chemical secretion, behavioural changes, etc., in both prey and predator.

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Competition is also a form of interaction between species or populations, which is detrimental to one of the interactants. Aggressive behaviour leading to fights is a direct competition. One species making the habitat unfavourable for the other is indirect competition. Competitions occur for food, space, mate and other resources.

Figure 8.10 Dinosaurs

Extinction: Extinction is complete disappearance of a species. Just as evolution is a natural process, extinction also is a natural and inevitable process.

Speciation and extinction are the two faces of a coin. Whenever there is imbalance created in nature due to physical, chemical and biological changes, species that cannot adapt to such changes disappear. Extinction is a gradual process, however, mass extinction can happen due to some abrupt disasters. When 50 to 90 percent of the species disappear within a short duration, it is called mass extinction. For example, extinction of dinosaurs. Habitats left by the extinct species open up opportunities for the new species, and leads to increase in species diversity. For instance, extinction of dinosaurs was quickly followed by speciation of mammals.

Extinction in the past took place due to natural reasons like continental movements, changes in climate, sea level, volcanic activity, asteroid bombardments, etc.

However, species extinction in recent years continues at a faster rate due to human actions. More than 700 species is estimated to have disappeared from the face of the Earth since 1600 AD.

Questions

1. What is biodiversity?
2. Explain the levels of biodiversity in your neighbourhood with examples?
3. Using an example, explain how evolution created diverse life forms?

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2. Geographical Distribution of Biodiversity

Learning Objectives

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

- *appreciate the richness of species on the Earth.*
- *illustrate the distribution of species.*
- *explain the biodiversity hotspots.*
- *measure the species richness in a given area.*

The distribution of biodiversity is determined by the ecology and history of the Earth, particularly the continental drift. On the basis of animals and plants present in various regions of the Earth, eight biogeographical zones have been identified. Each biogeographical zone contains biomes, which are largely defined by climatic factors.

Activity 8.2: Biodiversity in your area

Materials required

Measuring tape, field guides, rope, magnifying lens, pegs

Procedure

1. Identify an area in or near the school.
2. Set up a study plot of size 2 X 2 feet.
3. Fix pegs at four corners and tie a string around these pegs to fix the study plot.
4. Lay out the study plot in different areas in terms of plant type, sun or shade, etc.
5. Observe all forms of life in the study plot.
6. Tabulate the observations.
7. Present your observation to the class. Refer Figure 8.12.

Answer the following questions

1. Which plot has the maximum species of organisms? Why?
2. Is there any organisms that is common among the plots? Why do you think so?
3. Draw circle graphs to show the density of species in different plots.
4. What conclusion(s) can you draw from the activity?

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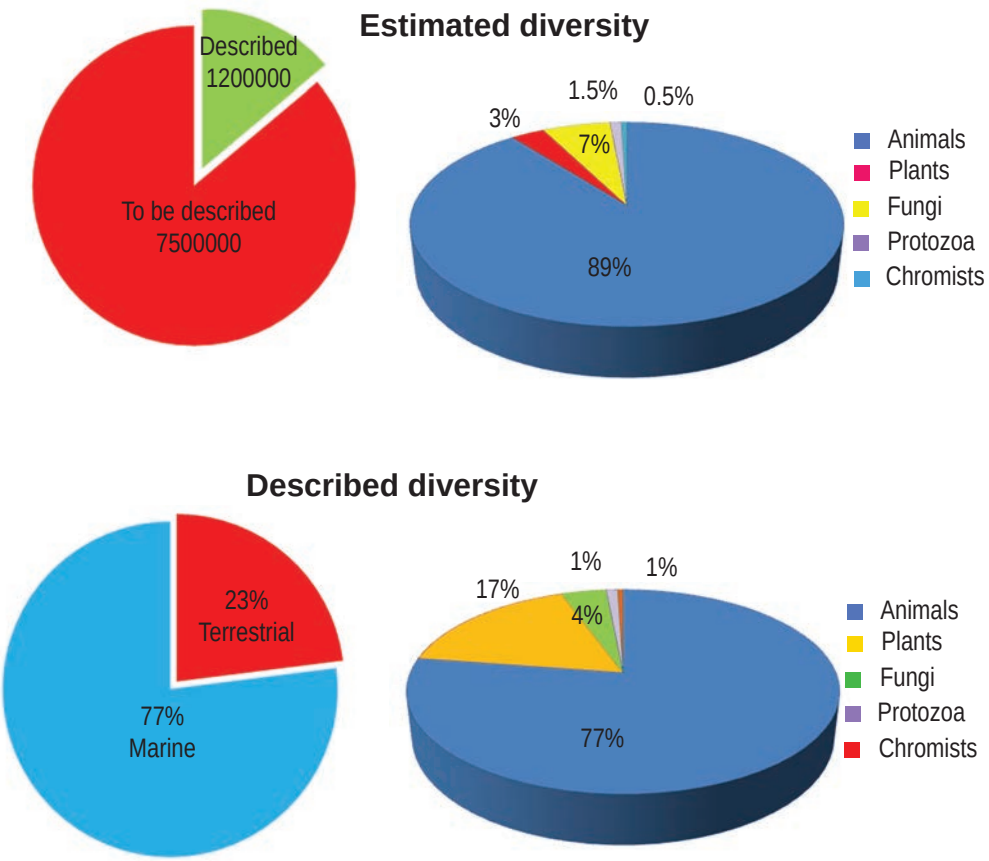

Figure 8.11 Estimated and described global diversity of species

It is difficult to determine the exact number of species and their distribution on the Earth. However, recent studies have shown that there are approximately 8.7 million species on the Earth (Figure 8.11).

Some of the biogeographic regions are the repositories of biodiversity, but are under threat due to human activities. These regions are called biodiversity hotspots (Figure 8.12).

An area qualifies to be a hotspot, if it contains at least 1500 species or 0.5 percent of the world's plant species as endemic species, and it should have lost at least 70 percent of its original habitat.

Do you know?

The Hindu Kush-Himalayas of which Bhutan is a part, houses about 25,000 plant species, which accounts to 10 percent of the world's total plant diversity.

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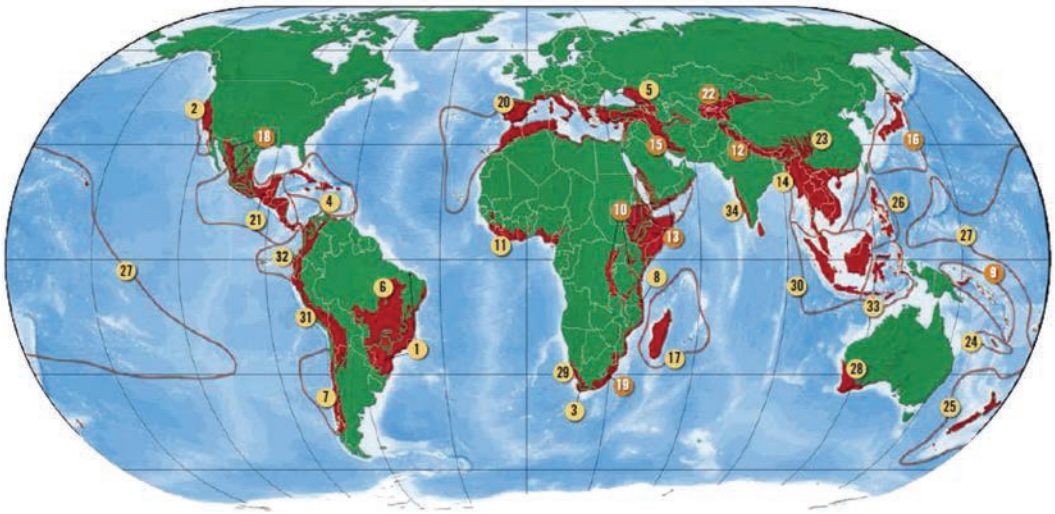

Figure 8.12 Biodiversity hotspot of the World

There are 34 biodiversity hotspots around the world, as shown in Figure 8.13. They house at least half of the world's total plant species as endemics. They have lost around 86 percent of their original habitat. Bhutan falls under the Eastern-Himalayan hotspot.

Countries that harbour the majority of the Earth's species are considered extremely biodiversed, and are called mega diverse countries. Conservation International identified 17 mega diverse countries in 1998. All are located in, or partially in, tropical or subtropical regions (Figure 8.13).

Figure 8.13 Mega Biodiverse Areas

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(1) Mexico-Guatemala, (2) Peru-Ecuador- Bolivia, (2A) Southern Chile, (2B) Southern Brazil, (3) Mediterranean, (4) Middle East, (5) Ethiopia, (6) Central Asia, (7) Indo- Burma, (7A) Siam-Malaya-Java, (8) China and Korea.

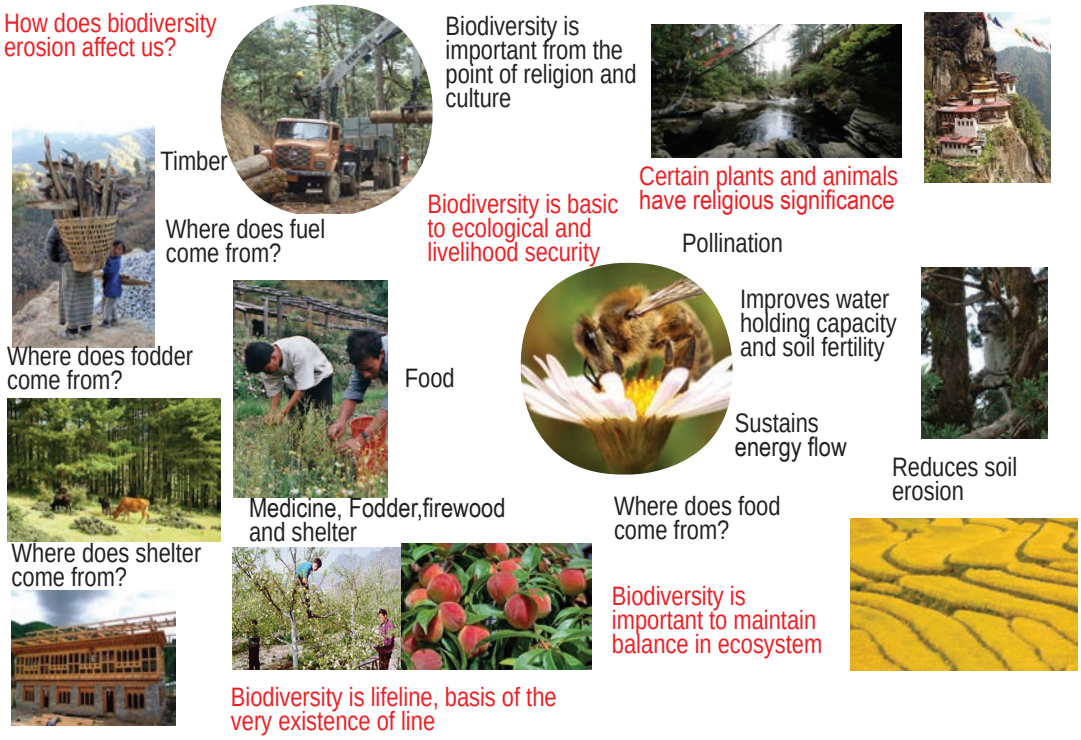

Figure 8.14 Importance of biodiversity

Questions

1. Why are biodiversity hotspots not located in the inland or the Arctic region?
2. How do the species found in biodiversity hotspots and continents differ?
3. Explain why the South East Asian countries have a rich biodiversity.
4. Describe the species richness on the Earth.

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3. Importance of Biodiversity

Learning Objectives

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

- *explain the economic, social, cultural and ecological importance of biodiversity.*
- *appreciate biodiversity as the lifeline and the basis of existence of life.*

Activity 8.3: Why is biodiversity important

Instruction

Study Figure 8.15, and discuss the importance of biodiversity in groups.

Answer the following questions

1. How does biodiversity help to maintain the ecological balance?
2. Explain how biodiversity contribute towards socioeconomic development of the community.
3. Recall your day-to-day activities, and list the activities that use biodiversity.
4. Explain briefly the influence of religious practices on the local biodiversity.
5. Explain the importance of biodiversity to the Bhutanese people.

Human societies are highly dependent on the biological resources, and the biological processes for their sustenance, health and well being. Forests, wetlands and water resources supply food, fodder, fiber, fertilizer, medicine and housing needs. More than 10,000 plant species and several animal species are directly used for various needs by humans. Hence, biodiversity is important from an economic point of view. It is the basis for food and livelihood security of the world's population.

Biodiversity is an important part of religion and culture. Several plants and animals are worshipped, and several others are considered sacred because they are associated with the local deities. According to traditional literature, every natural resource has distinct qualities, and definite roles to play in the maintenance of the ecosystem.

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Further, biodiversity is important for the well being of the environment. Trees, in particular, with their wide canopy, reduce the force of rain falling on the ground. The vast and extensive root system spreads underground and holds the soil particles; thereby, controlling both the soil erosion and water runoff. Biodiversity regulates the nutrient cycles, gaseous cycles and maintains the energy flow in the ecosystem. Biodiversity, therefore, is the basis of ecological security.

Figure 8.15 Singye Dzong

Most importantly, from the ethical point of view, each species is unique and has the right to exist, regardless of its value to human societies.

Questions

1. Explain with examples the significance of biodiversity to our lives in the following areas:
   i. economy.
   ii. social and culture.
   iii. ecology.
2. Explain the importance of Biodiversity in cultural practices in Bhutan.Describe the natural environment of the Dzong.

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4. Biodiversity in Bhutan

Learning Objectives

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

- *list major plants and animals of Bhutan.*
- *appreciate the rich biodiversity of Bhutan.*

The Eastern Himalayas is a global biodiversity hotspot. It is counted among the 234 globally outstanding eco-regions of the world. Bhutan is located in the southern slope of the Eastern Himalayas, at the juncture of the Palaearctic realm, the Indo-Malayan realm and the Oriental realm. Thus, Bhutan has many floristic elements: Asian-Malaysian, Himalayan-Chinese- Japanese, Deccan (India), Tibetan (China), and Euro-Siberian. The altitude of the country ranges from 100 to more than 7,500 metres. This geographical diversity and diverse climatic conditions, endows Bhutan with an outstanding habitat and ecosystem diversity.

A. Forest ecosystem

The diverse ecosystems and eco-floristic zones have made Bhutan home to a wide array of flora and fauna. Three major ecosystems have been identified: forest, aquatic and agriculture.

Forest ecosystem covers 71.5 percent of the geographical area. The three distinct zones are identified in Table 8.1.

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Table 8.1 Types of forest ecosystems

Forest ecosystems	Forest types	Main plants	Major animals
Alpine forest - 4000 metres above sea level	Forest scrub.	Alpine meadows with no tree cover.	Snow leopard, lynx, blue sheep, Himalayan marmot, Tibetan wolf, takin, musk deer.
Temperate forest - 2000 to 4000 metres above sea level	Fir forest. Mixed conifer forest. Blue pine forest. Broadleaf mixed with conifer forest. Broadleaf hardwood forest. Forest scrub.	Fir, spruce, larch, hemlock, oak, rhododendrons, blue pine, maple, birch, poplar, avocado.	Goral, serow, black bear, grey langur, red panda, Assamese macaque, leopard.
Sub tropical forest - 150 to 2000 metres above sea level	Chirpine forest. Broadleaf hardwood forest.	Oaks, alder, sal, teak, catechu, cotton tree, rhododendrons, walnut, acacias.	Water buffalo, golden langur, sambar deer, tiger, golden cat, clouded leopard, capped langur, gaur.

B. Aquatic ecosytem

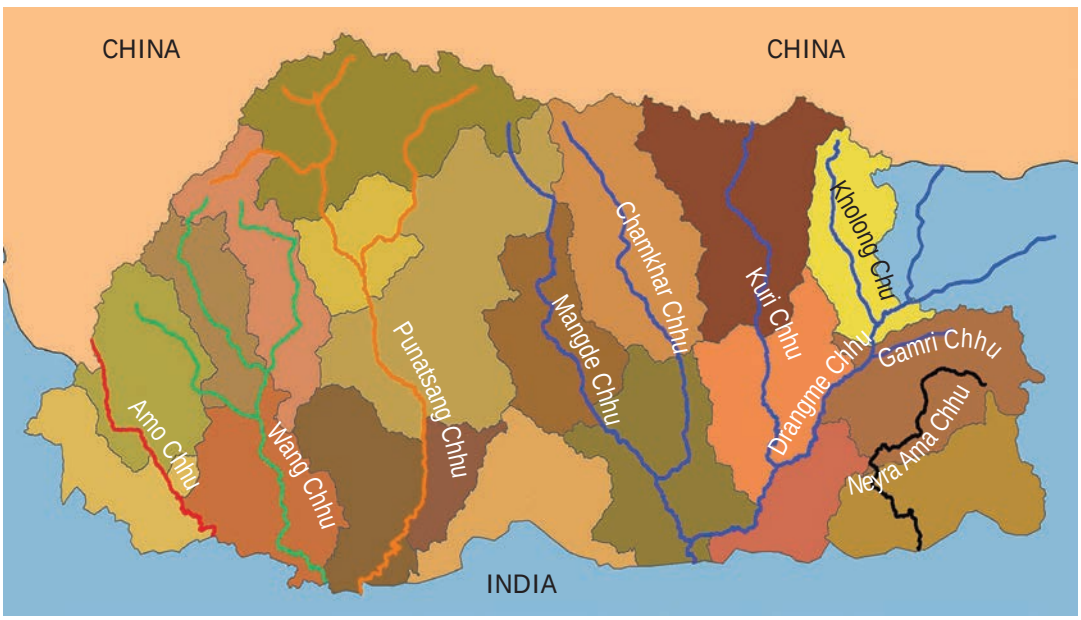

Figure 8.16 River basins of Bhutan

Aquatic ecosystems in Bhutan consists of extensive networks of river, rivulets and streams, glaciers and glacial lakes, and also marsh lands which hold water.

Amo Chhu (Torsa), Wang Chhu (Raidak), Puna Tsang Chhu (Sunkosh) and Drangme Chhu(Manas) are some of the river basins of Bhutan (Figure 8.16). There are about 2,674 lakes across the country. The largest is the *Raphstreng Tsho* at an altitude of 4,360 m in the north-west part of Bhutan.

Marshlands harbour a rich diversity of resident and migratory birds, reptiles, amphibians and fishes. Phobjikha valley is the best known marshland in Bhutan. Endangered black-necked cranes (*Grus nigrocollis*) roost here in large numbers during winter.

C. Agricultural ecosystem

Do you know?

The Himalayan yew *Taxus baccata* (subspecies *wallichiana*) is known to have cancer-curing properties.

Bhutan has six major agro-ecological zones that correspond with altitudinal range and climatic conditions. So, there is rich crop diversity in Bhutan. Alpine zone (3600 to 4600 m) has only meadows and nomadic yak herding communities. In the cool temperate zone (2600 to 3600 m), livestock farming is predominant. Warm temperate zone (1800 to 2500 m), dry subtropical zone (1200 to 1800 m), humid subtropical zone (600 to 1200 m) and wet subtropical zone grow a range of crops with rice as the staple crop.

