UTTARAKHAND OPEN UNIVERSITY
Teenpani Bypass Road, Transport Nagar, Haldwani - 263 139
Phone No. : (05946) - 286002, 286022, 286001, 286000
Toll Free No. : 1800 180 4025
Fax No. : (05946) - 264232, email : <info@uou.ac.in>
http://www.uou.ac.in

FR(N) -220

Biodiversity Conservation and Management

FR(N) - 220

Biodiversity Conservation and Management

Department of Forestry and Environmental Science
School of Earth and Environmental Science

Uttarakhand Open University
Haldwani, Nainital (U.K.)

FR(N)- 220

Biodiversity Conservation and Management

UTTARAKHAND OPEN UNIVERSITY

SCHOOL OF EARTH AND ENVIRONMENTAL SCIENCE

University Road, Teenpani Bypass, Behind Transport Nagar, Haldwani - 263 139

Phone No. : (05946) - 286002, 286022, 286001, 286000

Toll Free No. : 1800 180 4025, Fax No. : (05946) - 264232,

e-mail: info@uou.ac.in, Website: http://www.uou.ac.in

Board of Studies

ProgrammeCoordinator

Dr. H.C. Joshi
Associate Professor
Department of Forestry and Environmental Science,
SoEES, Haldwani, Nainital (U.K.)

Units Written by	Unit No.
Dr. Khashti Dasila*& Dr. H.C. Joshi **	1,8
Dr. Deepti Negi* & Dr. H.C. Joshi **	2,4
Adapted from EPG PathShala: Environmental Sciences-Module Id EVS/BC-III/03 Paper No: 03	3,7
Dr. Neha Tiwari *& Dr. H.C. Joshi **	5,6
Dr. Krishna Kumar Tamta*	9
Dr. Krishna Kumar Tamta*, Dr. Beena Tewari Fulara* & Dr. Khashti Dasila*	10
Adapted from EPG Pathshala; Environmental Sciences; Paper No: 03; Module 26	11
Adapted from OER Resources	12
Dr. Beena Tewari Fulara*	13
Dr. Beena Tewari Fulara* & Dr. Preeti Pant*	14

***Assistant Professor (AC),* Department of Forestry and Environmental Science, SoEES, Uttarakhand Open University, Haldwani.**
****Associate Professor, Department of Forestry and Environmental Science, SoEES, Uttarakhand Open University, Haldwani.**

Cover Page Design*& Format Editing

Dr. Krishna Kumar Tamta*, Dr. Deepti Negi, Dr. Preeti Pant,
Dr. Beena Tewari Fulara, Dr. Neha Tewari, Dr. Khasti Dasila, Dr. H.C. Joshi

Department of Forestry and Environmental Science (SoEES)
Uttarakhand Open University, Haldwani

Title	**:**	Biodiversity Conservation and Management FR(N)-220
ISBN	**:**	XXXX-XXXX
Copyright	**:**	Uttarakhand Open University
Edition	**:**	2024 (Restricted Distribution)
Published By	**:**	Uttarakhand Open University, Haldwani, Nainital – 263139
Printed at	**:**	

Table of Contents

Unit 01: Diversity in the Living World

Unit Structure

1.0 Learning Objectives

After the study of this unit, a learner would be able to:

- Understand biological diversity and its importance.
- Explain the evolution of biodiversity and the factors influencing its changes.
- Identify the fundamental properties of life.
- Explain the different levels of biological organization.
- Understand the Biosphere

1.1 Introduction

A wide variety of living things with different size, form, nutrition, reproduction, and habitat, can be found on Earth. We refer to this variance as "diversity in living organisms." It includes three different types of diversity such as **ecosystem diversity**: which refers to the different types of environments in a region; **species diversity**: the variety of species found within an ecosystem; and **genetic diversity**: which involves

the different genes within a species. Together, these forms of diversity play a crucial role in maintaining the health and adaptability of the environment (Smith, 2020).

1.1.1 Importance of Diversity

Biodiversity is essential for keeping ecosystems stable, supporting human life, and ensuring that natural processes work well. Healthy ecosystems give us important services, such as food, clean water, and climate control (Wilson, 1992). Diversity in ecosystems is crucial because it helps to maintain the vital functions in several ways as discussed below:

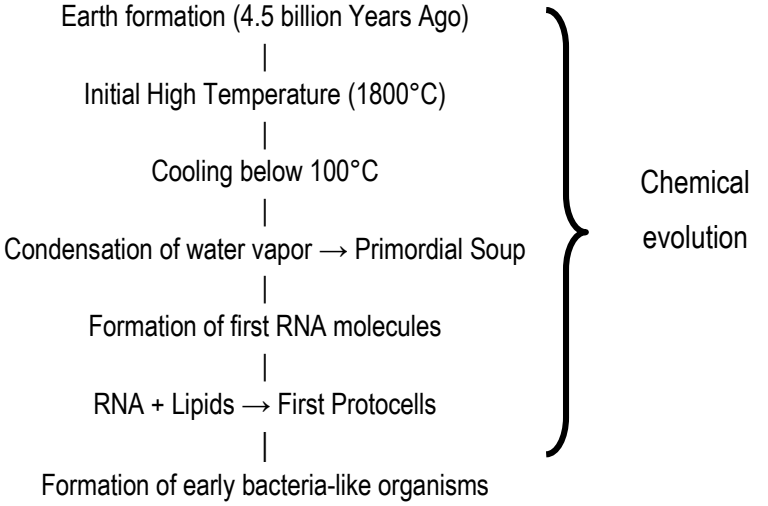
- **Stability:** Forthe sustainable environment.
- **Genetic reserves:** genetic diversity contributes resilience against diseases and environmental shifts.
- **Medicinal:** medicines against diseases and improve health
- **Agricultural:** providing a variety of foods that sustain human life
- **Industrial:** rely on natural resources for building materials and products we use daily.
- **Scientific:** leading to new technologies and discoveries
- **Aesthetic:** the beauty of diverse ecosystems enriches our lives, offering inspiration and recreation
- **Ethical:** biodiversity challenges us to consider our responsibility to protect and preserve the environment
- **Religious:** religious beliefs regarding the Environment

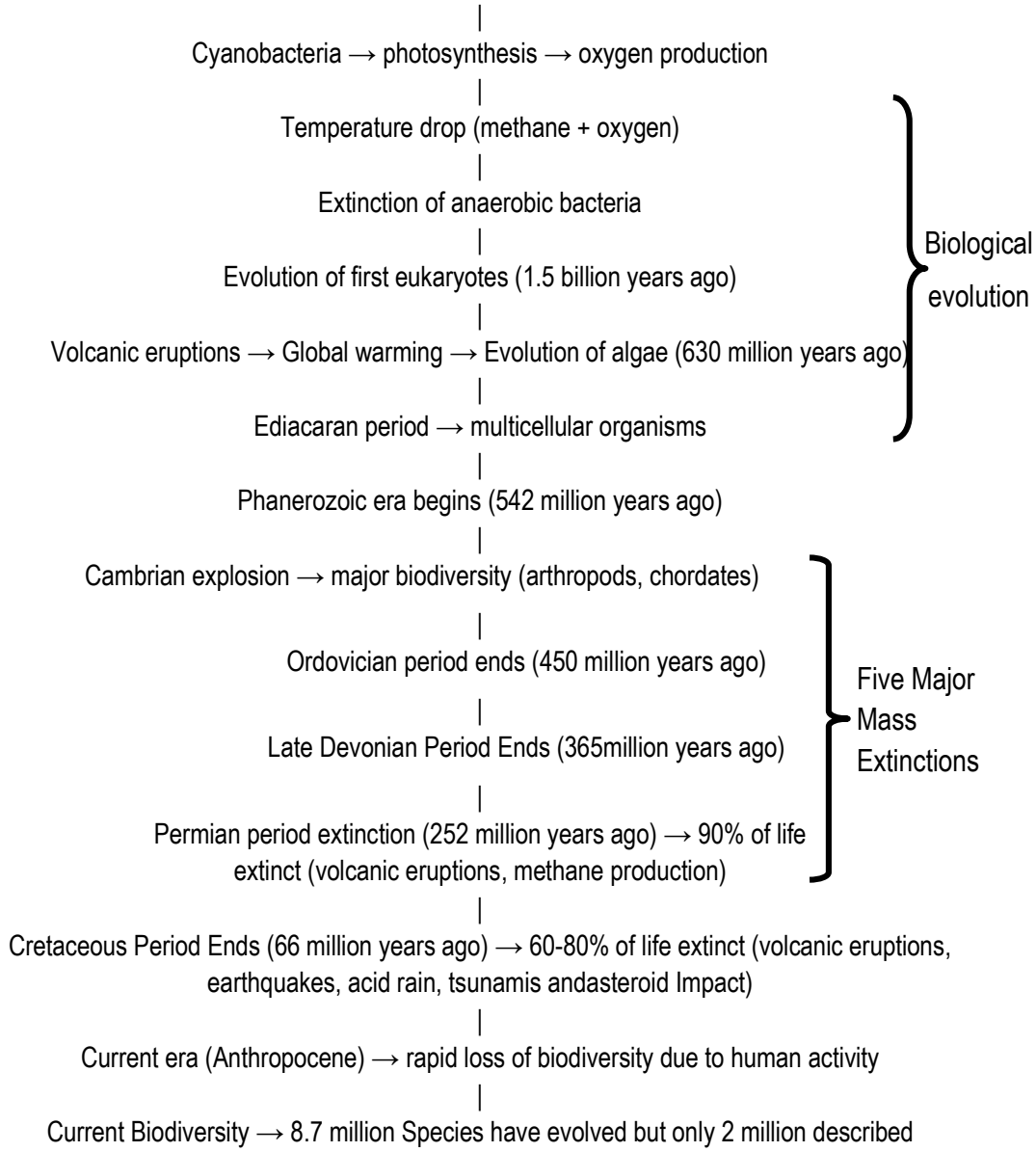
1.2 Evolution of Biodiversity

Earth formed about 4.5 billion years ago. Initially, it was extremely hot, with temperatures around 1800°C. As the planet cooled to below 100°C, water vapor condensed, leading to the formation of a "primordial soup" where the first organic molecules, known as RNA, appeared. Lipids combined with these RNA molecules to create the first protocells, which eventually developed into early organismssimilarto bacteria. Cyano-bacteria began photosynthesis, producing oxygen that reacted with methane in the atmosphere, causing a temperature drop and the extinction of anaerobic bacteria.

Around 1.5 billion years ago, the first eukaryotes evolved. Approximately 630 million years ago, volcanic eruptions caused global warming, promoting the evolution of algae. During the Ediacaran period, fossils of multicellular organisms appeared. The Phanerozoic era began 542 million years ago, the Phanerozoic era began 542 million years ago leading to the evolution of existing biodiversity. There were six significant mass extinctions events during the evolution time. The first event known as Cambrain period characterized with rapid increase in biodiversity and evolution of major groups like arthropods and chordates. The Ordovician period ended 450 million years ago due to global warming and sea level rising which causes 86 % of life lost. The Devonian extinction ended around 365 million years ago period due to global cooling due to glaciations causes fall in sea level and subsequently the lose of habitat. The Permian period ended 252 million years ago was the most severe extinction marked by volcanic eruptions and massive methane release that causes loss of nearly 90% of life. The Cretaceous period ended 66 million years ago, following volcanic eruptions, earthquakes, acid rain, tsunamis and an asteroid impact, causing the extinction of 60-80% of species.

The current era considered as Anthropocene which is characterized by human activity and largely responsible for the rapid loss of biodiversity. From a single species that emerged 4.5 billion years ago, an estimated 8.7 million species have evolved on Earth. However, only about 2 million of these species (14% of terrestrial and 9% of marine species) have been described and classified by scientists. This vast number and variety of species is what we call biodiversity.





Flowchart: The sequence of events leading to Earth's current biodiversity.

1.2.1 Forces of Evolutionary change

The Hardy-Weinberg equilibrium describes populations where allele frequencies stay the same, meaning no evolution is happening. In real life, this is not usually the case, so the theorem helps us understand how evolution works by showing us what changes allele frequencies. These changes are driven by four main factors: mutation, gene flow, genetic drift, and natural selection (Smith, 2022).

I. **Mutation:** Mutations create new genetic changes in a population by adding new alleles. In species that reproduce sexually, only mutations in eggs and sperm can be passed to the next generation and affect evolution. While mutations are

rare and don't usually change allele frequencies much on their own, they are important because they provide the genetic differences needed for other evolutionary processes to work (Alberts et al., 2002).

II. **Migration (Gene Flow):** Gene flow occurs when move into or out of a population, which can change the frequency of different gene variations (alleles) in both the old and new populations (Figure 1). This movement can include the organisms themselves or their reproductive cells like pollen in plants. New or different alleles brought in through gene flow can significantly impact evolution.

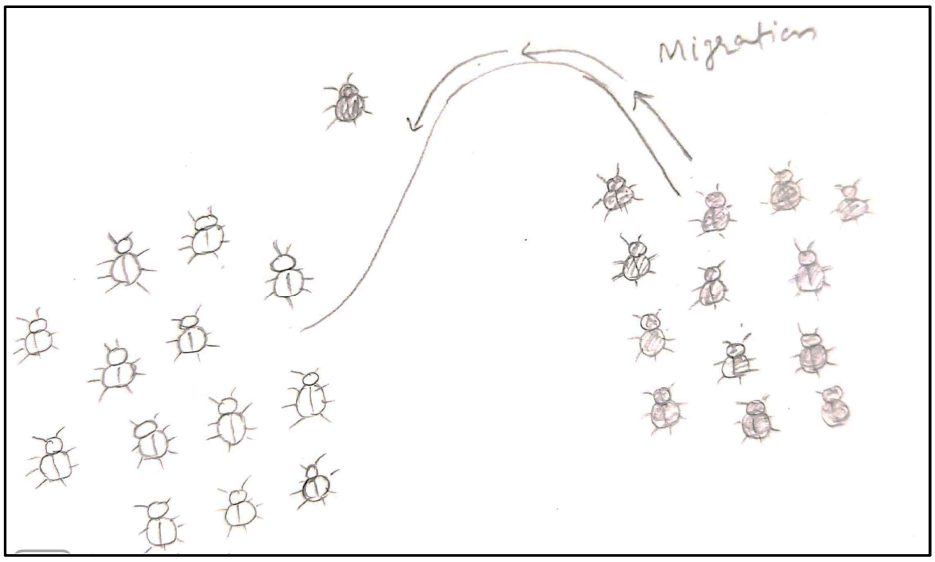


Figure 1. Migration (Gene flow)

III. **Genetic Drift:** Genetic drift involves random fluctuations in allele frequencies within small populations. When a small number of parents produce a limited number of offspring, the allele frequencies in the offspring may differ from those in the parents due to chance. This is analogous to flipping a coin a few times, which might lead to an uneven number of heads or tails purely by chance. In small populations, allele frequencies can unpredictably shift from one generation to the next. Genetic drift can be observed in two specific scenarios: the bottleneck effect and the founder effect.

IV. **Bottleneck Effect**: This occurs when a population experiences a significant reduction in size, often due to a catastrophic event, leading to a smaller population with potentially different allele frequencies compared to the original group (Figure 2).

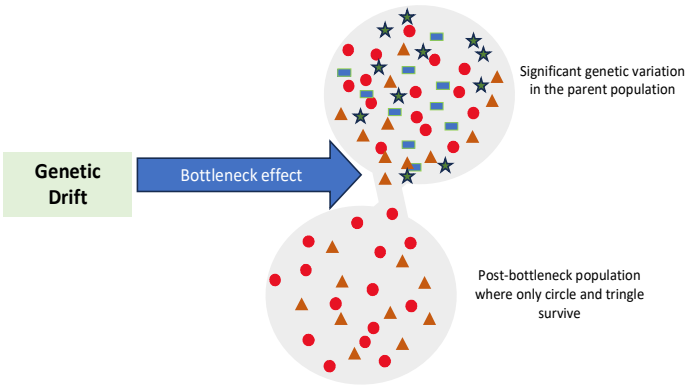


Figure 2. Genetic drift (Bottleneck effect). Different shapes indicate different population

V. **Founder Effect**: When a new and small group of population is established by separating from large population group (Figure 3).The allele frequencies may differ from those in the original population and genomic variation is reduced in founder effect. This phenomenon may occur due to natural disasters like flood, volcanic activity which crates new environment for small and separate groups.

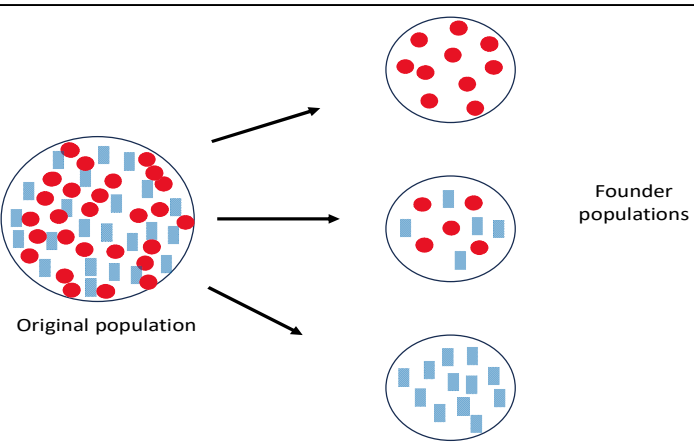


Figure 3. Genetic drift (Founder effect)

VI. **Natural Selection:** It is a fundamental mechanism of evolution described by Charles Darwin in 1859. This process explains show environmental factors influence the species for their survival and reproduction (Darwin, 1859). Darwin's theory of evolution by natural selection includes several key principles like:

- Organisms must produce more offspring to survive
- Not all offspring will survive and reproduce
- Individuals within a species exhibit variation in traits

- Variation in traits can be heritable and responsible for survival and reproduction.

Self-Assessment 1

Multiple choice Questions:

1. What was a key factor in the formation of the first organic molecules on Earth?

A) Volcanic eruptions
B) Cooling of Earth below 100°C
C) Formation of multicellular organisms
D) Photosynthesis by cyanobacteria

2. Which event marked the end of the Cretaceous period?

A) A rapid increase in biodiversity
B) The evolution of the first eukaryotes
C) A long extinction event during the Devonian period
D) Volcanic eruptions and an asteroid impact

3. What does "diversity in living organisms" encompass?

A) Only the variety of ecosystems
B) Only the variety of species within an ecosystem
C) The variety of ecosystems, species, and genes within a species
D) The variety of climates in different regions

4. Which importance of biodiversity challenges us to consider our responsibility to protect and preserve the environment?

A) Ethical
B) Industrial
C) Scientific
D) Agricultural

5. Which of the following is an example of the medicinal importance of biodiversity?

A) Supporting human life through food supply
B) Providing raw materials for daily products
C) Developing medicines to treat diseases
D) Offering recreational opportunities

6. Which type of diversity refers to the different types of environments in a region?

A) Species diversity
B) Genetic diversity
C) Ecosystem diversity
D) Population diversity

7. Assertion: Gene flow plays a significant role in the evolution of populations.

Reason: It introduces or removes alleles from a population, which can alter the genetic composition of population.

A) Both Assertion and Reason are true, and Reason is the correct explanation of Assertion.

B) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.

C) Assertion is true, but Reason is false.

D) Assertion is false, but Reason is true.

8. Match the following forces of evolution with their explanation and select the correct option.

List I	List II
A. Mutation	**I**. A significant reduction in population size leading to changes in allele frequencies.
B. Genetic Drift	**II**. Introduction of new genetic changes by adding new alleles to a population.
C. Founder Effect	**III.** Process where traits that enhance survival and reproduction become more common over generations.
D. Evolution by Natural Selection	**IV.** Establishment of a new population by a small group of individuals with different allele frequencies.

A) A- II; B – II, C = II, D = IV

B) A- II; B – I, C = IV, D = III

C) A- I; B – II, C = III, D = IV

D) A- I; B – III, C = II, D = IV

1.3 Properties of Life

The properties of life refer to the fundamental characteristics and processes essential for the growth, reproduction, survival, and evolution of species. To understand the properties is essential for making strategies to conserve and manage the biodiversity

and ecosystems effectively (Odum and Barrett, 2005). Here are the key properties of life in this context:

I. Diversity and Adaptability

Diversity at the ecosystem, species and gene level allows the species to adapt to changing environmental conditions, enhances ecosystem stability and resilience. Diverse ecosystems support a wide range of species and contribute to overall ecological health.

II. Reproduction and Continuity

Organisms multiply through different reproductive strategies such as sexual and asexual means for their survival and existence in the world. Determining the population dynamics is essential for maintaining species diversity and preventing them from extinction. Population dynamics is the study of how populations fluctuate over time, including migration, birth rates, and death rates.

III. Interdependence

It describes how different species and their interactions rely on each other to maintain a balanced and healthy ecosystem. This includes symbiosis, food webs and Niche differentiation. **Symbiosis** is the interactions between species, such as mutualism, commensalism, and parasitism. These relationships are vital for the survival and functioning of ecosystems. **Food web is** the complex networks of predator-prey and other ecological interactions. Healthy food webs ensure the flow of energy and nutrients through ecosystems. **Niche Differentiation** defined as the role or function of a species within its ecosystem, including its habitat, resource use, and interactions with other species. Niche differentiation reduces competition and allows multiple species to coexist.

IV. Growth and Development

Every organism has to complete its life through various developmental stages from birth to maturity to death is called “Life Cycle”. The natural process of establishing species and community composition changing over time is called succession. Considering succession is one of the important criteria for restoration of the ecosystem. Conservation programs may support the protection of species from vulnerable and threatened conditions in their life cycle.

V. Homeostasis

Homeostasis is described as the capacity of an organism to maintain a constant internal environment against the external environmental fluctuations. This feature is essential for both ecosystem stability and survival in changing environments. For the survival and sustenance of the organisms resources like food, water, and shelter are consistently available in stable ecosystems. Stable ecosystem is better equipped to tolerate and recover from disturbance, like natural disasters or anthropogenic (human associated) activities which helps maintain the suitable conditions required for life.

V. Growth and Development

Every organism has to complete its life through various developmental stages for birth to maturity to death is called “Life Cycle”. The natural process of species composition and community organization changing over time is called succession. For ecosystem restoration succession is an important criterion to consider. The conservation programs may support the protection of species from vulnerable conditions in their life cycle.

VI. Energy Flow and Nutrient Cycling

There are two fundamental processes namely photosynthesis and respiration that drive the energy flow in the ecosystems. Photosynthesis occurred in plants, blue-green algae, and some bacteria to synthesize glucose and oxygen by utilizing carbon dioxide, water, and sunlight. This process is crucial to produce the energy-rich compounds that fuel nearly all life on Earth.

On the other hand, respiration is the process by which organisms use the energy stored in carbohydrates mainly, glucose. During respiration, glucose is broken down with oxygen to produce carbon dioxide, water, and energy in the form of ATP (adenosine tri-phosphate). This energy is essential for all cellular activities and overall metabolism in the living being.

Decomposition and nutrient cycling play a vital role in regulating biochemical processes in ecosystems. Organic matter is broken down, and nutrients are returned to the ecosystem through various biogeochemical cycles. Decomposers such as bacteria and fungi, break down dead organic matter, returning essential nutrients to the soil play a crucial role in maintaining soil fertility and ecosystem health.

VII. Evolution and Natural Selection

The diversity on the Earth is the result of random variations in genetic material over time called mutations. These variations in organisms help to adapt the changes in the surrounding environment. Natural selection is the process by which species acquire traits that increase their survival and reproduction in that habitat or environment. One of the main objectives of conservation efforts is to maintain the species ability to evolve.Speciation is the evolution process of formation of new species.

VIII. Resilience

Resilience is the ability of organisms and ecosystems to recover from environmental disturbances like natural disasters or human activity. It is essential to adapt and recover from environmental shifts to improve biodiversity management and conservation.

Self-Assessment 2

Fill in the following Blanks

1. The variety of species within an ecosystem is known as ……..diversity.
2. The interactions between species, such as mutualism, commensalism, and parasitism, are referred to as……...
3. The study of how populations change over time, including birth rates, death rates, and migration, is called ……dynamics.
4. The stages of development that organisms go through from birth to maturity are known as……..
5. The natural process of change in species composition and community structure over time is called……...
6. The processes by which plants convert sunlight into energy and organisms use that energy for growth and metabolism are called……..
7. The process by which species evolve traits that enhance their survival and reproduction in specific environments is called…….
8. The formation of new species through evolutionary processes is known as……

1.4 Organization of life

The term "biological organization" describes the hierarchical structure of biological systems, where life is arranged from the smallest units of life to larger systems (Figure 4). This process is applied for both ecosystems and organisms. The study of biological organization is essential to understand the interaction and function of living components at different stages.

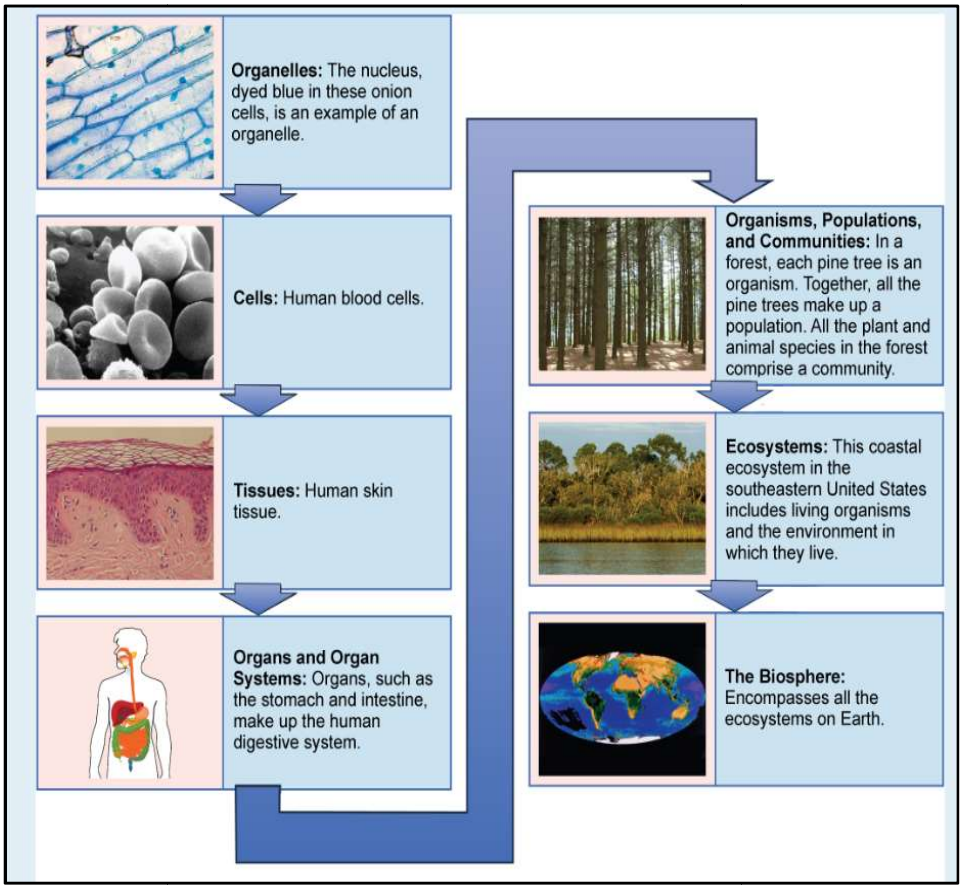


Figure 4. Different levels of organization of life.

Source: "molecule": modification of work by Jane Whitney; credit "organelles": modification of work by Louisa Howard; credit "cells": modification of work by Bruce Wetzel, Harry Schaefer, National Cancer Institute; credit "tissue": modification of work by "Kilbad"/Wikimedia Commons; credit "organs": modification of work by Mariana Ruiz Villareal, Joaquim Alves Gaspar; credit "organisms": modification of work by Peter Dutton; credit "ecosystem": modification of work by "gigi4791"/Flickr; credit "biosphere": modification of work by NASA)

1.4.1 Levels of Biological Organization

The life is organized from the simplest molecular components to complex biosphere through various structural level (Alberts, et al., 2002).Each level has significant

importance contribution in the overall diversity and functioning of life as discussed below.