The country is predominantly agricultural and grows diverse crop varieties. There are about 80 species of crop species, 350 rice varieties, 47 maize varieties, 24 wheat varieties and 30 barley varieties.

Other than cultivated varieties, there are wild relatives of these crops and horticultural varieties.

Livestock in Bhutan includes yak, sheep, horses, pig, birds, mules, goat, cattle, etc. Several livestock breeds are specific to Bhutan. For instance, the Nublang (Figure 8.17) is said to have originated in Sombaykha Gewog of Haa.

Figure 8.17 Nublang

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The yaks in Bhutan are similar to those which commonly habitat cold places in the Himalayas and Tibetan plateau. There appears to be distinct genetic differences between yaks in eastern and western Bhutan, with higher level of genetic diversity in the east. Yak and cattle hybridisation is commonly practiced in central and eastern Bhutan, producing several sub-breeds such as Zo and Zom.

Horse breeds found in the country are also considered to be unique. These breeds are Yuta, Boeta, and Jata. Ass breeds are imported from Tibet or India for crossbreeding with horses to produce mules.

Activity 8.4 Finding out crop biodiversity in the locality

Instructions

1. Visit a nearby village and interview a farmer and note down the following details:
   i. Crops varieties cultivated and reasons for selecting them.
   ii. Crop species diversity.
   iii. Cropping pattern.
   iv. Source of seeds, land preparation required, means of propagation, source of water, types of fertilizers used, types of crop diseases and their preventions.

Answer the following questions

1. How many varieties of crops are cultivated in the locality?
2. Among these varieties of crops, which is the most preferred? Why?
3. Explain the positive and negative effects of agriculture practices on biodiversity?

Do you know?

Swallow tail butterfly (Ludlow's Bhutan Glory) was re-discovered in 2009 after a gap of 80 years since it was first spotted in 1935.

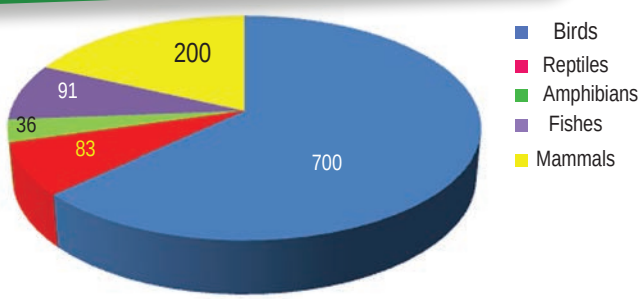

Figure 8.18 Animal Biodiversity of Bhutan

D. Wildlife diversity

Bhutan harbours some rare animal biodiversity (Figure 8.18). Of the 36 species of cat family, 11 are found in Bhutan. The royal bengal tiger and snow leopard are some of the examples. Bhutan harbours 27 species of globally threatened mammals, and 18 species of globally threatened birds. Around 800 to 900 butterfly species have been identified.

Bhutan has 23 Important Bird Areas (IBA), eight eco-regions, and a number of Important Plant Areas (IPA) and wetlands, including two Ramsar sites.

Bhutan's protected areas are spread across the country at strategic locations. There are five National Parks, four Wildlife Sanctuaries and one Strict Nature Reserve (Figure 8.19). They ensure biodiversity conservation at genetic, species and ecosystem levels. In short, they act as storehouse of biodiversity.

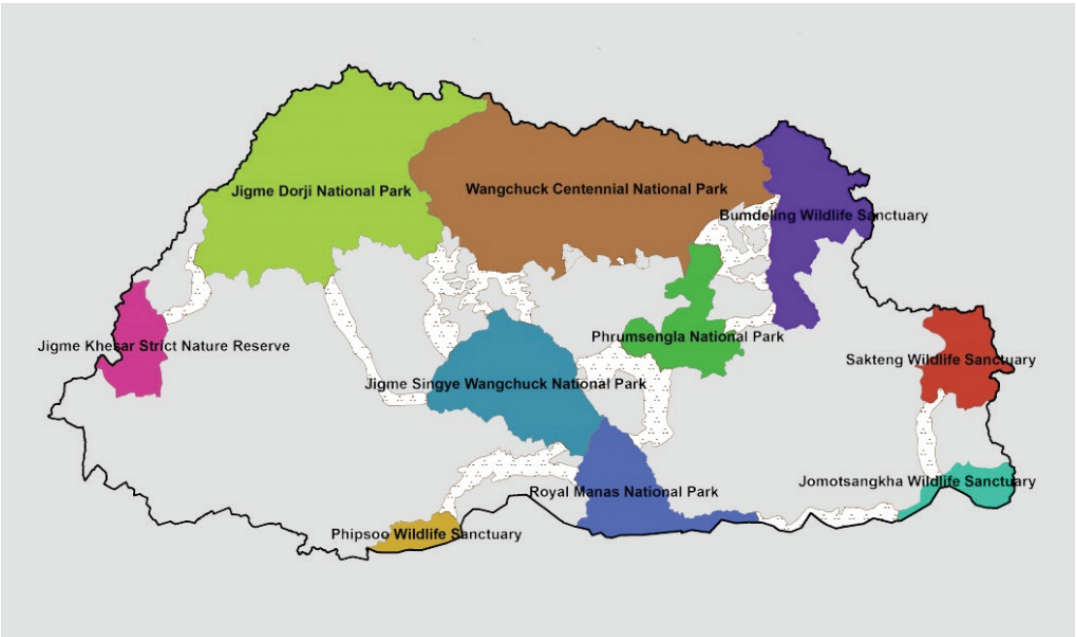

Figure 8.19. Protected areas and biological corridors of Bhutan

Bhutan is losing many of the indigenous crops species since many new varieties that promise more yields are being introduced. However, the National Biodiversity Centre of Bhutan (NBC), through its gene bank, is conserving the indigenous species found in the country.

Materials required

Large bags, notebooks, pencils, old newspapers, chart sheets, magnifying glasses and field handbooks.

Instruction

1. Divide class into teams of two students each.
2. Collect specimens of small plants with all the parts intact. Tag them with date, location (pond, forest) and give them a number. If you know their names, you may write them. Use a big plastic bag to keep specimens that you collected, ensuring that they remain fresh. Pick only 2 or 3 specimens of one plant. Care should be taken not to harm the plant while collecting the specimens.
3. Place the specimen between sheets of newspaper neatly. Lay it on a plain surface. Keep some weight on top, so that it exerts uniform pressure on the sheets with the specimen inside. Make sure to change the newspaper sheets regularly until the specimen is completely dried. This process helps to reduce the fungus attack on the specimens when you store them.
4. Use perforated chart papers cut to a size slightly bigger than the specimen. Mount the specimens by sticking each specimen to the paper using glue.
5. Use one corner of the sheet to label the following:
   - Name of the of collector
   - Date of collection
   - Name of plant (Local name, English name and scientific name)
   - Location
   - Habitat
   - Brief description of the plant
   - Uses

Your herbarium is now ready.

Answer the following questions

1. What is a herbarium?
2. What are the reasons for writing labels and short description of each specimen?
3. Why is this collection important?
4. List the problems that you encountered during the entire process of herbarium making.

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Activity 8.5 The Story of Nublang

Instructions

1. Read the case study below and answer the following questions.

Case study - Nublang, a dying breed

Nublang, an indigenous cattle breed unique to Bhutan, is slowly disappearing. According to the Ministry of Agriculture and Forests, there are an estimated 250,000 Nublangs. The actual figure may be much lower - around 20 percent.

In the past, the Nublangs were a symbol of wealth. They were prized for their strength and dairy products. With the introduction of power tillers and high yielding breeds like Jersey, the Nublangs came to play a less important role; their value decreased. One of the few places where the Nublang is still found is Sombaykha Gewog in Haa. For the people of Sombaykha, Nublangs are the main source of income.

Sangay Dorji, a villager, said, "We can sell butter for Nu.150 a kilogram and a ball of cheese for Nu.10 right here in our village. In a week, we earn about Nu. 4000." Some families own around 20 Nublangs. A few own as many as 100 Nublangs. People sell the dairy products in Sibsoo and Haa. The market depends on the location of pasture land. People living in Baysogang sell the produce in Samtse.

The government is taking various initiatives to ensure its survival like organising annual expos to showcase the cattle and forming a Nublang breeding association in Sombaykha. The government also provides Nublang bulls free of cost for breeding purposes.

Source: Bhutan Broadcasting Service, July 31 2011.

Answer the following questions

1. Why do you think the Nublang breed is disappearing?
2. What measures have been put in place to conserve Nublang?
3. What are some of the potential threats to biodiversity in Bhutan due to the gradual decline of Nublang species?

Bhutan is not losing much of the diversity since most of the ecosystems are under various protected areas, providing a safe haven for biodiversity to thrive. Despite this, threats to wild species diversity still persist.

Do you know?

For instance, the Golden Toad (1989), a fluorescent amphibian found in the high-altitude ridges of Costa Rica, disappeared due to pollution, global warming and fungal skin.

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Some of the common threats are:

- over exploitation of species through hunting, collection, fishing, logging and many other activities;
- habitat destruction through development of urban spaces, expansion of agricultural lands, industries;
- habitat fragmentation by creating barriers within habitats through road construction, power transmission lines and so on;
- introduction of invasive species, which are non-native to the area impact native species, ecosystems, and human health.

These threats cause the loss of biodiversity. If unchecked, it will result in the erosion of genetic diversity, extinction of species and degradation of ecosystems. Biodiversity conservation is important for our survival as it is our lifeline.

Questions

1. Name some of the indigenous breeds of plants and animals of Bhutan, and discuss their status.
2. How is biodiversity connected to livelihoods of people in Bhutan?
3. Explain religious perspectives with regard to biodiversity?
4. What are some of the prominent threats to biodiversity in Bhutan?
5. How would you as an individual conserve biodiversity?

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Summary

- Biodiversity is the diversity of life, including the diversity of the ecosystems they live in.
- The three levels of biodiversity are genes, species and ecosystems.
- The wide range of altitudinal variation and diverse climatic conditions make Bhutan rich in biodiversity.
- Biodiversity is important for economy, health, religion reasons, and maintaining the ecological balance in nature.
- Forest is the major ecosystem in Bhutan.
- Biodiversity hotspots contain high diversity of endemic species.
- Protected areas are a storehouse of biodiversity.
- Bhutan's protected area system cover more than half of the total land area. They conserve genetic diversity, species diversity and ecosystem diversity.
- Protected areas serve various functions, ranging from research and education to conservation; and deriving environmental benefits, and maintaining healthy ecosystems.
- Biodiversity faces several threats from human activities, which lead to loss of biodiversity.

Exercise

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

a. ..... is the diversity of life on the Earth.

b. The Theory of Evolution was put forth by ……..

c. Dinosaurs were ruling the Earth in …….. era.

d. Bhutan is the part of the ..... hotspot.

e. 'Ridham' can contribute to …… of biodiversity

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2. Match the following

Column A	Column B
1. Habitat	A. degradation of environment.
2. Over exploitation	B. physical environment.
3. Species richness	C. origin of biodiversity
4. Genetic diversity	D. storehouse of biodiversity.
5. Protected areas	E. number of species in an area.

3. Write TRUE or FALSE for the following statements. Rewrite the false statements in the correct forms.

a. Colouration in some animals is an adaptive feature.

b. Global warming does not alter biodiversity.

c. Fewer than 100 species currently provide most of the world's food supply.

d. The biological resources of developing countries are a possible source of income.

e. National parks and sanctuaries are for genetic conservation of species.

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

a. All of the following are functions of a protected area, except
   A. carrying out scientific research.
   B. protection of sacred sites.
   C. provision of environmental services.
   D. agriculture purposes.

b. The darkening of skin while moving to hotter places is an example of
   A. Adaptation
   B. Evolution
   C. Extinction
   D. Mimicry

c. Pine trees can survive in dry soil because
   A. leaves are needle shaped.
   B. stem grow tall.
   C. bear cones.
   D. leaves are green.

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d. The most relevant reason for differences amongst the individuals of the same species is
   A. Environmental changes
   B. Variation in genes
   C. Change in habitat
   D. Ecological resilience

e. Ecosystem is defined as
   A. the community of organisms together with the environment in which they live.
   B. the abiotic component of a habitat.
   C. the part of the Earth and its atmosphere, which inhibits living organisms.
   D. a community of organisms interacting with one another.

5. Answer the following questions.

a. Adaptation leads to speciation. Explain with an example.

b. What will happen if forests get fragmented?

c. Do adaptations make survival easier, or more difficult for organisms?

d. What are the three major forest ecosystems of Bhutan?

e. How is the health and stability of our ecosystem related to biodiversity?

f. Give examples of how we can protect biodiversity by our daily actions?

g. Describe the main idea of Darwin's theory of evolution by natural selection.

h. Why is Bhutan rich in biodiversity?

i. The rapid population growth of a few species can destabilize the ecosystem. Explain, why this situation is a threat to biodiversity?

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Fundamentals of Watershed Management

Water resources are important for the health and wellbeing of all the living beings and ecosystems. Water flows from snow, glacial lakes, wetland and streams through a network of drainage system into rivers, lakes, seas, and oceans. The demand for water resources is increasing every day. Judicious use and efficient management of water resources is crucial for sustaining continuous supply of water. All the resources in the ecosystem are interconnected, and overuse of one resource adversely affects the other. This chapter provides an overview of watershed management and its importance with special reference to Bhutan.

1. Watershed

Learning Objectives

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

- *describe watersheds with examples.*
- *explain the types of watersheds.*
- *explain the key features of watershed.*
- *explain the importance of watersheds.*

A. What is a watershed

A watershed is a geographical area, or an extent of land through which the water flows and drains into a common body of water such as streams, rivers, lakes, or oceans. Rain water and water from the melting of snow flows as streamlets. Several streamlets join to become a stream, which further join bigger water sources like rivers or lakes. This system of drainage pattern of water from different destinations into a common point is called watershed. Watersheds include both the surface water that

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flows through streams and rivers, as well as the ground water flow. Watershed is like a funnel collecting all the water within an area to a single point, as shown in Figure 9.2. Watershed is described by other terms like drainage basin, catchment area, catchment basin and river basin.

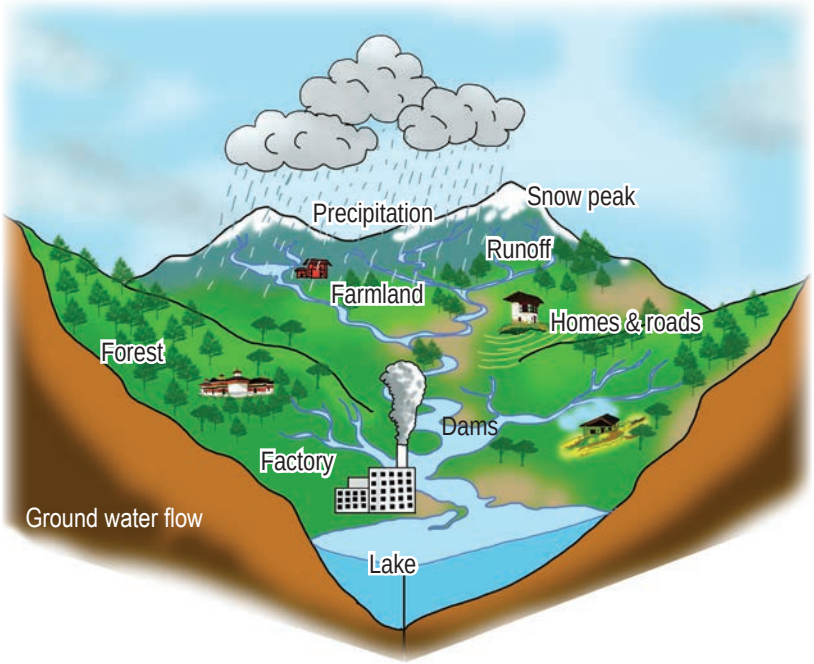

Figure 9.1 watershed

Activity 9.1: Creating a Watershed

Materials required: Chart paper, tray, water colour, brushes and water bottle.

Instruction: Work in groups.

Procedure:

1. Crumble the chart paper into a loose ball, and then partially open and spread the sheet on the tray, so that the crisps resemble mountains, ridges, cliffs, valleys, etc.
2. Identify one of the main ridges, and put a line of colour just below the ridge of one side only.
3. On the opposite side of the ridge, paint the line in a different colour. Repeat for some of the other main ridges.
4. Gently spray water, or have water droplets dripping over the mountains and valleys until the different colours begin to run off on the paper.
5. Make a sketch of the structure (watershed).

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Answer the following questions

1. What do the ridges on the crumbled paper indicate?
2. Identify all the geographical features in the structure.
3. How many watersheds can you identify from the structure?
4. Define watershed in your own words.
5. Use your knowledge to explain the watershed in your locality.

Watersheds are of two types, namely open and closed watershed. In open watersheds, water flows through streams, rivers and ultimately connects to oceans. For instance, Drangme chhu in eastern Bhutan joins river Bhramhaputra in India, ultimately draining into the Bay of Bengal. In closed watersheds, water from different points converges to a single point, which may be a lake, or it may even seep into the ground. These are inland basins and do not drain into oceans. These are also called endorheic basins. Much of the Sahara desert acts like an endorheic basins. The Dead Sea is another example of an endorheic watershed. Water in these basins is more saline, compared to oceans.

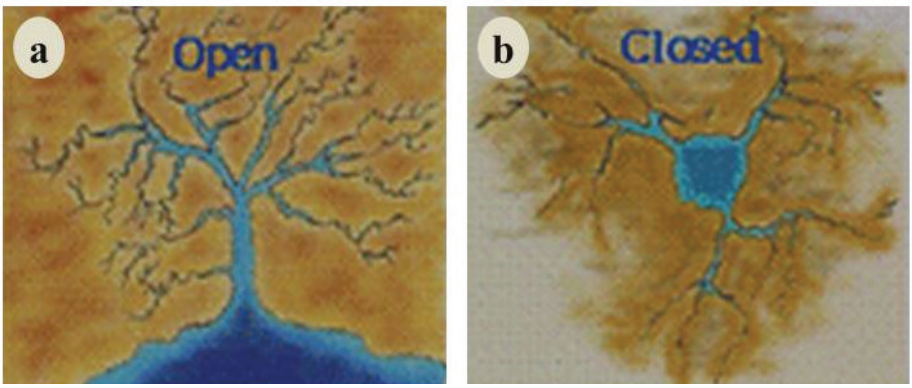

Figure 9. 2 Open and Closed watershed

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B. Key features of a watershed

The key features of watersheds are:

i. Size

Watersheds vary in size. Size is important in determining the amount of water that it can hold. Larger the watershed, larger is the channel and storage of water in basin.

ii. Shape

The shape decides the speed of water run-off reaching a river, or the common point. A long and narrow catchment will take more time to drain out water than a circular catchment.

iii. Drainage divide or watershed boundary

The natural elevated areas like ridges, hills and mountains form a barrier that determines the direction of the flow of water.

iv. Topography or terrain

If the area is steep, water is likely to flow rapidly. Such watersheds pose threat of soil erosion, floods and landslides. Relatively, flat watersheds have slow flowing water.

v. Soil type

Soil type determines the quantity of water reaching river and the ground water recharge. For instance, water on sandy soil is likely to be absorbed by the ground, while the clay soils permeate less water and causes more runoff.

vi. Land use

Land use pattern determines the volume of water reaching the river. For instance, forested land, or any vegetated land absorbs water and improves ground water status. This allows minimum runoff due to the vegetation canopy and extensive root systems. However, deforested land, or land devoid of vegetation increases the water runoff, raising the volume of the river.

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Activity 9.2: My Watershed

Materials required

Note book, colour, pencil.

Instructions

1. Draw or obtain a map of your locality.
2. Trace the streams, river and its tributaries in one color on the map.
3. Lightly color the area that feeds each of the streams in different colour.
4. With a black coloured pencil, draw arrows to show the direction of the water flow.
5. Present and share your map.

Answer the following questions

1. Identify the type of watershed of your locality.
2. Describe the watershed of your locality referring to the key features of the watersheds.
3. What are the human activities happening in this watershed?
4. What are some of the effects of human activities in this watershed?
5. What are the potential threats due to this type of watershed?
6. Suggest some ways to protect this watershed.

The Earth consists of several watersheds. We all live in one, or the other watersheds. Watersheds are important source of natural resources. Therefore, watersheds provide services, which are given in the Activity 9.3.

Activity 9.3: Why is watershed important?

Instructions

Read the following statements on the importance of watersheds.

1. Supplies drinking water for living organisms, including human societies.
2. Provides water for growing crops and ensuring food security.
3. Supplies rich resources, such as fuel, fodder, fish, and other food.
4. Contributes to industrial and manufacturing activities, including hydroelectricity generation; thus, supporting the economy of a country.
5. Provides diverse habitats to variety of plants and animals.
6. Stabilizes land by trapping sediments.

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7. Recharges the ground water resources, and ensures the ground water supply.
8. Contributes to water cycle.
9. Helps in nutrients cycles.
10. Traps pollutants and processes them, rendering pollutants less harmful.
11. Prevents flood.
12. Regulates the atmospheric temperature and, thereby, the climate.
13. Provides educational opportunities.
14. Provides aesthetic and spiritual services.
15. Serves as recreational facility.

Answer the following questions

1. Classify the statements into economic, socio-cultural, aesthetic and ecosystem services categories.
2. What are the benefits your locality derives from the watersheds?
3. How does watershed provide ecological services?
4. How do watersheds influence the belief system of the communities?
5. Why should Bhutan conserve watersheds??

Questions

1. List the types of watersheds with examples.
2. What are the key features of watersheds?
3. Why are watersheds important?
4. Study the picture given in Figure 9.7 and answer the following questions.
   i. Identify the type of watershed.
   ii. What does the dark blue line represent?
   iii. Briefly describe the watershed.

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Figure 9.3 Woochu Watershed in Paro

2. Watershed Management

Learning Objectives

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

- *discuss the impact of human activities on the watershed.*
- *explain the principles of watershed management.*
- *list the steps involved in watershed management.*
- *develop a simple action plan to protect a stream, or a pond in your locality.*

Human societies use watersheds for various purposes. Overuse of watersheds may cause reduction in the water flow and pollution of river, streams and ponds, which affects the health of the ecosystems in the watershed.

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A. Causes of watershed degradation

Socio-economic activities such as urbanization, industrialization, dam construction and deforestation affect the quality and the quantity of water flow in watersheds. The increase in natural resources demand, increase in number of domestic animals, and changing of agricultural practices adversely affect watersheds. Pesticides and chemical fertilizers affect the quality of watersheds.

Distribution and intensity of rain, soil texture, infiltration rate and topography also lead to degradation of watersheds. Sediment deposits in rivers and lakes due to soil erosion reduce water holding capacity of the watersheds.

Watershed degradation is a worldwide concern. Increase in human population has posed a great threat to the existing watersheds. Pollutants from different sources enter the water and soil. Through the food chain, they enter the living organisms including humans, causing threat to life through the process of biomagnification. Pollutant and soil deposition have created turbidity and reduction in the Biological Oxygen Demand (BOD). This may result in eutrophication in the water body. All these disturbances in the watershed lead to loss of biodiversity.

B. Managing watersheds

Watershed management is the practice of managing land, water and vegetation in a holistic manner for the conservation of the natural resources that support life. Watershed management involves integrated planning and implementation of activities in an efficient and effective manner to restore and improve the health of watersheds.

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Activity 9.4: Watershed management principles

Instructions:

Study the flow chart given in Figure 9.4.

Discuss in groups the principles of watershed management.

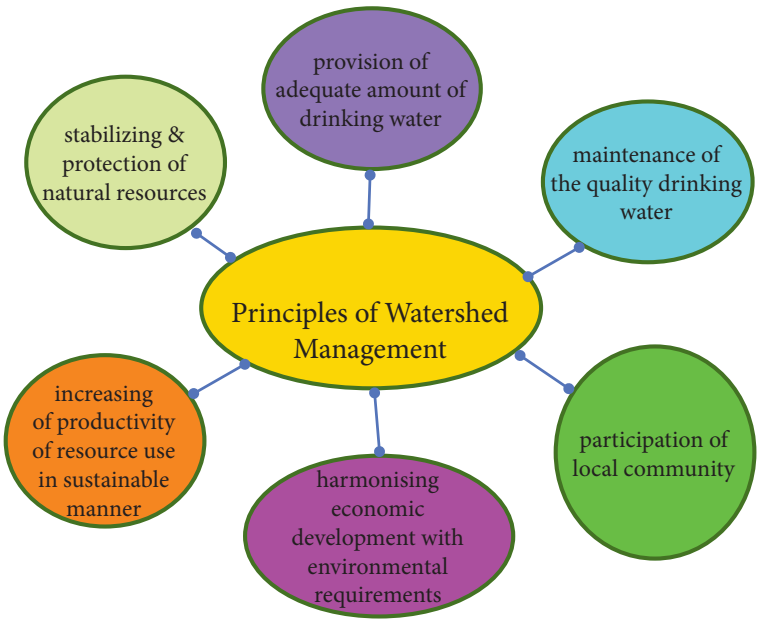

Figure 9.4 Principles of Watershed Management

Answer the following questions

1. Which principle ensure adequate safe drinking water for people?
2. Explain, how a community can contribute to watershed management.
3. Explain six principles that govern the efficient management of watershed.

The watershed management practices involve the following steps:

i. Identifying the watershed services.
ii. Identifying the users to engage them in planning and implementation.
iii. Assessment of watersheds to understand the current condition of the key watershed features such as size or area, shape, topography, geology, rock and soil, climate, vegetation, and land use.
iv. Development of management plan for the efficient utilization of watershed resources and effective action on the ground.
v. Review of implementation plans to improve, if required.

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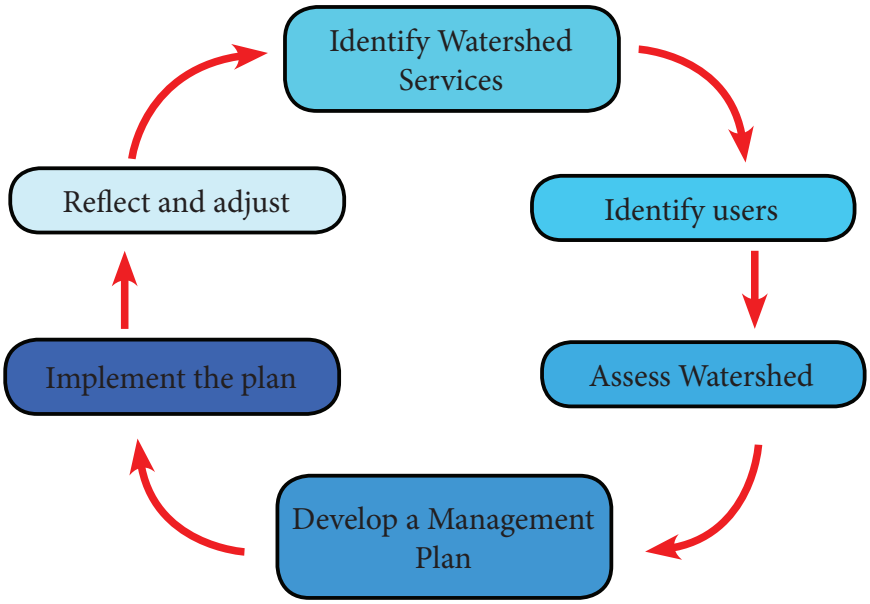

Figure 9.5 Watershed Management Process

Watershed management is about understanding problems, identifying and integrating suitable activities, and implementing the identified activities in the watershed. The major watershed programmes are:

1. Land management programme: It deals deals mainly with the management of agricultural land, including orchards and pasture land. The major activities constitute soil-water conservation, development of pasture and agro-forestry, forestry on government, private and community lands.
2. Sub-watershed protection programme: It deals with activities at the sub watershed level, such as promoting stall grazing, and planting around the water resources.
3. Water management programme: It provides training to water user groups on irrigation, canal maintenance and related fields.
4. Livestock development programme: It deals with livestock rearing along with subsistence farming for the community in a given watershed. In order to overcome the problem of overgrazing due to large livestock population, improved breeds and fodder species are introduced, and stall feeding is encouraged.

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Activity 9.5: How healthy is our watershed?

Materials required

Pen, paper, petri dish, magnifying glass, beakers, safety gloves.

Procedure

1. Visit a nearby watershed.
2. Observe and record your information in the Table 9.1.

Table 9.1

Step	Activity	Yes	No
1	Is the vegetation coverage good?		
2	Is the slope of the watershed steep?		
3	Is the gradient of the stream/river gentle?		
4	Are there any other water bodies?		
5	Are there domestic animals in the watershed?		
6	Are there wild animals present in the watershed?		
7	Are there aquatic species in the water?		
8	Are there mining activities in the watershed?		
9	Is the watershed polluted?		
10	Is the stream or river water transparent?		

3. Describe the vegetation types (forest, agriculture, scanty) of the selected watershed.
4. Describe the land use (mining, agriculture, forest, pasture and infrastructure) types in the watershed.
5. Map the water bodies (springs, streams, marsh lands, lakes, ponds) in the watershed.
6. Observe, identify and record any aquatic species.
7. Analyze the information collected.
8. Present the conclusion about the health of the watershed.

Safety issues

- You should be equipped with rain gears and comfortable shoes.
- Take care not to step on or near slippery areas or slopes.

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Questions

1. Explain watershed management.
2. Why is watershed management important?
3. What are the principles of watershed management?
4. A village has acute water shortage due to the degradation of the watershed. Due to this, nearly 50% of plants have dried up. You as a Gup, formulate a plan to restore the watershed.

3. Watersheds of Bhutan and their Management

Learning Objectives

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

- *illustrate the major watersheds of Bhutan.*
- *relate the importance of watershed to Bhutanese lifestyle.*
- *explain the relevance of watershed management in Bhutan.*

Bhutan is dominated by mountains and valleys, and is endowed with rich biodiversity and fresh water resources. The water resources are fed by glaciers, rivers, streams, wet lands and lakes. These resources maintain watersheds relatively healthy. Vegetation cover prevents surface runoff and protects the soil, regulates the water, and the microclimate in the area.

Despite rich water resources in the country, people lack access to both domestic and irrigation water. This is mainly due to seasonal fluctuations, difficult terrain, lack of technology and services.

A. Watersheds of Bhutan and their importance

Bhutan as a whole can be visualized as a big watershed, consisting of numerous small watersheds draining into five major river basins and two minor basins. Rain and melting glaciers are the main sources of water in these watersheds. The five major river basins of Bhutan are:

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1. Amo Chhu
2. Wang Chhu (Haa Chhu, Pa Chhu, Thim Chhu)
3. Puna Tsang Chhu (Mo Chhu, Pho Chhu, Dang Chhu, Daga Chhu)
4. Manas (Mangde Chhu, Chamkhar Chhu, Kuri Chhu, Drangme Chhu)
5. Nyera Ama Chhu

Manas is the biggest river basin, covering almost half of the country from central to the East. There are several minor river basins in southern Bhutan. The two important minor basins are Mao basin under Sarpang, and Jomo basin in Samdrup Jongkhar.

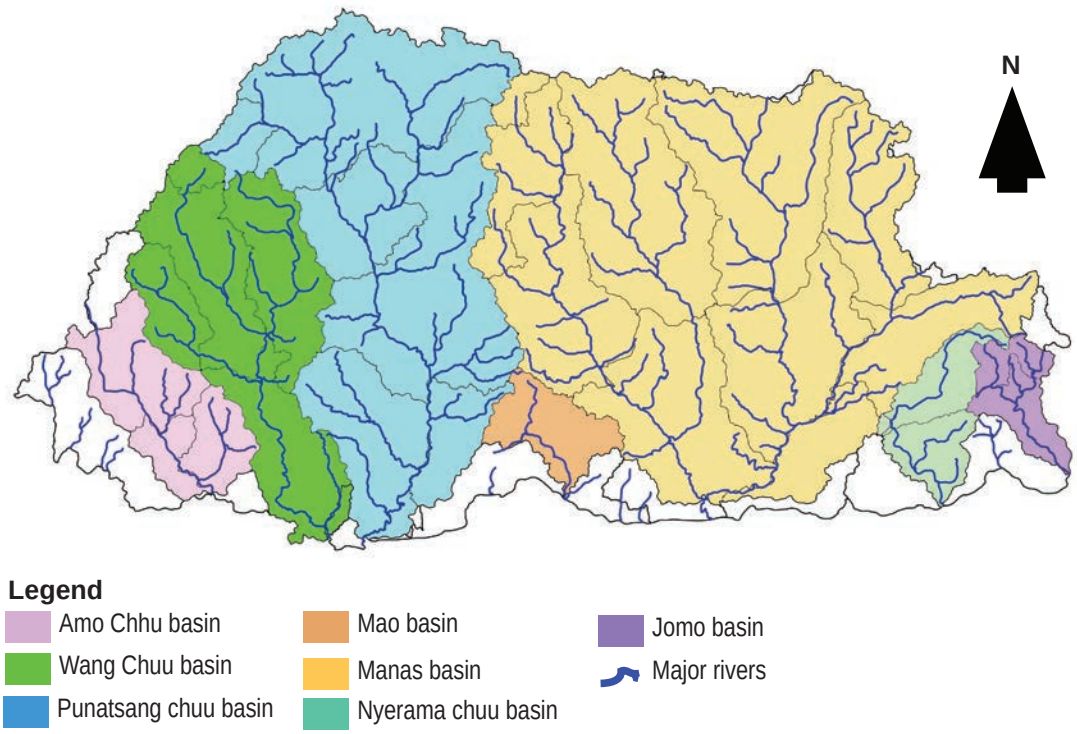

Figure 9.6 Major river basin of Bhutan

Activity 9.6: My Watershed

Instructions

1. Use Google Earth software to locate your location.
2. Find out the watershed that you belong to on the Google Map.
3. Mark the boundary of the watershed. Using various tools available on the Google Earth, find out the total area of the watershed, length of rivers, and elevations of the highest and lowest points in the watershed.

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Answer the following questions

1. What is the approximate area of the watershed?
2. List the land use type that you are able to see in the map.
3. Using the Google Earth, briefly explain how land use type might impact the watersheds.

Watersheds are not only the hydrological units, but are also socio-economical and ecological entities. The following reasons explain the importance of watersheds for Bhutan.

i. Socio-economic

Watersheds in Bhutan play a significant role in the national and local economy of the country. Watersheds are important for poverty reduction and the production of hydropower.

a. Poverty reduction

In Bhutan, majority of the people depend on farming, forestry and animal husbandry for their livelihood. Watersheds supply water and provide fertile soil for cultivation, and its forests supply resources such as fuel wood, timber and other produce. It has improved the livelihood opportunities of local communities, and has enhanced the income generating capacity of people.

b. Hydropower production

The rich water resources in Bhutan have been the rationale behind the hydropower projects. The export of hydro power is a major revenue contributor to the country's Gross Domestic Product (GDP). However, hydropower generation can be sustained only by conserving healthy watersheds.

ii. Environment

Ecosystems such as forests, grasslands, rivers and lakes sustain due to healthy watershed. These watersheds provide essential resources such as food, water, shelter, energy, and livelihoods.

iii. Cultural heritage

Forest, water, land and animals are an integral part of the cultural heritage that maintains the historical and aesthetic value of the landscape. In Bhutan, some of the landscapes are considered as sacred places (neys) and the abode of local deities. The 'drupchhus' and 'menchhus' found across the country are believed to have healing effects. This belief has helped in conserving those watershed areas. For example, Tsheringma Drupchhu enroute to Trongsa-

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Thimphu highway is believed to assist good crop yield. Hence, the watershed of 'drupchhu' is strictly protected by the local community. Drupchhus, menchhus and tshachhus are other areas that are revered by people.

In addition, there are other beliefs attached to certain trees and forests as the abode of spirits or deities. These are strictly protected by the communities. These traditions and beliefs have also helped in maintaining the health of the watersheds.

Traditionally, watershed management is intricately woven into the culture and beliefs of Bhutan from time immemorial through activities like 'ridhams' and 'tsadhams'. Ridham is a practice of prohibiting human activities in the designated forest areas for a specific period of time. Tsadham is a practice of prohibiting cattle grazing in a particular grazing area for a specific time interval. These practices are common in eastern Bhutan.

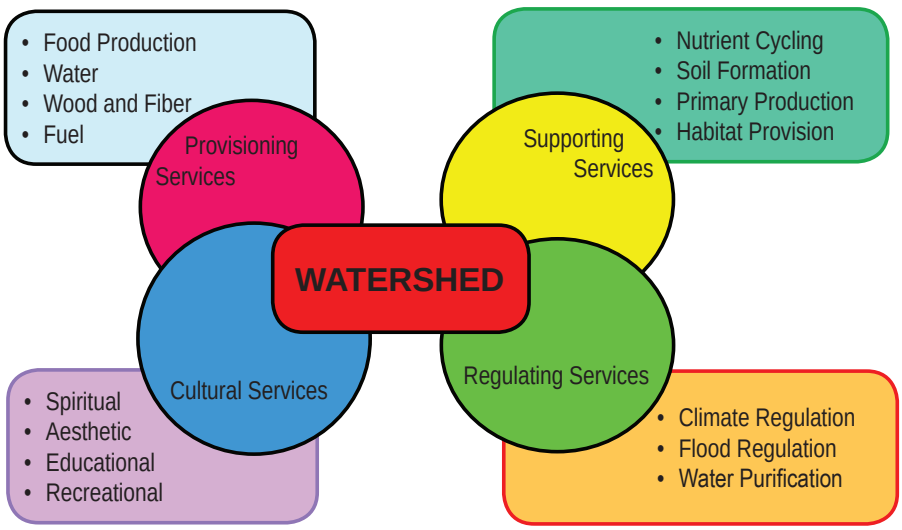

Figure 9.7 Watershed and its values

B. Watershed management in Bhutan

Watershed management in Bhutan is a national priority. The Government has established a Watershed Management Division in 2009, under the Department of Forests and Park Services, Ministry of Agriculture and Forests. The primary responsibility of this division is to manage watersheds throughout the country. It adopts a holistic approach, looking at several areas to conserve healthy watersheds. This approach involves multiple stakeholders, such as farmer groups, relevant government departments and agencies, corporate agencies, non-governmental organizations and others work together towards efficient management of watersheds.