I. Molecular Level

The molecular level is the foundation of biological organization. It includes the smallest units of matter such as atoms and molecules involved in life processes. The components of molecular level are as **Atoms**; the basic units of chemical elements, consisting of protons, neutrons, and electrons, **Molecules**; combinations of atoms bonded together like water (H_2O) and organic molecules like glucose ($C_6H_{12}O_6$) and **Macromolecules**; large, complex molecules such as proteins, nucleic acids (DNA and RNA), carbohydrates, and lipids, essential for the structure and function of cells.

Importance: Molecules and macromolecules form the basis for all biological structures and functions. For instance, DNA stores genetic information crucial for heredity and cell function.

II. Cellular Level

The cell is the basic unit of life. It is the smallest entity capable of performing all the essential processes of life. **Prokaryotic cells** are the simplest cells such as bacteria and archaea without a nucleus and their genetic material i.e., DNA is not enclosed with amembrane. On the other hand, **eukaryotic cells** (plant, animal, fungal, and protist) are comparatively complex cells with a well-defined nucleus and cellular organelles such as mitochondria, endoplasmic reticulum, Golgi body, peroxisome etc.

Importance: Cells are the building blocks of all living organisms which carryout vital cellular processes like growth, metabolism and reproduction.

III. Tissue Level

Tissues are collections of similar kind of cells working together to carry out a specific function. They are divided into different types according to their functions. For example, **epithelial tissue** acts as a protective barrier covering body surfaces and lining cavities. **Connective tissue** binds and supports other tissues and organs, such as bone, blood, and adipose tissue. **Muscle tissue**, which includes skeletal, cardiac, and smooth muscle types, and **nervous tissue**, are responsible for transmit of signals to brain through neurons and glial cells.

Importance: Tissues responsible for the specialization of cells, to allow them to perform complex cellular functions such as sensation, contraction, and secretion.

IV. Organ and Organ System Level

Organs are composed of multiple tissues that work together to perform specific functions such as lungs (facilitate gas exchange between the body and the environment) and heart (comprised of cardiac muscle, connective, and epithelial tissues and pumps blood throughout the body). Similarly, organ systems are groups of organs that carry out physiological roles such as circulatory system. Circulatory system composed of three different components or organs namely heart, blood, and vessels which together transports the nutrients and gases. Similarly, digestive system that breaks down food and absorbs nutrients, involving the different organs like stomach, intestines, liver, and pancreas.

Importance: Organ systems ensure that the body functions as a coordinated whole, maintaining homeostasis and responding to external changes.

V. Organismal Level

The organismal level represents the complete living entity that can carry out all life processes independently. Organisms can be unicellular or multi-cellular(Campbell and Reece, 2005).**Unicellular Organisms**: Single-celled organisms, such as bacteria, that perform all life functions within one cell. **Multicellular Organisms**: Composed of multiple cells that are specialized into tissues, organs, and systems. Examples include humans, plants, and animals.

Importance: At this level, all levels of biological organization converge to form a functioning, living being capable of growth, reproduction, and response to stimuli.

VI. Population Level

A population is a group of individuals of the same species living in a specific area, capable of interbreeding and interacting with each other (Begon and Townsend, 2021).The population level deals with key concepts like **Population density** which deals with the number of individuals per unit area or volume, **Population dynamics** defined as how populations change over time, including factors like birth rates, death rates, and migration and **Gene pool** responsible for the total genetic variation within a population, representing the sum of all alleles present.

Importance: Populations are the units of evolution, as natural selection acts on genetic variation within populations to drive evolutionary change.

VII. Community Level

A biological community includes all the populations of different species that live and interact in a specific area (Ricklefs et al., 2013). In community, the population of different species interacts through symbiotic, predation, competition, mutualism, parasitism, and commensalism relationships called s**pecies Interactions**. There is a variety of species within a community which contributes to the stability and resilience of ecosystems.

Importance: Communities form the basis of ecosystems, with species interactions shaping the structure and function of ecosystems.

VIII. Ecosystem Level

An ecosystem encompasses all the living organisms (biotic components) and non-living elements (abiotic components) in a specific area, interacting as a system (Odum and Barrett, 2005).The biotic such as **Producers:** the organisms like plants and algae that produce energy through photosynthesis), **Consumers** (heterotroph): the organisms that obtain energy by consuming other organisms, including herbivores, carnivores, and omnivores and **Decomposers**: Organisms like bacteria and fungi that break down dead organic material, recycling nutrients. Abiotic factors such as sunlight, temperature, water, and soil composition that influence living organisms.

Importance: Ecosystems are dynamic systems that regulate energy flow and nutrient cycling. They provide essential services such as food, water purification, and climate regulation.

IX. Biosphere Level

The biosphere is the global ecological system integrating all living beings and their relationships, including the interaction with elements of the lithosphere, hydrosphere, and atmosphere (Chapin et al., 2002). The global processes include biogeochemical cycles like the carbon; nitrogen, phosphorous and sulfur cycles that maintain the nutrient balance in soil which act as universal system for life biosphere. Anthropogenic activities such as deforestation, pollution, and climate change have significant effects on the biosphere, leading to global ecological changes.

Importance: The biosphere is the highest level of biological organization, encompassing all ecosystems and living organisms on Earth. Understanding the biosphere is critical for addressing global environmental challenges.

Self-Assessment 3

Very short answer type questions

1. What is the basic unit of life?
2. What type of cell lacks a nucleus?
3. Which molecule stores genetic information?
4. What is called similar group of cells working together?
5. Which level of organization includes all ecosystems on Earth?
6. Which organisms produce energy through photosynthesis?
7. What is the smallest unit of chemical elements?
8. What level includes all living organisms and non-living elements in an area?

1.5 The Biosphere: Life on Earth

Now are aware of the different levels of biological organization. We know the biosphere is the global ecosystem that includes all living organisms and their interactions with the physical environment. It is often referred to as the "zone of life" on Earth. The term 'biosphere' was first introduced by geologist **Eduard Suess** in 1875and the comprehensive concept was developed by Russian scientist **Vladimir Vernadsky** in the 1920s The biosphere made up of four components namely hydrosphere (water), lithosphere (land),atmosphere (air) and Ecosphere (living beings) (Figure 5).

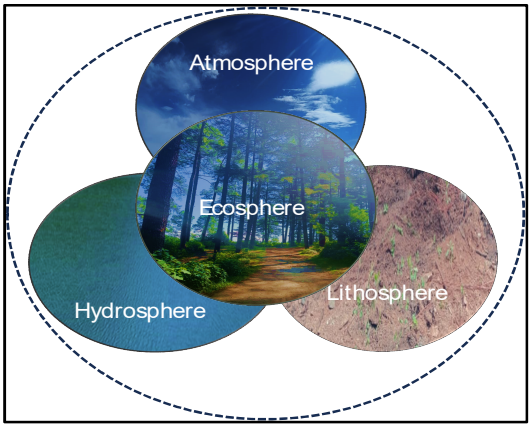


Figure 5. The Biosphere

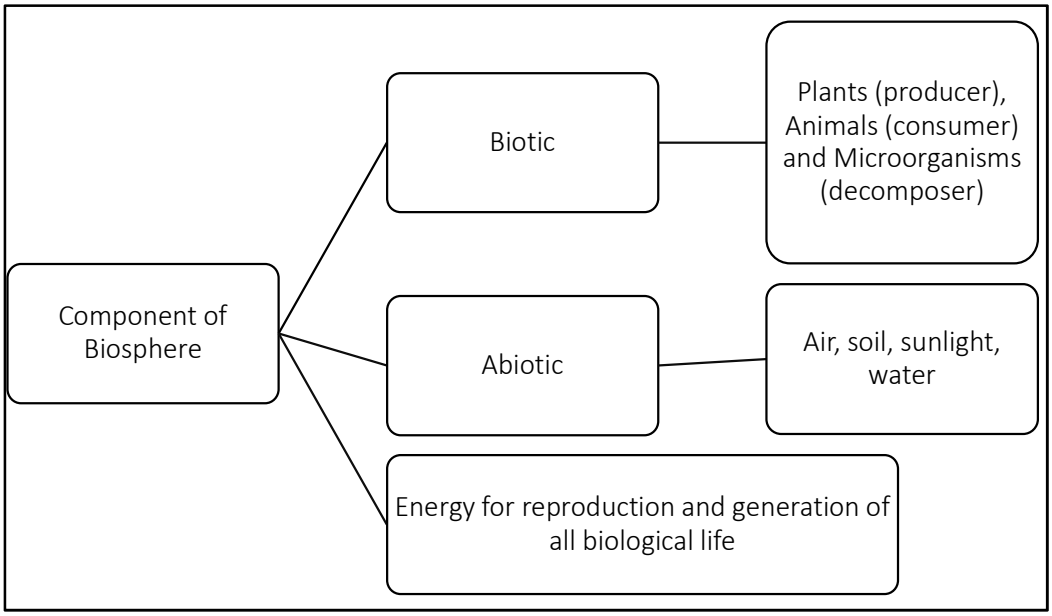
1.5.1 Components of the Biosphere

The biosphere consists of both living (biotic) and non-living (abiotic) components:

I. **Biotic Components**: These include all forms of life from microorganisms to large animals which interact within ecosystems to form complex food webs that maintain ecological balance.

II. **Abiotic Components**: These are the physical and chemical elements like sunlight, temperature, water, soil, and atmospheric gases, which are crucial for providing energy and nutrients necessary for life (Odumand Barrett, 2005).

III. **Energy**: It is vital component of the biosphere which is essential for reproduction and generation of all biological life on Earth.



1.5.2. Structure of the Biosphere

The biosphere is divided into **biomes** the large regions with distinct climates, vegetation, and wildlife which include tropical rainforests, deserts, tundra, oceans etc.

Tropical Rainforests: It is characterized by warm and moist regions near the equator. The biodiversity is rich biodiversity with dense vegetation.

I. **Deserts**: Desserts are arid regions with extreme temperatures with low humidity and rainfall. The vegetation is characterized by scanty which is adapted to survive with minimal water conditions.

II. **Tundra**: It is cold and low biodiversity regions found in polar areas. They are characterized with short growing seasons and permafrost.

III. **Oceans**: Oceans covers about 71% of Earth's surface. It is the largest biome hosting a vast diversity of marine life.

Each biome contains **ecosystems** where communities of organisms interact with their physical surroundings. This ecosystem varies in size and maintains a unique balance of resources and species (Odum & Barrett, 2005).

1.5.3. Functions of the Biosphere

The biosphere supports essential functions that support life on Earth as discussed below:

I. **Nutrient Cycling**: Various biogeochemical cycles regulating and managing the essential nutrients like carbon, nitrogen, and phosphorus. These nutrients are required for the growth and development of all living organisms. For example, the nitrogen cycle converts atmospheric nitrogen into soluble form by plants then pass through the food chain.

II. **Regulation of Atmospheric Gases**: The balance of oxygen, carbon dioxide and other gases in the atmosphere is regulated by the process of photosynthesis, respiration and biogeochemical reactions, respectively.

III. **Energy Flow**: The energy from sunlight utilized by plants through photosynthesis and transferred through food chains from producers to consumers and decomposers. This energy transfer influences the structure and dynamics of ecosystems.

1.5.4 Human Impact on the Biosphere

I. **Deforestation**: Large-scale forest clearing for agriculture, logging, and urbanization has led to habitat destruction, species loss, and disrupted carbon and water cycles.

II. **Pollution**: Pollutants released into the air, water, and soil has damaged ecosystems, causing problems like acid rain, eutrophication, and bioaccumulation of toxins.

III. **Climate Change**: Human-induced climate change, driven by fossil fuel use and deforestation, has led to global warming, rising sea levels, and altered weather patterns, threatening ecosystem stability and species survival. The term “Anthropocene” has been proposed to describe the current geological era where human activity dominates Earth's environmental changes (Steffen et al., 2007).

1.5.5. Conservation of the Biosphere

Conservation efforts aim to protect and restore ecosystems to maintain biodiversity and the essential services they provide:

I. **Protected Areas**: National parks, wildlife reserves, and marine protected areas help conserve habitats and species from human exploitation.

II. **Sustainable Practices**: Encouraging the integrated management of land, water and air can minimize environmental impact and ensure ecosystem productivity and resilience.

III. **Global Environmental Agreements**: International agreements like the Paris Agreement on climate change, Convention on Biological Diversity (CBD), Conference of parties (COP) meetings, Ramsar Convention and others seek to address global environmental issues and promote coordinated efforts to protect the biosphere.

Summary

- Diversity is defined as the variety of life forms on Earth which includes ecosystem, species and genetic diversity.
- Biodiversity is important to support ecosystem stability, provides food, medicine, industrial resources, and has scientific, aesthetic, ethical, and religious significance.
- The evolution of biodiversity traces the development of life from Earth's formation 4.5 billion years ago to the current biodiversity emphasizing major extinction events.
- The properties of Life include diversity, adaptability, interdependence, reproduction, homeostasis, growth, energy flow, and resilience.
- Life is organized or structured hierarchically from molecular to the biosphere (Molecular→ cellular→ tissue → organ and organ system → organism → population → community → ecosystem → biosphere level) with each level contributing to overall biological complexity.
- The biosphere encompasses all living organisms and their interactions with the physical environment. It includes biotic (living organisms) and abiotic (physical and chemical elements like sunlight and water) components, which are essential for life and energy flow.

- The biosphere is divided into biomes based on different climatic conditions and ecosystems such as tropical rainforests, deserts, tundra's, and oceans. It performs critical functions including regulating atmospheric gases, nutrients cycling, and transferring energy through food chains.
- Anthropogenic activities such as deforestation, pollution, and climate change, have adversely affected the biosphere. Conservation efforts, including protected areas, sustainable practices, and global agreements aim to mitigate these impacts and preserve biodiversity and ecosystem services.

Terminal Questions

1. How biodiversity is important for maintaining ecosystem functioning?
2. How the life evolved on the Earth?
3. What are the forces responsible for evolutionary changes?
4. What is the hierarchical structure of biological systems?
5. Define the term Biosphere and its components
6. How the anthropogenic activities impact the biosphere negatively?

Answer Keys

Self -Assessment 1: 1 – B; 2 – D; 3 – C; 4 – A; 5 – C; 6 – C; 7 – A; 8 - B

Self -Assessment 2: 1 – species; 2 – symbiosis; 3 –population; 4 – life cycles; 5 – succession; 6 –photosynthesis and respiration; 7 – adaptation; 8 - speciation

Self -Assessment 3: 1 – cell; 2 –prokaryotes; 3 – DNA; 4 – tissue; 5 – biosphere; 6 – producers; 7 –atom; 8 - ecosystem

References

AlbertsB, JohnsonA, Lewis J, Raff M, RobertsK, Walter P (2002). *Molecular Biology of the Cell* (4th ed). Garland Science.

BegonMTownsendCR (2021). *Ecology: from individuals to ecosystems*. John Wiley & Sons.

Campbell NA, Reece JB(2005). *Biology*. Pearson Education India. Millennium Ecosystem Assessment. *Ecosystems and Human Well-being: Synthesis*. Island Press.

ChapinFS, Matson PA, Mooney HA, VitousekPM(2002). Principles of terrestrial ecosystem ecology. Springer.

DarwinC (1859). *On the Origin of Species by Means of Natural Selection*. John Murray.

OdumEP, BarrettGW (2005). *Fundamentals of Ecology* (5th ed). Thomson Brooks/Cole.

RicklefsRE,Relyea RA(2013). *Ecology: The Economy of Nature* (7th ed). WHFreeman and Company.

Smith J(2020). *Understanding Biodiversity: The Key to a Healthy Ecosystem*. Green Earth Publishing.

SmithJ (2022). *Principles of Evolutionary Biology: Understanding Mutation, Gene Flow, Genetic Drift, and Natural Selection*. Evolutionary Science Press.

Steffen W, Crutzen PJ, McNeillJR(2007).The Anthropocene: Are Humans Now Overwhelming the Great Forces of Nature?" Ambio, 36(8): 614-621.

WilsonEO(1992). *The Diversity of Life*. Harvard University Press.

Unit 2: Concept of Biodiversity

Unit Structure

2.0 Learning Objectives

After going through this unit you will be able to:

- Explain what is the concept and definition of biodiversity
- Define the levels of organization and dimension of bio-diversity
- Describe the various bio-geographical regions of India
- Identify the common flora and fauna of India along with endangered and endemic species
- Explain the concept of extinction and evolution of species

2.1 Introduction

In the previous chapter you learnt briefly about diversity of living world, which includes general discussion of biodiversity and biosphere. This chapter is dedicated to discuss in detail the core concept of biodiversity, its definition, dimension, levels of

organization, global biodiversity gradient, bio-geographical regions of India, important flora and fauna of India, etc.

2.1.1 Concept and definition of biodiversity

Biodiversity encompasses various life forms on earth, including a variety of genes, species, ecosystems, and ecological processes (Heydari et al., 2020). The term 'biodiversity' was coined by Dr. Walter G. Rosen in 1985 and he originally used this term in internal paperwork. Rosen defined biodiversity as "the very stuff of life" and "the variety of life on earth and the natural patterns it forms". While the term biological diversity was coined by Thomas Lovejoy in 1980. Edward O. Wilson is an eminent scientist, naturalist, author and teacher is regarded as "the father of biodiversity".

In simple words biodiversity means biological diversity of various species of flora, fauna and microorganisms found in various types of habitats, the genes they contain and the ecosystem they form. It refers to genetic variation, species variation, ecosystem variation, within an area, biome or planet. All organisms totally depend on it for their basic requirement of breathing air, food, shelter and clean water. It plays an important role in the proper functioning and regulation of an ecosystem like:**1)** trees and plants decrease global warming by absorbing atmospheric carbon, **2)** bacteria and fungi break down organic material in order to increase soil fertility, **3)** wetlands are the major sites of water purification, thereby acts as kidneys of nature, **4)** regulation of hydrological and other bio-geochemical cycles, **5)** helps in absorption of pollutants and waste material, **6)** formation and protection of soil, etc. Therefore, we can say that native species richness is directly correlated to the health of all ecosystems. Despite the benefits from biodiversity, today's threats to species and ecosystems are increasing day by day with alarming rate due to human mismanagement of biological resources. In recent times many biologist noticed the global loss of species therefore it requires a need to address the biodiversity of earth. It is estimated that more than 90% of the species still not discovered and might become extinct even before taxonomists could identify and describe them.

The term "biodiversity" is relatively new, although "biological diversity," or the total number of species, is not. However, a lot of people have argued that biodiversity and species richness are not the same thing. Species richness is only one component of biodiversity. The thought of biodiversity become popular after Rio Summit in 1992

known as Convention on Biological Diversity (CBD). The CBD defines biological diversity as "the variety and variability among living organisms from all sources, including inter alia, the terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part, this includes diversity within species, between species and of ecosystems". The main focus of CBD was on:

- Sharing benefits of biodiversity and conventional knowledge
- Conservation and sustainable utilization of biological diversity
- Protection of traditional knowledge related to biodiversity
- Sharing biodiversity benefits fairly and equitably
- Conservation of biological diversity
- Protection and rehabilitation of endangered species (Sridhar, 2006).

The Convention is now one of the most widely ratified international treaties on environmental issues, with 194-member countries. So far, CBD's generate a massive amount of interest in biodiversity which is a significantly important for environment related issue, both in developed and developing countries. Biological diversity of a geographical area is governed by three main factors: **1)** its species richness, **2)** level of endemism and **3)** degree of threat of these species.

2.2 Levels of organization

There are three levels of biodiversity as shown in figure 1.

2.2.1 Genetic diversity

Every living thing on Earth contains a unique code within them called DNA. Similar to how letters are arranged into sentences, DNA arranged into genes. Genes are responsible for proper functioning of our body. Even among members of the same species, have distinct DNA codes. This is referred to as genetic diversity. Variations in genetic diversity can be observed in the forms of human eye color (black, brown and blue), hair color, bird beaks, and tomato flavors etc (Minter et al., 2022). When a species has a lot of differences in its DNA, we say that genetic diversity is high. In species with high genetic diversity, there are lots of mutations in the DNA, which cause differences in the way individuals look as well as differences in important traits

(Frankham et al., 2002). Therefore; genetic diversity is the range of genetic characteristics within a species.

Genetic diversity is dependent on the heritable variation within populations of organisms. New genetic variation arises due to mutations in gene and chromosome, and in organisms with sexual reproduction. Other kinds of genetic diversity can be identified at all levels of organization, including the amount of DNA per cell and chromosome structure and number. Continuous variation within a population over a period of time along leads to evolution. Genetic variability is the clay of evolution, providing the base material on which adaptation and speciation depend.

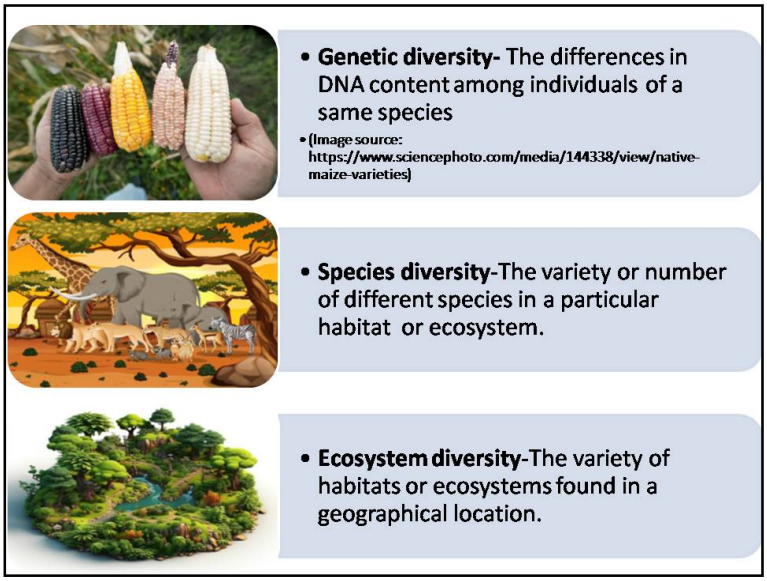


Figure 1. Levels of biodiversity

2.2.2 Species diversity

Species are the fundamental expressive units of the biological world. Species diversity is defined as the number of species present in a community and relative abundance of each of those species. Relative abundance is the even distribution of individuals among species. The quantitative measurement of species diversity is calculated by using Shannon wiener and Simpson index on the basis of species richness and species evenness.

(i) Species richness- The total number of species present in a given area.

(ii) Species evenness- Similarity of number of individuals of each species in a given area. Species evenness is high if the number of individuals within a species is fairly constant across communities and evenness is low, if the number of individuals varies

from species to species. Species evenness is inversely proportional of species dominance, if species are not even in a community that means some or one species is dominant.

If we consider all domains of life, it is estimated that there are ∼8.7 million eukaryotic species globally, of which ∼2.2 million are marine. However, till yet the taxonomic classification of over 1.2 million species was catalogued in a central database but results suggest that some 86% of existing species on earth and 91% oceanic species still await description (Mora et al., 2011). The current estimates of insect species on earth range from 5 to 30 million species and recently 422,000 seed plant species identified on Earth (Espírito-Santo and Fernandes, 2007). Although most of the earth's species are insects and microorganisms, So far, less than 3-5 percent of microorganisms have been described (Carreon-Lagoc, 1994).

2.2.3 Ecosystem diversity

Ecosystem diversity is the largest scale of biodiversity and includes both genetic and species biodiversity. An ecosystem is defined as a community of biotic species interacting with each other and also with their non living environment. Ecosystem diversity deals with the variations in ecosystems within a geographical location and its effects on human and other living organisms. The vast range of terrestrial and marine environments on earth creates many ecosystems. Major ecosystem types include tropical rain forests, grasslands, deserts, wetlands, oceans and mangroves. Over a period of time, the species compositions of an ecosystem gradually vary. Regions containing a great variety of ecosystems are rich in biodiversity, but individual ecosystems containing endemic species make a significant contribution to global biodiversity. Tropical moist forests are the world's richest habitats but cover only 7 percent of the world's surface, contain 90 percent of all plant and animal species (Carreon-Lagoc, 1994).

Self-Assessment 1

Multiple choice questions

1. Who first coined the term biodiversity?

a) Edward O. Wilson

b) Walter G. Rosen

c) Alexander von Humboldt

d) Norman Myers

2. Who is regarded as "the father of biodiversity"?

a) Edward O. Wilson

b) Walter G. Rosen

c) Alexander von Humboldt

d) Norman Myers

3. Nature's kidneys are?

a) Tropical rain forests

b) Deserts

c) Wetlands

d) Ocean

4. What are the main functions of biodiversity?

a) Regulation and maintenance of hydrological and other bio-geochemical cycles b) Trees and plants decrease global warming by absorbing atmospheric carbon

c) Bacteria and fungi break down organic material in order to increase soil fertility

d) Helps in absorption of pollutants and waste material

e) All of the above

5. Which factors are responsible for the biological diversity of a geographical area?

a) Species richness

b) Level of endemism

c) Degree of threat

d) All of the above

6. The difference in DNA content among individual of a same species is known as:

a) Genetic diversity

b) Species diversity

c) Ecosystem diversity

d) Functional diversity

7. Match the following:

List I	List II
A. Species diversity	**i)** Total number of species present in a given area
B. Species richness	**ii)** Based on species richness and species evenness
C. Species evenness	**iii)** Variations in ecosystems within a geographical location and its effects on human and other living organisms
D. Ecosystem diversity	**iv)** Similarity of number of individuals of each species in a given area

Choose the correct option:

a) A-ii, B-i, C-iii, D-iv

b) A-i, B-ii, C-iii, D-iv

c) A-ii, B-i, C-iv, D-iii

d) A-ii, B-iv, C-iii, D-i

2.3 Dimensions of Biodiversity

There are three fundamental dimensions of biodiversity i.e., genetic diversity, phylogenetic diversity, and functional diversity as shown in figure 2. Genetic diversity indicates the diversity at gene level including genomic, transcriptomic, and proteomic diversity. Phylogenetic diversity refers to the evolutionary history of a species and its relationship among other species. Functional diversity refers to the roles that organisms play within the populations, communities, and ecosystems, including the regulation and maintenance of ecological processes. The dynamic relationships among these three dimensions indicate how relationships change and evolve over time. Main focus is to

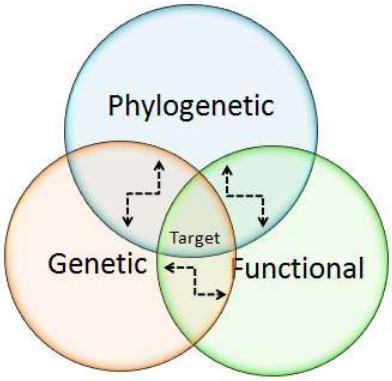


Figure 2. Three dimensions of biodiversity: Genetic, Phylogenetic and Functional.

understand the unknown mechanisms responsible for the origin, regulation, maintenance, and functional roles of biodiversity. These dimensions reveals the number, evolutionary history and capabilities of species in proper ecosystem functioning.

2.4 Global biodiversity gradient

Biodiversity is not evenly distributed throughout the earth is called the global biodiversity gradient, also known as the latitudinal diversity gradient (LDG). The LDG is one of the most widely accepted patterns in ecology and has been observed in almost all organisms, where nature has created a balance between the biodiversity and the ecosystem that includes all form of life from aerial to land dwellers and from land to marine life forms. This uneven biodiversity distribution is highly concentrated at the equator with species richness and decreasing towards the poles or high latitudes (figure 3). There are three main subcategories of biogeography (the geographical distribution of plants and animals):

I. **Ecological biogeography:** related to the current factors affecting the distribution of plants and animals in the earth.

II. **Historical biogeography**: concerned with the study of past distribution of species.

III. **Conservation biogeography**: mainly focused on the protection and restoration of species on the basis of historical and current ecological information.