Activity 9.7: Analyse the case of Gamri Watershed management strategy

Instruction

Read the case study below.

Gamri Watershed

Gamri Watershed has an area of 745 km^2 and is located between altitudes of 600 m to 4465 m under Tashigang Dzongkhag. Figure 9.13 shows that Gamri Watershed encompasses eight gewogs. The source of Gamri starts from Sakten Gewog and flows down swiftly joining the Drangmechu, just below the Tashigang Dzong. The Gamri drains water from eight gewogs of Sakten, Phongmey, Radhi, Shongphu, Samkhar, Bartsham, Bidung and Merak. Due to steep gradient, the Gamri flows swiftly and transports all debris downstream.

The watershed is important for rice cultivation and rearing livestock. With a large number of people living in the area (Table 9.2), and an equally high livestock population (Table 9.3), some of the problems the Gamri Watershed faces are over utilisation of grasslands, degradation of agricultural lands, formation of gullies, flash floods, increasing demand for natural resources.

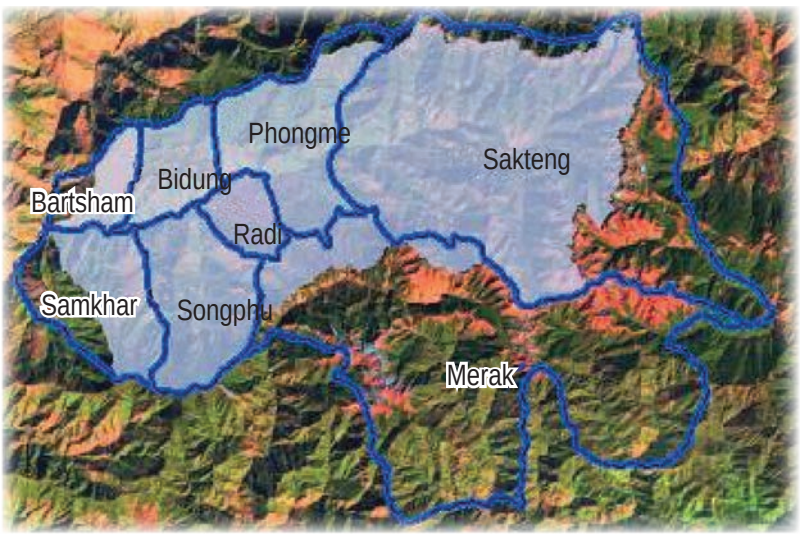

Figure 9.13 Outline of Gamri Watershed

Table 9.2

Parameter	Zone I		Zone II		Zone III			
Gewog	Merak	Sakteng	Phongmey	Radhi	Bartsam	Bidung	Shongphu	Samkhar
Population*	1957	2251	4428	5437	3465	3714	5433	5679

Source: www.trashigang.gov.bt

To address these problems in the Gamri Watershed, some of the measures identified are soil and water conservation through stabilization of landslips, gullies and slopes, and pasture development. Maintenance of drains of farm roads, banning grazing in

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critical areas, and improving cattle breeds were also identified. The other important measures included training the local people in proper management of water and fodder development.

Table 9.3

Gewog	Local cattle	Brown Swiss	Cattle Jersey	Yaks	Horses	Donkeys	Mules	Pigs	Poultry	Sheep	Goats
Sakteng	404	11	70	5809	655	26	1	382	11	954	49
Merak	6171	196	8	2,809	957	0	82	0	450	1115	24
Phongmey	1101	0	750	0	150	6	12	72	1353	26	13
Radhi	508	0	1090	0	364	3	60	3	1354	0	0
Bidung	0	0	238	0	0	0	0	0	0	0	0
Shongphu	607	0	686	104	77	0	10	93	2800	41	2
Samkhar	505	0	914	0	108	1	6	70	1362	50	38
Bartsham	560	0	751	0	55	1	12	4	791	0	22

Answer the following questions

1. Identify the problems in the Gamri Watershed.
2. How have the communities living in the Gamri Watershed aggravated the problems?
3. What are the measures identified for the Gamri Watershed management? Are these measures adequate? Give reasons to support your answer.
4. How can you participate in the watershed management programme?

Questions

1. What are some of the benefits of watersheds?
2. How do the 'neys', 'drupchhus' or 'menchhus' help protect watersheds?
3. What are the initiatives taken by stakeholders to conserve watersheds?
4. Recollect incidences in elsewhere in the world, wherein the lives of people are severely affected due to the poor management of their watersheds.

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Summary

- Watersheds comprise of land, water and vegetation.
- Watersheds can vary in size, from a few square kilometers to thousands of square kilometers.
- Watersheds are important for the supply of water for irrigation, domestic use, and hydropower; timber for construction; wood for household use; habitat for wildlife; and grazing land for livestock.
- Watershed management involves identifying users and uses, assessment, classification, consultation with people, and development and implementation of management plans.
- Watershed management is the practice of managing land, water and vegetation in a holistic manner for conservation and sustainable utilization of natural resources.
- Some of the indicators of a good watershed, include high forest coverage, clean drinking water, less landslide and erosion, and absence of mining activities.
- A well-designed strategy will help in conserving watersheds.

Exercise

1. Fill in the blanks with the correct form of word/s.

a. Watersheds comprise of ……., water and …….

b. Watersheds are also called as …… basins.

c. Wangchhu and Paachu watersheds are separated by …… divide.

d. The Dead Sea is an example of ---------- watershed.

e. The river systems in Bhutan drain into the Bay of Bengal. This type of watershed is known as …….. watershed.

2. Write TRUE or FALSE for the following statements. Rewrite the false statements in the correct forms.

a. Boundaries of watersheds are mountains or ridges.

b. Except in closed basins, all watersheds eventually drain into an ocean or sea.

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c. Watersheds are of same sizes and shapes.

d. Rivers flow into tributaries.

e. Contamination of a river system does not degrade the watershed.

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

a. A watershed is an area of

A. land drained by a river or river system.

B. continuous land form.

C. forest.

D. lake, ocean or sea.

b. The ice capped mountains in Bhutan forms a watershed that has link to

A. Brahmaputra.

B. Bay of Bengal.

C. Ganges.

D. Manas.

c. In an open watershed, water flows from

A. tributary-ocean-river.

B. tributary-river-ocean.

C. ocean-river-tributary.

D. river-tributary-ocean.

d. There are series of land slides and rivers carry large amounts of silt and soil. The biodiversity is also dwindling. The cause of this situation can be due to

A. agricultural activities.

B. air.

C. discharge from plants.

D. All of the above.

e. The watershed that Paachhu flows into is the

A. Dangchhu.

B. Kholongchhu.

C. Wangchhu.

D. Mangdichhu.

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1. **Answer the following questions.**
   a. How do watersheds maintain ecological balance?
   b. How will you evaluate the quality of a watershed?
   c. Considering the following land use proposals for a specific location, explain the impacts on the watershed.
      i. Establishing a city.
      ii. Converting a forest into agriculture land.
      iii. Setting up of industrial estates.
   d. Watersheds play an important role in Bhutanese economy. Explain.
   e. How do you relate conservation of watershed to educating for Gross National Happiness (GNH)?
   f. Using your ideas on watershed, explain the causes of drought and its effects on the lives of community.

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Energy Resources

Energy is fundamental to all the activities, processes and changes that drive the ecosystem. It is essential for the survival and function of life on the Earth. Since energy is important resource for the development of a country, it is considered as one of the major development indicators. The amount of energy consumed in a country indicates its developmental status. The quality and quantity of energy consumption is vital from the point of view of environmental health. Continuous supply of adequate, affordable, clean, secure and safe energy is necessary for the progress of human societies. Various forms of energy are used by the human societies for different activities and functions. Human societies derive energy from a range of sources such as water, wood, coal, wind, Sun, etc.

This chapter gives an overview of the energy resources, consumption and challenges. It also discusses energy scenario in Bhutan.

1. Energy

Learning Objectives

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

- *identify different forms of energy.*
- *classify energy resources with examples.*
- *differentiate between renewable and non-renewable energy.*
- *outline the advantages and disadvantages of renewable and non-renewable energy resources.*

A. What is energy?

Energy is the capacity to do work. We require energy to perform activities like walking, talking, running, eating, cooking, respiring, etc. Energy exists in various forms. The major energy forms identified are chemical energy, electrical energy, radiant (light) energy, mechanical energy, thermal (heat) energy, nuclear energy, gravitational energy and sound energy.

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Activity 10.1: Understanding forms of energy

Instructions

Copy Table 9.1 and fill it with appropriate energy form, description and source.

Table 9.1

Sl. No	Form of energy	Description	Source
1	Chemical energy	energy stored in the substances.	
2			Hydropower, solar, wind
3	Radiant energy	energy of electromagnetic waves.	
4		energy due to position and motion of the objects.	
5	Thermal energy		sun, core of earth, coal
6	Nuclear energy	energy released by radioactive substance.	
7		Energy associated with the force of attraction of earth.	
8	Sound energy		Vibrating objects.

All forms of energy can be converted from one form to another. The Figure 10.1 shows the energy transformation in a monkey on leaping a tree.

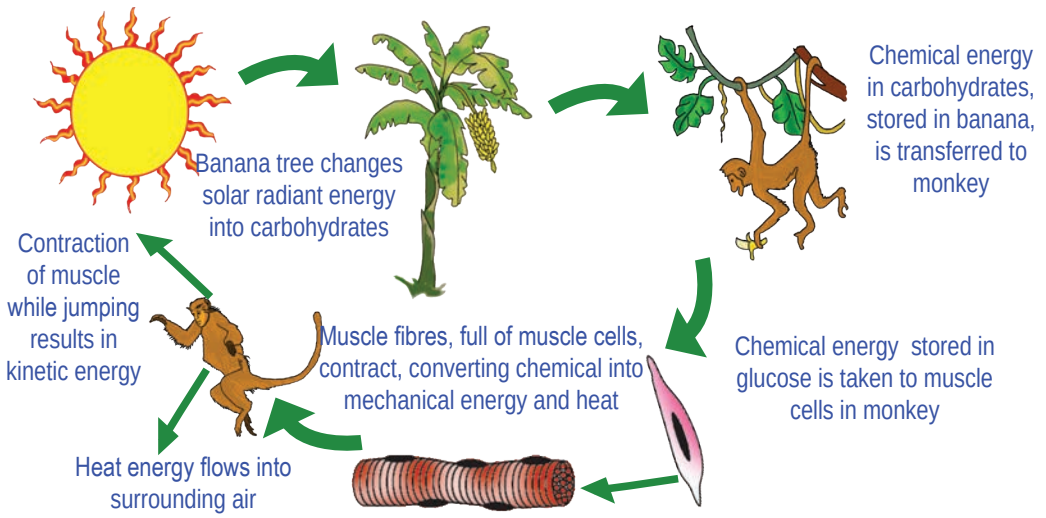

Figure 10.1 Transformation of energy

Energy flow in the ecosystem is a good example to understand the transformation of energy (Figure 10.2).

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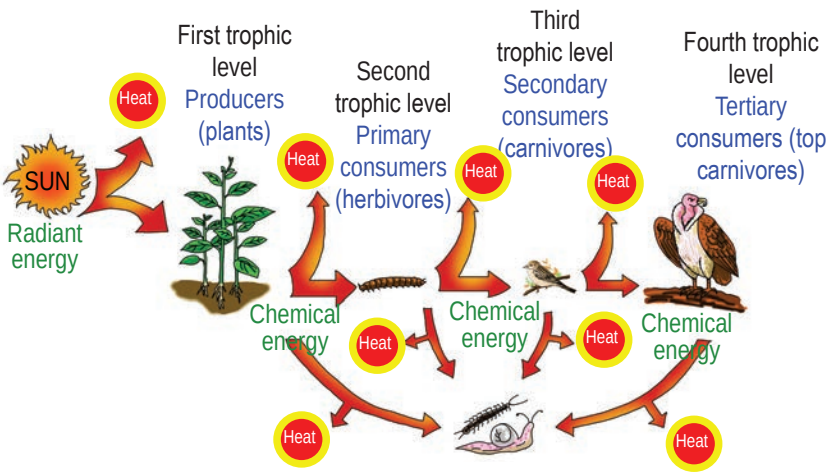

Figure 10.2 Energy flow through different trophic levels

B. Energy Resources

Earth is a storehouse of energy. Human societies derive energy from various natural resources such as water, wind, fossil fuel, forest, geysers, etc. The Sun is the primary source of energy for all these sources.

The energy sources can be classified in a number of ways. One way of classification is based on the nature of their transaction, as commercial and noncommercial sources of energy. All energy resources, particularly the commercial ones, are natural. Coal, oil and nuclear sources constitute commercial sources, while firewood, biomass and animal dung constitute non- commercial sources.

Energy resources are also classified as primary source, or secondary source. Primary energy sources are those which occur in natural environment. Fossil fuels, natural gas, sun, biomass, wind, water etc are all primary energy sources. Secondary energy sources are produced by using primary energy sources. Heat is secondary energy source produced from primary energy sources, such as wood, natural gas or sun.

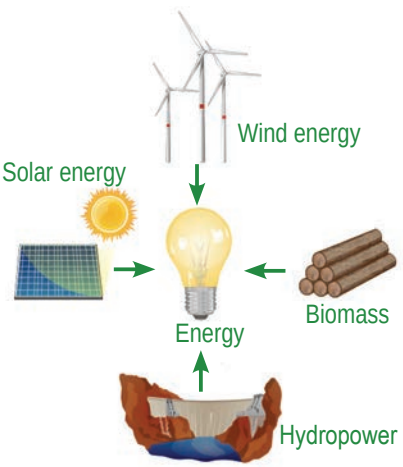

Figure 10.3 Renewable energy sources

The abiotic resources include all the nonliving things (rocks, minerals, hot springs, fossil fuels, etc.), while biotic resources encompass all the living organisms in biosphere (humans, flora, fauna, etc.) from which energy can be extracted.

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The most widely used classification is based on the finite and infinite nature of energy resource upon usage over one human life cycle. Energy sources are thus classified as renewable (inexhaustible) or nonrenewable (exhaustible) resources (Figure 10.3).

Non-renewable energy sources are limited, and will deplete upon use. These resources cannot be renewed, or replenished in one human life cycle. They may be in the form of gas, liquid or solid. Examples are oil (petroleum), natural gas, coal and uranium (nuclear Figure 10.4).

Renewable energy sources can be constantly renewed, or replenished naturally in one human life cycle. They are also called the infinite source. Sun, water, wind and biomass are the common renewable sources.

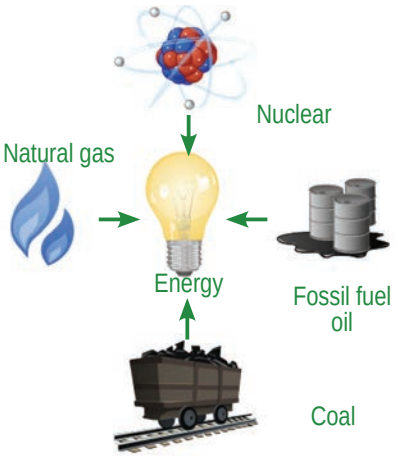

Figure 10.4 Non-renewable energy sources

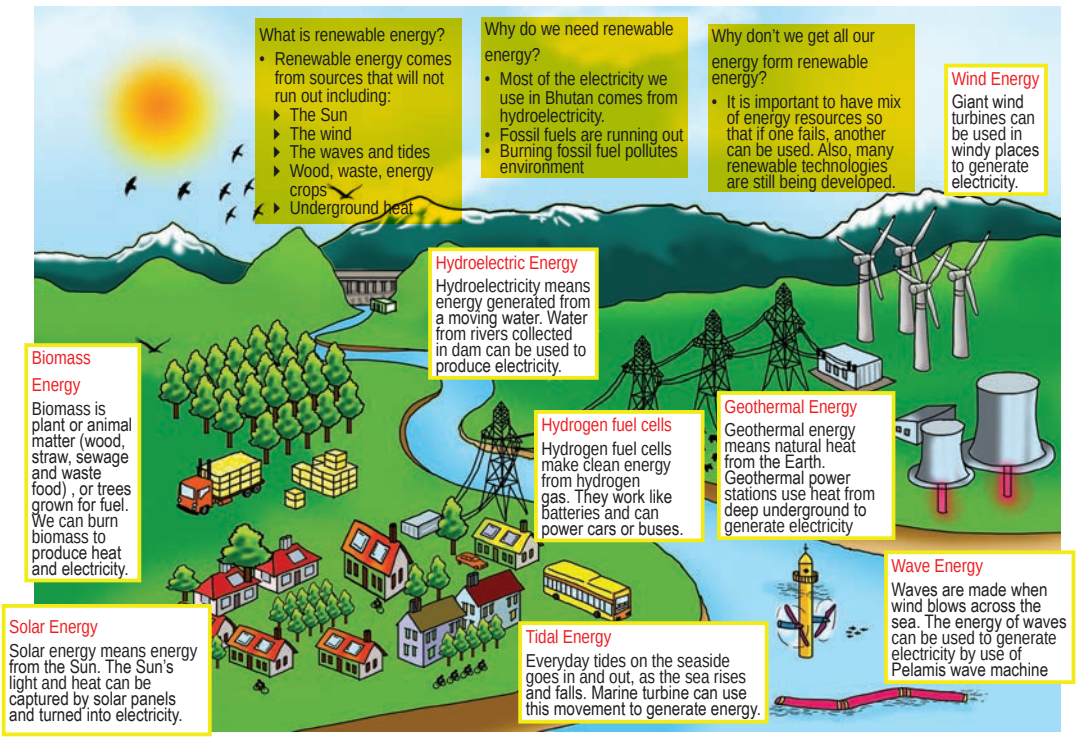

Figure 10.5 Renewable energy

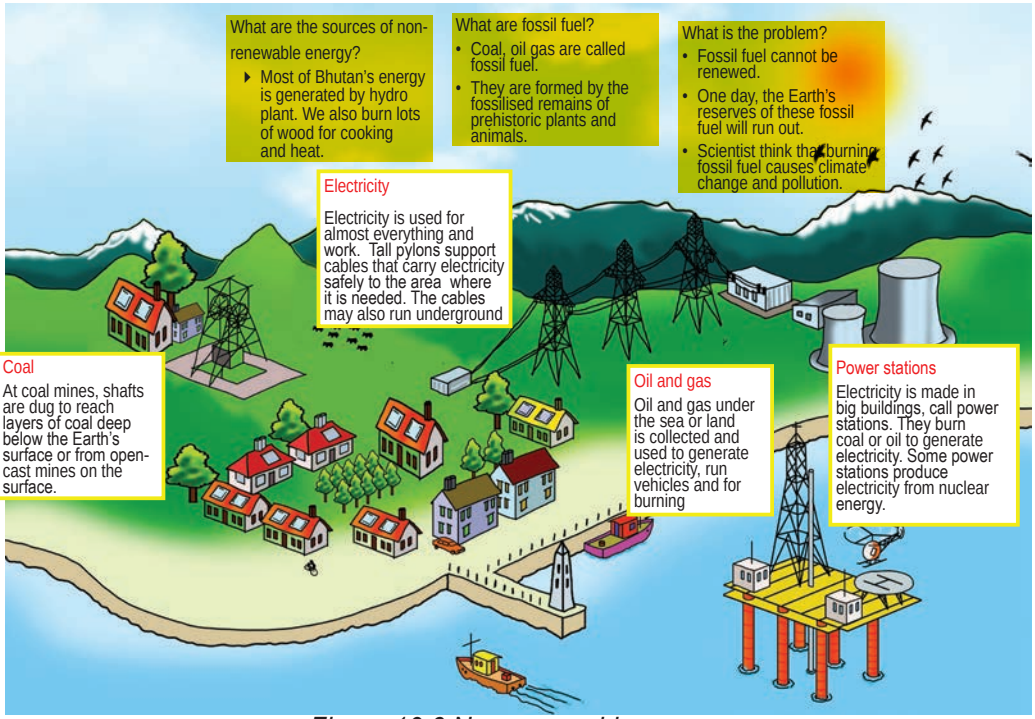

Figure 10.6 Non-renewable energy

Activity 10.2: Studying energy resources

Study the poster given in Figure 10.5 and Figure 10.6, and answer the questions that follow.

1. Describe renewable energy and non-renewable energy in your own words.
2. Describe the types of renewable energy used in Bhutan.
3. List the advantages of renewable energy over the non-renewable energy.
4. Biomasses (trees) can be non-renewable energy resource. Justify the statement.

Another important renewable source of energy that we use in our daily lives is the animal and human muscle power. For example, use pedal power driven by human muscles or animals in bicycles, cycle rickshaws, water pumps and corn grinders, transportation of load on animal backs, oxen ploughing, etc. This is also known as animate energy. It plays a vital role in transportation, crop land preparation and related agricultural activities, and manufacturing.

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Questions

1. Why is coal called black gold?
2. What are the similarities and differences between geothermal energy and petroleum?
3. List the traditional applications of wind and solar energy ?
4. Illustrate the transformation of energy forms in the generation of hydro electricity.
5. Why is secondary energy preferred? Justify with examples.

2. Energy Consumption

Learning Objectives

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

- *outline the history of energy use in the development of human societies.*
- *compare the consumption pattern of various energy sources.*
- *compare the energy consumption and supply over a time line.*
- *explain energy as a development indicator.*

The use of energy is closely associated with human evolution and development. The history of energy use tells mostly of the story of gaining control over energy sources for the benefit of society in the pursuit of development. A million years ago, primitive human societies harvested only the natural energy flows in the ecosystem. The period from 18th to 20th century marks the industrial era during which, societies have explored and exploited energy sources to the maximum on the Earth. Humans have developed ways to convert energy from one form to another. The capacity to harvest more and different sources of energy is ever increasing, due to advancement of technologies. In this technological world, the move is towards cleaner, cheaper and renewable energy that can be easily transported. But today, the world energy consumption is still dominated by fossil fuels. Figure 9.6 gives an overview of the energy sources harnessed at different periods in the human history.

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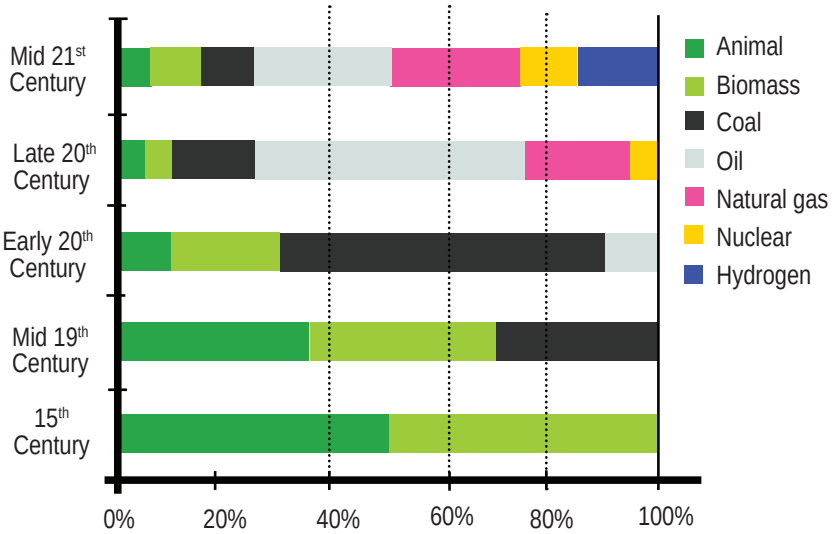

Figure 10.7 Use of energy sources at different periods

As per the U.S. Energy Information Administration data of 2012, the sector-wise analysis of world energy consumption (Figure 10.8), shows that the industrial sector use more than 50 percent of the total energy used globally. This sector includes agriculture, mining, manufacturing and construction.

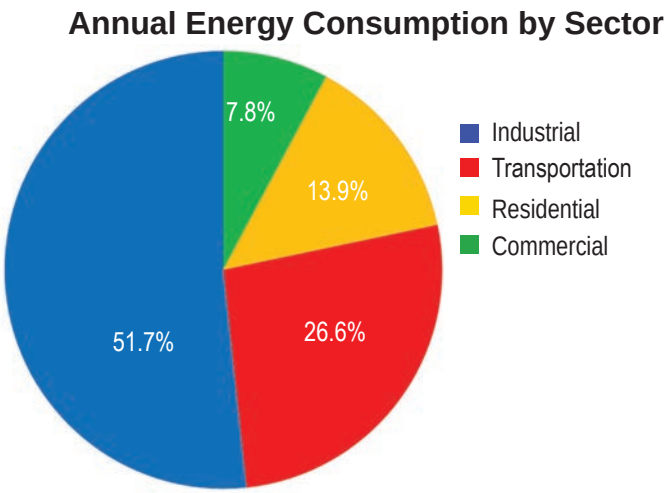

Figure 10.8 Sector wise energy consumption

Instructions

Study the graph in Figure 10.9, and answer the following questions.

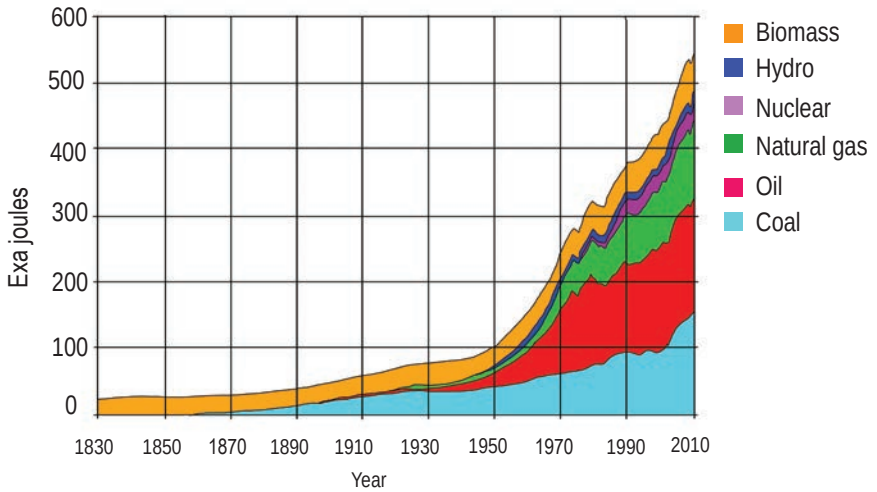

Figure 10.9 Energy sources

1. Which are the two most recent energy sources?
2. Which source provides the maximum energy now?
3. Calculate the percentage of each energy source for 2010, and draw a pie graph showing the share of each energy source.

Instructions

Study the graphs in Figure 10.10 and Figure 10.11, and answer the following questions.

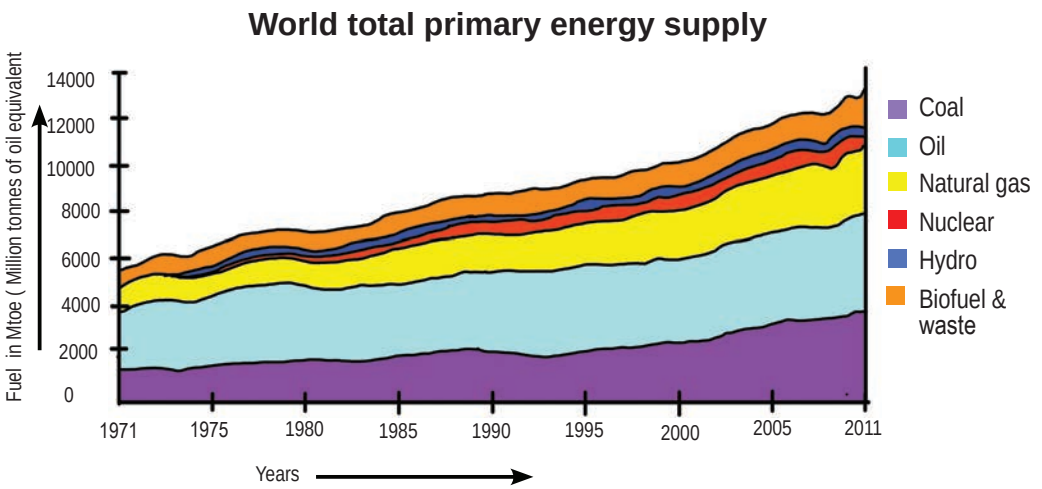

Figure 10.10 Energy Supply

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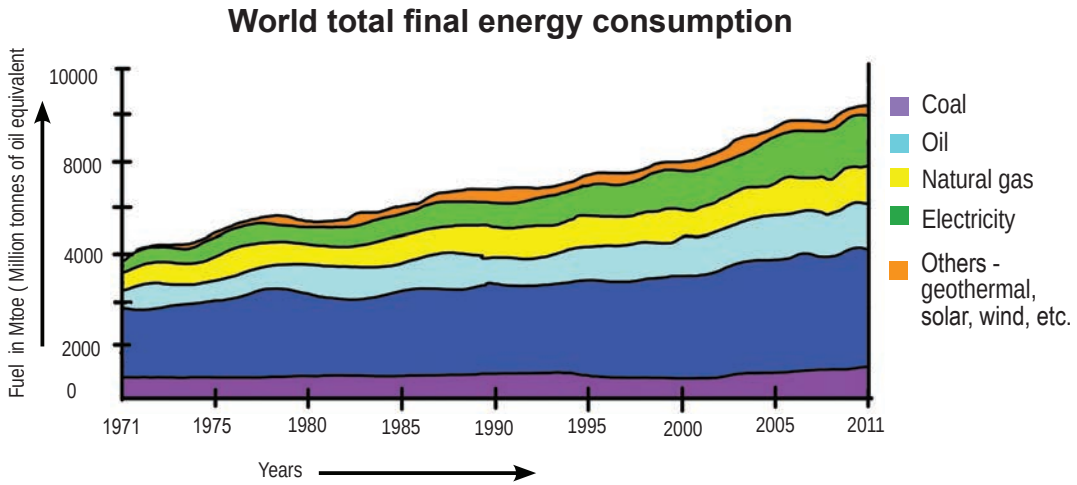

Figure 10.11 Energy Consumption

1. Which form of energy has increased over the years?
2. Supply of nuclear energy is evident, but is not reflected as consumed. Give reasons.
3. Why is electricity not featured in the supply Figure 10.10?
4. Explain mismatch of the supply and consumption of coal.
5. Using the Figures 10.10 and 10.11, describe the energy sources status of the world.

The world average energy consumption per person is less than 2000 kg of oil equivalent. In industrialized countries, people use four to five times more energy than the world average energy consumption, and nine times more than the average for the developing countries.

Although more than 80 percent of the world's population lives in the developing countries, the energy consumption by this population is estimated to be about 40 percent of the world's total energy consumption.

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Activity 10.3: Developed and developing

Instructions

Study the graph in Figure 10.9.

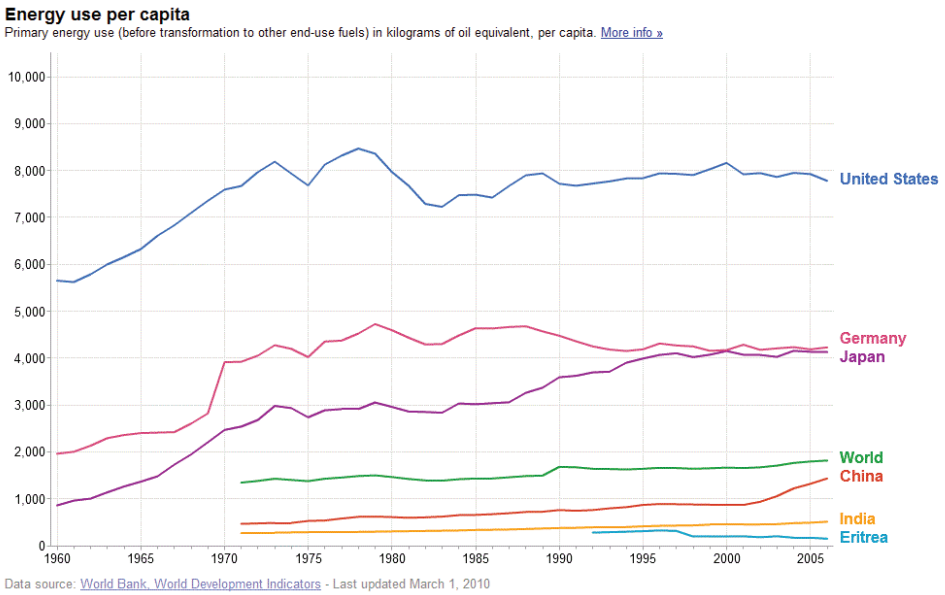

Figure 10.9 Energy Use

Answer the following questions

1. Draw bar graphs of per capita energy consumption for the United States, Japan, Germany, India, China and Eritrea for 2005.
2. Which period indicates the sharp rise in consumption of energy?
3. 'Energy consumption is the indicator of development.' Explain the statement.
4. Why do you think a person in the United States consumes more energy?
5. What will be the pattern of energy consumption for Unites States and India in the next ten years?

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Questions

1. Illustrate the relationship between energy sources and development.
2. Which form of energy do you think will be consumed the most in the coming years? Why?
3. Based on the trend, which energy sources in your opinion will be our future fuels? Why?
4. What is the difference between the energy consumption pattern between developed and developing countries? Give reasons.
5. Explain the mismatch of global total primary fuel supply and the total final consumption.

3. Energy Challenges

Learning Objectives

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

- *examine the advantages and disadvantages of various energy sources.*
- *explain energy efficiency and energy conservation with examples.*

A. Energy concerns

The socio-economic benefits of energy are many, but there are also several disadvantages which lead to environmental hazards. These environmental hazards later manifest themselves into economic and social disadvantages, majorly health implications. Some of the major challenges of using non renewable and renewable energy are as follows.

Non-renewable energy sources

1. Non renewable energy sources are finite sources, and can run out over a period of time. At the current rate of consumption, it is estimated that the oil and coal reserves can last for about maximum of 100 years.

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2. Fossil fuels are rich in carbon. The burning of these fossil fuels gives out carbon dioxide in great proportions. Solid fuel like coal causes more pollution, at least 30% more than the petrol. The air pollution leads to health hazards, enhances the greenhouse effect, causing global warming and acid rains.
3. Mining of non-renewable resources leads to deforestation, soil erosion, water pollution and biodiversity loss.
4. Uranium, which is a source for nuclear energy has radioactive properties. Exposure to radioactive elements creates major health hazards among living organisms, including humans. The nuclear waste is buried deep in the soil, or in the ocean, thereby harming the organisms, including humans.

Renewable energy

Renewable energy sources cause less damage to the environment compared to the nonrenewable resources. They are infinite and less polluting. However, there are challenges as follows.

1. Establishment of solar, wind or hydropower projects cause major deforestation, loss of farms land and displacement of communities.
2. Cost of installation of alternative energy technologies such as solar and wind are very expensive.
3. Some of the renewable resources like wind, tide and geothermal are location specific. This incurs transportation expenses.

Figure 10.10 Hydropower plants

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4. Biomass needs to be harvested. Unless it is produced at the rate it is harvested, then it can become non-renewable energy resource. With biomass, the problem of pollution persists. However, with more efficient technologies, such as efficient cook stoves, biogas, biomass gratifiers, etc., the efficiency of use of biomass is increased. However, the cost of installation is expensive at an individual level

Figure 10.11 Solar panels and windmills

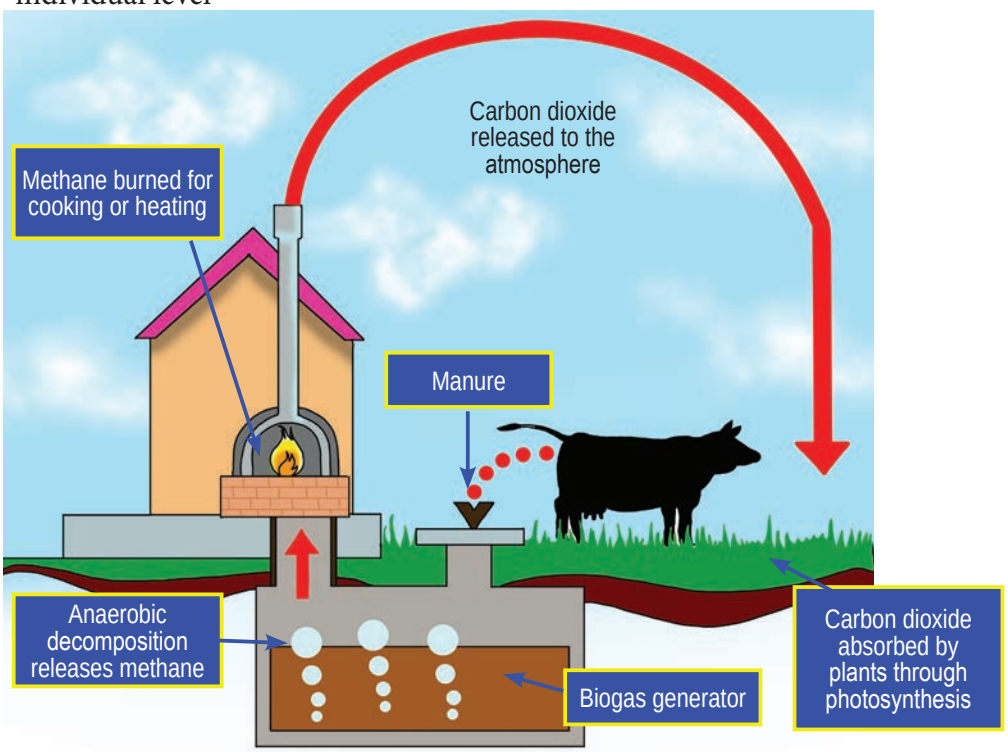

Figure 10.12 Biogas

The use of any source of energy has its advantages and disadvantages; each comes with some environmental, social and economic costs. However, there is a global interest to promote the use of renewable energy sources and to harvest the existing resources efficiently. The share of renewable energy used is slowly but certainly increasing.