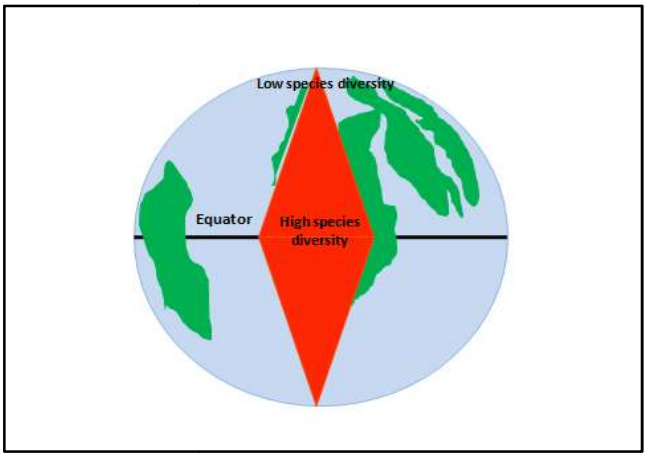


Fig. 3. Global biodiversity gradient

What are the main factors behind planetary biodiversity gradient? Several biogeographers have suggested that latitude and age are two main factors responsible

for it. One popular theory concluded that higher latitudes are species poor because species that were displaced to lower latitudes by glaciations have not all yet returned to their original latitude (Turner, 2004).

The biotic environment of arctic animal species is relatively simple with few enemies, competitors, diseases, parasites and available food resources. Arctic microorganisms are also well adapted to the arctic's climate: some can metabolize at temperatures down to −39°C. Cyanobacteria and algae have a wide range of adaptive strategies that allow them to avoid, or at least minimize UV injury. Microorganisms can tolerate most environmental conditions and they have short generation times which can facilitate rapid adaptation to new environments. Arctic plant and animal species are likely to change their distributions in response to warming (Callaghan et al., 2004).

Self-Assessment 2

Fill in the blanks

1. Three fundamental dimensions of biodiversity are ……, …… and …….. diversity.

2. …….. diversity indicates the diversity at gene level including genomic, transcriptomic, and proteomic diversity.

3. ……. diversity refers to the evolutionary history of a species and its relationship among other species.

4. ……. diversity refers to the roles that organisms play within the ecosystems, including the regulation and maintenance of ecological processes.

5. Biodiversity is not evenly distributed throughout the earth is called the ……

6. Biodiversity distribution is highly concentrated at the …… with species richness and decreasing towards the ……..

7. …….. biogeography related to the current factors affecting the distribution of plants and animals in the earth.

8. …… biogeography mainly focused on the protection and restoration of species.

2.5 Life zones: biogeographical regions of India

A biogeographic zone is a region where different species of plants and animals with similar or different characteristics live together. India is a rich store house of biodiversity such as Himalayan zone, Indian desert zone, trans-himalayan region, western ghats etc. A biogeographical region shows the regional pattern of distribution of world's flora and fauna at continental scale. Based on some common characteristics shared by both plants and animals, the biogeographical areas are recognized, defined, and represented on the map. Biogeographical region may be described as an area possessing a particular set of climatic conditions i.e., its own distinctive temperature and rainfall regime and its own diurnal and seasonal changes which give rise to a particular kind of vegetation which in turn give rise to a particular kind of animal life (Jamal, 2020). Rogers and Panwar divided Indian region into 10 biogeographical regions (figure 4) and 27 biogeographic provinces (Rodgers and Panwar, 1988).

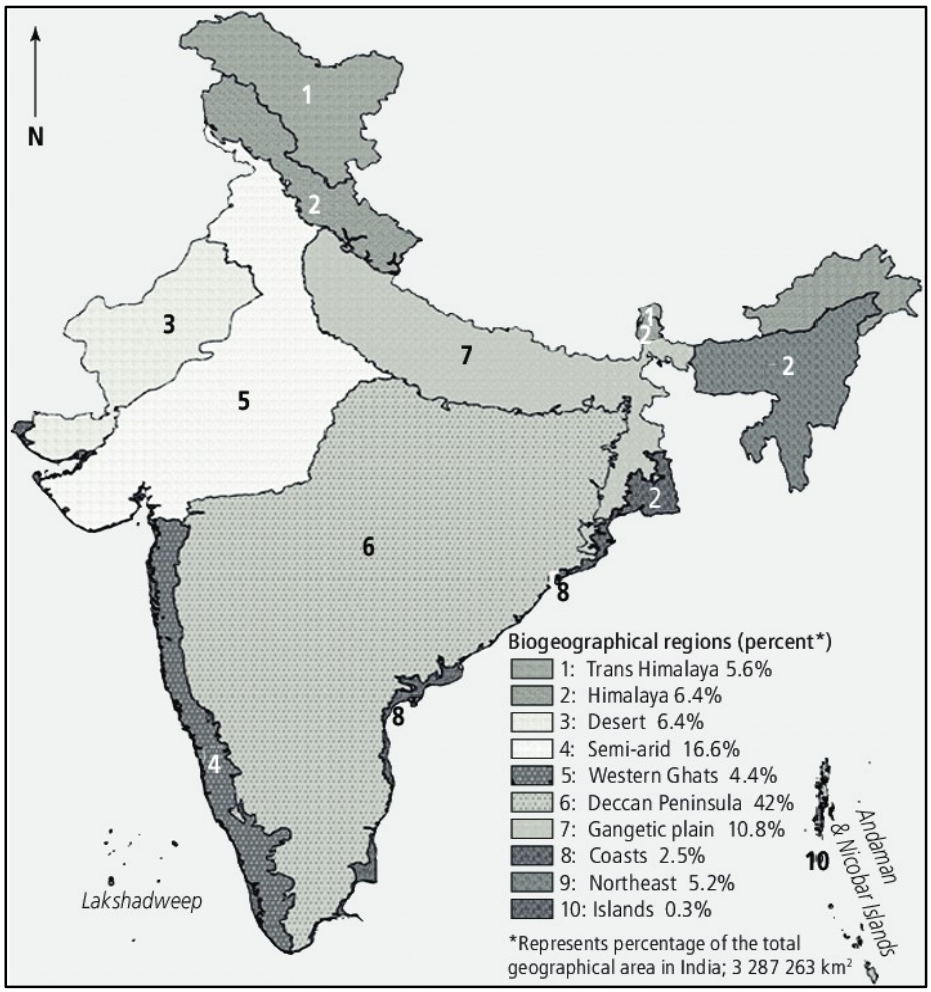


Figure 4. Biogeographic zones in India (Source: Wildlife Institute of India, GSI Cell 2002)

I. **Trans-Himalaya:** The region beyond the Himalaya is known as trans-himalaya. It mainly comprises the cold and arid region to the north of the great himalayan range and lies between 4500 m and 6000 m above sea level. This region characterized by harsh climatic conditions, sparse alpine vegetation, snow-fed mountains, less precipitation, fast blowing wind and glacier fed rivers. Figure 5 shows the trans-himalayan region of chandertaal wild life sanctuary situated in the Lahaul and Spiti district of Himachal Pradesh.

Figure 5. Trans-Himalaya biogeographic region

II. **The Himalaya:** The highest and young mountain chain in the world. Its biogeography provinces are north-west Himalaya, west Himalaya, central Himalaya, and east Himalaya. It consists of four parallel mountain ranges from south to north: the Sivalik Hills; the lower Himalayan range; middle Himalayan range the great Himalayas.

III. **Desert:** Hot and dry land with little precipitation mostly found in the subtropics. Desert ecosystems are dominated by scrub and grassland vegetation types. Its biogeographic provinces are Thar and Katchchh, which are one of the earth's major ecosystems having unique biomes and living conditions.

IV. **Semi-arid:** A transition zone between desert and denser forests consisting largely of thorn forests and savannahs.

V. **Western Ghats:** This comprises of plains and mountains with peaks 800 m – 1500 m above sea level. Western Ghats includes a wide range of flora types, such as montane grasslands, tropical dry thorn forests, and tropical evergreen

forests. It is challenging to maintain agriculture in semi-arid areas due to their unstable ecosystems, unpredictable weather patterns, and susceptibility to droughts and water scarcity. In addition, their soil structure is poor, their soil organic carbon content is low, and they face threats from salt, erosion, and human activity.

VI. **Deccan Peninsula:** a large region in the Indian subcontinent that covers most of the southern part of the country. It is a semi arid region that falls in the rain shadow area of the Western Ghats, A major portion of the Deccan peninsula is covered by Tropical thorn forests and tropical dry and moist deciduous forests and degraded shrub lands (Jamal, 2020). Dominated by teak and sal bearing tropical forests.

VII. **Gangetic Plains:** Most fertile and largely populated plains lie in the foothills of Himalaya. It is known as the food bowl of India and it provides foodgrains to millions of population. Suitable for agriculture and the perennial rivers which provides irrigation throughout the year. Vegetation types include dry and moist deciduous forests.

VIII. **Coasts:** India's coastline, which spans from Gujarat to Cape Comorin in the east, is home to two important types of vegetation: beach and mangrove forests.

IX. **North-East:** Transition zone between Indian, Indo-Malayan and indo-Chinese biogeographical regions as well as being a meeting point of the Himalayan Mountains and peninsular India. This zone is the richest in biological diversity and endemism. This zone, which includes a portion of Arunachal Pradesh, is home to almost 50% of all species found in India

X. **Islands:** Consisting of nearly 600 islands, includes the Andaman and Nicobar groups of island in the Bay of Bengal with 348 islands show an interesting biogeography. Centers of high endemism and contain some of India's finest evergreen forests and support a wide diversity of corals.

2.6 List of common flora and fauna of India

All plant life is referred to as flora, and all animal life is referred to as fauna. Indian subcontinent is a blessed with all type of weathers, climate, topology, environment and forests. Therefore, has a diversified flora and fauna, with many different kinds of plants and animals. There are more than 18000 flowering plants, around 50,000 plant

species, about 500 different varieties of mammals, 2000 species of birds, 30,000 types of insects and several varieties of fish, amphibians and reptiles. The forest areas in Andaman, eastern himalayas, western himalayas, indus plains and deccan ranges have about 3000 endemic species of plants.

Table 1: List of common flora of India

(Source: https://www.biodiversityofindia.org/index.php?title=Official_flora_and_fauna_of_India)

S. No.	Flora of India	Common name	Family
1	*Hibiscus rosa-sinensis*	China rose, Shoeblack plant	Malvaceae.
2	*Jasminum officinale*	Common and white jasmine	Oleaceae
3	*Tagetes erecta*	Marigold	Asteraceae
4	*Bougainvillea spectabilis*	Great bougainvillea,	Nyctaginaceae
5	*Nelumbo nucifera*	Sacred lotus, Indian lotus	Nelumbonaceae
6	*Rosa pendulina*	Rose, Gulaab	Rosaceae
7	*Rhododendron ponticum*	Buransh	Ericaceae
8	*R. campanulatum*	Pink buransh	Ericaceae
9	*R. arboreum*	Red buransh	Ericaceae
10	*Saussurea obvallata*	Brahma kamal	Asteraceae
11	*Nyctanthes arbor-tristis*	Parijaat	Oleaceae
12	*Bauhinia variegata*	Bauhinia, Butterfly tree	Caesalpiniaceae
13	*Mangifera indica*	Mango	Anacardiaceae
14	*Paphiopedilum insigne*	Lady's slipper orchid	Orchidaceae
15	*Dendrobium nobile*	Orchid	Orchidaceae
16	*Rhynchostylis retusa*	Foxtail orchid	Orchidaceae
17	*Renanthera imschootiana*	Red vanda	Orchidaceae
18	*Lilium mackliniae*	Siroi lily, Shirui lily	Liliaceae
19	*Cedrus deodara*	Deodar	Pinaceae
20	*Gmelina arborea*	Gamhar, Gmelina	Lamiaceae
21	*Alnus nepalensis*	Alder, Utis	Betulaceae
22	*Acacia catechu*	Kahir, Black catechu	Fabaceae
23	*Azadirachta indica*	Neem, Indian lilac,	Meliaceae
24	*Ficus benghalensis*	Bargad, Banyan	Moraceae
25	*Platanus orientalis*	Chinar , Oriental planetree	Platanaceae
26	*Alstonia scholaris*	Blackboard tree, Scholar tree	Apocynaceae
27	*Dipterocarpus retusus*	Hollong	Dipterocarpaceae
28	*Aquilaria malaccensis*	Eaglewood	Thymelaeaceae
29	*Ficus religiosa*	Peepal, Sacred fig	Moraceae
30	*Shorea robusta*	Sal	Dipterocarpaceae.
31	*Santalum album*	Sandalwood, Chandan	Santalaceae
32	*Cocos nucifera*	Nariyal, Coconut	Arecaceae
33	*Mesua ferrea*	Nag keshar, Cobra's saffron	Clusiaceae
34	*Dalbergia sissoo*	Sheesham, Indian rosewood	Fabaceae
35	*Prosopis cineraria*	Khejri	Mimosaceae
36	*Butea monosperma*	Palash, Flame of the forest	Leguminosae
37	*Tectona grandis*	Teak	Lamiaceae
38	*Emblica Officinalis*	Amla	Euphorbiaceae
39	*Terminalia chebula*	Haritaki, Harad	Combretaceae
40	*Terminalia bellirica*	Baheda, Bahera, Behada,	Combretaceae

Table 1: List of common fauna of India

S. No.	*Fauna of India*	Common name	Family
1	*Pavo cristatus*	Indian Peacock, Peafowl	Phasianidae
2	*Grus nigricollis*	Black-necked crane	Gruidae
3	*Tragopan melanocephalus*	Western tragopan	Phasianidae
4	*Lophophorus impejanus*	Himalayan monal, Pheasant	Phasianidae
5	*Halcyon smyrnensis*	White-throated kingfisher	Alcedinidae
6	*Panthera tigris*	Sher, Bagh, Tiger	Felidae
7	*Panthera leo*	Lion	Felidae
8	*Panthera uncia*	Snow leopard	Felidae
9	*Panthera pardus*	Leopard	Felidae
10	*Cervus canadensis*	Kashmir stag, Hangul	Cervidae
11	*Moschus chrysogaster*	Himalayan musk deer	Moschidae
12	*Ithaginis cruentus*	Blood pheasant	Phasianidae
13	*Gracula religiosa*	Common hill myna	Sturnidae
14	*Asarcornis scutulata*	White-winged duck	Anatidae
15	*Ducula aenea*	Green imperial pigeon	Columbidae
16	*Ailurus fulgens*	Red panda	Ailuridae
17	*Rhinoceros unicornis*	Indian rhinoceros	Rhinocerotidae
18	*Bos frontalis*	Gayal	Bovidae
19	*Syrmaticus humiae*	Hume's pheasant	Phasianidae
20	*Tragopan blythii*	Grey-bellied tragopan	Phasianidae.
21	*Prionailurus viverrinus*	Fishing cat	Felidae
22	*Neofelis nebulosa*	Clouded leopard	Felidae
23	*Trachypithecus phayrei*	Phayre's leaf monkey	Colobinae
24	*Antilope cervicapra*	Blackbuck	Bovidae

Self-Assessment 3

Very short answer type question

1. How many biogeographical regions are found in India?

2. What do you understand by the term trans-himalaya?

3. What are the main vegetation types of desert ecosystem?

4. What are the main vegetation types of India's coastline?

2.7 Endangered and endemic species

2.7.1 Endangered species

An endangered species is a plant, animal or microorganism that's considered in a danger of extinction or we can say abundance of a species is declining. Globally, International Union of Nature (IUCN) is the nodal agency for the assessment of threatened species. While, in India various agencies, program's, agreements,

convention, institutes, etc. are involved in the compilation of threatened species including Environmental Information System (ENVIS), Council of Scientific and Industrial Research (CSIR), Red Data Book of India (RDB), Convention on International Trade in Endangered Species of wild fauna and flora (CITES), National Biodiversity Authority (NBA), etc. Any species considered endangered if it meets certain criteria, including:

- Habitat destruction
- Over-exploitation, overgrazing, deforestation
- Increasing disease or predation threats
- Insufficient protection by government and local inhabitants
- Other anthropogenic factors having short or long-term effect on species.

Over 15,000 species of flowering plants are found in India. This is about 6% of all plant species in the entire world. Many species are at a high risk of being endangered due to global warming, deforestation and habitat loss. This clearly shows the human interferences increase number of endangered species. One of the major problem is that the ecotourism is developing very fast worldwide, therefore it is necessary to provide general awareness among ecotourists to focus their interest on reasons behind extinction of diversity (Sridhar, 2006).

The examples of some endangered flora species are: *Cycas circinalis* (queen sago), *Abutilon indicum* (Indian mallow), *Taxus wallichiana* (himalayan yew), *Taxus contorta* (west himalayan yew), *Acacia planifrons* (umbrella tree), *Belosynapsis vivipara* (spider wort), *Chlorophytum tuberosum* (musli), *Angelica glauca* (chora or gandrayan), *Lotus corniculatus* (bird's foot), *Astragalus munori* (milkvetch), *Polygala irregularis* (milkwort), *Berberis lambertii* (Indian barberry) etc.

Endangered fauna species are: *Panthera tigris tigris* (bengal tiger), *Panthera leo persica* (asiatic lion), *Panthera uncial* (snow leopard), *Antilope cervicapra* (blackbuck), *Nilgiritragus hylocrius* (nilgiri tahr), *Cervus canadensis* (kashmir red stag), Cervus canadensis (hangul deer), *Ailurus fulgens* (red panda), *Biswamoyopterus biswasi* (namdapha flying squirrel), *Porcula salvania* (pygmy hog), *Ursus arctos isabellinus* (himalayan brown or red bear), *Crocidura andamanensis* (Andaman white-toothed shrew), *Macaca Silenus* (lion tailed macaque), *Equus hemionus* (wild ass), *Viverra civettina* (malabar large-spotted civet), Trachypithecus geei (golden langur), *Platanista*

gangetica (ganges river dolphin), *Cuon alpines* (asiatic wild dog), *Caprolagus hispidus* (assam rabbit), *Rucervus eldii* (Brow-antlered deer), *Moschus leucogaster* (himalayan musk deer), *Axis porcinus* (indian hog deer), *Pantholops hodgsonii* (tibetan antelope), *Nilgiritragus hylocrius* (nilgiri tahr), etc.

2.7.2 Endemic species

The term 'endemism' was coined by A.P. de Candolle in 1855. Endemic species refers to “organisms that are present only in a particular geographical area, either a country, island, or state, and do not present naturally anywhere else in the world. The cosmopolitan distribution (extremely widespread) is the direct opposite of endemic. India is home to an unusually large number of endemic species and ranks sixth among the 12 mega biodiversity centers of the world. Eastern Himalaya, Indo-Burma region, Western Ghats and Sri Lanka, and Sundaland are the four terrestrial biodiversity hot spots lies partly in India. India ranks tenth in the world and fourth in Asia in terms of plant diversity. There are over 45,500 plant species, which is nearly 11% of the world’s known floral diversity. However, many species are not yet explored due to remote geographical areas and many organisms especially in lower groups such as bacteria, fungi, algae, lichens and bryophytes are yet to be described. New plant species, however, are continually being discovered in the country. For example, 41 plant taxa were discovered from diverse bio-geographic zones of India during 2007 by Botanical Survey of India (BSI) and other researchers.

2.8 Extinction and evolution of species

2.8.1 Extinction of species

Extinction is a gradual process of nature. Study on fossil record proves that species are not immortal, only 2 to 4% of the ever-lived species are still surviving while rests are extinct long before the arrival of humans. However, the current status of rapid loss of species is estimated between 1000 and 10,000 times higher than the “past” or expected natural extinction rate. Unlike the mass extinction events of geological history, the current extinction phenomenon is one for which every single species is totally responsible. This is known as “the sixth extinction crisis”, after the five known extinction waves from Ordovician to Cretaceous period. The most familiar species like the Polar Bear, Hippopotamus, sharks, freshwater fish and Mediterranean flowers

known to be threatened with extinction. In the last 500 years, anthropogenic activities are known to have forced 869 species to extinction. Classic examples of the extinction of island endemics include the dodo (*Raphus cucullatus*) from Mauritius and elephantbirds (*Aepyornis maximus*) from Madagascar. Humans are concerned directly or indirectly in the 100- to 10,000-fold increase in the ‘‘natural’’ or ‘‘background’’ extinction rate that normally occurs as a consequence of gradual environmental change (Sodhi et al., 2009).

Extinction is generally considered to be the death of the last individual of that species (although the capacity to breed and recover may have been lost before this point). Global extinction of any species is the most critical situations, which needs immediate attention. The loss of species can be temporary or permanent, depending on whether the environmental degradation is reversible through ecological restoration or it may be permanent. Generally, there are two types of extinction exist:

I. **Background extinction:** Background extinction rate or normal extinction rate is a natural part of evolution, where number of species that would be expected to go extinct over a period of time, based on non-anthropogenic (non-human) factors. For example, a high estimate is that 1 species of bird would be expected to go extinct every 400 years. So, it refers to the gradual, low-level ongoing extinction of individual species, generally triggered by biological factors (predation or competition) or ecological factors such as climate change, disease, loss of habitat, or competitive disadvantage in relation to other species.

II. **Mass extinction:** The extinction of a large number of species within a relatively short period of geological time, typically by means of some form of catastrophic event (volcano eruption or an asteroid hitting the earth) that occurs too rapidly. Five major extinctions have been identified in the fossil record, coming at or toward the end of the Ordovician, Devonian, Permian, Triassic, and Cretaceous Periods. The Permian extinction (245 million years ago) also known as the "Great Dying”, is the largest known mass extinction in the Earth's history, resulting in the extinction of an estimated 90 percent of marine species. In the Cretaceous extinction (65 million years ago) an estimated 75 percent of species, including the dinosaurs, became extinct,

possibly as the result of an asteroid colliding with the earth. Mass extinctions can also be caused by environmental or biological factors.

2.8.2 Evolution of species

A species is belongs to the organisms which can interbreed to produce viable, fertile offspring because the species as a whole has a common gene pool, a collection of gene variants. Species is a key of evolution. Evolution is responsible for both the similarities as well as diversity of life. New species formed by the process of speciation. It happens when groups in a species become reproductively isolated and diverge. It's a a lineage-splitting event that produces two or more separate species. Or in other words, an ancestral species splits into two or more descendant species.

Speciation can occur into two broad categories:

I. **Allopatric speciation:** allo meaning other and patric meaning homeland. This type of speciation happens when individual of a species separated by any physical barrier, such as a mountain, river or geographic separation of populations from a parent species and subsequent evolution. A part of a population might get split by a physical barrier at some point, leading to reproductive isolation. Now the newly formed subpopulations of the original are being exposed to different environmental conditions (abiotic and biotic), they will face different selection pressures leading to possible genetic divergence. That is with time they may gradually become more and more different in their genetic make and as they diverge, and will keep evolving along separate paths. That is, they won't exchange genes with one another even if the geographical barrier is removed. At this point, the groups can be considered separate species.

II. **Sympatric speciation:** Sym meaning same and patric meaning homeland— involves speciation occurring within a parent species remaining in one location. This speciation is characterized by reduction of gene flow. Imagine a situation in which a population extends over a broad geographic range, and mating throughout the population is not random. Individuals in the far west would have zero chance of mating with individuals in the far eastern end of the range. So we have reduced gene flow, but not total isolation. This may or may not be sufficient to cause speciation. Speciation would probably also require

different selective pressures at opposite ends, which would alter gene frequencies in groups at different ends of the range so much that they would not be able to mate if they were reunited.

Summary

In this unit we have discussed various aspects of biodiversity. So far you have learnt that:

- Biodiversity is the variety and variability of life and play a crucial role in well functioning of an ecosystem and ultimately the whole earth.
- Genetic, species and ecosystem diversity are the three levels of biodiversity organization.
- Genetic diversity deals with diversity at genetic level within individuals of a same species, species diversity related to the number of species present in a given area and ecosystem diversity deals with the variation in ecosystems within a geographical area.
- Global biodiversity gradient depict that species are highly concentrated near the equator and decreases towards the pole.
- India is classified into 10 biogeographical regions.
- An endangered species is a plant, animal or microorganism that's considered in a danger of extinction or we can say abundance of a species is declining.
- A species become endangered due to habitat destruction, over-exploitation, overgrazing, deforestation, Increasing disease or predation threats, insufficient protection by government and local inhabitants.
- Extinction is a gradual process of nature; background and mass extinction are its two major types.
- New species formed by the process of speciation. It happens when groups in a species become reproductively isolated and diverge either by allopatric or sympatric speciation.

Terminal Questions

1. What is biodiversity and explain its level of organization?

2. Give a brief account about biogeographical regions of India?

3. What do you understand by the term endangered species?

4. Define the term extinction of species?

5. What is speciation and how it affects species evolution?

Answer keys

Self assessment 1: 1-b; 2-a; 3-c; 4-e; 5-d; 6-a, 7-c.

Self assessment 2: 1-genetic, phylogenetic and functional; 2-genetic; 3-phylogenetic; 4-functional; 5-global biodiversity gradient; 6-equator, poles; 7-ecological; 8-conservational.

Self assessment 3: 1-ten; 2-beyond the Himalaya; 3-scrub and grassland; 4-beach and mangrove forests.

References

Callaghan, T.V., L.O. Björn, Y. Chernov, T. Chapin, T.R. Christensen, B. Huntley, R.A. Ims, M. Johansson, D. Jolly and S. Jonasson, 2004. Biodiversity, distributions and adaptations of arctic species in the context of environmental change. AMBIO: A Journal of the Human Environment, 33(7): 404-417.

Carreon-Lagoc, J., 1994. Genetic, species, and ecosystem diversity. Aqua Farm News, 12(3):

Espírito-Santo, M.M. and G.W. Fernandes, 2007. How many species of gall-inducing insects are there on earth, and where are they? Annals of the Entomological Society of America, 100(2): 95-99.

Frankham, R., D.A. Briscoe and J.D. Ballou, 2002. Introduction to conservation genetics. Cambridge university press.

Heydari, M., R. Omidipour and J. Greenlee, 2020. Biodiversity, a review of the concept, measurement, opportunities, and challenges. Journal of Wildlife and Biodiversity, 4(4): 26-39.

Jamal, S., 2020. 10 biogeographical classification of india. Available from https://ebooks.inflibnet.ac.in/geop08/chapter/biogeographical-classification-of-india.

Minter, M., E.S. Nielsen, C. Blyth, L.D. Bertola, M.B. Kantar, H.E. Morales, C. Orland, G. Segelbacher and D.M. Leigh, 2022. What is genetic diversity and why does it matter?

Mora, C., D.P. Tittensor, S. Adl, A.G. Simpson and B. Worm, 2011. How many species are there on earth and in the ocean? PLoS biology, 9(8): e1001127.

Rodgers, W. and H. Panwar, 1988. Planning a wildlife protected area network in india.

Sodhi, N.S., B.W. Brook and C.J. Bradshaw, 2009. Causes and consequences of species extinctions. The Princeton guide to ecology, 1(1): 514-520.

Sridhar, K., 2006. Biodiversity—visible and invisible. In: National Seminar on Biodiversity.

Turner, J.R., 2004. Explaining the global biodiversity gradient: Energy, area, history and natural selection. Basic and Applied Ecology, 5(5): 435-448.

Unit 03: Values of Biodiversity and Eco-System Services

Unit Structure

3.0 Learning Objectives

After the study of this unit, a learner would be able to:

- Discuss the importance of Biodiversity
- Explain the tangible and intangible benefits from biodiversity
- Discuss about tangible uses (goods) provided by the biodiversity
- Discuss about intangible benefits (services) provided by the biodiversity
- Explain the inconspicuous services of the biodiversity
- Explain the ecosystem stability

3.1 Introduction

Planet Earth's biodiversity plays a central role in the health and wellbeing of not only humans but also all other living beings. However, we know only the tip of the massive iceberg; it is estimated that more than 90% of the species remain to be discovered and it might even go extinct even before taxonomists could name and describe them. The known biodiversity is estimated to be around 2 million species, while the total unknown species varies between 8 million to one trillion. Vast majority of microorganisms remains undescribed and that is one of the major reasons for this wide disparity in number of species estimates. We could culture only around 10000 species of microorganisms; vast

majority of microorganisms can only be studied in situ using advanced techniques such as environmental DNA meta-genomics.

An ecosystem consists of biologically interacting organisms and their physical environment, while the term biodiversity refers only the diversity of organisms. Values and uses are synonymous terms; nevertheless, these terms can be finely delineated as follows. Values refer the intangible, indirect uses of biodiversity, while uses refer the tangible, direct utility of the biodiversity. As the term Ecosystem goods and services are more popular, the ensuing discussion had been bifurcated into the goods and services provided by the biodiversity, for the sake of brevity.

3.2 Importance of Biodiversity

The Ecological diversity includes the species found in habitats including forests, grassland, wetlands, deserts, and aquatic systems. The biotic (living) components interact with abiotic components such as air, water, and soil. These different and complex interconnections within and among the ecosystems form the network of life. People are the essential part of this network which entirely dependent on it (ecosystem) for the growth and survival. Ecosystem offers the basic needs such food, air and water for the survival of life, offer defense from natural calamities and disease by the regulation of climatic conditions, floods and pests and provide a basis for human cultures. Ecosystem services also referred as nature's services are benefits provided by ecosystems to individuals, which contribute to enabling and justifying the pursuit of human existence. Biodiversity significantly can affect ecological services directly. For instance, mankind obtains most of their essential food and fibers from animals and plants, respectively as majority of animals and plants are the important category of the traditional knowledge systems. Therefore, the ecological diversity contributed significantly in the well-being of mankind by providing various ecosystem services at every local, regional and global level.

Self-Assessment 1

True and False

1. Ecological diversity includes the species found in habitats such as forests, grasslands, wetlands, deserts, and aquatic systems.

2. The interaction is not required between the biotic component and abiotic components for the stability of an ecosystem.
3. Human are depended on the Ecosystem for their survival.
4. Ecosystem services, also known as nature's services, are the benefits provided by ecosystems to individuals that support their existence.
5. More than 90% of the Earth's species are estimated to be undiscovered, and some may go extinct before being identified.
6. The known biodiversity on Earth is estimated to be around 10 million species.
7. The indirect and direct use of biodiversity is also referred to intangible and tangible utility.

3.3 Uses (values) of biodiversity

The global biodiversity provides a large number of goods that are directly used by the humanity. The most tangible goods is indeed food and agriculture, as without these the global human population would collapse. Crops, vegetable and fruit cultivation provide direct food and nutrition for the human sustenance. A large majority of humanity also depend upon animal-based food sources, including honey, dairy, poultry, and meat and fish products. The biodiversity also provide food for the sustenance of these animals in the form of forage and fodder. A large number of food additives, natural preservatives and natural colorants are also derived from the nature; examples include agar and carrageenan from marine algae as food additives; rosemary extract, vinegar, alcohol, and hopes as food preservatives, and turmeric as food colorant.

As per the current estimates, more than 50% of drugs of modern medicine currently available in the world's markets are derived from organisms, and more than 80% of the world population depends upon the biodiversity for the supply of medicines of both modern medicine and traditional/alternative medicine. World's indigenous communities have a rich repertoire of indigenous/traditional medicine, a subject covered under the discipline of ethnomedicine. Most of the world's bioprospecting efforts are targeted towards this indigenous medicinal knowledge. Therefore, existence of the medicine and pharmaceutical industries directly depend upon the goods from biodiversity. In addition, the biodiversity provides goods for cosmetic (for example, aloe extracts and natural UV-B protectant),

nutraceutical (examples include microbial probiotics like Yakult, spirulina and cod-liver oil supplements) industries.

There are a huge number of industrial products derived from the nature; examples include building and furnishing materials like timber and straw, textiles (cotton and silk), biodegradable biopolymers, leather and so on. A vast majority of world's paper industries are dependent upon pulp obtained from forest resources. World's automobile industry is dependent upon rubber, which is produced from the latex of rubber tree. Several natural pigments are being used for painting, marine natural products are used for the development of antifouling paints, some of the world's toughest glues are developed from animal exudates including that of a marine barnacle, a large number of natural products are used as jewellery (examples include pearl, amber, ivory) and perfume (musk, ambergris, essential oils, sandalwood, etc.), and so on.

In addition to the direct tangible goods, biodiversity also provides rich genetic resources for the humanity. Examples include disease-resistance genes for cloning and development of genetically modified organisms that are disease resistant, genes coding for enzymes (insulin), biochemicals (Alkaline Phosphatases and Taq Polymerase) and drugs (key targets of cancer molecular pathways). Biodiversity goods also serve as an inspiration for the synthetic chemists and engineers to develop similar products. The disciplines of biomimetics and bionics were developed from this idea of imitating the nature for the product development. An example is the development of commercial product Velcro from the natural materials. Natural product structures provide a scaffold for the further modification and development of nature-identical synthetic products for the chemist's, and structural database of natural products provide bioinformaticians to hunt for potential inhibitors for the key disease pathways, such as cancer.

A direct, albeit converted by natural processes, good from biodiversity is the so-called 'fossil fuel', coal and petroleum products. While coal is derived from terrestrial plants, petroleum is from marine plants, especially microscopic phytoplankton that live in the ocean surface waters and performing photosynthesis whereby fixing the atmospheric carbon dioxide into the stored biomolecules like sugars and starch. When these organisms dies sink down to the ocean floor along with the fixed biomolecules. These layers of dead plant matters form marine sediments that build one upon another for millions of years, and

get crushed by the extreme hydrostatic pressure at the seabed, thus forming the crude oil. These fossil fuels are an example of non-renewable resources, as the production of these resources takes millions of years, its quick renewal is impossible. Human-mediated accelerated productions of these resources are also not possible. Therefore, world's stored fossil fuel resources are extremely limited and are rapidly diminishing.

Self-Assessment 2

1. The global biodiversity provides a large number of goods that are directly used by……...
2. The most tangible goods from biodiversity are ……..and ……
3. A large majority of humanity depends upon ……. based food sources, including honey, dairy, poultry, and meat.
4. The biodiversity also provides food for the sustenance of animals in the form of …… and ……...
5. More than 50% of drugs of modern medicine are derived from ……..
6. More than 80% of the world population depend upon biodiversity for the supply of ……..
7. The industrial products derived from nature include building materials like ……. and …… such as cotton and silk.
8. Coal is derived from terrestrial plants, while petroleum is derived from…… especially microscopic phytoplankton.

3.4 Services (values) provided by the biodiversity

Biodiversity services can be defined as suite of intangible benefits that the biodiversity provide to the humanity. Biodiversity services can be grouped into four subdivisions;

I. Provisioning services,

II. Supporting services,

III. Regulatory services and

IV. Cultural services

I. Provisioning services

These are production of renewable resources that the humanity is dependent upon. As these have already discussed under goods (uses), this section is being omitted because of redundancy. However, note that there are several intangible biodiversity services involved in the production of tangible goods. Perhaps the most important among such services is pollination. Pollination, the transfer of pollen between flowers for the plant reproduction, is being carried out by pollinators, mostly by bees and other hexapod insect species (and to a minor extent by birds as well). Almost the entire pollination in nature happens through these pollinators; pollination using Unmanned Aerial Vehicles is currently being tested. Without these pollinators, world's food production would be collapsed. At present several reports suggest that world's pollinators are at high risk of extinction from global warming. The value of this pollination service is estimated to be 14.6 billion USD annually worldwide, highlighting the importance.

II. Supporting services

It includes primary production, nutrient recycling through global biogeochemical cycles, soil formation, habitat refugation and so on. Plant Biodiversity is at the primary trophic level of ecological energy pyramid, and are the sole primary producers at both land and aquatic systems. Therefore, the plant biodiversity is responsible for maintaining the rest of the biodiversity that are dependent upon it (animals, fungi, heterotrophic bacteria and so on). In addition, a minor group of chemoautotrophs live in some of the extreme and mysterious environments of the world, including that at submarine hydrothermal vent systems and subterranean hot springs. These primary producers produce the food that the rest of the trophic levels at these extreme habitats depend upon.Biodiversity is involved at all the major global biogeochemical cycles, including Carbon, Nitrogen, and Phosphorous and so on. For example, free-living nitrogen fixing bacteria and symbiotic nitrogen fixing bacteria that live inside the root nodules of leguminous plants are the crucial players for the sustenance of global nitrogen cycle; without them, the cycle would not have been complete and the equilibrium would soon be lost. Various soil- dwelling organisms including earthworms and various soil bacteria are responsible for the production of soil ecosystem. Detritus decomposers including various species of fungi recycle the waste foliage and produces natural fertilizers at forest ecosystems. Various species of lichens- symbionts between fungi and algae are responsible for weathering of rocks to produce soil-based

ecosystems. Lichens are also amongst pioneer species that first colonizes barren lands, the first step of primary succession. Roots of riparian flora traps sediments from its runoff into riverine systems. Habitat refugation is a term to refer providing a safe refugial habitat for a specialist biodiversity. Many unique habitats are being formed by the biodiversity itself; for example, seaweed beds, sea-grass meadows, coral reef systems, tropical rain forests and so on. These living habitats usually house a rich biodiversity typically consisting of several endemic species, and therefore the habitat refugation services are key to the proper functioning of such ecosystems. A number of recent researches have revealed fascinating facets of such living habitats previously unknown to the humanity. For example, human body is home to 100 trillion natural flora of bacteria that are involved with several key physiological processes, including prevention of diabetes and heart diseases. All macroscopic living beings, including plants and animals have this kind of microflora and are responsible for the health and wellbeing of such organisms. Natural microflora not only consist of bacteria but also fungi, protozoa and viruses; diversity of which remain mostly unknown. While lichen mycobionts house yeasts and algal symbionts, coral reef-building cnidarians house dinoflagellate algae.

III. Regulating services

These services regulate major ecosystem processes. This includes biological production of oxygen, biological sequestration of CO2, climate regulation, purification of air and water, biological control, bioremediation, disturbance prevention and so on. Perhaps the most obvious service of biodiversity towards humanity and all other living beings is through guaranteeing a steady supply of oxygen. More than 65% of the oxygen produced in the world are by two picoplankton species living in the oceans across the world from Arctic to Antarctic. Oxygen production happens during photosynthesis where in 'photolysis' of water molecule in the beginning of electron transport chain results in the breakage of oxygen-hydrogen bond of water molecules, resulting in the production of oxygen. These planktonic blue-green algae of the species *Synechococcus* and *Prochlorococcus* also does the majority of natural carbon dioxide sequestration during the photosynthesis, when they absorb (thus, remove) carbon dioxide from the seawater/atmosphere and convert it to food stored within its cells. This process is important, as carbon dioxide is a well-known greenhouse gas and excess CO2 from the atmosphere need to be removed to buffer its

concentration. Therefore, biodiversity plays a key role in the regulation of climate. A Methanogenic bacterium that lives on normal flora of the intestine of ruminants including cattle produce large amount of methane, an important greenhouse gas. An estimate is that cows produce 250-500 litters of methane per day. Large-scale pastoral fields for raising ruminant livestock, therefore, contributes a large portion of atmospheric methane production. Biodiversity is also investigated for its uses in the mitigation of climate change; especially algae for the Carbon Capture and Sequestration(CCS) emulating the natural carbon capture and sequestration that algae had been doing for billions of years. However, a large-scale meta analysis of algal photobioreactor-based CCS concluded that this is not an economically viable technological strategy for climate change mitigation.

Global biodiversity is also involved with purification of key natural resources including air and water. Plants, especially forest canopy, is perceived by the general public as a key "filter" for the purification of air, as it removes CO_2 and generates O_2. As stated earlier, this O_2 generation and CO_2 assimilation is performed at far higher efficiency and far higher level by oceanic picoplanktons. Much cited 'clean air' study by NASA identified a number of plants (such as bamboo palm, cornstalk dracaena, peace lily, snake plant etc.) that can remove toxic volatile substances such as benzene, toluene, xylene, trichloethylene, formaldehyde, ammonia etc. from households if planted indoor environments. Several plant species also have the ability to purify the water resources. Wetland ecosystem is afamous example; where in most of the nutrient load accumulated from agricultural runoff is being assimilated by the plants in the wetlands and is removed before the final discharge into the ocean. However, human mediated habitat destruction of the wetlands has caused this crucial water clean-up step to collapse, and the riverine discharge to start wreaking havoc to the local coastal ecosystem. Wetlands and floodplains also serve its role in disturbance prevention. These natural landscapes serve as a buffer that protects humans from destructive perturbations; for instance flood where in wetlands and floodplains trap and contain the excess storm water. Storm surges and oceanic surf can be buffered to a certain level by natural and/or introduced coastal vegetation. Anthropogenic habitat destruction affecting these buffer zones ultimately removes the natural disturbance prevention protection system, aggravating the damage of natural calamities several fold.

A number of plant species have demonstrated their ability as hyperaccumulators of heavy metals; if planted, they could remove dangerous heavy metals from the contaminated soil. For example, sunflower can accumulate arsenic, willow tree can accumulate cadmium, Indian mustard and poplar trees can accumulate lead, and so on. This process is known as phytoremediation. Apart from direct use of these plants, a number of genetically modified plants containing cloned bacterial genes responsible for hyper accumulation have also been developed. A related process is known as bioaugmentation where in bacterial or micro algal cultures are used to speed-up degradation of the contaminant. For example, municipal sewage treatment plants employ trickling filters containing bio film of microorganisms; these filters use-up the nutrients from the waste water when passed through. A number of natural (such as *Alcanivorax* and *Methylocella silvestris*), as well as genetically modified bacteria (such as Pseudomonas putida, engineered by Indian scientist Ananda Mohan Chakrabarty) have been identified/developed that can be used to augment clean-up of oil spillages.

A number of organisms have been identified for its application in biological control, or biocontrol- the control of pests using its natural enemy (predator, parasite, herbivore etc.).For example, cats have been employed by human being since time immemorial to control murine infestation. A number of insect species is being deliberately introduced into agricultural fields to control certain pests; for example, live ladybugs is introduced to control aphids, parasitoid wasps introduced to control greenhouse whitefly, and predatory mite introduced to control the spider mite infestation. In addition, a number of microorganisms can be used to specifically target the pests; for example, entomopathogenic fungi is widely used to control pest aphid, and baculoviruses to control various insect pests.

One major advantage of biocontrol is that as no insecticides or pesticides are used, the produces are free from these dangerous synthetic chemicals and therefore healthier. However, many of these introduced species escape the field and have ramification on the biodiversity of neighborhoods. Another form of biocontrol employs genetically modified organisms containing active biocontrol genes; one famous example is cloning andexpression of a gene from bacterium *Bacillus thuringiensis*, “cry” gene, coding for crystal protein (delta-endotoxin) that is specifically toxic to a number of insect species,

while harmless for human consumption. A number of genetically modified plants containing cloned cry gene, such as bt-cotton, bt-maize, bt-tobacco and so on. Although a number of potential side effects were proposed such as cry protein being toxic to human beings, toxicity towards natural pollinators like monarch butterfly, genetic mixing of GM and wild plants and so on, most of these allegations were concluded to be hoaxes. More often, biocontrol is part of a broader Integrated Pest Management System (IPMS) where the community ecology is regarded with prime importance. Specifically, IPMS is not targeted for total eradication, but to control, with certain acceptable levels of pests in the field. In addition, IPMS also allows responsible use of pesticides; therefore, it is a combined approach involving various alternative strategies (biocontrol, synthetic pesticides, mechanical control, cultural practices etc.) for the management of pests.

Several studies have revealed that a mixed community involving multi-trophic level ecological niche is far superior and stable comparing with monoculture, the culture/cultivation of just one species, as commonly used in agriculture or aquaculture. This phenomenon is sometimes referred as 'portfolio effect'; analogy here is a stock portfolio containing a diversified admix of stocks from various sectors and various risk levels have far stable and superior returns than portfolio consisting of just a single stock. The diversified portfolio is more resilient as well (it can recover from sudden market collapse).Similarly, a multi-trophic community is far more stable and resilient (able to recover from natural calamities faster). Modern agricultural practices especially that of the cereal crops, has started a marked shift from crop monoculture to a polyculture or 'multitrophic' agriculture. Similarly, instead of culturing a single species of marine animal (for example,a species of fish), modern aquaculture has adopted Integrated Multi-Trophic Aquaculture(IMTA) wherein several species of animals and plants occupying its own unique niche in the mixed community is being adopted. For example, a number of seaweed species are deliberately introduced into shrimp or fish aquaculture systems that can assimilate excess inorganic nutrient, while a number of shellfish species (like abalone) to extract the organic nutrient load such as the fish excrements. As excess nutrients have effectively being used by other trophic levels and sequestered, problems such as eutrophication can be prevented.

A number of filter feeders, such as coprophagous organisms (assimilating excreta), decomposers, detritivores (such as fungi) can also be introduced as part of this system. Such a system is more balanced, resilient, stable, and is more economical (as the fisherman can as well harvest abalones and seaweeds in addition to the fish/shrimps).

IV. Cultural services

Finally, the global biodiversity endures human life, experience and fulfilment through a number of its cultural services including tourism, outdoor activities, spirituality, art and aesthetics, and so on. An aesthetically pleasing landscape containing rich biodiversity promotes ecotourism- the tourism directed towards exotic natural environments and its conservation. For example, a number of tourist services are being offered at national parks, wildlife sanctuaries, marine protected areas, wetlands, mangrove forests and so on. There are now specialized tourist operators to cater the tourists looking for nature trail and mountain hiking experiences; these activities are undeniably enriched with a richer biodiversity. Biodiversity also support a number of hobby clubs around the world, for example, bird watching clubs (Bombay Natural History Society is a famous example from India) and butterfly spotting clubs. Other activities that are indirectly benefited by the biodiversity include gardening, fish keeping and specimen collecting. Specialized ecotourism operators organize oceanic cruises to some of the biodiversity hotspots, including the famous Galapagos Cruises. A related emerging field is agritourism that is intended to expose the tourists towards first-hand experience in an agricultural or aquacultural field. Incorporation of sustainable cultivation practices such as organic farming, polyculture, IMTA etc., arguably motivates the agritourism industry.

Biodiversity has been inspiring world's artists, musicians, painters, sculptures, writers and so on for thousands of years. A number of classical 'pagan' religions are based on consideration that the nature and its biodiversity as their almighty; examples include Hinduism, Japanese Shintoism, Ancient Egyptian Kemeticism and other hundreds of tribal and indigenous religions. A number of plant and animal species are revered in Hinduism despite its minimum perceived human utility; examples include peacock, tiger, elephants, snake, turtle, the Peepal tree (*Ficus religiosa*), the Ashoka tree (*Saraca asoca*), and the herb Tulsi (*Ocimum tenuiflorum*). These religions have also been instrumental in biodiversity conservation; a famous example is sacred groves of South India (Hindiism)

and North East India (Indigenous/tribal belief system). Rich, aesthetically pleasing landscapes have been attracting spiritualists and meditation practitioners for thousands of years for a more fulfilling life experience; for example, saadhu and sanyasi hermits of Hinduism seeking spiritual refuge at the Himalayan valleys that offer an unperturbed natural habitat with rich biota. Biodiversity also have bequest and existential values. Bequest value refers the value as a resource for our future generations. A number of species might not have any apparent uses for the humanity as of today; that does not mean these species are useless to the humanity. The case might simply that its uses are yet to be discovered, and therefore, it serves as a potential resource for our future generation to discover. Existence value refers the value simply for the sake of knowing its existence. For example, most of the humanity have never been to tropical rain forests or coral reefs, yet they are aware of its existence through famous documentaries and books, and they care for its conservation. People are happy just by knowing the existence of these biodiversity, the existential value of it; and they are disturbed if they know that many such habitats are under severe threats from humanity.

Self-Assessment 3

Multiple choice Questions:

1. Which of the following is a provisioning service?

A) Soil formation

B) Pollination

C) Climate regulation

D) Spiritual enrichment

2. What role do picoplankton play in regulating services?

A) Pollination

B) Carbon dioxide sequestration

C) Soil formation

D) Habitat refugation

3. Which process is NOT a supporting service?

A) Nutrient recycling

B) Biological control

C) Soil formation

D) Habitat refugation

4. Which of the following is an example of a cultural service provided by biodiversity?

A) Air purification

B) Pollination

C) Ecotourism

D) Water purification

5. Which plant is known for accumulating arsenic as part of phytoremediation?

1. Sunflower
2. Willow tree
3. Indian mustard
4. Poplar tree

6. What is one major advantage of biological control?

A) Complete eradication of pests

B) Use of synthetic pesticides

C) Healthier produce free from synthetic chemicals

D) Increased monoculture stability

7. Match the following list A with List B and select the correct option.

List A	List B
A. Biological production of oxygen	**I.** The process where picoplankton absorbs CO_2 from the seawater and convert it into food.
B. Biological sequestration of CO_2	**II.** The removal of CO_2 and generation of O_2 by plants, including forest canopies and algae.
C. Disturbance prevention	**III.** Wetlands and floodplains acting as buffers to trap excess storm water and reduce damage from natural calamities.
D. Purification of air and water	**IV.** The purification of air by removing toxic substances like benzene and formaldehyde through indoor plants.

A) A- II; B – II, C = III, D = IV

B) A- II; B – I, C = IV, D = III

C) A- I; B – II, C = III, D = IV

D) A- I; B – III, C = II, D = IV

8. Match the following list A with List B and select the correct option.

List A		List B	
A.	Biological control using natural enemies	**I.**	The use of plants like sunflower and willow trees to remove heavy metals from contaminated soil.
B.	Phytoremediation	**II.**	Utilizing bacteria or microalgae to speed up the degradation of contaminants, such as in municipal sewage treatment.
C.	Bioaugmentation	**III.**	Introducing live ladybugs to control aphid populations and using genetically modified organisms with biocontrol genes.
D.	Integrated Pest Management System (IPMS)	**IV.**	A combined approach involving various strategies like biocontrol, mechanical control, and responsible pesticide use to manage pests.

A) A- II; B – I, C = III, D = IV

B) A- III; B – I, C = II, D = IV

C) A- I; B – II, C = III, D = IV

D) A- I; B – III, C = II, D = IV

9. Assertion (A): Biodiversity is essential for maintaining the health and stability of ecosystems.

Reason (R): Biodiversity provides various services such as pollination, climate regulation, and nutrient recycling that contribute to ecosystem stability.

A) Both A and R are true, and R is the correct explanation for A.

B) Both A and R are true, but R is not the correct explanation for A.

C) A is true, but R is false.

D) A is false, but R is true.

10. Assertion (A): The use of genetically modified organisms in biocontrol is without risks. **Reason (R)**: Genetically modified organisms in biocontrol are specifically designed to be harmless to humans and natural pollinators.

A. Both A and R are true, and R is the correct explanation for A.

B. Both A and R are true, but R is not the correct explanation for A.

C. A is true, but R is false.

D. A is false, but R is true.

3.5 Ecosystem stability

The Ecosystem experience regular environmental disturbance or changes. Ecosystem stability described as "the ability of an ecosystem to maintain its structure and function over long periods of time and despite disturbance". The structure of the ecosystem includes both physical and geological structures of the landscape where the diversity of species, population and their interaction occurred. The ecosystem function refers to processes such as water and nutrient cycling and biomass productivity that the ecosystem provides.

3.5.1 Components of Ecosystem Stability

There are two components of ecosystem stability:

I. **Resilience:** The ability of the ecosystem to recover after disturbance.

II. **Resistance:** The ability of the Ecosystem to continue to function without any variation under stress or perturbation by distribution.

The degree of stability may vary the resistance and resilience in the Ecosystem. The high degree of stability may have different combinations of resistance and resilience. It is reported that species diversity is the determining factor for the resilience and resistance in the ecosystem. As high species diversity will likely more stable than low species diversity. Species react to environmental variation in many ways that enable them to maintain homeostasis. Population/species response against this variation reflect the success and failure of the species to sustain and reproduce. The variation in environmental condition

may responsible for the decline of local biodiversity subsequently may also decline resistance and resilience of the Ecosystem.

Factors affecting stability

There are the following factors responsible for the stability of the Ecosystem as below:

- Species Diversity, interactions, and reproductive strategies.
- Disturbance frequency and intensity
- Trophic complexity, redundancy, and structure of food web.
- Rate of nutrient or energy flux in the Ecosystem.

Self-Assessment -3

Very short type answers type questions?

1. What is the ability of an ecosystem to maintain its structure and function over time?
2. What are the two components of ecosystem stability?
3. What is the ability of an ecosystem to recover after disturbance?
4. What is the ability of an ecosystem to continue functioning under stress?
5. What is the determining factor for resilience and resistance in an ecosystem?
6. What can affect the rate of nutrient or energy flux in an ecosystem?

Summary

- At present, we know only a very small part of the global biodiversity, yet it is clear that the biodiversity has immense uses and values that has ramifications on every part of human existence.
- Global biodiversity is immensely useful to the humanity as it produces several renewable goods such as food, fodder, forage, drugs, cosmetical products, nutraceuticals, wood, paper, rubber, leather, perfumes and so on.
- World's non-renewable fossil energy resources are also a product of biodiversity. As the rate of production is extremely slow, petroleum resources of the world are rapidly diminishing

- Apart from tangible goods, biodiversity is also useful to humanity in a number of ways through various services that it offers. Services can arbitrarily be grouped into four as Provisioning services, Regulating services, Supporting services and Cultural services
- Perhaps the most important among services of biodiversity is global biogeochemical cycles as well as production of oxygen combined with natural sequestration of CO_2.Another service with huge economical ramification is pollination.
- A mixed community involving multi-trophic level ecological niche is far superior, resilient and stable comparing with monoculture, the culture/cultivation of just one species, as commonly used in agriculture or aquaculture. Integrated Multi Trophic Aquaculture is an example of such a polyculture system in aquaculture
- Biodiversity also provides several cultural values, such as inspiring artisans, writers, painters, sculptors, musicians and so on. A number of world's pagan belief systems have in-built biodiversity conservation element; sacred groves of India for example.
- The ability of an ecosystem to continue operating normally over time in a situation of disruptions is referred to as ecological stability. It consists of two main parts: resistance (the ability to continue operating normally under pressure) and resilience, (the ability to bounce back from adverse conditions). Species diversity is essential for ecosystem stability. Stability is influenced by trophic complexity, species variety, disturbance frequency, and energy or nutrient input.

Terminal Questions

1. What is the importance of Biodiversity?
2. Discuss the tangible and intangible values of Biodiversity?
3. How the biodiversity serves the Humanity? Discuss.
4. Explain the regulating services of biodiversity.
5. What is the role of oceanic picoplanktons?
6. What is phytoremediation?
7. What are the advantages of application of Biocontrol agents?

8. Write some plants used by you in cultural practices/services in your area.
9. Explain the Ecosystem stability?

Answer Keys

Self- Assessment 1: 1- True; 2 – False; 3 – True; 4 – True; 5 – True; 6 – False; 7 – True

Self- Assessment 2: 1- humanity; 2 – food and agriculture; 3 – animal; 4 – forage, fodder; 5 – organisms.6 – medicines; 7 – timber, textiles; 8 - marine plants

Self- Assessment 3:1 - D; 2 - B; 3 - B; 4-C; 5 - A; 6 - C; 7 – A; 8 – B; 9 - A; 10 – A

Self-Assessment4:1 - Stability; 2 – Resilience and Resistance; 3 - Resilience; 4- Resistance; 5 - Species diversity; 6 – Disturbance

References

Biodiversity and Conservation: Values and uses of biodiversity; Module Id EVS/BC-III/03 Paper No: 03 Biodiversity and Conservation

Module: 03 Values and uses of biodiversity

Unit 04: Biodiversity and Ecosystems

Unit Structure

4.0 Learning Objectives

After going through this unit you will be able to:

- Understand the role of biodiversity in ecosystem functioning
- Describe the flow of energy and nutrient within the ecosystem
- Explain the concept of food chain, food web and ecological pyramids
- Define various methods of biodiversity assessment

4.1 Introduction

In recent time the correlation between biodiversity and ecosystem functioning has emerged as a fundamental issue in environmental sciences, because ecosystems regulate the biological, geochemical, and physical processes of the environment. Biodiversity play a crucial role in regulation and maintenance of ecosystem. Higher the diversity better will be the ecosystem functioning that's why large number of species is required for its proper functioning. Ecosystem functions sustain human life and if it provides a positive benefit to humans it is called ecosystem services. The ecological consequences of biodiversity loss due to anthropogenic disturbances and various other natural causes declining species richness from local to global scales, which in turn changes the ecosystem functioning. As we study, the exterior and interior

morphological and physiological characteristics of an organism in order to understand the structure, function and its life process. Similarly, we can understand the ecosystem by studying the structural and functional characteristics of all its biotic and abiotic components. The closely-linked structural and functional characteristics are significant for the continuous operation of an ecosystem and their incorporated understanding provides an entire conceptualization of the ecosystem dynamics.