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Activity 10.4: The Story of Ap Jambay

Instructions

1. Divide the class into 4 groups.

2. Read the story given below. Discuss and answer the question assigned to each group.

Ap Jambay of Phobjikha

Ap Jambay lives in Phobjikha under Wangdue Dzongkhag with his family and practise mixed farming. Ten years back, fuel wood was gathered from the forest for free. Ap Jambay wisely harvested only the branches that grew back after cutting. He used axe for cutting the fire wood. Ap Jambay used fuel wood as their source of energy for cooking, heating and fodder processing for his cattle. However, he realised that burning of fuel wood was making his house smoky, causing breathing problems among his family members and irritation to eyes. During rainy months, gathering of wood and stocking were getting more difficult. The soot produced while cooking and kerosene lamp made his house dark and dirty. He used kerosene lamp for lighting. Ap Jambay's power tiller and chainsaw operated on petrol and diesel.

The Royal Society for Protection of Nature (RSPN) introduced Solar Photovoltaic (PV) home lighting systems. Like his neighbours, Ap Jambay and his family also got Solar PV set for free. The use of solar light proved beneficial. Family members could carry out household chores even after dark. Their house was bright and children's eyes were not stained anymore while reading. More time could be spent for farming. But, Ap Jambay found that solar lights would not function during prolonged cloudy and rainy days. The next year, storm came in and blew the solar panel off the roof and was broken. The cost of equipment was very high and was expensive to replace. Again the family returned to the use of kerosene lamp for lighting.

After a five year long wait, hydropower grid reached Phobjikha. All the houses in the village were electrified. His household uses electricity for various domestic activities, like cooking, heating and lighting. Kerosene is no more required. However, he continues the use of petrol and diesel to run power tiller and chainsaw, although almost every month the prices of fossil fuel increases.

Group A

i. Make a timeline of the energy sources used by Ap Jambay and his family.

ii. List some other sources of energy that Ap Jambay could have used.

iii. Why is the use of fuel wood considered better than diesel or petrol?

Group B

i. What are the advantages and disadvantages of using fuel wood as energy source?

ii. Can you suggest any alternative to fuel wood?

iii. Fuel wood is a renewable energy. Justify

Group C

i. What are some advantages of using solar PVs?

ii. What are the drawbacks in using solar energy?

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iii. List the ways you use solar energy in daily activities.

Group D

i. What are the advantages and disadvantaged of electricity generated from hydropower?

ii. List some benefits and concerns related to fossil fuel use.

iii. List the health problems that may arise from the use of fuel wood.

All Groups

i. Present your findings to the class, using variety of methods like slide presentations using computer, photographs, posters, mind maps, illustrations, etc.

ii. Discuss the benefits and concerns of various energy sources in the class.

B. Energy conservation and efficiency

Energy security plays a vital role in economic growth and for the wellbeing of the population. Energy security refers to the availability of undisrupted energy source at an affordable price. The best ways to achieve energy security are: diversifying energy sources, reducing consumption, dependence on multiple suppliers and domestic production of energy.

Energy conservation is a practice of reducing the quantity of energy used through judicious use of energy, or by replacing high energy consuming appliances with less energy consuming alternatives for carrying out the same activity. The following are some of the ways that could be adopted to conserve or to enhance the efficiency of energy use:

i. Avoid using vehicles for short journey, rather walk and cycle that will also keep you healthy.

ii. Design energy efficient buildings and houses that consume less energy.

iii. Use seasonal and locally goods and services that consume less energy for their transportation.

iv. Using high energy efficient LED (Light Emitting Diodes) light that consume less energy over CFL (Compact Fluorescent Light) or incandescent lamps.

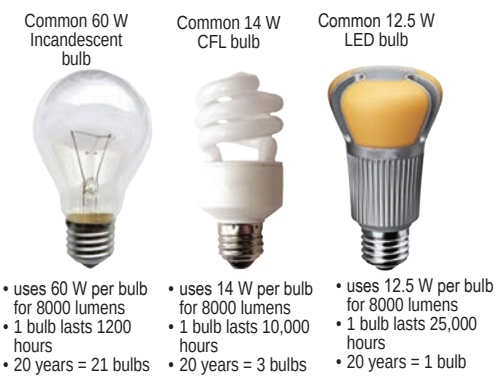

Figure 10.13 Energy efficient of lighting blubs

v. Opting for appliances, such as washing machine, refrigerator, ovens etc., with more energy star labels..

Do you know?

The incandescent light bulb is one of the most venerable inventions of its era but deemed too inefficient as 90% of the energy is wasted as heat.

It is cheaper to save an extra unit of energy than generating it. For our country, every unit of electricity saved by a citizen is an additional unit that can be exported.

Questions

1. List ten ways, in which energy is conserved or used efficiently at homes around the world.
2. Are all the conservation methods ecofriendly? Justify.
3. Differentiate between energy conservation and energy efficiency improvement.
4. How does saving energy lead to environmental conservation?
5. What is energy security, and what are the ways to achieve it?

4. Energy Scenario in Bhutan

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

- *explain the consumption and supply of energy in Bhutan.*

Traditionally, firewood has been the main source of energy in Bhutan. Even today, the predominant source of domestic energy remains the firewood. Harvested from forests, firewood is used in the domestic sector, particularly in rural areas for activities, such as cooking and heating homes.

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Hydropower is the main source of energy and revenue in Bhutan. With the increase in rural electrification, domestic hydropower consumption is increasing. Bhutan imports fossil fuels like diesel, petrol, kerosene, Liquid Petroleum Gas (LPG) and aviation turbine oil. Diesel and petrol are the primary transportation fuels. Import of the fossil fuels is increasing every year. There are no known fossil fuel reserves in Bhutan, except for minor coal deposits.

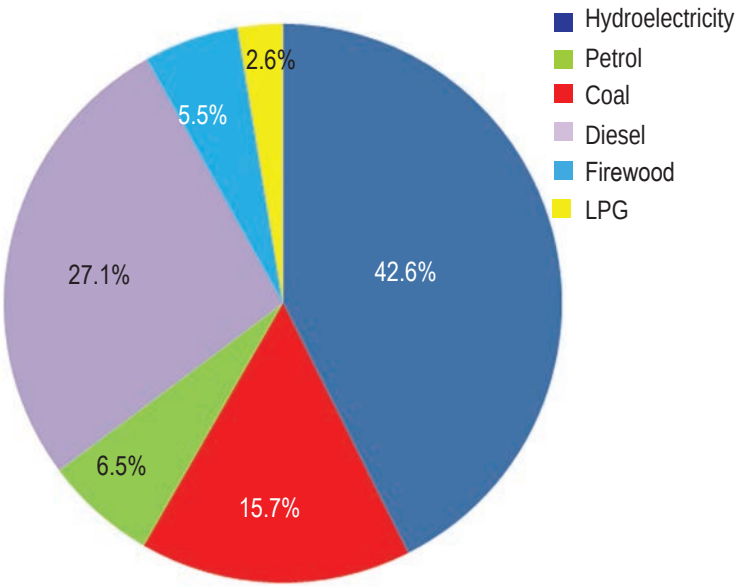

Figure 10.14 Baseline energy consumption

Bhutan has developed strong authorities, regulatory bodies and implementation agencies and departments to manage its hydropower projects, electricity generation, and transmission.

For energy security, Bhutan is embarking upon the development of strong renewable energy sources besides the hydropower. There are projects to enhance the use of solar, wind and biogas, energy conservation and small hydropower projects by the Department of Renewable Energy.

Instruction

vi. Divide the class into groups.

vii. Read the text on Bhutan Green Building Guidelines, and answer the questions that follow.

viii. Make presentation to the class to share your understanding.

Section 5: Energy efficiency in design

The following actions are means to reduce energy consumption:

- At the beginning of the planning process, a determination must be made to avoid energy-intensive or unnecessary operations.
- The design proposal must incorporate measures to minimize energy use by design and operation.

- Application of the best principles of siting and architectural design to reduce energy demands by passive solar design.
- Feasibility of use primary renewable energy sources such as solar, wind, biogas, and geothermal to satisfy the justifiable energy needs of the resort.
- Installing efficient appliances and taking measures = to minimize the need and use of energy-consuming utilities (air-conditioning, water heaters, high-level artificial lighting).
- Use of energy meters to monitor and illustrate energy consumption to aid in conservation.
- In addition, considerable electrical and thermal energy can be saved through facility design that incorporates day lighting and the other passive energy-conserving strategies appropriate to the local climatic environment.
- In all cases, the need for energy-intensive mechanical air-conditioning of facilities can be effectively eliminated by appropriate use of principles of site planning and building design.
- Natural lighting should be used wherever possible. Lighting design should be based on standards of reduced general lighting with task lighting and highlighting for specific functional considerations.
- Where artificial light is needed, LED or regular and compact fluorescent lighting should be used. Fluorescents use 75% less electricity and the average life is 10 times longer than incandescents, reducing maintenance and transportation costs. The environmental payback is immediate.

Source: Bhutan Green Building Guidelines: Draft No. 3, Department of Engineering Services, Ministry of Works and Human Settlements, May 2013.

Answer the following questions

1. What do you understand about the term "design"?
2. List the benefits to people of their compliance to these guidelines.
3. How do the guidelines contribute to "Bhutan Green Building" drive?
4. Why should Bhutan adopt these guidelines?

Questions

1. What is your opinion on the energy security of Bhutan?
2. Bhutan is highly dependent on hydropower. Comment.
3. Study the chart and answer the following question.

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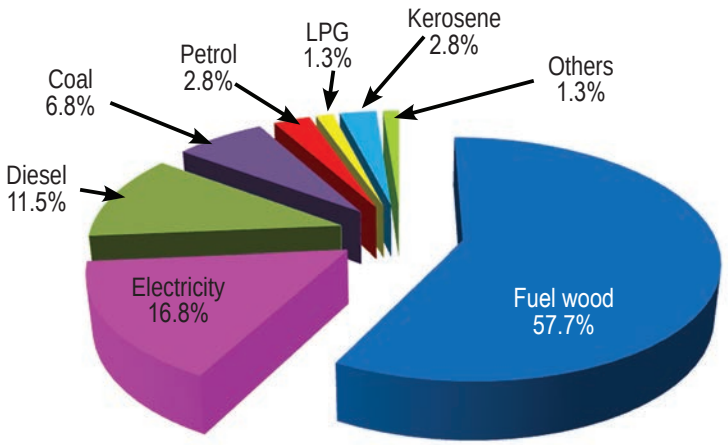

Figure 10.15 Use of energy sources in Bhutan

i. If we consider coal to be domestically produced and other fuels imported, what would be the total percentage of the fuels imported?

ii. If we consider 100% electricity from hydropower and fuel wood in Bhutan, what is the share of renewable and non-renewable energy in Bhutan?

4. What are the causes of rapid increase in petrol and diesel consumption in Bhutan?

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Summary

- Energy is fundamental to all the activities, processes and changes that drive the ecosystem. It is essential for the survival and function of life.
- Renewable energy sources are those that do not exhaust. Examples are wind, solar, hydropower, biomass and geothermal energy.
- Non-Renewable energy sources are those that are limited and cannot be regenerated in a human life cycle. Examples of non-renewable energy sources are fossil fuels and uranium.
- Renewable energy sources are usually cheaper and cleaner, but have limited availability.
- Non-renewable energy sources are efficient and convenient to use, but they pollute the environment and are expensive.
- Biomass is one of the major fuel sources in Bhutan.
- Hydropower is the major revenue generating energy source in Bhutan.
- Fossil fuels like diesel, LPG, petrol and kerosene used in Bhutan are imported.
- There are several agencies working on different aspects of energy in Bhutan for energy planning, generation, transmission and regulation.
- Energy conservation is not using energy when not required.
- Energy efficiency improvement is minimising the waste of energy, and producing the same output with lesser input of energy.
- Energy security is important for economic growth and well being of the population. It involves ensuring energy supplies that are readily available, affordable and reliable source of power without vulnerability to long or short-term disruptions.
- Bhutan is embarking upon projects to enhance the use of solar, wind, biogas, energy conservation and small hydropower projects.

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Exercise

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

a. The two main energy sources are…… and …….. of energy.

b. Green energy means energy, which has minimum ..... and is environment friendly.

c. The SODIS used in the least developed countries is a method to ..... energy.

d. Energy …….. is important for economic growth and reliable source of power.

e. Planting new trees will ensure ……of biomass.

2. Write TRUE or FALSE for the following statements. Rewrite the false statements in the correct forms.

a. Energy cannot be converted from one form to the other.

b. Solar energy is a non-renewable source of energy.

c. Bhutan has the potential for tidal energy.

d. Human development is dependent on energy sources.

e. The sources of energy can be classified using different criteria.

3. Match the items of Column A with the most appropriate items of Column B. Rewrite the correct matching pairs.

Column A	Column B
A non-renewable energy source with less emission, but produces hazardous solid waste	Industrial sector
An option to reduce the energy bill	Energy security
Largest consumption of energy	Fossil fuel
Energy supplies that are readily available, affordable and reliable	Nuclear power
Use of energy source sustainably	Energy efficiency
	Energy conservation

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

a. Which one of the following is true about non-renewable energy?

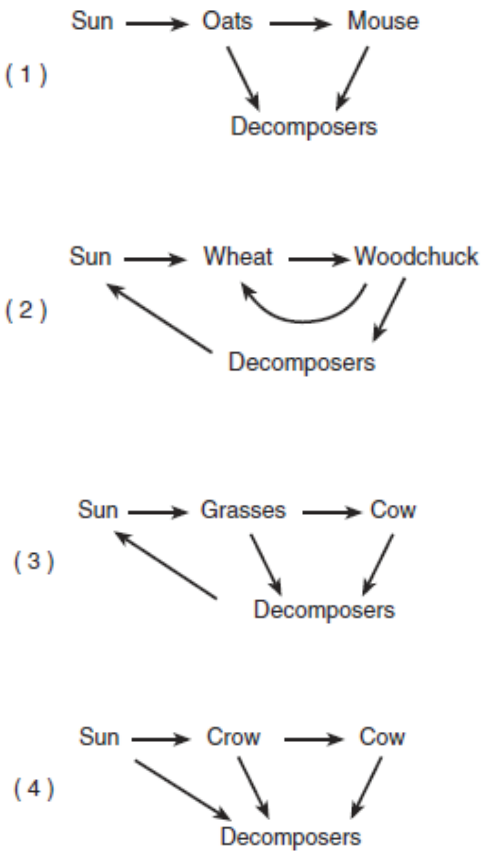
A. They are easy to transport.

B. They are energy efficient.

C. They can be used to run machines.

D. Have minimal impact on the environment.

b. Four students each drew an illustration to show the flow of energy in a field ecosystem. Which illustration is the most accurate?



A. (1)

B. (2)

C. (3)

D. (4)

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c. Fuel woods usage will reduce
   A. greenhouse gas emission.
   B. regeneration of biomass.
   C. depletion of non-renewable resources.
   D. eye and breathing problems.

d. Some people see the benefit of wind energy as a clean alternative to fossil fuels for energy production. Others believe it is dangerous for migratory birds. These opinions best illustrate that decisions about alternate energy sources
   A. will usually favor older methods of energy production over newer methods.
   B. must be made by weighing the risks and costs against the benefits.
   C. must be made by taking into account the present needs of the citizens without looking toward the future.
   D. should be the responsibility of the government alone to reduce the import of fossil fuels.

e. Which practice would most likely deplete a nonrenewable natural resource?
   A. Harvesting trees on a tree farm
   B. Burning coal to generate electricity in a power plant
   C. Restricting water usage during a period of water shortage
   D. Building a dam and a power plant to use water to generate electricity

5. Answer the following questions

a. We must have various alternative resources. Explain.

b. What are the alternative energy sources in Bhutan? Why?

c. Sonam walks to office everyday instead of driving the car. What are the benefits of this action?

d. Tashi wants to buy a refrigerator. She finds two types of refrigerators, one with star rating and the other without it. The shopkeeper suggests her to buy a refrigerator that has a star rating, which is expensive. The shopkeeper says she will save electrical energy. Do you agree? Give reasons.

e. Today, one of every eleven persons in Bhutan owns a vehicle. In this context, what plans can you offer to make Bhutan energy secure?

f. Write the advantages and disadvantages of renewable and non-renewable energy sources.

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g. Compare incandescent bulbs, CFLs bulbs and LED bulbs in terms of energy conservation.

h. Read the following passage and answer the questions that follow.

Urban residential sector is the highest electricity consuming sector. Thimphu Dzongkhag consumes more than 61 percent of electricity. It is worth noting, that Thimphu accounts for only 48 percent of the number of consumers. With 5.6 individuals as an average urban population per electricity connection, which is among the lowest in the country, this is an indication that with growing affluence and access to electricity, the per capita consumption is probable to increase substantially. The per capita electricity consumption in an average urban household is close to three times that of a rural household.

(Source: Bhutan Energy Efficiency Baseline Study – Final Report 2012)

i. List the issues related to energy consumption.

ii. Justify the difference in consumption of electricity in an average urban household from that of the rural household.

iii. Will the consumption of electricity in Bhutan increase in the coming years? Why?

iv. The use of electric cars is encouraged. Outline the pros and cons of using electric cars.

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Environment & Development

Development is inevitable in improving the quality of human life. Environment is an integral part of any developmental process. Development in any area needs to harness the resources from the environment. Thus, the exponential rise in developmental activities has increased the pressure on the natural resources, resulting in natural resource degradation. Realizing the adverse impacts of development on the environment, most countries in the world are now adopting the principle of sustainable development.

This chapter discusses the concepts and perspectives of development, its relation with the environment, and the perspectives of sustainable development.

1. Development

Learning Objectives

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

- *explain various perspectives of development.*
- *explain the parameters and indicators in the measurement of development.*
- *describe MDGs, targets and achievements of Bhutan.*

A. What is development?

According to World Bank, development is defined as, "reaching an acceptable standard of living for all people by improving economic and social conditions". The acceptable standard of living includes having access to the basic needs, such as food, housing, jobs, health services, education, safety and security.

Development can be interpreted in the context of its prospective. For instance, for an engineer, it may mean the construction of improved roads, bridges and buildings, while a doctor may see it as provision of improved health care. Similarly,

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a businessman may mean availability of more choices to a buyer and expansion of production. Important elements considered in defining development are:

- conservation of nature and natural resources.
- opportunity to have a satisfying livelihood.
- improvement in health and nutritional status.
- improvement in educational status.
- increase in real income per capita.
- access to resources.
- a fairer distribution of income.
- assurance of basic human rights.

Instruction

Read the case study and answer the following questions.

The Story of Pleasant Island

Nauru is a tiny island on the western Pacific. It is the world's smallest and most isolated republic with an area of 20 square km. A century ago, this island was rich with natural resources. It was then that the richest piles of phosphate rock on the globe were discovered on this island. Phosphate had been deposited here from the product of fossilized sea bird - guano, and a primeval stew of marine microorganisms, millions of years ago. Strip mining of phosphate began and was exported as fertilizer to other countries. Through this, Nauru generated unprecedented wealth that would make even the oil-rich countries envious. The 7,500 people of the island are among the richest in the world because of the phosphate mines that are worth millions of dollars.