In short we can say that biodiversity and ecosystem function provide a very important idea about the levels of ecosystem functions including productivity, nutrient cycling, decomposition etc. and the strength of those functions directly depend on the level of biodiversity, including genetic, species and ecosystem diversity of all living organisms. For example if density of flora is high in any geographical area it will ultimately increase its productivity.

4.2 Ecosystem functioning

In an ecosystem; a specific function is played by each component and while adding the functions of all components it will define the ecosystem function as a whole. Most importantly, function means showing activity, and does not say that organisms perform determined roles in ecosystem-level processes. Ecosystem functioning indicates the combined life activities of plants, animals, and microbes and the effects these activities like feeding, growing, moving, excreting waste, etc. on the physical and chemical conditions of their environment. For example, a functional forest ecosystem exhibits rates of carbon storage, plant production and nutrient cycling that are attributes of most forests. If the forest is converted to an agro-ecosystem, its functioning alters. The major concept of “ecosystem function” is based on a viewpoint that focuses on the entire system and the functional roles played by each component within it. However, the concept of ecosystem functioning also extends towards interest of society. Ecosystem functioning are categorized into three categories namely, ecosystem processes, ecosystem properties, and ecosystem values (composed of ecosystem goods and services) (Giller et al., 2004). For instance, ecosystem function of a lake ecosystem give rise to an ecological system that refers to processes and the causal relations and the interactions between organisms of different species along with the role of organisms within it, overall biomass of the system, flow of energy, overall

processes that sustain it, long-term dynamics of different populations, and nutrients within it, and ultimately to the services it gives to human beings or other organisms.

4.2.1 Energy flow

Within the ecosystem, there is a constant interaction between flora, fauna and their environment to manufacture and exchange materials. The only source of energy needed for all this cycling of materials is the sun. All green plants are autotrophs also known as producers because they fix the solar energy in presence of chlorophyll, water, CO_2 into chemical energy. This chemical energy is stored in various forms like starch, cellulose etc. in the plants and can taken by other organisms (herbivores) as a source of energy and pass it on further to other organisms. During this eating process, a reasonable proportion of energy is lost out in respiration, locomotion, excretion and other vital activities of the living system. The whole process is known as flow of energy. All living and non-living systems are involved in a continuous flow of energy in an ecosystem.

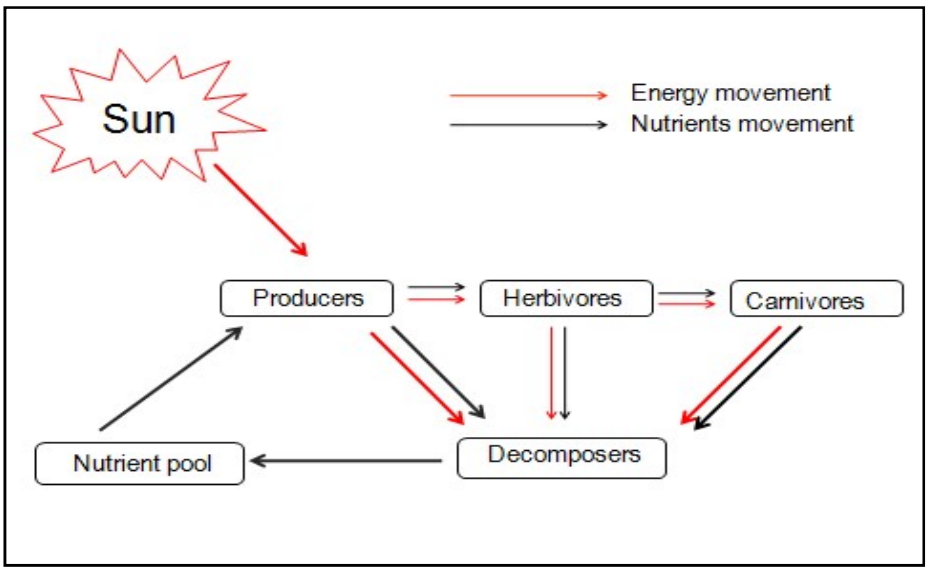


Figure 1. A diagrammatic representation of energy and nutrient movement in ecosystems

The flow of energy is non-cyclic and unidirectional, whereas the movement of nutrient is cyclic. The structure of an ecosystem is closely related to its functional processes and vice-versa. For example, the flow of energy is based on the trophic (food) structure of the ecosystem (plants are producers; herbivores, carnivores, and omnivores are consumers and microbes are decomposers). The energy flows from sun to producers, from producers to herbivores and from herbivores to different levels of carnivores, each

level is called trophic levels or trophic structure of the ecosystem. The flow of energy is unidirectional and non-cyclic as shown in figure 1.

The universal energy flow model (Y-shaped energy flow model), is given by E. P. Odum in 1983, however this model originally proposed by H. T. Odum in 1956. The two arms of the Y-shaped model represent herbivore and decomposer or detritus food chains, respectively. There is a gradual decrease in energy at each trophic level that's why each trophic level receives less energy. The left over energy is stored as biomass and available for next trophic level. An energy flow diagram or energy flow model is shown in figure 2, it's a representation of trophic levels connected with each other viewing the inputs and losses of energy during energy transfer at each trophic level.

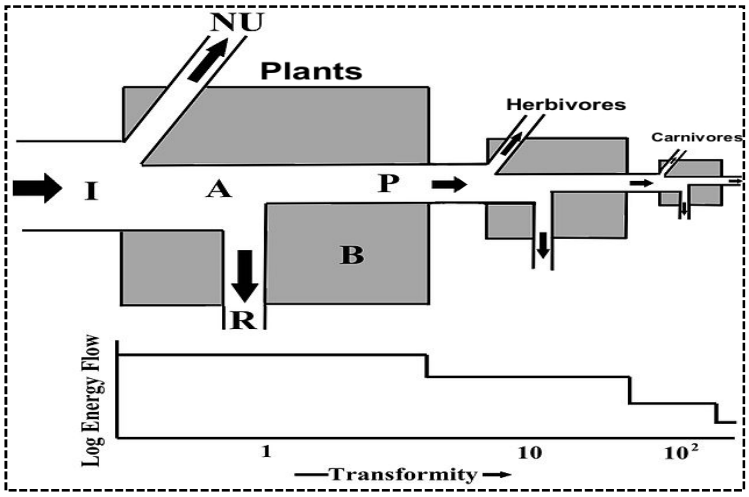


Figure 2. Energy flow model

(I=input, A=assimilation, R=respiration, NU=not utilized, P=production, B=biomass)

(***Source: https://www.google.com/search?q=energy+flow+transformity&sca_esv)***

Raymond L Lindeman in 1942 proposed the "ten percent law" of energy transfer and gave the concept of "trophic dynamic in ecology". According to him only about ten percent of the energy consumed at one trophic level and transferred from one trophic level to higher level. While ninety percent is lost or broken down in respiration, transfer, or lost to incomplete digestion by higher trophic levels. The "universal" model of energy flow in the individual or species population, biomass or living structure is represented in Figure 3. Where, I represent the input energy (light in case of autotrophs and food in case of heterotrophs), A is assimilated, while NU is unusable expelled part. A large portion of assimilated energy must be respired (R) to provide existence energy to keep the body functioning and repaired.

Producers convert the solar energy into chemical energy in the form of food. This forms two major energy pools:

(i) Living organic matter (plant biomass)

(ii) Nonliving organic matter (plant detritus).

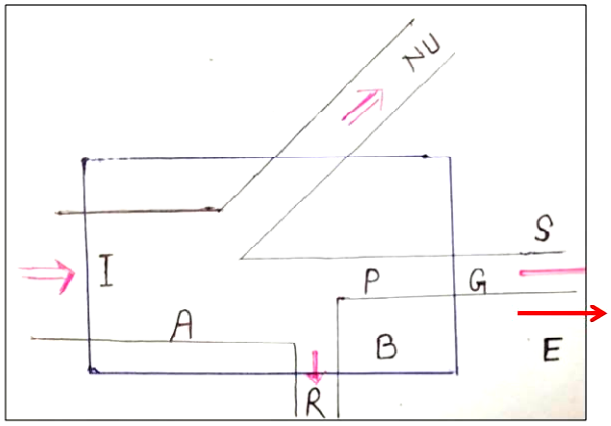


Figure 3. A universal energy flow model (based on Odum)
I-Input energy; NU-Not utilized; A-Assimilated; P-Production; R-Respiration; B-Biomass; G-Growth; S-Stored energy; E-Excreted energy

Based on these two organic matter pools there are two major pathways of energy transfers as shown in Figure 4.

(i) The grazing or biophagic pathway- Includes the ingestion of living organic matter by herbivores or the energy is transferred between the autotrophic plants and herbivores. The autotrophs acquired the energy from photosynthesis. Organisms which follow the biophagic pathway constitute biophagic subsystem in an ecosystem.

(ii) The detritus or saprophagic pathway- This food chain starts with dead organic matter. For example leaves debris or dead animals, consumed by decomposers and detritivores. Organisms which follow the saprophagic pathway comprise the decomposition subsystem in an ecosystem.

All heterotrophic organisms directly or indirectly depend on food produced by autotrophs (primary producers) are called secondary producers and the organic matter synthesized by them constitutes secondary production.

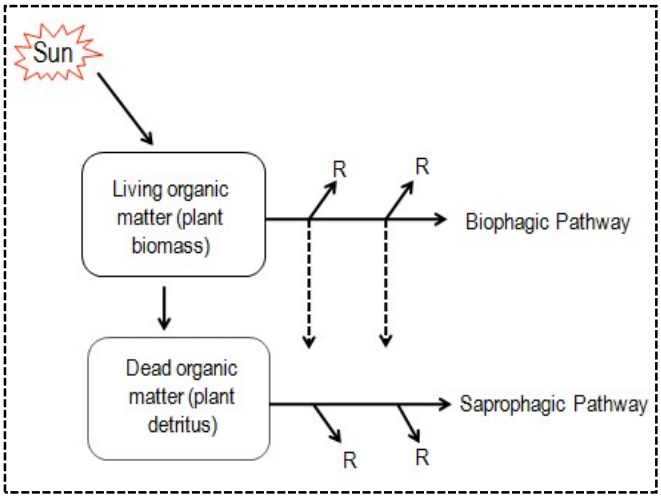


Figure 4. Energy pools and associated energy transfer pathway

Self-Assessment 1

(A) Multiple choice questions

1. The flow of energy in an ecosystem is?

a) Unidirectional

b) Bidirectional

c) Multidirectional

d) All of the above

2. Why Raymond L Lindeman famous for doing in the year 1942?

a) Working on ecosystem ecology

b) Studying ecological succession

c) Coining the term "ecology"

d) Pioneering the concept of 'trophic dynamics in ecology'

3. The law proposed by Lindeman was?

a) Ten percent law

b) Twenty percent law

c) Thirty percent law

d) Forty percent law

(B) Fill in the following blanks

1. …… convert the energy derived from sun into chemical energy in the form of food.

2. Energy flow is ……. and ……., whereas nutrient movement is …….

3. Energy flows from sun to producers, to herbivores and then to different levels of carnivores are generally termed as ……. of the ecosystem.

4. …… pathway comprises the ingestion of living organic matter by herbivores.

5. In the …… pathway, detritus is consumed by the detritivores or saprovores.

4.2.2 Food chain and food web

A number of microscopic phytoplanktons, lower and higher group of plants perform the primary job of energy fixation. In this procedure the producers are eaten by herbivores, these herbivores are eaten by carnivores or predators in different ecosystems. The energy is transferred from plants through a series of organisms eating one and being eaten by other is called food chain. A typical example of a food chain is found in a grassland ecosystem as shown in Figure 5.

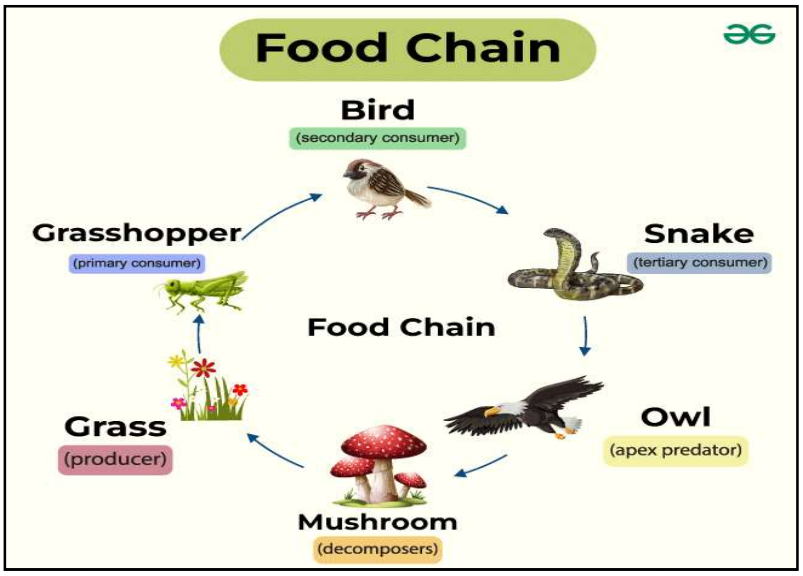


Figure 5. Flow of energy in a grazing food chain

(Source: https://www.google.com/search?q=grazing+food+chain&sca_esv)

However, the food relations are not so simple; rather it's a complex process. This trophic inter-relationship among organisms within the ecosystem is not always in a simple chain-like manner but forms a more complicated network. This complex net-like trophic inter-relationship is called a food web. Since, each trophic level includes several species that feed on a common set of organisms and also fed on by another common set of organisms are known as **trophic species** (Cohen and Briand, 1984). By the analysis of food webs it is easy to understand the ecosystem dynamics in terms of limited euryphagy and euryphagous primary and secondary consumers as shown in figure 6. According to Robert Paine (1980), there are three types of food webs exist in nature:

(i) Connectedness webs- Also called topological food webs, it is based on the concept of 'who eats whom', focusing the feeding relationships. These represent only the presence or absence of a trophic interaction.

(ii) Energy flow webs- Where energy flow through the food web is estimated and quantified by the flux of energy between a resource and its consumer.

(iii) Functional webs- Also called interaction food webs. The idea of functional food webs developed on the basis of impact of each species in maintaining the integrity of a community and reflects influence on the growth rate of other species populations.

The food webs have also been described as source webs- refer to one or more kinds of organisms that eat them, their predators, and so on, sink webs- refer to one or more kinds of organisms, the organisms they eat, their other prey, and so on (descending trophic levels), and community webs- represents a group of species within a defined area of habitat.

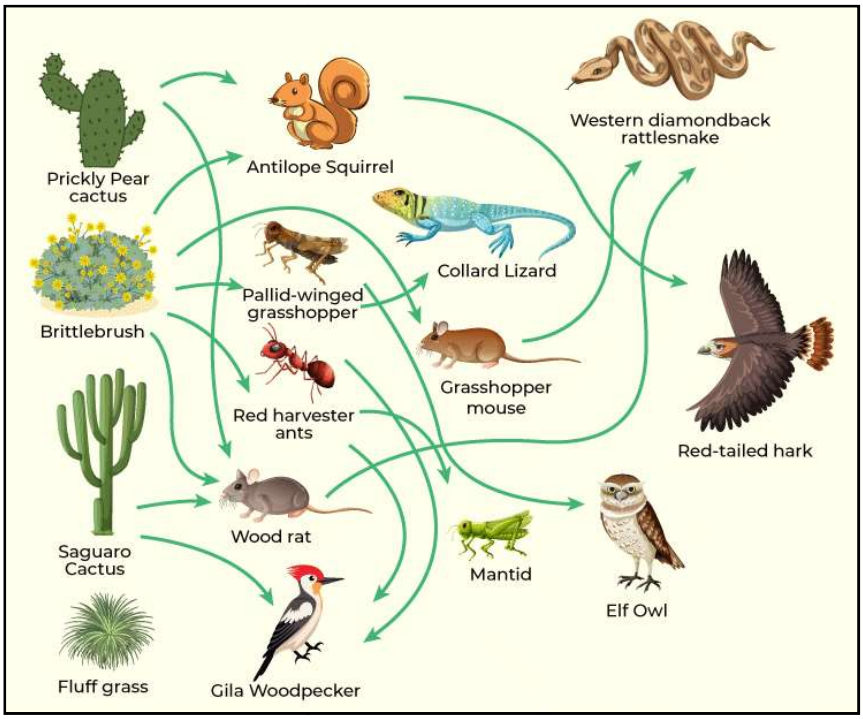


Figure 6. Inter-linked network of food chain and food web

(Source: https://media.geeksforgeeks.org/wp-content)

4.2.3 Ecological pyramids

The relationship between the numbers, biomass, and energy contents of the primary producers, first and second order consumers, and so on to the top carnivores is exist in all ecosystems. An ecological pyramid is a diagrammatic representation of the relationship between the different living organisms at different trophic levels. These pyramids are looking like actual pyramids, with the broad base representing the lowest trophic level, i.e., producers; next level is occupied by the next trophic level, i.e., the

primary consumers and so on. Ecological pyramids are classified into three categories, (i) numbers, (ii) biomass, and (iii) energy or productivity. The concept of the pyramid of numbers was developed by Charles Elton, pyramid of biomass was developed by Bodenheimer and the idea of the pyramid of energy or productivity was developed by G. Evylen Hutchinson and Raymond Lindeman. The ecological pyramid of numbers is usually upright pyramidal but inverted pyramid in some situations like that of the detritus food chain, where many organisms feed on one dead plant or animal. The pyramid of biomass is also upright but may be inverted as observed in oceans where large numbers of zooplanktons depend on a relatively smaller number of phytoplanktons. As the energy flow in a food chain is always unidirectional that's why the pyramid of energy is always upright or triangle-shaped. Pyramid of numbers illustrates the number of individuals at each of the successive trophic levels, then counted and plotted per unit area (Figure 7). Pyramid of biomass, includes the total biomass is measured in terms of dry weight or caloric value, per unit area and plotted at each of the successive trophic levels (Figure 8), while in case of pyramid of energy, the energy flow per unit time at each of the successive trophic levels is measured and plotted (Figure 9).

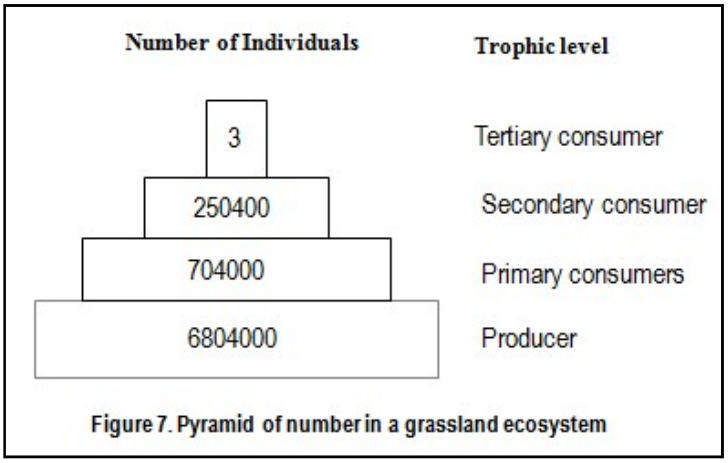


Figure 7. Pyramid of number in a grassland ecosystem

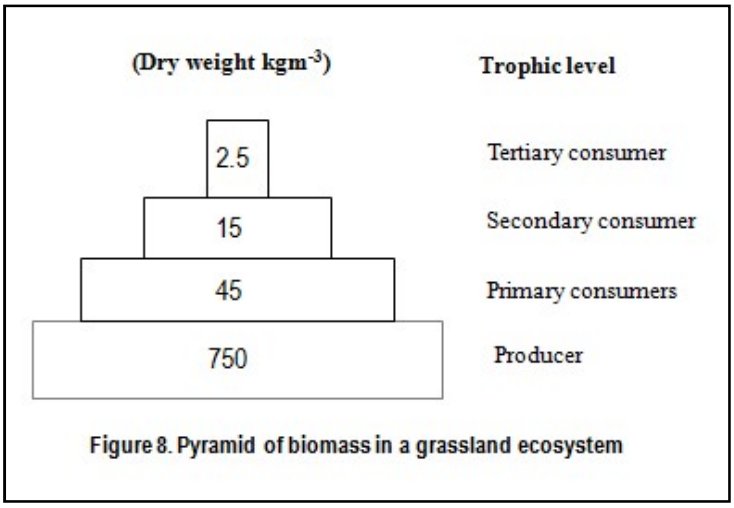


Figure 8. Pyramid of biomass in a grassland ecosystem

The pyramid of energy flow is governed by the second law of thermodynamics therefore, it is considered as one of fundamental significance because it illustrates the actual functional relationships between the trophic levels. Energy flow declines from the producer level to successive trophic levels. As a result, the pyramid of energy forms a typical upright pyramidal shape, reflecting a stepwise decrease in energy towards increasing trophic level. However, its shape does not affected by size or rate of metabolism of organisms, although the other two pyramids are affected. Plants have smaller biomass per unit area as compared to animals, but their production per unit time per unit area would be much larger than that of animals. Energy comes from the sun is transferred throughout the ecosystem by passing through various trophic levels. Only 10% of the energy is transferred from one trophic level to the next (Figure 9).

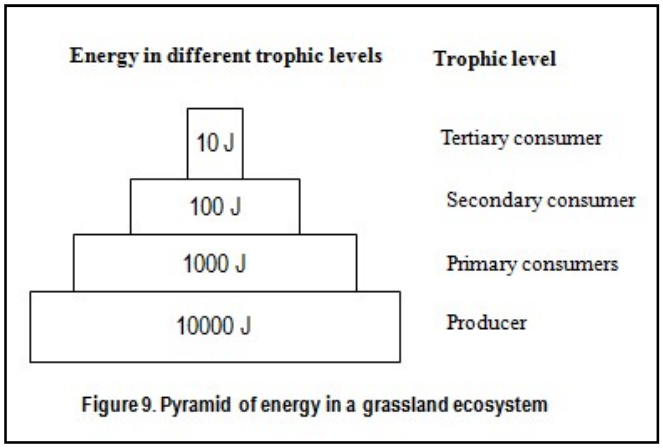


Figure 9. Pyramid of energy in a grassland ecosystem

Self Assessment 2

(A) Multiple choice questions

1. The concept of pyramid of number was developed by?

a) Charles Elton

b) Bodenheimer

c) G. Evylen Huchinson

d) Raymond Lindeman

2. The concept of pyramid of biomass was developed by?

a) Charles Elton

b) Bodenheimer

c) G. Evylen Huchinson

d) Raymond Lindeman

3. The concept of pyramid of energy was developed by?

a) Charles Elton

b) Bodenheimer

c) G. Evylen Huchinson and Raymond Lindeman

d) None of the above

4. Pyramid of energy is always?

a) Inverted

b) Upright

c) Spindle shaped

d) U shape

(B) Short answer type question

1. What do you understand the term food chain?

2. Define food web?

3. What is trophic species?

4. Name the types of food webs?

5. Name the categories of ecological pyramids?

4.2.4 Nutrient cycling

The two processes run parallel in ecosystems, first is the unidirectional flow of energy and second is the cycling of nutrients. Biotic stability is not only energy dependent but also depends on the availability of key nutrient elements important for different life processes. In these processes, nutrients get absorbed, transferred, released and reabsorbed called the recycling system of mineral nutrients. Most importantly, as we know that the flow of energy is unidirectional and non-cyclic, while the movement of nutrient elements is cyclic. Nutrients are transferred between living organisms and non-living parts of an ecosystem. The transfer of light energy into chemical energy during the process of photosynthesis, a number of inorganic elements and compounds are incorporated into the protoplasm of green plants or producers. Carbon dioxide and water are the raw material of photosynthetic reaction. Instead of carbon, hydrogen, oxygen (CHO) other essential vital macronutrients for protoplasm synthesis are nitrogen, phosphorus, sulfur, magnesium, potassium and calcium. In addition to this

some micronutrients are also required in small quantities. Herbivores consume green plant; they get stored chemical energy in the form of carbohydrates, fats, and proteins along with other nutrients. Likewise, both, chemical energy and nutrients are transferred from herbivores to carnivores and so on and at last to the decomposers. Therefore, the continuous flow of energy and nutrients run simultaneously in an ecosystem generally in a similar manner. Though, there is a gradual decrease of energy in successive trophic levels in a food chain, but the nutrients are not diminished. Nutrients consumed by plants and animals are returned and releases back to the environment after death and decomposition. At last, protoplasm (nutrient-rich) is decomposed that releases nutrients in the environment that is available for recycling and reutilization. Soil micro flora plays a significant role in nutrient recycling by the process of decomposition of organic matter and release nutrients. In addition, they trap and transform nutrients into the soil, which can be utilized by plant roots. Nutrient cycling process is closely linked with the contact of physical, biotic and chemical, factors in an ecosystem. Ecosystems, work as an open system participates in a variety of biogeochemical processes through a system of inputs and outputs. This is important to recycle and constantly refill nutrients into the environment for the existence of life. Generally, there are two interconnected nutrient budget systems in an ecosystem as shown in figure 10.

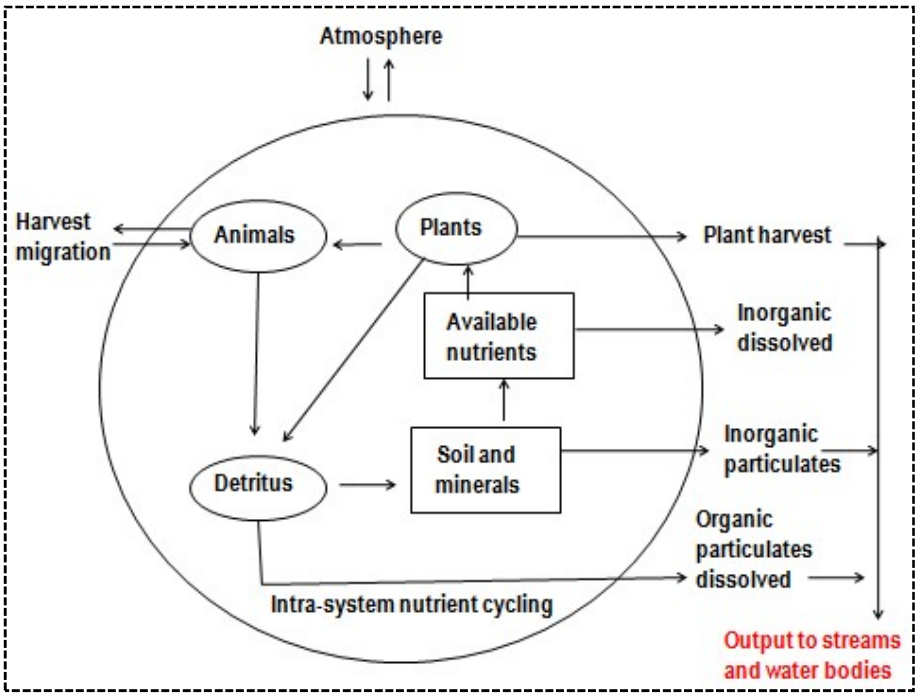


Figure 10. A diagrammatic view of intra-system nutrient cycling and extra system nutrient transfer

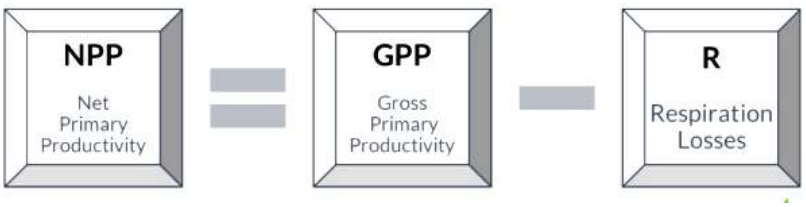
(i) Intra-system cycling of nutrients and

(ii) Extra-system nutrient transfers

The intra-system cycling incorporates the circulation of nutrients through the living (biotic) and nonliving (abiotic) compartments of an ecosystem. It includes the input and output throughout the different trophic levels and the exchanges between reservoirs and sediments of an ecosystem. On the other hand, the extra-system transfers concerned with the intake and output of the whole ecosystem in relation to other ecosystems.

4.2.5 Productivity

The pyramid of energy is a very important factor because it includes the rate of energy fixation by green plants, which ultimately regulates the rate of production of complex organic material from simple inorganic substances (CO2 and H2O) in a given geographical area over a period of time. The rate at which photosynthetic organisms produce organic matter in an ecosystem is known as primary productivity, measured in terms of new biomass created per unit area. Therefore, the primary productivity can be defined as the primary fixation of light energy by plants as organic substances and subsequent use of the fixed energy by herbivores, carnivores, and decomposers. Total amount of energy that is fixed by plants in a unit area in a given period of time is "gross primary productivity". A considerable part of this energy is released during plant respiration and other metabolic activities, is excluded from gross productivity (GPP). Hence, net primary productivity is smaller, because it excludes the losses of plant respiration and is calculated by only taking the resultant organic matter, which is transferred to the food web.



NPP is measured as mass per unit area in unit time. NPP is dependent on several factors such as sunlight, temperature, nutrient availability, humidity, etc. present in an ecosystem. Highest NPP is observed in tropical forests and lowest in deserts. About 1% of the total incident solar energy per unit area and time gets stored in the form of

biomass. A fixed portion of energy gets transferred from autotrophs to heterotrophs that ingest living matter and the remaining is converted to detritus pool to support those heterotrophs that feed on non-living organic matter. Producers mainly are responsible for more than 90% of the total productivity of the food web, then herbivores and carnivores less than 1%. There are a number of factors which influence the rate and amount of energy fixation during photosynthesis viz. the accessibility of basic chemical components of photosynthesis (nutrients, moisture, dissolved substances, etc.), species diversity, and diurnal and seasonal changes in physical and biological factors in an ecosystem, etc. The availabilities of different factors are different in various worlds' ecosystems; therefore they differ greatly in the amount of productivity that they sustain. A sustainable ecosystem maintains balance between the resource utilization and production.

4.3 Biodiversity assessment

To assess the status of biodiversity is crucial for designing sustainable development strategies at all levels, from local to global. Biodiversity is essential for the earth wellbeing. The ecological and evolutionary processes maintained through ecological communities. The measurement of species diversity is a methodical process that measures the variety and distribution of life in a specific area and provides an important preliminary assessment of overall biodiversity. It is helpful in evaluating the richness, evenness, and heterogeneity of biotic organisms in an area. Species diversity can be measured by measuring i.e. species richness, taxonomic uniqueness, taxonomic diversity, and species-diversity indices.

4.3.1 Species richness

This is one of the most commonly used measures of species diversity. Simply, it is the total number of species in a given area. It provides equal importance to all species and does not take into account the number of individuals or population of a species. As we know that a single species will result in greater genetic diversity thereby produce a large number of individuals and thus positively influence overall biodiversity. Therefore, total counts of species richness of an area are seldom possible; in order to avoid this, the measure of species richness is often based on sampling smaller representative sites within the area to be assessed. Sampling should be accurate while estimating

species richness. Ecologists and biogeographers measure the complex spatial patterns of biodiversity at different scales:

(i) Point richness- As the name indicates it is the number of species that can be found at a single point in space.

(ii) Alpha (α) richness- It refers to the number of species or average species diversity found in small, homogenous area or ecosystem. It is expressed as the number of species (i.e. species richness) in an ecosystem. As shown in figure 11 the alpha diversity of sites A, B and C is 7, 5 and 7 species respectively. Alpha diversity is a widespread pattern characteristic of many taxa and are powerfully linked with physical environmental gradients. For example; tropical regions have more marine and terrestrial species related to higher taxonomic groups than those in higher latitude communities. In case of most taxa the species richness is positively correlated with habitat structural complexity. For instance structurally simple habitats like open grasslands, oceans, etc. generally support fewer species than structurally complex communities such as coral reefs and forests. Maximum species richness of most groups is found at depths between 2000-4000 m in open oceans. Corals are mostly found in the photic zone. There species richness peaks found at depths between 15-30m because corals depend on photosynthetic organisms to obtain energy, these photosynthetic organisms is embedded in their tissues. Mainland communities are species richer then the island communities.

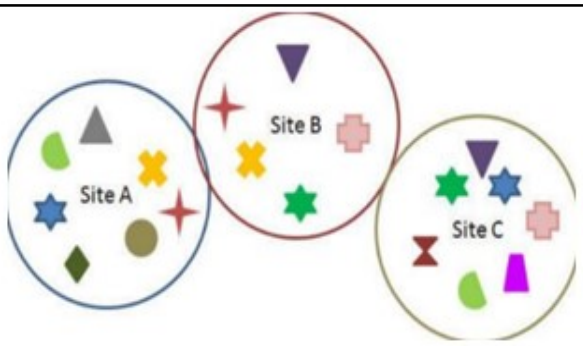


Figure 11. Alpha diversity of sites A, B and C is 7, 5 and 7 species respectively, beta diversity of site A and B=8 species, site B and C=6 species and site A and C=10 species and gamma diversity or overall diversity of these three habitats is 12 species diversity.

(iii) Beta (β) richness- Beta diversity represented by the species diversity between two adjacent ecosystems. It's determined by comparing the number of species unique to each ecosystem. The beta diversity of site A and B is 8 species, site B and C is 6 species and site A and C is greatest i.e., 10 species (differ between them and only two species in common).

(iv) Gamma (γ) richness: The species diversity across a landscape, also comprise the alpha and beta diversity. For instance, if we study the alpha, beta and gamma species diversity of a mountain slope, alpha diversity would be represented by species diversity in each forest or grassland patch, beta diversity would be the species diversity between those patches, and gamma diversity would be the species diversity along the entire slope. Therefore, gamma diversity is a measure of the overall diversity for different ecosystems in a region. The gamma diversity or overall diversity of all three sites is 12 species.

4.3.2 Taxonomic uniqueness

Species richness in terms of numbers alone does not enough to take into account the reality that more distantly related species from others, contribute greater to the overall biodiversity of earth. For instance, two species of genus *Sphenodon* (Tuatara) reported from New Zealand are the only extant members of the reptile order Rhynchocephalia. They have a unique and very different genetic make-up from their closest relatives. It can be concluded that such species contribute more towards maintaining a high global biodiversity as compared to species having a large number of very closely related species. Therefore, various measures are now being developed to consider the taxonomic uniqueness of a species while assessing biological diversity. For example, a simplest method of assigning taxonomic uniqueness to endemic species is based on the family to which it (the genus) belongs and the diversity of the genus.

4.3.3 Taxonomic diversity

In biodiversity the number and abundance of species in a community along with its ancestor descendant relationships is measured in terms of taxonomic diversity. For example, an area with only three species of mammals although both have three species each has lower species diversity than an area of similar size with two species of mammals and one species of reptile. Similarly, an area occupied by a large number of closely related species is not as diverse as an area with distantly related species. In other words we can say that a site with a large number of higher taxa possess more taxonomic diversity with greater genetic variation as compared to a site with more species but less higher taxa. Some common methods used to measure taxonomic diversity include:

i) Species richness

This is one of the simplest measures of species diversity, only considered numbers of species present in an ecosystem not their abundance.

ii) Simpson index

This index was proposed by Edward H. Simpson in 1949. This is a mathematical measure of species diversity in a community. It takes into account the number of different species (species richness) as well as abundance (evenness) in a given area. Therefore, diversity increases with increasing species richness and evenness. It is ranged between 0 to1. High score (close to 1) indicate high diversity while low score (close to 0) indicates low diversity. The formula is given below;

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

n = the total number of organisms of a particular species
N = the total number of organisms of all species

iii) Shannon–Weiner index

It was originally introduced by Claude Shannon. This diversity measure is based on information theory of measure of order (or disorder) within a particular system. For our uses, this order could be characterized by the number and/or the number of individuals in each species, within our sample plot. By applying these numbers to the Shannon-Wiener equations we can determine what is referred to as the degree of uncertainty. With this number we can then specify our degree of diversity. The Shannon-Weiner species diversity index is measured by considering the following steps

i) Total number of individual in each species

ii) Calculate Pi ie., the proportion each species is of the total number of individuals

iii) Natural log of the proportion for each species

iv) Sum the proportion times

Since this is a negative number, we then take the negative of the negative of this sum. The higher the number, the higher is the species diversity. In the ideal situation, one should compare populations that are the same size in numbers of individuals. The formula is as follows;

$$H' = -\sum_{i=1}^{s} p_i \ln p_i$$

Where H' is the species diversity index, s is the number of species, and pi is the proportion of individuals of each species belonging to the i^{th} species of the total number of individuals.

Summary

In this unit we have discussed various aspects of biodiversity and ecosystem functioning along with biodiversity assessment. So far you have learnt that:

- Biodiversity or diversity of life play a significant role in ecosystem functioning, large number of species diversity is required for proper ecosystem functioning.
- Ecosystem functions sustain human life and if it provides a positive benefit to humans it is called ecosystem services.
- Plants are the primary source of energy and nutrients either directly or indirectly for all other organisms.
- The flow of energy is non-cyclic and unidirectional, whereas the movement of nutrient is cyclic.
- Raymond L Lindeman in 1942 proposed the "ten percent law" of energy transfer and gave the concept of "trophic dynamic in ecology".
- There are two major pathways of energy transfers i.e., the grazing or biophagic pathway and the detritus or saprophagic pathway.
- Energy flow in a food chain is always unidirectional that's why the pyramid of energy is always upright or triangle-shaped.
- There are two interconnected nutrient budget systems in an ecosystem i.e., intra-system cycling of nutrients and extra-system nutrient transfers.
- Species diversity can be measured by species richness, taxonomic uniqueness and taxonomic diversity index.

Terminal questions

1. What is the role of biodiversity in ecosystem functioning?

2. What is the difference between food chain and food web?

3. Explain the types of Ecological pyramids?

4. What is the role of nutrient cycling in ecosystem functioning?

5. Describe the common methods used to measure taxonomic diversity?

Answer keys

Self Assessment 1: (A) 1-a; 2-d; 3-a. **(B)** 1- Producers; 2-unidirectional, noncyclic, cyclic; 3- Trophic level; 4- biophagic or grazing; 5- detritus or saprophagic.

Self Assessment 2: (A) 1-a; 2-b; 3-c; 4-b.

(B) 1. The transfer of energy fixed by plants through a series of organisms eating one and being eaten by other is called food chain.

2. A complex net-like trophic inter-relationship of food chains that shows how species in an ecosystem are connected through their feeding relationships is called a food web.

3. The organisms that feed on a common set of organisms and are fed on by another common set of organisms are referred to as trophic species.

4. Connectedness, energy flow and functional food webs.

5. Three categories of ecological pyramids are (i) numbers, (II) biomass and (iii) energy or productivity.

References

Cohen, J. E. and Briand, F., 1984. Trophic links of community food webs. Proceedings of the National Academy of Sciences, 81(13), pp.4105-4109.

Giller, P. S., Hillebrand, H., Berninger, U.-G. et al. 2004. Biodiversity effects on ecosystem functioning: emerging issues and their experimental test in aquatic environments. Oikos 104: 423-436

Odum, E. P. 1953. Fundamentals of Ecology. Saunders, Philadelphia. First edition, 384 pp. Odum, E.P., Barrett, G.W. 2005. Fundamentals of Ecology (5th ed.). Thomson, Brooks/Cole: Australia.

Unit 5: Biodiversity Threats, Conservation Approaches and Management

Unit Structure

5.0 Learning Objectives

After completion of this unit, you will be able to:

- understand the concept of biodiversity and hotspots of biodiversity
- discuss the role and approaches of biodiversity conservation
- understand different types of biodiversity threats
- understand the concept of species extinction and IUCN category
- understand the reason of biodiversity loss

5.1 Introduction

Biodiversity means different types of flora, fauna, and microorganisms present in the earth's surface. Nowadays, the number and variety of different living organisms is reducing day by day due to human activities, industrialization, urbanization. Biodiversity is very important for human as it provides food, medicine, timber, fodder and other products. However, due to anthropogenic activities such as overexploitation, pollution, climate change and industrialization leads to habitat loss and fragmentation of biodiversity. Therefore, there is an urge to conserve biodiversity by different conservation strategies and by implementing several policies and laws for the conservation of wild flora and fauna.

5.2 Decline of biodiversity

Biodiversity means variety and variability of species and ecosystems in a particular area. It includes abundance, genetic material or diversity of any organisms from different habitats like terrestrial, marine and aquatic systems. The process of declining of biodiversity is also called as biodiversity loss, and once biodiversity is lost then it cannot be recreated. Simply biodiversity loss means extinction of species that are gradually declining thus leading to the death of the ecosystem. When the rate of biodiversity loss exceeds the natural rate due to some reasons, then it can be said that the process of extinction is underway. Extinction means death of the last surviving individual of a species or group globally or locally. The reason for extinction could be anthropogenic activities like deforestation, urbanization, and clearance of land for agricultural purpose and other factors. Due to these activities few important species may die, that ultimately disturbs the ecosystem.

Nowadays, the process of extinction is occurring at a very fast rate. Previously, it was thought that the main cause of the extinction of species was human hunting. However, in recent years, direct factors such as extensive forest clearing for agriculture, pollution, urbanization, over-exploitation of natural ecosystems, have been blamed for the loss of biodiversity. It has been estimated that roughly ten thousand species go extinct annually. This causes an alarming situation and lead to biodiversity threat. By the middle of the twenty-first century, 1/3 to 2/3 of our current biodiversity might go extinct if this trend continues.

5.2.1 Statistics of biodiversity loss

According to World Wide Fund for Nature (WWF) report, approximately 52% of world's biodiversity including from land, water has been lost in a 40-year span between 1970 and 2010. Among these, freshwater diversity was the most affected one. International Union for Conservation of Nature (IUCN) report reveals that one-third of the world's reef-building corals, 75% of the fisheries stock, and 75% of the genetic variety of agricultural crops are either threatened or extinct. Among the faunal species, 42% of amphibians, 25% of mammals, and 19% of reptile species are considered as threatened with extinction. Additionally, among the floral species, 71% of magnolias, 63% of cycads, and 34% of conifers are classified as threatened. Some research states that half of the world's animal and bird species could go extinct in the next 200–300 years. However, due to inadequate biodiversity monitoring and the undiscovered status of biodiversity on earth, estimating the rate of extinction is challenging.

5.3 Major causes of biodiversity loss

There are several factors that cause the loss of biodiversity. The majority of the loss of biodiversity in the last few decades has been driven by human activity rather than natural factors. Some of the most important factors are discussed below:

5.3.1 Habitat loss and fragmentation

Habitat loss refers to the process of alteration of natural environment of flora and fauna, sometimes leading to the extinction of the species. This alteration of habitat is increasing day by day to fulfill the personal and economic needs of the humans. Habitat loss occurs due to deforestation, urbanization, agricultural expansion, infrastructural development,

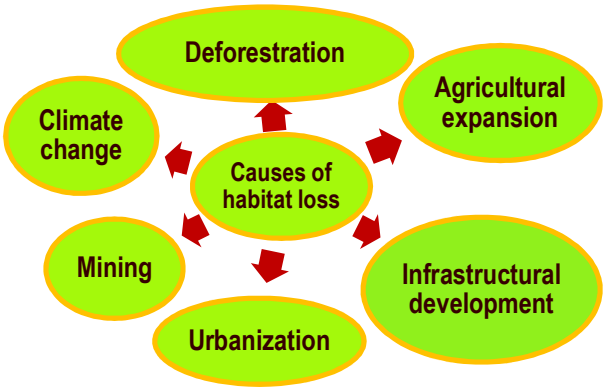


Figure 1. Causes of habitat loss

climate change and mining activities (**Figure. 1**). Due to anthropogenic activities, many habitats become fragmented and disturbs the ecosystem. When fragmentation occurs, smaller population of the species are formed that are unable to survive. Additionally, fragmentation brings a physical barrier that prevents biodiversity from spreading and colonizing new surroundings.

5.3.2 Pollution

All the natural ecosystems of the earth get polluted due to different pollutants entering into the environment. Due to excessive industrial activities and vehicular emission, the level of different pollutants like SO_2,CO_2, Nitrates, Pb, CO and Particulate matter increases, thus become a threat to biodiversity. In case of aquatic ecosystem, oil spill and pesticide and insecticide runoff cause the death of several aquatic organisms. Dumping of sewage and solid waste into the terrestrial and water bodies, severely impacted the flora and fauna present in the earth. Toxic substances such as pesticides, insecticides, heavy metals, and persistent organic pollutants accumulate into the environment. As a result, many species get lost and only those species can survive who modified themselves with the changing environment.

5.3.3 Overexploitation and poaching of wildlife

The pressure on biodiversity has greatly increased due to exponential expansion in the global human population over the last few decades. Growing populations have led to an over-demand for resources, which is typically met by unethical activities including poaching, targeted hunting, overfishing, and overharvesting. When fishes are over exploited, then it is called as overfishing and due to this over exploitation 90% of commercial fish stocks are reduced. Illegal killing of wild animals is called as poaching and there are 2 types of hunting *i.e.* subsistence and sport hunting. Subsistence hunting means killing of animals for getting food while sport hunting means killing animals for selling their meat, horns, tusks, skin and fur. Due to illegal trading of animals and plants, many species like rhinoceros, elephant, tiger, leopard are becoming endangered. Poaching of the top predators in the food chain causes the disruption of the entire food web.

5.3.4 Exotic species

Exotic species is also called as alien species, they are intentionally introduced to some areas to get some benefits. Exotic species replaces the native one and compete with them for food, habitat and other resources. Invasive alien species are the primary cause of species extinction in most ecosystems and are regarded as the second most important factor for reducing biodiversity. Exotic species destroyed the whole ecosystem by displacing its natural predators in the area and can destroy both terrestrial and aquatic ecosystem.

5.3.5 Climate change

Climate plays a very important role in the distribution of species around the world. Climate change influence the composition of plants and animals, thus disturb the entire ecosystem. Climate change is the phenomenon that occurs naturally over millions of years. However, anthropogenic factors and human actions have been blamed for the current climate change. The rate of change is so rapid that plant and animal species are not able to adjust to it and are gradually becoming more susceptible to the process of extinction. Due to climate change the timing of agricultural activities, flowering seasons, migratory patterns, and other phenomena occur. The food webs and chains within the ecosystems may shift as a result of these modifications. Numerous species are impacted by these factors. According to an Intergovernmental Panel on Climate Change (IPCC) report, if greenhouse gas emissions continue at the current rate, then 20–30% of plant and animal species are "likely to be at increased risk of extinction."

There are several other factors that cause biodiversity loss such as forest fire, volcanic eruption and man wildlife conflict.

Self-Assessment 1

1. Explain the main threat of biodiversity loss?

2. What is the full form of IPCC?

- **A.** Intergovernmental Panel on Climate Change.
- **B.** Intergovernmental Panel on Critical Change
- **C.** Intergovernmental Position on Climate Change

D. None of the above

3. Assertion: The decline in biodiversity is primarily due to human activities such as deforestation, pollution, and climate change.

Reason: Human activities alter natural habitats, leading to loss of species, disruption of ecosystems, and changes in climate that further stress wildlife populations.

A. Both assertion and reason are true and the reason is a correct explanation of the assertion.

B. Both assertion and reason are true but reason is not a correct explanation of the assertion.

C. Assertion is true but reason is false.

D. Both assertion and reason are false.

4. How does habitat destruction contribute to the loss of biodiversity?

5. Explain exotic species?

5.4 Impact of biodiversity loss

Decline in biodiversity causes a huge impact on human activities, natural ecosystems and their functioning is also disturbed. Out of the eight million species, around one million are threatened and can extinct in the coming decades due to human-induced climate change, misuse, and unregulated resource usage. Some of the impact of biodiversity loss are discussed below:

i. Biodiversity is necessary to life, and any decrease in it cause disruption to the ecosystem's food chain. It seems that certain species play the most significant role in maintaining ecosystems as a whole. The loss of these species disturbs the entire web of life and eliminates mutual benefits.

ii. Introduction of invasive species kill many native species of that area, thus reduces the number of flora and fauna present in the area.

iii. Several ecosystem services get disrupt due to loss of biodiversity.

iv. Loss of biodiversity influence human health, as humans depend upon ecosystem products like food, freshwater and medicinal plants.

v. When humans damage a wild animal's habitat, the animal is compelled to leave the forest in search of food in the neighboring human towns. When this happens, the animals attack humans by accident.

5.5 Direct and indirect threat to biodiversity

Due to anthropogenic activities like industrialization, urbanization, deforestation and mining activities, biodiversity is declining day by day. There are direct and indirect threats to biodiversity, some of the direct threat includes habitat destruction, habitat fragmentation, overexploitation of resources, competition with invasive species, epidemics, pollution and illegal trading of flora and fauna. Indirect threat includes poverty, population growth and high consumption rates, inappropriate macroeconomic policies and bad policies.

5.6 Reason for conservation

Biodiversity conservation is essential in order to keep ecosystems healthy and stable, which in turn supports all life forms on Earth. Biodiversity conservation not only saves individual species but also preserve the intricate network of life that sustains ecosystem services such as clean water, air, and fertile soil that are vital to human survival. The necessity to maintain biodiversity is highlighted by its immense importance. Wildlife is a gift from nature that needs to be protected. A valuable resource for both people and the country is biodiversity. Therefore, protecting it and using it wisely are essential for achieving sustainable development. In order to preserve biological diversity, the World-Wide Fund for Nature (WWF) was established in 1994. WWF conserves biodiversity by establishing and managing systems of efficient and sustainable protected areas, preserving specific species that are of particular concern, and advancing environmental education to help people manage the environment responsibly.

5.7 Methods of biodiversity conservation

There are several methods and strategies for conserving biodiversity and several governments, organizations, communities, and individuals working together can make conservation efforts more effective. The goal of biodiversity conservation is to maintain the

diversity of life on Earth, which includes species, ecosystems, and genetic variation. Here are a few essential techniques:

I. **Protected Areas:** Protected areas mean developing marine protected areas, national parks, and wildlife reserves to save animals and their habitats from development and human exploitation.

II. **Habitat restoration:** Rehabilitating and returning damaged or destroyed habitats to their original state in order to support various plant and animal species.

III. **Legislation and Policy:** Putting into effect and upholding rules and legislation, including the Endangered Species Act, that safeguard endangered animals and their ecosystems.

IV. **Sustainable Practices:** Encouraging methods of fishing, forestry, and agriculture that are less harmful to ecosystems and don't overuse resources.

V. **Community Involvement:** It involves local populations in conservation initiatives so they can profit from and take part in the preservation of natural resources.

VI. **Education and Awareness:** Using outreach initiatives, campaigns, and educational programs, increasing public knowledge of the value of biodiversity and conservation.

VII. **Research and Monitoring:** Performing scientific studies to gain a deeper understanding of ecosystems and species; keeping an eye on population trends to identify shifts and modify conservation approaches.

VIII. **Genetic Resource Conservation:** Ensuring that species can adapt to changing environments by maintaining the genetic diversity of species through methods like cryopreservation and seed banking.

IX. **In-Situ Conservation:** The preservation of species in their native environments, including habitat management to preserve ecological processes and interspecies relationships. The greatest way to save a species is to safeguard both it and all the other species that call its natural environment home. It includes National Parks, Wildlife Sanctuaries and Biosphere reserves.

X. **Ex-situ Conservation:** Breeding and maintaining endangered species in man-made habitats like zoos, nurseries, botanical gardens and gene banks. The

creatures are less in competition with one another for food, water, and space. But the cost for managing these rare plant and animal breeding initiatives is higher than that of managing a Protected Area.

5.8 Ecoregion

An ecoregion is a geographical area distinguished by its unique natural environment, which includes its soil, vegetation, fauna, and climate. Rather than depending solely on political or geographic borders, the idea is utilized to categorize regions according to their ecological traits. By combining regions with comparable ecological processes and circumstances, ecoregions aid in the understanding and management of ecosystems.

Ecoregions are regions with essentially similar ecosystems in terms of type, quality, and quantity of environmental resources. The patterns and composition of biotic and abiotic phenomena that influence or reflect variations in ecosystem health and integrity can be used to identify ecological zones. The term ‘‘ecoregion’’ was first proposed by Canadian forest researcher Orie Loucks in 1962. Natural sizes of ecoregions vary widely, and they can be categorized in a hierarchical fashion at different scales or levels of detail. Large physiographic land units should be less ecologically relevant than ecoregions.

For instance, the Sahara Desert ecoregion is not the same as the Amazon Rainforest, which has its own distinct flora, fauna, and climate. Scientists and conservationists can better solve environmental concerns, manage natural resources, and save biodiversity by identifying and researching ecoregions. Ecoregions are important for biodiversity conservation, ecosystem management, climate adaptation, restoration projects, sustainable development, research and education, cultural and economic values, policy and planning.

5.9 Mega diverse countries

There are 17 megadiverse countries in the world, as recognized by the World Conservation Monitoring Centre in July 2000. Mega diverse nations are characterized by high biodiversity, encompassing a broad range of species, ecosystems, and genetic diversity and their diversity in habitats, climates, and landscapes is a major factor in their richness. The overall number of species found in a nation as well as the degree of

endemism at the species and higher taxonomic levels form the basis of the idea of megadiversity. Australia, The Congo, Madagascar, South Africa, China, India, Indonesia, Malaysia, Papua New Guinea, Philippines, Brazil, Colombia, Ecuador, Mexico, Peru, United States and Venezuela are the megadiverse countries of the world. These countries have more than 70% of the world's biological diversity, but making up less than 10% of its surface. Two-thirds of all primate species were found to be distributed within four countries, according to an examination of conservation priorities for primates. Afterwards, more mammals, birds, reptiles, amphibians, plants, and particular insect families were included to the analysis. Later the analysis was published in 1997 in the book: Megadiversity: Earth's biologically wealthiest nations.

5.9.1 India as a mega diversity nation

India's mega diversity is due to its varied climates, landscapes, and ecological zones, as well as its rich cultural heritage that often intertwines with environmental management. It is essential to preserve this abundance of biodiversity for the country's cultural and economic well-being as well as for preserving ecological equilibrium. Our vast and diverse biodiversity is a result of India's unique geographic location between three different centers of biological evolution and species radiation. India is ranked in the top 10 or 15 ecologically rich countries due to its wide range of flora and fauna, many of which are unique to the country.350 distinct mammal species, 1200 bird species, 453 reptile species, and 45,000 plant species including 1022 fern species and 1082 orchid species are found in India. Out of this, 18% of plants in India are native to the nation and cannot be found anywhere else in the globe. 50,000 insect species is present in India, out of which 13,000 are moths and butterflies (**Fig. 2**). Sixty-two percent of the amphibians in India are unique to the nation. A total of 153 known species of lizards is known, out of which only 50% or 43

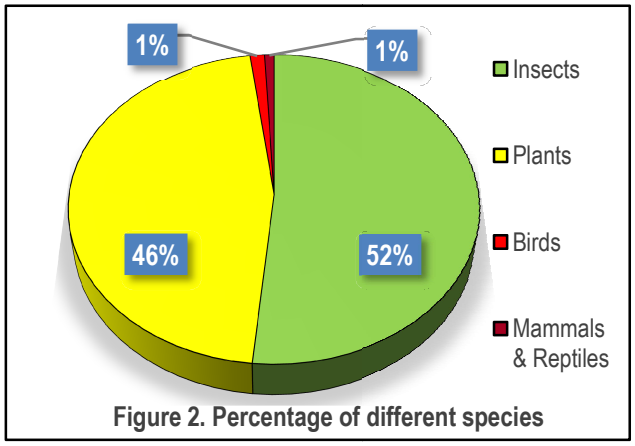


Figure 2. Percentage of different species

species are endemic. Additionally, a number of insect groups, including worms, centipedes, mayflies, and freshwater sponges, have been found to have high endemism.

5.10 Biodiversity hotspot

In 1988 and 1990, British ecologist Norman Myers introduced the idea of a biodiversity hotspot in "The Environmentalist" article. Biodiversity hotspot are the areas having higher species richness with diverse local endemic species, that are particularly found in those areas only (**Fig. 3**). These are the large areas in the world and are vulnerable to extinction as a result of habitat loss. At present, there are 35 biodiversity hotspots, out of which 8 are considered as hottest hotspots. There are four biodiversity hotspots in India: The Western Ghats, Sundaland, Indo-Burma, and the Himalaya. Biodiversity hotspots areas are important because of the significant global value of the unique species, high vulnerability of habitat and also provide essential ecosystem services that are useful for the survival of humans.