With this easy money, Nauruans stopped farming decades ago. They started using shipped-in canned and frozen foods. Spam, canned corned beef, potato chips and beer have replaced the traditional diet of fresh fish and vegetables. As a result, the island reports one of the highest rates of obesity and diabetes in the world. Nine out of every ten islanders are obese, and young men weigh more than 135 kg. Life expectancy is only 50 for men and 55 for women. With only one road around the island, the average family owns at least two vehicles. They also have microwave ovens, stereo equipment, and multiple televisions per family. Many have no employable skills. The islanders cannot even fish. In fact, they import fish! Thousands of workers from China, India, Philippines and other Pacific islands carry

out the manual labour.

"Our cultural traditions have been basically wiped out," laments a Nauruan teacher.

Phosphate mining has plundered their mineral wealth, destroyed a tropical ecosystem and has crushed the native culture. Nauru is the most environmentally ravaged nation on the Earth.

Because of the mining, the weather has changed. Heat waves hit the island and rain has decreased.

"I wish we'd never discovered that phosphate, I wish Nauru could be like it was before. When I was a boy, it was so beautiful. There were trees. It was green everywhere, and we could eat the fresh coconuts and breadfruit. Now I see what has happened here, and I want to cry", said a Minister from the Nauru. Enchanted by its luxuriant tropical vegetation, European sailors called Nauru the Pleasant Island in the 18th century. Today, the name is a shame.

Many islanders have to move out. Islanders are trying to bring back its glory. However, environmentalists say, it is highly unlikely.

(Source: A Pacific Island Nation Is Stripped of Everything By Philip Shenonin The New York Times Published: December 10, 1995)

Answer the following questions.

1. What were the reasons for the unprecedented growth of wealth on the Nauru Island?.
2. What were the impacts of unprecedented wealth growth on the Nauruans?
3. Make a list of indicators that represent the quality of life of Nauruans.
4. Define "development" from the perspectives of Nauru Island.
5. Nauru was called the Pleasant Island in the 18th century. Today, the name is a shame. Explain.
6. Critically analyse, what were the serious mistakes in the developmental processes that make Nauruans to lament. Hypothesize some strategies by which, the natural beauty of the island could have been conserved.
7. Explain the pros and cons of the development.

Activity 11.1: Gypsum Mining in Pemagatshel

Instructions

Read the following case study and answer the questions that follow.

The Case of Gypsum Mining in Pemagatshel

Khothagpa gypsum mine is located in a village 13 km below Pemagatshel town.

Private mining companies operated it for over two decades, exporting gypsum to India, Nepal and Bangladesh.

In terms of economic benefits, the mining operation earned hard currency for the country, and created jobs and small businesses for the local community members. However, it caused several negative socio-economic and environmental impacts. Air

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pollution from the dust generated by the mining activity and from transportation was causing health issues. Water pollution, siltation and soil erosions were other observed adverse impacts.

In a typical agricultural community, mining had disrupted horticulture (mainly oranges) productivity. More people were engaged in the mines as part time workers, while the agricultural fields remained fallow.

According to the author's analysis, the cost of the mining in Pemagatshel overrides the benefits. He suggests further examination of the mining operation to see the deeper and long term social, economic and environmental costs.

(Excerpt from Socio-economic and Environmental Impact Analysis of Khothagpa Gypsum Mine, Karma Galey)

Answer the following the questions

1. Classify the impacts of mining in Table 11.1.

Table 11.1.

Social		Economic		Environmental	
Positive	Negative	Positive	Negative	Positive	Negative

2. Mining is an important activity for the development of the country. However, mining is hazardous to the environment, health and also the other livelihood activities. We should, therefore, stop mining completely. Comment on this statement.

B. Measuring development

There are several terms used in the context of development and its measurement. They are:

(a) Development parameters

Parameters are the factors that define a system and determine its performance. Some of the parameters of development are prices, costs, numbers of jobs, carrying capacities, growth rates, gender disparity, carrying capacity, equity and justice, etc. Functions of these parameters may be to propose indicators. Some parameters are themselves the indicators, such as Gross Domestic Product (GDP).

(b) Development indicators

Development indicator is a simple measure that helps us to understand the state of development. They measure the progress in development at different stages. A good

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indicator alerts about a problem before it gets worse, and helps in making plans to fix the problem. As per the World Development Reports, the most widely used indicators of a nation's income are Gross Domestic Product (GDP), Gross National Income (GNI) and Gross National Product (GNP).

i. Gross Domestic Product (GDP)

The GDP reflects the economic output of the country. It is an estimated market value of the country's total production and services, within its boundary, by its citizens and foreigners, calculated over the course of one year. The GDP is calculated as:

GDP = (consumption) + (investment) + (government spending) + (exports – imports)

The GDP per capita is the total GDP divided by the number of people in the country. This gives an average of the income each person makes. However, GDP per capita does not represent a person's actual income. It is often used as an indicator of a country's material standard of living. The GDP per capita is measured in two ways: GDP Nominal and GDP PPP (Purchasing Power Parity).

The GDP (PPP) refers to amount of local goods, like food, clothes and household appliance and tools, and the services a person can afford. The GDP per capita Nominal refers to amount of international traded goods, like electronic goods, food and clothes, and the services that a person can afford.

ii. Gross National Income (GNI)

The Gross National Income (GNI) is the total value of goods or services that are produced within a country, plus the net income obtained from overseas, calculated over the course of one year.

Therefore,

GNI = GDP + net income obtained from overseas

In this respect, GNI is quite similar to Gross National Product (GNP), which measures the output from the citizens and companies of a particular nation, regardless of whether they are located within its boundaries or overseas. The GNI is also expressed as PPP and Nominal.

For instance, if a company in Bhutan has a firm in India, the profits from the products will not be part of Bhutan's GDP, as production has taken place in another area. However, the profit would account for Bhutan's GNI, as Bhutanese own the firm, even though it is located in India.

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iii. Gross National Product (GNP)

The Gross National Product (GNP) is an estimated value of the total worth of production and services, by the citizens of a country, on its land or on foreign land. It is calculated over the course of on one year. The GNP does not include earnings by foreign residents, while inside the country.

The GNP is thus expressed as:

GNP = GDP + NR (Net income inflow from assets abroad or Net Income Receipts) - NP (Net payment outflow to foreign assets)

iv. Human Development Index (HDI)

In the social sphere, the Human Development Index (HDI) is regularly calculated. It is an index that measures average achievements of a country in three basic domains of Human Development: longevity, knowledge, and a decent standard of living. Longevity is measured by life expectancy at birth; knowledge is measured by a combination of the adult literacy rate and the combined primary, secondary, and tertiary gross enrollment ratio; and the standard of living is measured by adjusted GDP per capita.

The HDI is also used to rank countries into four broad human development categories: Very High Human Development, High Human Development, Medium Human Development and Low Human Development . Bhutan falls in the Medium Human Development category according to HDI (UNDP, 2018).

C. The Millennium Development Goals (MDGs)

The Millennium Development Goals (MDGs) are eight international development goals. At the turn of the millennium, countries across the world felt that if goals, targets and deadlines are set, development would gain focus, and the development would be guided to achieve common, real and concrete outputs. The MDGs and targets are framework for monitoring the developmental progress at the community, regional, country and global levels. They also represent a partnership between the developed countries and the developing countries "to create an environment – at the national and global levels alike – which are conducive to development and the elimination of poverty".

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Activity 11.2: Understanding the Millennium Goals

Instructions

1. There are eight MDGs goals and eight symbols given below.
2. Study each goal and match them to the MDGs symbol.
3. Explain each of the goals based on your understanding.

The Millennium Development Goals (MDGs)

D. Eradicate extreme hunger and poverty
E. Achieve universal primary education
F. Promote gender equality and empower women
G. Reduce child mortality
H. Improve maternal health
I. Combat HIV/AIDS, malaria and other diseases
J. Ensure environmental sustainability
K. Develop a global partnership for development

MDGs Symbols

2. Sustainable Development - Concepts and Practice

Learning Objectives

By the end of the topic, you should be able to:

- *explain sustainable development.*
- *describe the dimensions of sustainable development.*
- *relate the importance of environment for sustainable development.*
- *identify sustainable development practices in Bhutan.*

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A. Concepts and principles of sustainable development

Sustainable development refers to development, which is long term, equitable and balanced. Sustainable development promotes alternative ways, and considers environment as a critical part of human well-being, to live sustainably. Sustainable development takes into account all associated dimensions, such as the economy, society and the environment to consume resources in a way that it is available for generations to come. It strongly advocates lifestyle change, and reduction, reuse and recycling of resources. Therefore, sustainable development is about balancing the objectives simultaneously in the three major interrelated areas – economic, social, and environmental as shown in Figure 11.2.

The widely accepted definition of Sustainable Development is 'development that meets the needs of the present without compromising the ability of the future generations to meet their own needs'. Strategies of sustainable development are based on nine principles. The first of the nine are about ethics, the next four explains the objectives, and the last four are centred on the processes and systems.

1. All life forms should be respected. Humans should care for each and every life form.
2. There is a need to improve the quality of human life.
3. The diversity and energy of the Earth should be protected.
4. Use of non renewable sources should be reduced to control their depletion.
5. There is a need to protect the carrying capacity of the Earth.
6. Attitudes and practices have to be changed.
7. Communities should be empowered and capacity built, so that they can monitor their environment.
8. There is need for a national framework for integrating development and conservation.
9. A global network should be built to achieve the goals of sustainable development.

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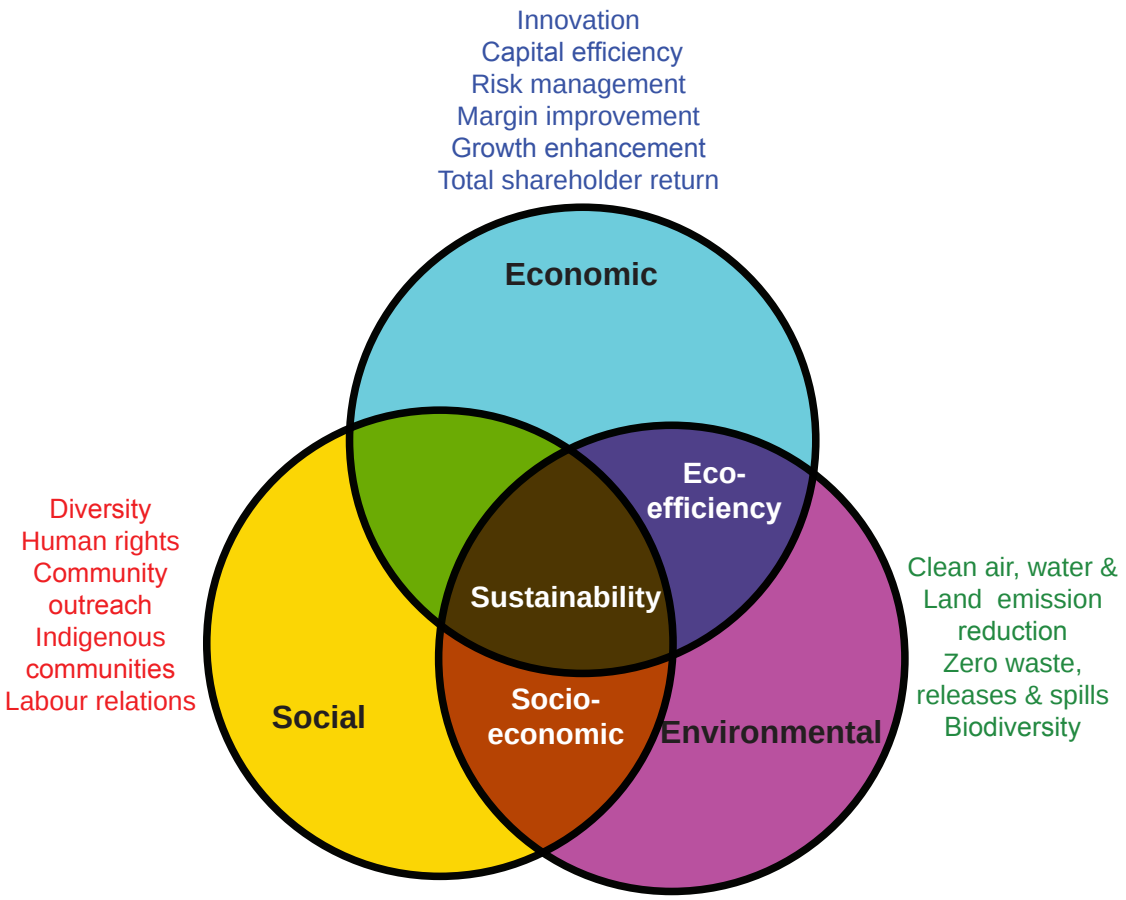

Figure 11.2 Sustainable development principles

Activity 11.3: Sustainable or Unsustainable?

Instruction

1. Work in groups.
2. Study Table 11.2, and mark each activity as sustainable or unsustainable. Give reasons for your answers.

Table 11.2

Activities	Sustainable (S) or Unsustainable (US)	State your reasons
1. Planting local species in degraded forest.		
2. Using private vehicles.		
3. Living a subsistence lifestyle of pastoralist.		
4. Use of solar energy for heating the house.		

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Activities	Sustainable (S) or Unsustainable (US)	State your reasons
5. Traveling to school by bicycle.		
6. Eating bananas that are shipped from Africa to Bhutan.		
7. Drinking bottled water.		
8. Motor car racing.		
9. Importing durable items.		
10. Growing organic vegetables at home.		
11. Using electric cars.		
12. Practicing "Move for Health".		
13. Implementing the Biodiversity Act of Bhutan.		
14. Offices in Bhutan rely on hard copies of any document		
15. Using telecommunication system rather than letters.		

B. Practices of sustainable development

Green economy for sustainable development

Green economy has been defined by the United Nations Environment Programme (UNEP) as, "one that results in improved human well-being and social equity, while significantly reducing the environmental risks and ecological scarcities." Its key strategies include: diversifying the economic base with minimal ecological footprint; harnessing and adding value to natural resources in a sustainable manner; and reducing dependency on fossil fuel, especially in respect of transportation. The three major avenues are hydropower development, based on integrated watershed management; agricultural development, based on sustainable production practices; and industrial development, based on effective pollution controls and enforcement of environmental standards. Towards achieving the goals of green economy in Bhutan, relevant agencies implement various strategies guided by policies, laws and acts.

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Activity 11.4: Finding about sustainable practices

Instructions:

i. Divide the class into groups.

ii. Each group will discuss on one of the following sectors given in Table 11.3.

iii. Explore on current sustainable practices adopted by the sector and present to the class.

Table 11.3.

Sector	Sustainable practices
Energy	
Agriculture and Forest	
Biodiversity	
Tourism	
Transportation	
Industry	
Education	

Questions

1. Identify two unique features of sustainable practices.
2. Explain the purpose/ goal of sustainable practices.

3. Developmental Perspective of Bhutan-Gross National Happiness (GNH)

Learning Objectives

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

- *describe the developmental perspectives of Bhutan.*
- *identify four pillars and nine domains of GNH.*
- *appreciate the GNH as Bhutan's contribution to the global community.*

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The GNH development philosophy is the Bhutanese version of the global concept of sustainable development. The concept of sustainable development is entrenched in the Bhutanese development philosophy of Gross National Happiness (GNH). The concept of GNH was first enunciated by His Majesty the Fourth King of Bhutan in the early 1970s, long before the sustainable development became a global agenda. His Majesty's proclamation that "Gross National Happiness is more important than Gross National Product" echoes the traditional Bhutanese belief that there is more to life than just material development. It is based on the premise that true development takes place when social, economic, spiritual and environmental well-being occur in harmony to complement and reinforce each other.

A. Gross National Happiness (GNH)

Bhutan has identified Gross National Happiness as the nation's priority, even above GDP, a unique Bhutanese way of looking at the global concept of sustainable development. In the sphere of public policy, the GNH philosophy is based on the following four main pillars:

- equitable socio-economic development, ensuring equity between individuals and communities, as well as regions, to promote social harmony, stability and unity and to contribute to development of a just and compassionate society;
- conservation of the environment, ensuring development pursuits are within the limits of environmental sustainability and are carried out without impairing the biological productivity and diversity of the natural environment;
- preservation and promotion of culture, instilling appreciation of the cultural heritage and preserving spiritual and emotional values that contribute to happiness and cushion the people from the negative impacts of modernization;
- promotion of good governance, developing the country's institutions, human resources and systems of governance and enlarging opportunities for people at all levels to fully participate and effectively make development choices that are true to the circumstances and needs of their families, communities and the nation as a whole.

These four pillars have been further defined with greater specificity into nine domains as shown in Figure 11.3.

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Figure 11.3. Domains of Gross National Happiness

Activity 11.5: Exploring GNH in your school

Instructions:

i. Work in groups.

ii. Discuss on the following questions and present your views to the class.

   a. Does your school provide adequate awareness and facilities for proper health and hygiene? Justify with examples.

   b. What are some of the activities carried out in your school that contribute towards conservation of environment?

   c. Does your school provide opportunity to promote cultural diversity? Justify with examples.

   d. Do you think your school have safe and conducive learning environment? Justify.

   e. How are your parents and the community involved in different activities in the school?

iii. Design a poster of a safe and a happy school or a village.

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Summary

- Environment is an integral part of development. It provides natural resources like minerals, fossil fuels, plant and animal products and services like climate regulation and nutrient cycling that make development possible.
- 'Development' may be defined as the process of change by which, human societies improve living conditions.
- The most widely used indicators of national income are Gross Domestic Product (GDP), Gross National Income (GNI) and Gross National Product (GNP).
- The Human Development Index (HDI) is a development indicator that combines three dimensions: a long and healthy life; education index and a decent standard of living or GNI per capita.
- Based on HDI, countries are grouped as Very High Human Development, High Human Development, Medium Human Development and Low Human Development.
- The Millennium Development Goals (MDGs) are eight international development goals.
- Sustainable development is the development that meets the needs of the present without compromising the ability of the future generations to meet their own needs.
- Sustainable development takes into account all associated dimensions, such as the economy, society and the environment to consume resources in way that it is available for generations to come.
- Sustainable development promotes alternative ways that consider the environment as a critical part of human well-being to live sustainably. It strongly advocates lifestyle change, and resource use reduction, reuse and recycling of resources.
- Bhutan's indigenous approach to sustainable development is the unique concept of Gross National Happiness (GNH). Bhutan has identified GNH as the nation's priority, above GDP. This is truly a valuable contribution to the global community.
- GNH encompasses the four pillars of sustainable and equitable socio-economic development, preservation and promotion of culture, conservation and sustainable utilization and management of the environment, and promotion of good governance.

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Exercise

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

a. The factors that define a system and determine its performance are known as development .....

b. The Environmental Impact Assessment (EIA) is to ensure that the development is ……

c. Family income, years of schooling and healthy long life are the determinants of .....of a country.

d. Sustainable development has ……..., ……. and …… dimensions.

e. Promotion of good governance is one of the pillars of ……...

2. Write TRUE or FALSE for the following statements. Rewrite the false statements in the correct forms.

a. Sustainable development advocates the change in attitudes and practices.

b. Import of packaged food items is a sustainable practice.

c. Gross National Happiness is more important than Gross National Product.

d. GDP and GNI are one and the same.

e. Having the latest car and other appliances is an indicator of high standard of living, but not of quality of life.