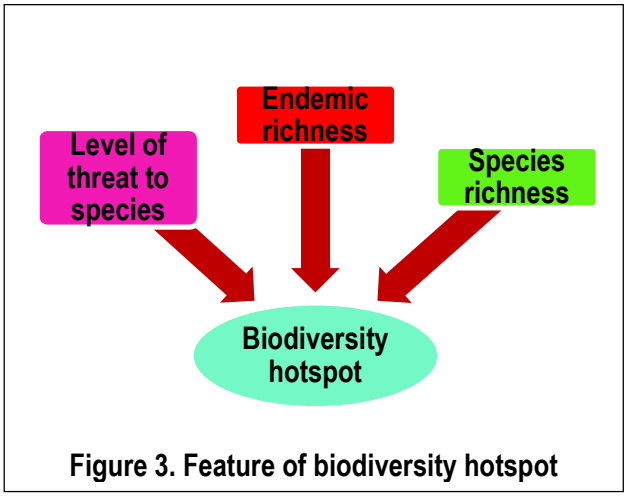


Figure 3. Feature of biodiversity hotspot

5.11 Invasive species

An invasive species are organisms (plants, animals, fungi and microorganisms) that are introduced or transported in a habitat either intentionally or accidentally, where they are not native. An invasive species is also called as alien, exotic, non-indigenous, or non-native species. Invasive species have such traits that allow them to thrive in new environments and these traits include high reproductive rates, feeding habits, disease and pest resistance. Invasive alien species (IAS) is introduced into a new area and then it colonizes in that area and destroy or kill all the native species present there. Invasive alien species

have a negative effect on local ecosystem, adversely affect biodiversity, causes disease transmission and affect ecosystem functioning.

5.12 Spread of invasive species

Invasive species firstly colonize and then establish into the environment successfully. It is intentionally introduced in any area as fodder, fiber, medicinal and timber plant for fulfilling basic human needs. The invasive species can be spread via different sources like impure seed of the crop, attachment to domesticated animals and the soil around nursery stock roots. Disturb site for colonization of invasive species was formed because of several human activities like agriculture, grazing and logging.

5.13 Impact of invasive species

Invasive species causes a huge impact on the ecology of the area, where they are intentionally introduced and causes significant economic, social and environmental impact. Invasive alien species alters the physical and chemical composition of soil that replaces the native species, it makes the area fire prone and also alter or delimit the photosynthetic activity of the native species by reducing the availability of the light. Invasive alien species compete with the native species for food, light, nutrients and space; they disturb the productivity, water and nutrient cycle and functioning or services of the ecosystem. Invasive species also reduces the biodiversity, impact agricultural activities and its production and affect livestock and soil dynamics of an area.

Self-Assessment 2

1. Explain the direct and indirect threat to biodiversity?
2. How many megadiverse countries are in the world?
   - **a.** 12
   - **b.** 17
   - **c.** 18
   - **d.** 14
3. Who gave the term Biodiversity Hotspot?

a. Norman Myers

b. Ernst Haeckel

c. E.P Odum

d. A.G. Tansley

4. What is the impact of invasive species?

5. Explain ecoregion?

Summary

- This unit describes the concept of biodiversity and the various threats to biodiversity.
- The majority of the loss of biodiversity in the last few decades has been driven by human activity rather than natural factors. According to World Wide Fund for Nature (WWF) report, approximately 52% of world's biodiversity including from land, water has been lost in a 40-year span between 1970 and 2010.
- Habitat loss refers to the process of alteration of natural environment of flora and fauna, sometimes leading to the extinction of the species. Decline in biodiversity causes a huge impact on human activities, natural ecosystems and their functioning is also disturbed.
- Out of the eight million species, around one million are threatened and can extinct in the coming decades due to human-induced climate change, misuse, and unregulated resource usage.
- Biodiversity conservation is essential in order to keep ecosystems healthy and stable, which in turn supports all life forms on Earth.
- Biodiversity conservation not only saves individual species but also preserve the intricate network of life that sustains ecosystem services such as clean water, air, and fertile soil that are vital to human survival.
- There are 17 megadiverse countries in the world, as recognized by the World Conservation Monitoring Centre in July 2000.

- India's megadiversity is due to its varied climates, landscapes, and ecological zones, as well as its rich cultural heritage that often intertwines with environmental management. It is essential to preserve this abundance of biodiversity for the country's cultural and economic well-being as well as for preserving ecological equilibrium.

Answer keys

Self-Assessment 1: 1-See section 5.3, **2-**A, **3-**A, **4-**See section 5.3.1, **5-** See section 5.3.4

Self-Assessment 2: 1-See section 5.5, **2-**B, **3**-A, **4-**See section 5.13, **5-**See section 5.8.

References

Chitale VS, Behera MD, Roy PS. 2015. Global biodiversity hotspots in India: significant yet under studied. Curr Sci. 108: 149–150.

Myers, N., Mittermeler, R.A., Mittermeler C.G, Foneseca, G.A.B.D, Kent,J. (2000) Biodiversity hotspots for conservation priorities. Nature. 403(10).

Rani, S., Kumari, S., Kumar, P. and Kumar, V. (2021). Biological diversity: Introduction, values, threats and conservation measures. In: Biological Diversity: Current Status and Conservation Policies, Volume 1, Eds. Kumar., V., Kumar, S., Kamboj, N., Payum, T., Kumar, P. and Kumari, S. pp. 1-23, https://doi.org/10.26832/aesa2021-bdcp-01

Sharma, P.D. (2009) Biodiversity and wildlife of India and its conservation, Ecology and Environment, Rastogi publications.

Venkataraman, K. and Sivaperuman, C. (2018). Biodiversity Hotspots in India: Vertebrate Faunal Diversity, Conservation and Management. Volume 2, Singapore: Springer.

Unit 6: Global Biodiversity

Unit Structure

6.0 Learning Objectives

After completion of this unit, you will be able to:

- understand the concept of hotspots of biodiversity
- understand the concept of species extinction
- understand the concept of IUCN red list category
- understand the reason of biodiversity loss

6.1 Introduction

Biodiversity means variety and variability among different species of flora, fauna, and microorganisms present in the earth's surface. The three categories of biodiversity - genetic, species, and ecosystem all have major implications for humankind. Nowadays, the number and variety of different living organisms is reducing day by day due to human activities, industrialization, and urbanization. Humans depend largely on biodiversity for the

production of food, medicine, wood, fodder, and other goods. There are different strategies for the conservation of biodiversity, one of them is the listing of endangered species. This listing of endangered species of flora and fauna is called as Red list and is given by International Union for the Conservation of Nature and Natural Resource (IUCN).

6.2 Hotspots of biodiversity

In 1988, Norman Myers used the term "hotspot of biodiversity" and identified ten tropical forests that had significant habitat loss and a high endemism content. Myers discovered eight other hotspots later in 1990, and Conservation International (CI) adopted it.

According to Conservation International, an area is declared as biodiversity hotspot when:

I. It must have a significant proportion of endemic plant life, or at least 1500 vascular plants.

II. The original natural vegetation of an area must remain 30%, hence it should be threatened.

In 1999, 25 biodiversity hotspots were identified by Conservation International in the book “Hotspots: Earth’s Biologically Richest and Most Endangered Terrestrial Ecoregions”.44% of the world’s plants and 35% of terrestrial vertebrates in an area are endemic that formerly covered only 11.8% of the planet’s land surface. Later in 2005, CI updated the book “Hotspots: Earth’s Biologically Richest and Most Endangered Terrestrial Ecoregions”.

6.3 Global biodiversity hotspots

At present there are 36 biodiversity hotspots in the world on the basis of threat level, species and endemic richness and previously these hotspots covered 15.7% of the Earth's land surface. Due to anthropogenic activities, 86% of hotspots’ habitat is destroyed, leading to only 2.3% cover of earth's land surface. Hotspots have lost 70% of their native vegetation and are under severe threat. 50% of the world's plant species and 42% of its terrestrial vertebrate species are found in these 36 biodiversity hotspots. African continent has 8 biodiversity hotspot that contain variety of flora and fauna, that are not present anywhere in the world. It includes Cape Floristic Region, Coastal Forests of Eastern Africa,

Eastern Afromontane, Guinean Forests of West Africa, Horn of Africa, Madagascar and the Indian Ocean Islands, Maputaland-Pondoland-Albany and Succulent Karoo.

Asia-Pacific region contain 8 biodiversity hotspot that are rich in biodiversity and is composed of large land masses and islands. It includes East Melanesian Islands, Himalaya, Indo-Burma, Japan, Mountains of Southwest China, New Caledonia, New Zealand, Philippines, Polynesia-Micronesia, Southwest Australia, Forests of Eastern Australia (new), Sundaland, Wallacea, Western Ghats and Sri Lanka. Europe and Central Asia region contain 4 biodiversity hotspot and have unique diversity of flora and fauna. It includes Caucasus, Irano-Anatlian, Mediterranean Basin, Mountains of Central Asia. North and Central America act as an important habitat for diverse plants and animals. It includes California Floristic Province, Caribbean Islands, Madrean Pine-Oak Woodlands and Mesoamerica. The South America region is the richest one and contains diverse life on the earth. It includes Atlantic Forest, Cerrado, Chilean Winter Rainfall-Valdivian Forests, Tumbes-Choco-Magdalena and Tropical Andes (**Fig. 1**).

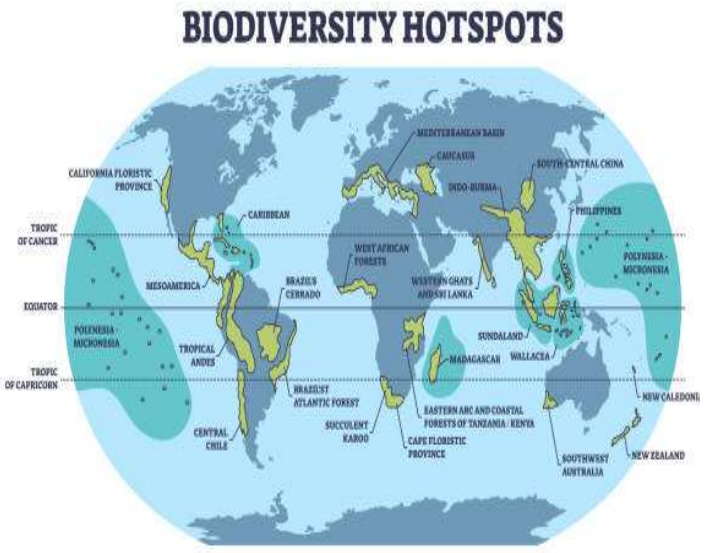


Fig. 1. Global Biodiversity Hotspots
Source: https://images.app.goo.gl/Ya3ycNhhxZDk3ikSA

6.4 Hottest hotspots

There are 8 hottest hotspots, they are much richer and diverse hotspot in terms of endemism as compared to another hotspot. Madagascar, Philippines, Sundaland, Brazil's Atlantic forests, Caribbean Island, Indo-Burma region, Eastern arc & coastal forests of Tanzania/Kenya, Western Ghats & Sri Lanka are the 8 hottest hotspots.

6.5 Hotspots of India

India is one of the megadiverse countries that contain 2.4% of world land area, 4% of fresh water and 7.3% of species. India is 3 most mega diverse country after Brazil and Costa Rica with highest concentration of species in Agasthymalai Hills in Western Ghats. There are 4 major biodiversity hot spots present in India. They are Himalaya, Indo-Burma, Sundaland and Western Ghats and Sri Lanka.

I. **Himalaya:** It includes entire Indian Himalayan region and encompasses Bhutan, north eastern India, Southern, central, and eastern Nepal.The Himalayan Mountain ranges from 500 meter to 8000 meter that causes the diversity of ecosystem from alluvial grasslands to subtropical and temperate broad leave forest. It also comprises of mixed conifer to alpine meadows. Himalayan hotspot consists of 163 threatened species of flora and fauna and 10,000 species of plants (**Figure 2).**

Figure 2. Himalaya

Source: https://images.app.goo.gl/rCHyNZk4gCkMMuWe7

II. **Indo-Burma:** The Indo-Burma region extends two million square kilometers and consists of several countries and has wide variety of climate and habitat pattern. This region is famous for its primate species and approximately 1300 bird species are present in this region (**Figure 3**).

Figure 3. Indo-Burma

Source: https://images.app.goo.gl/STfsqwLK4q2quzbk8

III. **Western Ghats and Sri Lanka:** Western ghat shows high level of species richness and endemism and is also called as Sahyadri Hills. This region containsmoist deciduous and rain forest and thus shows heavy rainfall pattern.There are over 6000 vascular plants, out of which 3000 are indigenous. (**Figure. 4**).

Figure 4. Western ghats & Sri Lanka
Source: https://images.app.goo.gl/CKEuGe8zssqjR1x57

IV. **Sundaland:** In 2013, United Nations declare Sundaland a World Biosphere Reserve and is biologically richest hotspots. This region consists of mangroves, coral reefs and 25000 vascular plant species and has rich marine biodiversity. However, the marine species suffer overexploitation by the humans (**Fig. 5**).

Figure 5. Sundaland
Source: https://images.app.goo.gl/oxeqkz6PWRBCyJti6

6.6 Value of biodiversity hotspots

Humans directly or indirectly depend on biological diversity for food, medicine, shelter, timber, energy, scientific purposes, tourism and other services. Biodiversity hotspots are very important from conservation point of view; hence they have conservation value. The regions of hotspots have diverse climatic conditions, thus are resistant to environmental stress and climate change. Hotspots are significant for scientific study or research and help to understand the process of evolution, interaction among species and several ecosystem dynamics. The region of hotspots has rich biodiversity, thus serve several ecosystems services like fresh air, purified water, forest and improve soil texture and fertility. Indirect values of biodiversity hotspots include social, moral, ethical, aesthetic, economic and scientific values (**Figure 6).**

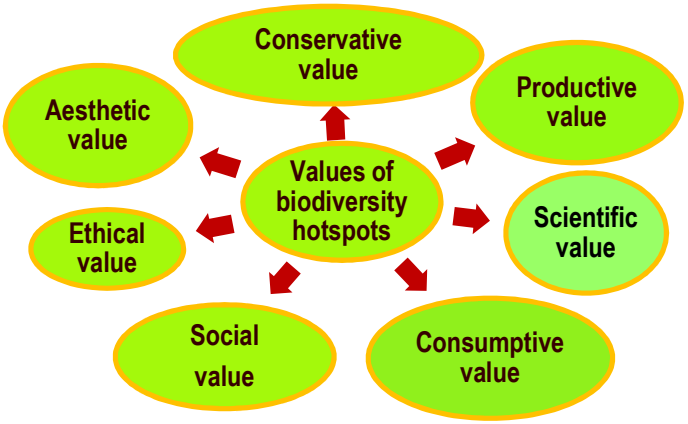


Fig. 6. Values of biodiversity hotspot

6.7 Loss of biodiversity

There are several factors that causes the loss of biodiversity from an area. These causes could be direct or indirect, and mainly occurs due to economic development, increasing demand of resources, overexploitation and increasing human population (**Figure. 7**). The loss of biodiversity is also called as decline of biodiversity or extinction crisis. Learners can see section 1.3 and 1.4 of unit 5 for better understanding, as this section consists the whole concept, causes and impact of biodiversity loss. Due to loss of biodiversity, several impacts occur in the environment like ecosystem services gets disturb, economic impact, health impact, threaten food security, diminish aesthetic and cultural value and reduces ecosystem stability.

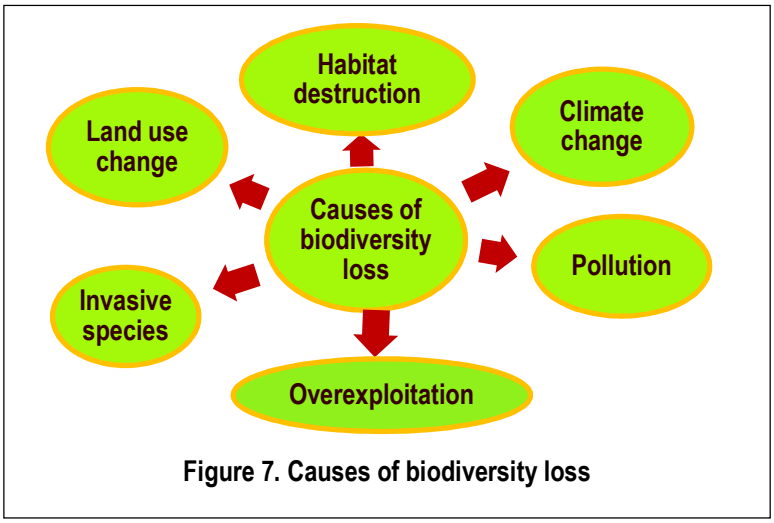


Figure 7. Causes of biodiversity loss

6.8 Extinction of species

The world has always been changing and always will be. Mountains have created and eroded over hundreds of millions of years, as have continents split apart and oceans emerged. Living creatures undergo changes in response to geological shifts: new lineages develop while existing species, populations, and entire lineages vanish.

Extinction is a natural phenomenon and the term is used in biology and ecology to describe the disappearance of a species or a group of taxa, thereby decreases biodiversity. The fossil record indicates that no species has yet demonstrated immortality; only 2–4% of all known species are thought to still be alive today. The great bulk of the remaining species had vanished long before humans emerged.

6.8.1 Types of Extinction

There are two types of extinction: Background extinction and mass extinction. When several species in a habitat disappear, one of the most pressing issues facing humanity is the extinction of species of plant, animal, or human which requires immediate attention.

I. **Background extinction:** Background extinction is the continuous one and is a part of natural evolution. In this extinction, low level species extinct from the earth due to environmental, ecological and biological factors. These factors include climate change, disease, habitat loss, competition or predation. The term background extinction rate is also known as normal extinction rate and the number of species that are predicted to become extinct over time depends on non-human factors.

II. **Mass extinction:** Mass extinction means some form of catastrophic event, in which a significant number of species extinct over a short period of geological time. These extinctions are assumed to be caused by things like massive environmental change that happens too quickly for most species to adapt. The fossil record shows that there were at least five mass extinctions that occurred throughout the Ordovician, Devonian, Permian, Triassic, and Cretaceous periods.

Nowadays, stochastic extinction is seen, this extinction occurs due to normal and random changes in the environment, that ultimately affects the species of the surrounding area.

Usually, stochastic extinction causes a population to shrink rather than to disappear, however it can also lead to deterministic extinction.

6.8.2 Causes of extinction

There are several factors that accelerate the rate of extinction. The key factors are discussed below:

I. **Genetics factor:** A population will become extinct if adaptation's increase in population fitness is less rapid than environmental degradation.

II. **Demographic phenomena:** Limited geographical range leads to background extinction and smaller populations of a species.

III. **Genetic pollution:** When genetic pollution occurs like uncontrolled hybridization, then the problem of extinction occurs. It occurs especially to the endemic species of an area.

IV. **Habitat degradation:** Currently, the primary human-caused factor leading to the extinction of species is habitat deterioration. Agriculture is the primary global driver of habitat degradation, followed by urbanization, logging, mining, and certain fishing methods. When a species' habitat is destroyed, it might change the fitness landscape to the point where the species can no longer thrive and goes extinct.

V. **Coextinction:** It represents the extinction of one species leading to the extinction of another.

6.8.3 Effects of species extinction

I. Ecosystem imbalance or collapse

II. Loss of biodiversity

III. Impact on other species

IV. Economic effects

V. Scientific and medicinal loss

VI. Cultural and aesthetic impact

VII. Altered ecosystem functions and services

6.9 International Union for Conservation of Nature (IUCN)

IUCN was founded in 1948 and is one of the biggest environmental organizations in the world with more than 1400 member organizations, more than 200 countries, and around 9000 non-governmental groups. It's headquarter is in Gland, Switzerland. IUCN receives funding from a number of governments, organizations, businesses, and foundation members and is granted official observer status at the UN General Assembly. Every four years at the IUCN World Conservation Congress, Member Organizations of the Union establish detailed guidelines for the Union's work and other worldwide conservation initiatives.

6.9.1 IUCN red list of threatened species

An extensive inventory that evaluates the global conservation status of plant and animal species is the IUCN Red List of Threatened Species. It was founded in 1964 and offers the exact, quantitative, scientific criteria needed to identify any threat to a species that apply to the majority of species around the globe. The Red List's categories are intended to show how likely it is that a species will go extinct and over 134,425 species have been evaluated. Every twice a year, the IUCN Red List is revised and more than 37,400 species are considered to be in danger of going extinct and currently, 160,000 species are to be assessed.

6.9.2 IUCN red list category

IUCN red list category has 9 categories, they are discussed below and the flowchart is given in **Figure 8**:

I. **Not evaluated (NE)**: The species of this category hasn't been evaluated with reference to the red list criteria and no taxon study has been completed.

II. **Data Deficient (DD):** The taxon is well investigated, but its population and distribution are either little understood or unknown. It becomes challenging to determine which group it falls into because of the lack of available data. OR Species for whom there is insufficient data to determine the risk of extinction, either directly or indirectly.

III. **Least Concern (LC):** The taxon does not need to be classified as endangered because it is widely distributed and reasonably abundant.

IV. **Near Threatened (NT):** The taxon is not listed in the list of threatened species, it is most likely to be added in the near future to the vulnerable, endangered, or critically endangered species lists.

V. **Vulnerable (VU):** There is a chance that the taxa will become endangered in the wild.

VI. **Endangered (EN):** In this category, the species faces a high risk of extinction in the wild.

VII. **Critically Endangered (CR)**:The risk of extinction for this taxon in the wild is very high.

VIII. **Extinct in the Wild (EW):** Species that are only known to exist in captivity, in cultivation, or as a naturalized population that has spread far beyond its historical habitat.

IX. **Extinct (EX):** No known members of the taxon are still alive.

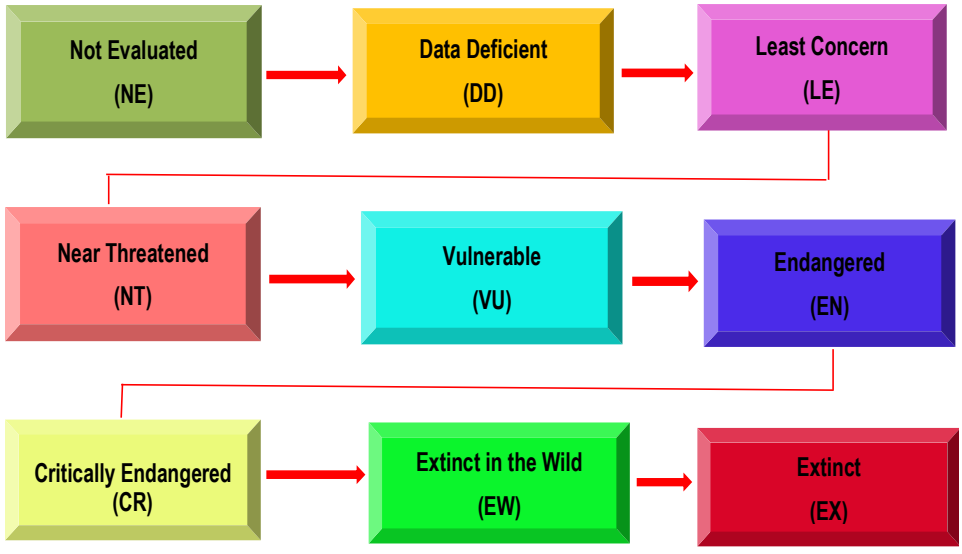


Figure 8. IUCN red list categories

Summary

- This unit describes the global biodiversity hotspots and IUCN red list categories. The three categories of biodiversity - genetic, species, and ecosystem all have major implications for humankind.
- At present there are 36 biodiversity hotspots in the world on the basis of threat level, species and endemic richness and previously these hotspots covered 15.7% of the Earth's land surface.
- Due to anthropogenic activities, 86% of hotspots' habitat is destroyed, leading to only 2.3% cover of earth's land surface.Hotspots have lost 70% of their native vegetation and are under severe threat. 50% of the world's plant species and 42% of its terrestrial vertebrate species are found in these 36 biodiversity hotspots.
- There are 4 major biodiversity hot spots present in India. They are Himalaya, Indo-Burma, Sundaland and Western Ghats and Sri Lanka.
- Biodiversity hotspots are very important from conservation point of view; hence they have conservation value, productive value, consumptive value, scientific value, ethical and moral value.
- There are two types of extinction: Background extinction and mass extinction. When several species in a habitat disappear, one of the most pressing issues facing humanity is the extinction of species of plant, animal, or human which requires immediate attention. IUCN red list category has 9 categories and every four years at the IUCN World Conservation Congress, Member Organizations of the Union establish detailed guidelines for the Union's work and other worldwide conservation initiatives.

Self-Assessment

1. How many biodiversity hotspots are present in the world?

a. 13

b. 36

c. 32

d. 23

2. What are the values of biodiversity hotspots?

3. How many hottest hotspots are present in the world?

a. 10

b. 12

c. 8

d. 7

4. Explain two different types of extinction?

5. Explain IUCN red list categories?

6. How many categories are there in IUCN red list?

a. 9

b. 13

c. 10

d. 8

Answers:

1. B
2. See section 1.6
3. C
4. See section 1.8.1
5. See section 1.9.2
6. a

References

CBD (2009). The Convention on Biological Diversity: Year in Review 2009 edited, researched and compiled by Johan Hedlund, CBD Secretariat.

National Wildlife Database (2021). December. Wildlife Institute of India.

Rani, S., Kumari, S., Kumar, P. and Kumar, V. (2021). Biological diversity: Introduction, values, threats and conservation measures. In: Biological Diversity: Current Status and

Conservation Policies, Volume 1, Eds. Kumar., V., Kumar, S., Kamboj, N., Payum, T., Kumar, P. and Kumari, S. pp. 1-23, https://doi.org/10.26832/aesa2021-bdcp-01

Sharma, P.D. (2009) Biodiversity and wildlife of India and its conservation, Ecology and Environment, Rastogi publications.

Sobhana, E., Sujithra, P. Elango, K., Vijayalakshmi, G. and Arunkumar, P. (2021). Climate change and its enormous impacts on global biodiversity. In: Biological Diversity: Current Status and Conservation Policies, Volume 1, Eds. Kumar., V., Kumar, S., Kamboj, N., Payum, T., Kumar, P. and Kumari, S. pp. 77-88, https://doi.org/10.26832/aesa2021-bdcp-05

Sujithra, P., Sobhana, E., Elango, K., Vijayalakshmi, G. and Arunkumar, P. (2021). Protected areas in biodiversity conservation of India: An overview. In: Biological Diversity: Current Status and Conservation Policies, Volume 1, Eds. Kumar., V., Kumar, S., Kamboj, N., Payum, T., Kumar, P. and Kumari, S. pp. 67-76, https://doi.org/10.26832/aesa2021 bdcp-04.

Unit 07: Biodiversity Conservation I

Unit Structure

7.0 Learning Objectives

After the study of this unit, a learner would be able to:

- Know strategies for Biodiversity Conservation
- Explain the in situ and ex situ conservation strategies
- Explain the advantages and disadvantages of conservation strategies
- Various types of in situ conservation methods
- Explain the current status of protected areas

7.1. Introduction

The word biodiversity comes from combination of two words 'Bio means living' and 'diversity means variation'. Hence in simple words the variation among the living beings is called biodiversity. The living beings range from very small size microbes to large size mammals. In the most widely used system of classification these have been divided into 5 main kingdoms: Monera, Protista, Fungi, Plantae and Animalia based on certain common features and are further subdivided into many categories. However, whether small or large organism, each plays a unique role and is important for ecological balance and environment. As per scientific estimates, a large number of organisms have extinct from

the earth since its formation due to various natural processes but in last 100 years the rate of extinction increased due to anthropogenic activities.