3. Match the items of Column A with the most appropriate items of Column B. Rewrite the correct matching pairs.

Column A	Column B
a. Unique developmental philosophy of Bhutan	i. GDP
b. Longevity, knowledge, and a decent standard of living.	ii. HDI
c. World Summit for Sustainable Development (WSSD)	iii. GNH
d. Economic output of the country	iv. 1992 Rio de Janeiro in Brazil

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

a. Which of the following options are the elements of development?

A. I and II
B. I and III
C. II and III
D. I, II and III

b. Which of the following represents an idea associated with environmental sustainability?

A. The capacity of the environment to absorb toxins is unlimited.
B. The human population continues to grow.
C. We are using fossil fuels as if they were present in unlimited supply.
D. The earth's resources are not present in infinite supply.

c. Sustainable development involves

A. reducing consumption, increasing efficiency and using renewable energies.
B. larger buildings using stronger design and materials.
C. developing better transportation by building more roads.
D. using all resources at maximum rates.

d. GNH encompasses the perspective of Sustainable Development except this

A. equitable socio-economic development.
B. preservation and promotion of culture.
C. conservation and sustainable utilisation of the environment.
D. promotion of good governance.

e. Which of the following component is not included in calculation of GNP of a nation?

A. Gross Domestic Product
B. Earnings by foreigners residing in the country.
C. Income obtained from the citizens working overseas.
D. ncome generated by the citizens within the country.

5. Answer the following questions

a. Establish the relations between social, economic and environmental dimensions in sustainable development with examples.

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b. What are the differences between GDP and GNI?

c. Write a short note on Millennium Development Goals (MDGs).

d. What are some of the sustainable practices that a family or school can adopt?

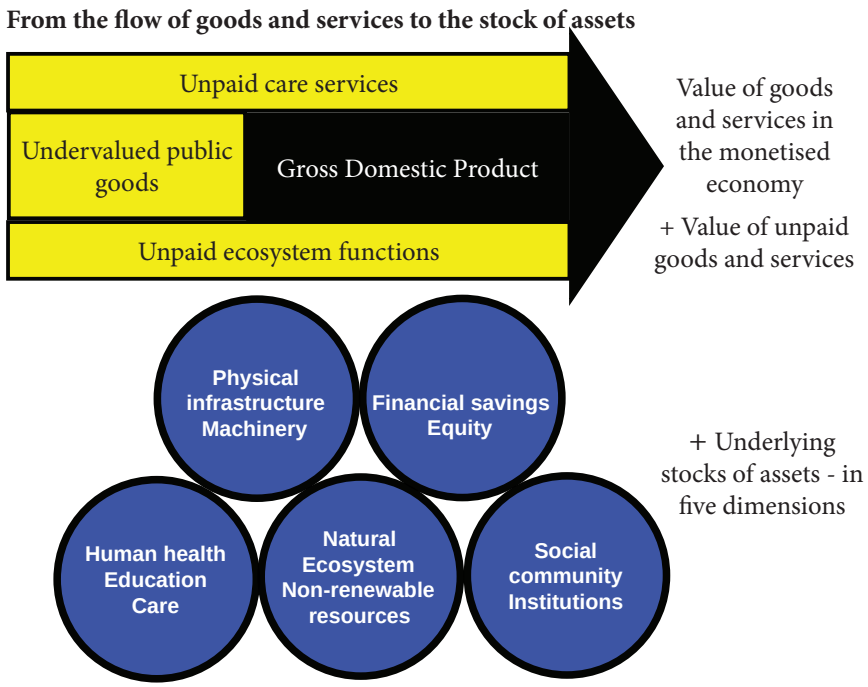

Figure 11.5

MODEL QUESTION

Environmental Science

Class: IX **Date:** ……

Time: 2 hours

Name: ……. **Roll No:** ……..

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. The major source of urban air pollution is
   A. thermal power plants.
   B. vehicles.
   C. industries.
   D. households.

ii. A network of food chains in an ecosystem consists of
   A. ecological niche.
   B. food web.
   C. food pyramid.
   D. food energy.

iii. The law of conservation of energy means that the plant will
   A. convert all the energy in the natural gas to electricity.
   B. be highly efficient in converting one form of energy into another.

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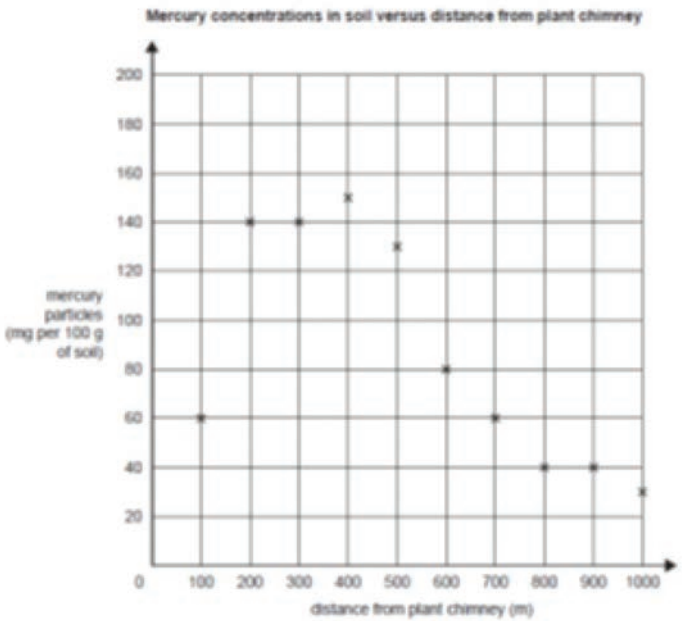
C. convert all the energy in the natural gas into other forms of energy.
D. be sustainable, since it will conserve unneeded energy for future use.

iv. The use of hydroelectric energy sources is in accord with the Kyoto Protocol, because the main aim of the Kyoto Protocol is to
A. reduce carbon dioxide emissions.
B. encourage the use of renewable energy sources.
C. encourage the use of sustainable energy sources.
D. create wetlands for the use of migratory water birds.

v. The following graph shows the average distribution of mercury in soil at various distances around a coal-fired power plant.



This distribution pattern shows that mercury is most likely to be
A. hazardous.
B. liquid.
C. dense.
D. toxic.

vi. Bioaccumulation is best described as
A. toxicity of a substance in fatty tissue.
B. increasing toxicity of a substance over a time.
C. increasing the exposure of a body to a toxic substance over time.
D. increasing concentration of a toxic substance in a biological system.

vii. Natural gas is an example of a

A. fossil fuel, renewable energy source.
B. non-fossil fuel, renewable energy source.
C. fossil fuel, non-renewable energy source.
D. non-fossil fuel, non-renewable energy source.

viii. The law of conservation of energy means that the plant will

A. convert all the energy in the natural gas to electricity.
B. be highly efficient in converting one form of energy into another.
C. convert all the energy in the natural gas into other forms of energy.
D. be sustainable, since it will conserve unneeded energy for future use.

ix. The production of electricity that occurs in the hydroelectricity system

A. is low in efficiency, because water is heated up during the process.
B. is low in efficiency, since many steps are involved in the conversion process.
C. results in the loss of water due to friction through the tunnels and aqueducts in the system.
D. is highly sustainable, because the water can be used in irrigation systems after passing through the power station.

x. The following activities in the environment contribute to human survival.

- *cleansing of water resources*
- *breakdown and absorption of pollutants*
- *soil formation and protection*

These activities can best be described as

A. ecosystem services.
B. ecosystem diversity.
C. population diversity.
D. environmental control.

xi. One consequence of small population size is demographic variation.

This means the population is particularly vulnerable to chance variation in

A. rainfall and temperature.
B. ratio of male and female individuals born.
C. number and type of species present in an ecosystem.
D. harmful genes present in the gene pool due to chance alone.

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xii. Which of the following is the best reason for considering the wind farm as ecologically sustainable?

The wind farm

A. minimises damage to the environment.

B. provides more income to the local community.

C. uses more commonly available materials in its construction and so is cheaper for the community and government.

D. meets the needs of this generation without compromising the ability of future generations to meet their own needs.

xiii. During high temperature combustion, nitrogen reacts with oxygen to form nitrogen dioxide which then combines with water in the atmosphere. What is the result of these processes?

A. Formation of acid rain.

B. Increased global temperatures.

C. Destruction of the ozone layer.

D. Depletion of nutrients in rivers.

xiv. There is a global concern on declining number of tigers in the world. Many countries have been working on numerous initiatives to conserve tiger in the ecosystem. The Nature Conservation Division in Bhutan pays compensation to farmers for predation by tigers. This is because

A. tigers are at the apex in food chain.

B. tigers help to maintain ecological balance.

C. body parts of tigers have medicinal values.

D. tigers attract many tourists into the country.

xv. Prolonged exposure to high levels of noise causes

A. hearing loss.

B. constriction of blood vessels.

C. gastric ulcers.

D. toxicity.

xvi. Which one of the following does not contribute to climate change?

A. NO

B. O_3

C. SF_6

D. HFCs

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xvii. Which of the following is not a type of ex situ conservation method?

A. Botanical garden.
B. Zoological park.
C. Wildlife sanctuaries.
D. Gene banks.

xviii. The Brundtland definition comprises of three components. They are

A. development, needs, future responsibility.
B. development, needs, future generation.
C. growth, needs, future generations.
D. development, issues, future generations.

xix. The tendency of biological systems to resist change and to remain in a state of equilibrium is called

A. homeostatis.
B. feedback mechanism.
C. ecological efficiency.
D. carrying capacity.

xx. Bhutan is located on the young Himalayan ranges and falls on an earthquake vulnerable zone. This is because

A. Bhutan lies on the major fault that divides Indian tectonic plate from the Eurasian plate.
B. earthquake is caused by the sudden movement of the tectonic plates.
C. earthquake can neither be predicted nor can be controlled.
D. Bhutan is a small country with fewer infrastructures as compared to many developed countries.

xxi. An organism's niche is the

A. way the organism uses the range of physical and biological conditions in which it lives.
B. all the biological and physical factors in the organism's environment.
C. functional role played by the organism where it lives.
D. range of temperature that the organism needs to live.

xxii. The pyramid of biomass is inverted in

A. forest ecosystem.
B. greenland ecosystem.

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C. aquatic ecosystem.
D. all of the above.

xxiii. Given below are two statements, one labelled as Assertion (A) and the other labelled as Reason (R).

Assertion (A) : Animals adopt various strategies to survive in hostile environment.

Reason (R) : Praying mantis is green in color which emerges with plant foliage.

Choose the correct code:

Codes :

A. Both (A) and (R) are true, with (R) being the correct explanation of (A).
B. Both (A) and (R) are true but (R) is not correct explanation of (A).
C. (A) is true, but (R) is false.
D. Both (A) and (R) are false.

xxiv. Environment, as defined by Boring is a person's

A. environment consists of the sum of total of the simulation, which he perceives from his conception until his death.
B. environment consisting of biological world.
C. environment of social and cultural belief system.
D. abiotic environment that provides energy.

xxv. What are the two factors on which the distribution of biomes depends on

A. size of the area of a place and season.
B. season and bogeographical zone.
C. precipitation and altitude.
D. allevation and biogeographical zone.

2. Fill in the blanks with the correct form of word(s). (5 marks)

i. The ozone layer lies between ..... and stratosphere.

ii. Our Earth consists of three spheres. The sphere on which plants thrive is ....

iii. Based on the nature, disaster can be classified into ..... and natural disaster.

iv. The fluffy hair of yak can be an example of Darwin's theory of .....

v. In urban areas, forest is important because it is .....

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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. GNH is more important that GDP	a. Conservation of biodiversity
ii. A non renewable energy with less emission with hazardous byproducts	b. Watershed
iii. The layer of the Earth supports majority of life forms	c. Dragon Kingdom
iv. Water from different places empty into a bigger water body	d. Biosphere
v. Jigme Dorji National park	e. Nuclear
	f. Biomass

4. Write TRUE or FALSE for the following statements. Rewrite the false statements in the correct forms. (5 marks)

i. Considering the overall global effect, carbon dioxide is the most significant contributor to the natural greenhouse effect.

ii. Mangde Chhu in the central Bhutan is an example of closed watershed.

iii. Fossil fuels are renewable source of energy.

iv. Bhutan has potential for tidal energy.

v. Bhutan pursues a unique philosophy of sustainable development.

5. Answer the following questions (10 marks)

i. Define sustainable development with a suitable example in context to Bhutan.

ii. Why is the emission of vehicles the source of acid rain?

iii. Explain Darwin's two theories of evolution with an example each.

iv. Bhutan has high potential for hydro-elecicity. Justify.

v. Explain global warming and its effects on farmers.

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Section B (50 marks)
Answer any **five** *questions.*

Question 1 **(10 Marks)**

Name a pollutant that you have studied this year. You should use this pollutant in answering parts **a to e**.

a. Explain why the substance that you have named is considered a pollutant. (2 marks)

b. Describe how this pollutant affects the human health. (2 marks)

c. Explains ways to minimize the production of this pollutant. (2 marks)

d. Explain with a chemical formula of how this pollutant contributes to acid rain formation (2 marks)

e. Justify why people have to pay Green Tax to the Government. (2 marks)

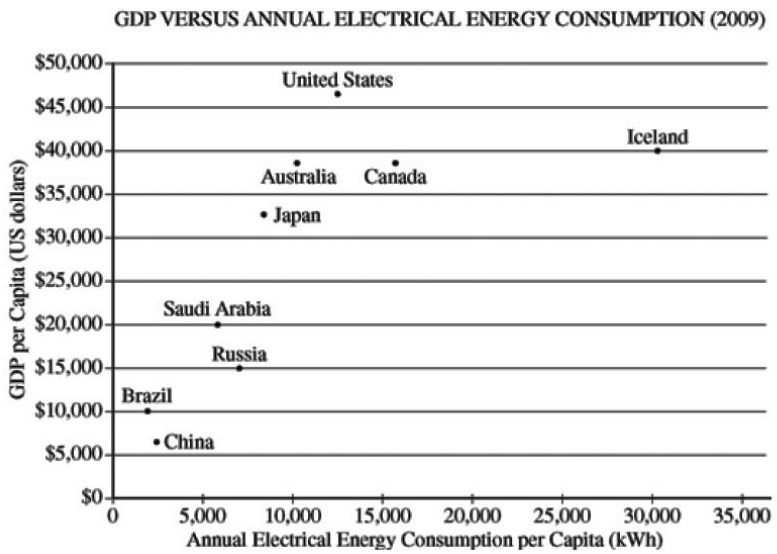
Question 2 **(10 Marks)**

1. Explain the importance of biodiversity to human. [2]

2. Describe primary and secondary sources of energy with examples. [2]

3. How does biodiversity contribute to economic growth of a country? [2]

4. Study the graph below and answer the questions that follow. [3]



i. Write down the relation between GDP and energy consumption.

ii. Will GDP increase if energy consumption is reduced? Explain.

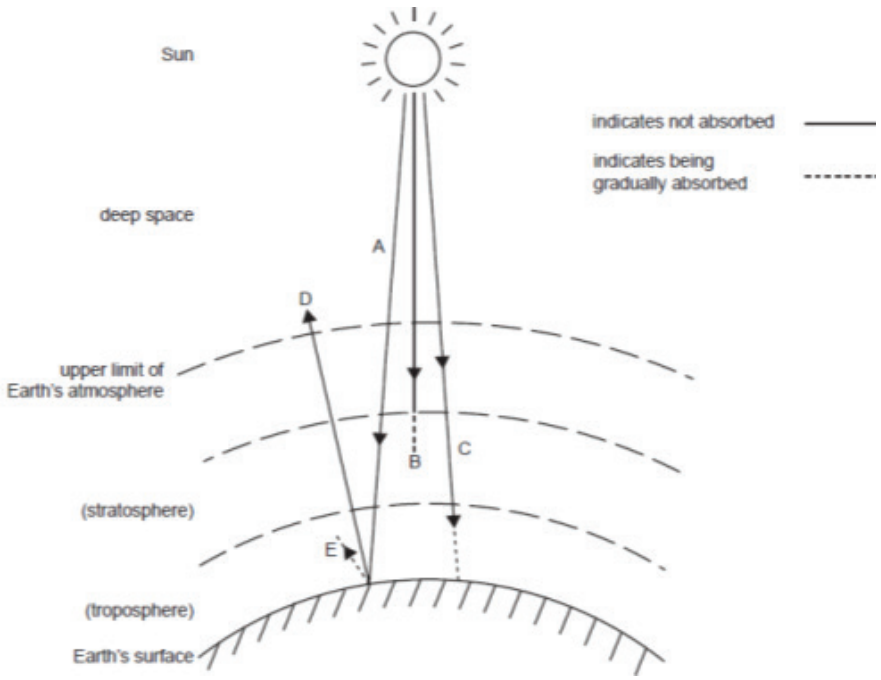
iii. Why is Japan placed towards the middle of the graph?

5. Why is ozone layer important? [1]

Question 3

1. What are some of the prominent reasons for rural-urban migration? [2]

2. Study the figure below and answer the questions that follow. [3]



i. Identify the process shown by the figure.

ii. For each of A–E, write in the box UV, visible or IR to indicate which type of radiation best fits that line.

Line	Radiation type (UV, visible, IR)
A	
B	
C	
D	
E	

3. Explain species diversity with a suitable example. [2]
4. Explain the formation of acid rain with balanced chemical equations. [2]
5. Define biome. [1]

Question 4 **(10 Marks)**

1. Describe the impacts of pollution on human health. [2]
2. Why is mitigation of hazards important? [2]
3. Describe the roles of organisms in maintaining balance in an ecosystem. [2]
4. Watershed plays an important role in Bhutanese economy. Explain. [2]
5. How can 'Duck, cover and hold' minimise the impact of hazards? [2]

Question 5 **(10 Marks)**

1. How do human activities contribute to degradation of biodiversity? [2]
2. How will energy consumption change in Bhutan in the coming years? [2]
3. The energy consumption in developed countries is more than that in developing countries. Support the statement giving suitable reasons. [2]
4. How does climate determine the species composition of an ecosystem? [2]
5. Differentiate between the point source and non-point source of water pollution.[1]
6. Define ecological niche. [1]

Question 6 **(10 Marks)**

1. Why is Green tax imposed? [2]
2. Natural greenhouse effect is necessary to maintain the temperature of the Earth. Justify. [2]
3. Identify and describe ecosystems that are predominant in Bhutan. [2]
4. Represent the structure of an ecosystem with a simple diagram. [2]
5. Suggest two ways of minimising global warming. [2]

Question 7 (10 Marks)

1. Bhutan is vulnerable to disaster by storm. Justify. [2]

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2. Forest fire is one of the major factors for natural resource degradation. Justify. [2]

3. Why do some species of lizards break off their tails when attacked? Identify the nature of adaptation. [2]

4. Explain at least two strategies implemented in Bhutan in order to achieve the following Millennium Development Goals (MDGs): [3]

   i. Eradicate extreme poverty and hunger.

   ii. Achieve universal primary education.

   iii. Ensure environmental sustainability.

5. Fossil fuel is non-renewable energy source. Justify. [1]

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