Biological diversity is the key foundation of a healthy, livable and sustainable planet but the increasing exploitation coupled with natural calamities has led to the rapid dwindling of important species. Large numbers of organisms are facing loss or extinction due to natural and anthropogenic reasons. It is estimated that 60,000 to 1,00,000 species with diverse economic uses are under threat of extinction and needs to be protected. This necessitates urgent measures to conserve the biodiversity at ecosystem, species and gene pool levels, and to enable sustained use for present and future generations. Conservation refers to the protection, preservation, management and restoration of the landscapes, ecosystems and species. An organism can be conserved in a natural/ artificial habitat or in the form of a germplasm (bacterial cultures, animal tissues, seeds etc.) by employing various methods. A number of efforts have been put forward by various governmental and non-governmental organizations aiming for the conservation of biodiversity. It includes certain in-situ and ex-situ approaches. Emergence of in-vitro technology as an adjunct to ex-situ conservation is being viewed with great expectations for conservation of threatened species. The need of hour is to amalgamate the traditional as well as emerging technologies towards conservation of biodiversity and genetic resources for sustainable development. The first and foremost step required in the direction of biodiversity conservation is about gathering knowledge on the existing biodiversity. It has been stated that the earth inhabits millions of plants and animal species, only a few of which have been identified so far. The taxonomists are required to identify and quantify more and more species so that closer estimates could be build up while measuring the biodiversity loss. Thereafter, appropriate plans and policies should be designed, depending on the habitats, species and conservation priorities. The last step requires the strong implementation of these conservation strategies by enforcing the laws in order to achieve the objective. Also, promoting awareness among the general public about the ongoing overexploitation and its future implications are required. It is also important for all the developed and developing countries to work in coordination, share as much information as they have about the biodiversity in their region and help each other for the realization of this goal.

7.1.1 Biodiversity Hotspots of India

In 1988, Norman Myers a British biologist coined the term "biodiversity hotspot" as a biogeographic region characterized both by exceptional levels of plant endemism and by serious levels of habitat loss. Hotspots comprise different regions on Earth which are biologically rich as well as deeply endangered and are characterized by forests and other remnant habitats which have at least 1,500 vascular plants as endemics. Any area with 30% or less of its original natural vegetation left is characterized as a hotspot. In other words, identification of any region as a hotspot depicts the vulnerability of that region. Around the world, 36 areas have been identified as hotspots. These areas acquire only 2.3% of Earth's land surface, but support more than half of the world's endemic plant species i.e., species which are unique to specific regions on earth. Approximately 43% of bird, mammal, reptile and amphibian species are characterized as endemic species around the world. As per the IUCN criteria, 4 regions in India have been recognized as biodiversity hotspots. These are:

I. **Himalaya:** Includes the entire Indian Himalayan region (and that falling in Pakistan, Tibet, Nepal, Bhutan, China and Myanmar)

II. **Indo-Burma:** Includes entire North-eastern India, except Assam and Andaman group of Islands (and Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China)

III. **Sundalands:** Includes Nicobar group of Islands (and Indonesia, Malaysia, Singapore, Brunei, Philippines)

IV. **Western Ghats and Sri Lanka:** Includes entire Western Ghats (and Sri Lanka)

Temporal Patterns of Biodiversity

Factors and processes related to biodiversity changes over time from ecological to geological scale. The background rates of extinction of various species over geological time can be predicted only up to a certain level by the knowledge of patterns of biodiversity over time. For most of the human history on earth, the global biodiversity has been relatively constant except for the last 1,000 years but the history of life is characterized by considerable change. The estimated background rates of extinction for different species

have been predicted to be roughly 0.1–1.0 extinctions per million species per year. These measurements for the extinction rates of species have been assessed using the length of species' lifetimes through the fossil records that range over 0.5–13 million years. This data is mostly derived from the taxa that are abundant and widespread in the fossil record and thus probably underestimate the background extinction rates.

Threats to Biodiversity

- Habitat Related (Loss, Degradation, Fragmentation)
- Pollution (Chemical, Light, and Noise)
- Overexploitation
- Invasive Species
- Anthropogenic Climate Change
- Disease (lesser threat to most taxa)
- UV radiation (primarily threat to amphibians
- Synergistic Effects of Threats
- Cascade Effects i.e. creation of a trophic cascading domino-like effect or a series of events within an ecosystem in which the primary extinction of a species triggers a sequence of secondary losses or extinctions of other species.

Self-Assessment -1

Very short type answer type questions?

1. What is the impact of human activities on biodiversity?
2. What is the goal of biodiversity conservation?
3. What are the two main approaches to biodiversity conservation?
4. Who coined the term "biodiversity hotspot"?
5. What are the key characteristics of a biodiversity hotspot?
6. How many biodiversity hotspots are identified globally?
7. How many biodiversity hotspots are in India?
8. What are the main threats to biodiversity?
9. What is the impact of the extinction of one species on others

7.2. Protected areas

Protected areas are the regions or zones that reserved for the purposes of conservation of nature and biodiversity. In India, the protected area networks to date are as follows:

The protected area status in India (ENVIS)

Protected area	Status
National parks	106
Wildlife sanctuaries	573
Biosphere reserves	18
Community reserves	220
Conservation reserves	123

Total protected area: 1,78,640.69km² (5.43 % of total geographical area)

7.3. In situ and ex situ strategy, advantages, risk and opportunities

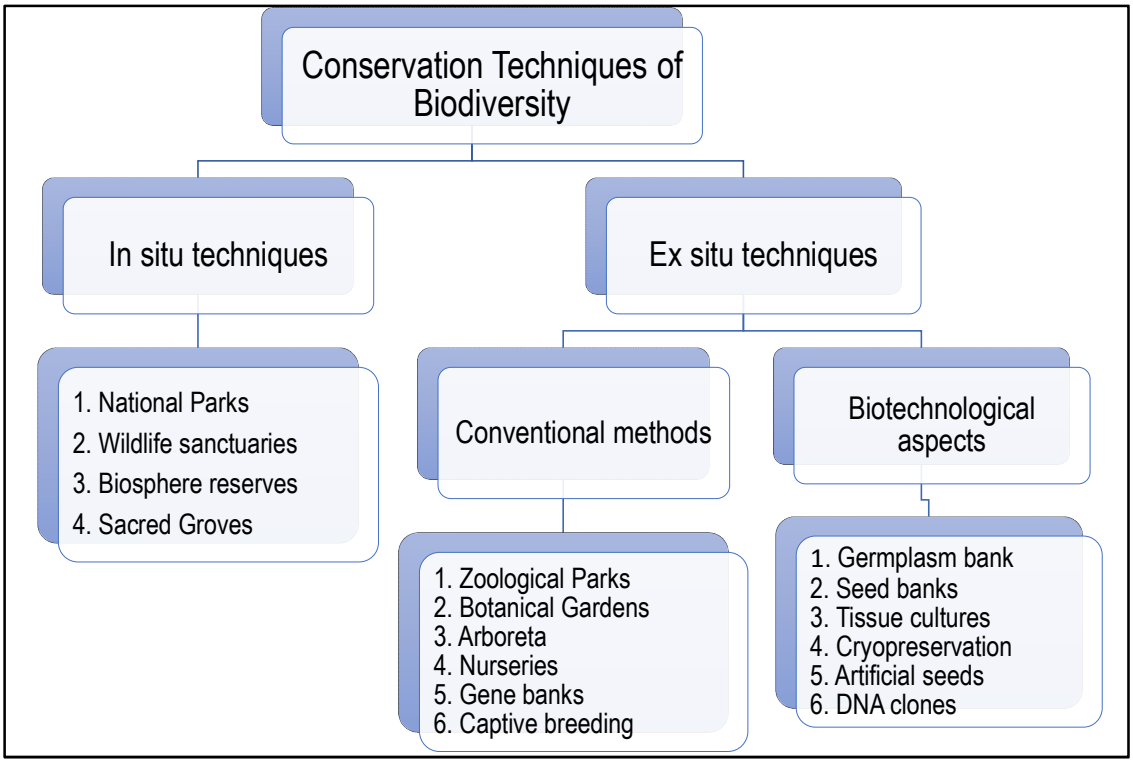
Insitu or "on-site" conservation is the protection of organism in its natural habitat where evolutionary progression continues. The in-situ approach includes protection of a group of typical ecosystems or the regions with high biodiversity through a network of protected areas. These are the terrestrial or marine areas, exclusively meant to protect biological diversity and its allied resources. This is the most appropriate method as the species are being conserved in their natural habitats. It includes National Parks, Wildlife Sanctuaries, Sacred groves, and Biosphere Reserves. Similarly, **Exsitu** or "off-site" conservation refers to the protection of elements of biodiversity outside their natural habitats. In this case, there is a cessation of evolutionary progression, but the desired genes would be preserved. This conservation strategy plays an important role in recovering the endangered species. It is particularly useful in the field of agriculture as the domesticated plants which cannot survive in nature unaided, can be preserved using various Ex situ techniques.

To achieve the conservation of biodiversity through an integrated approach to balance the in situ and ex situ conservation strategies. The conservation of species in situ condition has the advantages to allow the natural selection to act which is not shown by ex situ. The ultimate goal of in situ conservation is to maintain the viable and self-sustainable population of wild species however habitat destruction is unavailable and specially

endangered species need to be conserved before they extinct. However, on the other hand Ex situ conservation provide the chance to study the biology and understand the level of threats to vulnerable and endangered species in reference to eventually consideration of successful species recovery programs like reintroduction and restoration.

Following are the important aspects of in situ conservation

- Protecting habitats by establishing protected areas like national parks, Biodiversity serves and wildlife sanctuaries. These isolated areas are protected from detrimental human activities like overexploitation, deforestation, and pollution, and overexploitation allowing the natural ecosystems to flourish.
- In situ conservation also focuses on the threatened species particularly. The captive breeding programs for critically endangered animals, habitat restoration for migratory birds, or anti-poaching patrols to protect vulnerable populations.
- Role of local communities in in-situ conservation.



Self-Assessment -2

Fill in the blanks with appropriate answers.

1. …… conservation involves protecting organisms in their natural habitats.
2. …… conservation involves protecting organisms outside their natural habitats.
3. Protected areas like…… and …… are examples of in situ conservation.
4. …… conservation can help preserve endangered species.
5. Domesticated plants often require …… conservation to survive.
6. …… continues in in situ conservation.
7. Cessation of evolutionary progression occurs in …… conservation.
8. …… are types of in situ conservation area.

7.3.1 Advantages of In-situ Conservation

- Conservation of Natural Ecosystems
- Natural selection and genetic adaptation to varied environmental conditions and contributed to species resilience.
- Maintaining ecological balance to ensure the continuation of ecological processes such as nutrient cycling, dispersal, and pollination etc.
- Maintain biodiversity for the long-term survival, health and resilience of ecosystems.
- Protection of Keystone Species for the functioning, stability and health of entire ecological communities.
- In situ conservation also supports to preserve the Native Flora and Fauna
- It also promotes the sustainable resource management and land use.
- It also holds the cultural, aesthetic and economic Value.
- It also helps to adapt naturally to Climate Change
- It also provides legal protection and facilitates research and monitoring to access the status and health of ecosystem periodically.

7.3.2 Disadvantages of In Situ Conservation

Despite of several advantages, the in situ have some also potential disadvantages as follow:

- Limited control over external factors like deforestation, pollution and land use pattern.
- Habitat degradation due to anthropogenic and natural disasters.
- Conflict with local inhabitant activities such as logging, agriculture or infrastructure development.
- Threat of invasive species
- Impact of change in climatic condition on species.
- Significant consequences of disease outbreak
- Resource like funding and manpower limitations can affect the monitoring, conservation, and management practices.
- Single-Species (flagship species) Focus neglect the health of entire ecosystem.
- Genetic Diversity reduced due to small and isolated populations within a habitat which make them more vulnerable to environmental effect, diseases, and inbreeding depression.
- Slow Recovery of ecosystem from disturbance.

7.3.3 Advantages of Exsitu Conservation

- Ex-situ conservation protects the genetic diversity outside the natural habitats
- Ex-situ conservation helps recovery of species and breeding.
- It helps in species recovery and breeding (population management)
- It serves as educational resources and opportunities for scientific research on species behavior, biology, and ecology.
- It allows for the conservation of extinct in the wild.
- It ensures a repository the genetic strains of commercially important plants in seed banks
- It is long term cryopreservation techniques help the storage of gametes and seeds

7.3.4 Disadvantages of Ex situ Conservation

Disadvantages of Exsitu conservation is as follow

- In exsitu conservation species kept under controlled conditions that may lose their natural adaptations to specific ecological conditions over time, making them less fit for survival in the wild.
- Maintaining exsitu facilities like suitable care, veterinary facilities, and suitable living conditions, requires significant financial resources.
- It relies on human care.
- It may alter the genetic diversity and species fitness that effect the potential to adapt against the environmental conditions.
- Limited Species Representation: Exsitu facilities may not be able to accommodate all species and genetic diversity present in natural habitats, leading to a biased representation of biodiversity.
- Keeping species in captivity raises ethical concerns linked to their natural behavior, freedom and overall wellbeing. Therefore, balancing conservation strategies with ethical consideration is persistence challenge.
- The reintroduction of species is not so successful due to predation, habitat suitability and competition.

Self-Assessment -3

Ture and False

1. In situ conservation involves protecting species in their natural habitats.
2. Genetic adaptation is a disadvantage of in-situ conservation.
3. In situ conservation can contribute to climate change adaptation.
4. Habitat degradation is a disadvantage of in situ conservation.
5. In situ conservation always ensures the successful recovery of ecosystems from disturbances.
6. Ex situ conservation protects species outside their natural habitats.
7. Ex situ conservation can be expensive to maintain.
8. Ex situ conservation always guarantees successful reintroduction of species into the wild.
9. Genetic diversity can be reduced in ex-situ conservation due to limited space and resources.
10. Ethical concerns are not associated with Ex situ conservation.

7.4. National parks

National Parks are protected areas under government, secluded from any kind of human interference. These are the small reserves meant for the protection of wild life and their natural habitats. Activities like grazing, forestry etc. are not permitted in these areas.

Some Major National Parks in India

1. Gir National Park, Gujrat
2. Jim Corbett National Park, Uttrakhand
3. Kaziranga National Park, Assam
4. Bandipur National Park, Karnataka
5. Tudula national Park, Maharashtra
6. Kanha National Park, Madhya Pradesh
7. Manas National Park, Assam
8. ReibulLamjao National Park, Manipur

7.5. Wildlife Sanctuary

The Wildlife Sanctuaries are bounded to conserve the wild flora and fauna. Similar to National Parks, these are also government owned areas, but limited human activities such as harvesting of timbers, collection of forest products, cultivation of lands etc. are allowed in wildlife sanctuaries as long as these do not interfere with the wild environment.

Some Wildlife Sanctuaries in India

1. Bandipur Wildlife Sanctuary, Karnataka
2. Bhitarkanika Wildlife Sanctuary, Orissa

3. Gibbbon Wildlife Sanctuary, Assam

4. Dachigam Wildlife Sanctuary, Jammu and Kashmir

5. Sunderbans Wildlife Sanctuary, West Bengal

6. Keoladeo Bird Sanctuary, Rajasthan (Now converted to National Park)

7. Periyar Wildlife Sanctuary, Kerela

8. Mundanthurai Wildlife Sanctuary, Tamil Nadu

7.6. Biosphere Reserves

Biosphere Reserves, on the other hand are a special category of protected areas of land, where people are an integral component of the system. A biosphere reserve consists of a core, buffer and transition zones. The natural or core zone represents an undisturbed or least disturbed area of representative ecosystem. The buffer zone surrounds the core zone, and is managed for research, education and training activities. The transition zone is an area of active cooperation between reserve management and the local people. Its goal is to facilitate the conservation of biodiversity, foster sustainable economic and human development and to provide support for research, monitoring, education and information. Nine of the 18 Biosphere Reserves in India are included in UNESCO Man and the Biosphere Program list.

List of Biosphere Reserves in India

1. Nilgiri Biosphere Reserves, Western Ghats (1986)

2. Nandadevi Biosphere Reserves, Uttrakhand (1988)

3. Nokrek Biosphere Reserves, Meghalaya (1988)

4. Gulf of Mannar Biosphere Reserves, Tamil Nadu (1989)

5. Sunderbans Biosphere Reserves, West Bengal (1989)

6. Manas Biosphere Reserves, Assam (1989)

7. Great Nicobar Biosphere Reserves, Andaman and Nikobar Islands (1989)

8. Simlipal Biosphere Reserves, Odisha (1994)

9. Dibru-Saikhowa Biosphere Reserves, Assam (1997)

10. Dehang-Dibang Biosphere Reserves, Arunachal Pradesh (1998)

11. Panchmarhi Biosphere Reserves, Madhya Pradesh (1999)
12. Khangchendzonga Biosphere Reserves, Sikkim (2000)
13. Agasthyamalai Biosphere Reserves, Western Ghats (2001)
14. Achanakamar-Amarkantak Biosphere Reserves, Madhya Pradesh (2005)
15. Kuchchh Biosphere Reserves, Gujrat (2008)
16. Cold desert Biosphere Reserves, Himachal Pradesh (2009)
17. Seshachalam Biosphere Reserves, Andhra Pradesh (2010)
18. Panna Biosphere Reserves, Madhya Pradesh (2011)

7.7. Conservation Reserves

The preservation of the land, sea, and habitat of flora and fauna close to National Parks and sanctuaries. These are state-owned region managed by Conservation Reserve Management Committee. Any property controlled by the government may be considered as a conservation reserve by the state government after discussing it with nearby communities. There are 123 conservations reserves in India. some major conservation areas are as follows:

S.No.	Name of Conservation Reserve	State
1	Chharidhandh Conservation Reserve	Gujarat
2	Bir Bara Ban Conservation Reserve	Haryana
3	Saraswati Plantation Conservation Reserve	Haryana
4	Khiram Conservation Reserve	Jammu and Kashmir
5	Panyar Conservation Reserve	Jammu and Kashmir
6	Asan Barage Wetland Conservation Reserve(Bird)	Uttarakhand
7	Jhilmi Jheel Conservation Reserve (Bird)	Uttarakhand
8	Pawalgarh Conservation Reserve	Uttarakhand
9	Naina Devi Himalayan Bird	Uttarakhand
10	Darlaghat Conservation Reserve	Himachal Pradesh
11	Shilli Conservation Reserve	Himachal Pradesh
12	Shri Naina Devi Conservation Reserve	Himachal Pradesh

7.8.Community reserves

Any community or private land may be selected as a community reserve by the State Government. The concerned people of that community provided consent to such areas for the conservation of the local flora and fauna along with the culture, customs and practices. It is managed by a community reserve management committee. At present, there are 220 active community reserves in India.

State-wise break up of Community Reserves (Source: https://wii.gov.in)

State & UT	State Area (km²)	No. of Com R	Area(km²)	% of State Area
Arunachal Pradesh	83743	9	131.6	0.157
Bihar	94163	1	0.57	0
Haryana	44212	5	115.84	0.262
Karnataka	1,91,791	1	3.12	0.002
Kerala	3,88,63	1	1.5	0.004
Manipur	22327	11	112.6	0.464
Meghalaya	22,429	74	141.69	0.632
Nagaland	16,579	114	851.78	5.138
Punjab	50,362	4	96.46	0.191
	TOTAL	**220**	**1455.16**	**0.043**

Self-Assessment -4

Multiple choice Questions:

1. What is the primary purpose of national parks?
   A) To promote tourism and economic development
   B) To protect wildlife and their natural habitats
   C) To provide recreational facilities for the public
   D) To conduct scientific research
2. Which of the following activities is generally prohibited in national parks?
   A) Hiking and trekking
   B) Camping and picnicking
   C) Grazing and forestry
   D) Wildlife photography
3. What is the main difference between National Parks and Wildlife Sanctuaries?

A) National parks have more diverse wildlife
B) National parks are larger in size
C) Wildlife sanctuaries allow limited human activities
D) Wildlife sanctuaries are only for birds

4. Which of the following is a biosphere reserve in India?

A) Gir National Park
B) Jim Corbett National Park
C) Sunderbans
D) Keoladeo Bird Sanctuary

5. What is the core zone of a Biosphere Reserve?

A) An area of active cooperation between reserve management and local people
B) An area managed for research, education, and training
C) A buffer zone surrounding the core zone
D) An undisturbed or least disturbed area of representative ecosystem

6. What is the main goal of Biosphere Reserves?

A) To protect wildlife from poaching
B) To promote sustainable development and biodiversity conservation
C) To generate revenue for the government
D) To control pollution

7. Which wildlife sanctuary was converted into a national park?

A) Keoladeo Bird Sanctuary
B) Periyar Wildlife Sanctuary
C) Bandipur Wildlife Sanctuary
D) Dachigam Wildlife Sanctuary

8. Which national park is known for its one-horned rhinoceros?

A) Kaziranga National Park
B) Jim Corbett National Park
C) Gir National Park
D) Bandipur National Park

9. Assertion (A): Wildlife sanctuaries allow limited human activities.

Reason (R): Wildlife sanctuaries are government-owned areas where activities like harvesting timber and cultivation are permitted.

A) Both A and R are true, and R is the correct explanation of A.

B) Both A and R are true, but R is not the correct explanation of A.

C) A is true, but R is false.

D) A is false, but R is true.

10. Match the following National Parks with their respective states:

List (A)	List (B)
A) Gir National Park -	(I) Assam
B) Kaziranga National Park	(II) Maharashtra
C) Tudula National Park	(III) Gujrat
D) Kanha National Park	(IV) Madya Pradesh

A) A- I; B – II, C = III, D = IV

B) A- II; B – I, C = IV, D = III

C) A- III; B – I, C = II, D = IV

D) A- I; B – III, C = II, D = IV

Summary

- Biodiversity, a term derived from "bio" meaning life and "diversity" meaning variation, encompasses the variety of living organisms ranging from tiny microbes to large mammals. This variation is classified into five main kingdoms: Monera, Protista, Fungi, Plantae, and Animalia, with further subdivisions. Each organism, regardless of its size, plays a unique role in maintaining ecological balance. Historically, extinction rates were steady, but in recent decades, human activities have significantly accelerated the rate of extinction. Current estimates suggest that between 60,000 to 100,000 species face threats of extinction, emphasizing the urgent need for conservation efforts at the ecosystem, species, and genetic levels.

- Conservation strategies are categorized into Insitu and Ex situ approaches. In-situ conservation involves protecting species within their natural habitats, such as national parks, wildlife sanctuaries, and biosphere reserves. This method allows natural evolutionary processes to continue and maintains ecological balance. On the other hand, ex-situ conservation involves protecting species outside their natural environments, such as in botanical gardens or seed banks, which is crucial for recovering endangered species and studying their biology. Both approaches are necessary for a comprehensive conservation strategy, each with its own set of advantages and disadvantages.

- India is home to several biodiversity hotspots, regions rich in endemic species but under significant threat. The four recognized hotspots in India are the Himalaya, Indo-Burma, Sundalands, and Western Ghats and Sri Lanka. These areas are critical for global biodiversity, supporting a substantial portion of the world's endemic species.

- Temporal patterns of biodiversity reveal that while global biodiversity has been relatively stable over most of human history, recent changes in extinction rates have been dramatic. The background extinction rate is estimated to be between 0.1 and 1.0 extinctions per million species per year, though actual rates may be higher due to the limitations of fossil records.

- Threats to biodiversity are multifaceted, including habitat loss and degradation, pollution, overexploitation, invasive species, climate change, disease, and UV radiation. These threats often interact synergistically, creating complex challenges for conservation.

- Protected areas play a crucial role in biodiversity conservation. In India, there are various categories of protected areas including national parks, wildlife sanctuaries, biosphere reserves, conservation reserves, and community reserves. National parks are highly protected zones where activities like grazing and forestry are prohibited. Wildlife sanctuaries allow limited human activities but still prioritize conservation. Biosphere reserves integrate human development with conservation

efforts, consisting of core, buffer, and transition zones to support biodiversity while fostering sustainable development.

- Conservation reserves and community reserves are additional categories aimed at preserving habitats and involving local communities in conservation efforts. Conservation reserves are managed by government bodies and are located near national parks and sanctuaries, while community reserves are designated on private or community lands with local consent.

- In conclusion, conserving biodiversity requires a balanced approach integrating both Insitu and Exsitu methods, along with international cooperation and local community involvement. Efforts to protect and manage the diverse ecosystems and species are vital for maintaining the health and sustainability of our planet.

Terminal Questions

1. Explain the Biodiversity?
2. Discuss the Biodiversity Hotspots in India?
3. What are the threats to Biodiversity?
4. Differentiate between the In situ and Ex situ conservation.
5. What are the advantage and disadvantages of In situ and Ex situ conservation??
6. Discuss the methods of In situ biodiversity conservation.
7. What are protected areas?

Answer Keys

Self-Assessment 1:1- Increased extinction rates; 2 - Protection, preservation, and restoration of ecosystems; 3- In-situ and ex-situ; 4- Norman Myers; 5 - High endemism and significant habitat loss; 6 – 36; 7 – 4; 8- Habitat loss, pollution, overexploitation, invasive species, climate change, disease; 9 - Cascade effects

Self-Assessment 2: 1- In situ; 2 - Ex situ; 3- national parks, wildlife sanctuaries; 4- Ex situ; 5 - Ex situ; 6 – Evolutionary progression; 7 – Ex situ; 8- Biosphere reserves

Self-Assessment 3: 1- True; 2 - False; 3- True; 4 - Ture; 5 - False; 6 – False; 7 – True; 8- False; 9 – Ture; 10 – False

Self-Assessment 4: 1- B; 2 - C; 3- C; 4 – C; 5 - B; 6 – B; 7- A; 8- A; 9 – A; 10 – C

References

- **Biodiversity and Conservation:**Strategies of Biodiversity Conservation; Module Id EVS/BC-III/03 Paper No: 03 Biodiversity and Conservation

  Module: 21Strategies of Biodiversity Conservation

- https://parikshamanthan.in/what-is-ex-situ-and-in-situ-conservation/

- www.wiienvis.nic.in (accessed on September, 2024).

- https://wii.gov.in/nwdc_community_reserves

Unit 08: Biodiversity Conservation II

Unit Structure

8.0 Learning Objectives

After the study of this unit, a learner would be able to:

- Discuss the various conservation and management practices
- Discuss community-based conservation
- Explain the importance of traditional Ecological Knowledge
- Explain the role of Traditional Knowledge
- Discuss the traditionally conserved areas in India
- Explain the sacred groves and its importance

8.1. Introduction

In the previous chapter we discussed about the biodiversity hotspot, threat, need, strategies, advantages and disadvantages of In situ and Ex situ conservation in detail. Biodiversity and Environmental conservation are interallied subjects and can be treated as synonyms as the conservation of biodiversity will eventually have a positive effect on environmental conservation. Biodiversity defines the variation at the genetic, species and ecosystem level. The distribution of biodiversity is not even and is concentrated at the tropical forest and hotspots. The nature has created a balance between the biodiversity and the ecosystem that includes all form of life from aerial to land dwellers and marine life forms. This chapter is dedicated to discuss conservation and management practices, importance of traditional knowledge and traditionally conserved area in India.

With a total land area of 329 million hectares, India is the seventh largest country in the World and the second largest in Asia. The rich and diverse flora was supported by the enormous diverse habitats caused by the climatic and geographic dynamic of India. Due to the variation in agroclimatic conditions, India support the growth of a wide variety of plant and animal species. However, the nation faces a serious threat from the loss of biodiversity. Most people agree that deforestation is the primary cause of the current crises, and that it also contributes to global climate change, shifting agriculture, soil erosion, and uncontrolled expansion of urban areas.To preserve biodiversity for future generations, immediate, coordinated action is required due to the current rate of extinction.

Both In situ and Ex situ techniques could be used to conserve biodiversity. The productive and valuable biological resources are essential to long term, sustainable economic growth. The people living in rural areas always think that biodiversity is essential to their survival and means of subsistence. It is in our own best interests to preserve biodiversity, as sectors including waste management, horticulture, construction, pharmaceuticals, cosmetics, pulp and paper, and agriculture and agro-industries rely on biological resources. In developing nations, 70–80% of the populace uses plants exclusively for medical purposes.

8.2. Conservation and management practices

Conservation is defined as the protection, preservation, management, or restoration of natural environments and inhabited communities. Whereas, Management refers to the techniques/methods used to achieve conservation goals and ensure sustainable use of natural resources.

8.2.1. Objectives of Conservation and Management

The main objectives include the conservation of biodiversity, maintenance of ecosystem services, preventing habitat loss, and to ensure the sustainable use of natural resources.

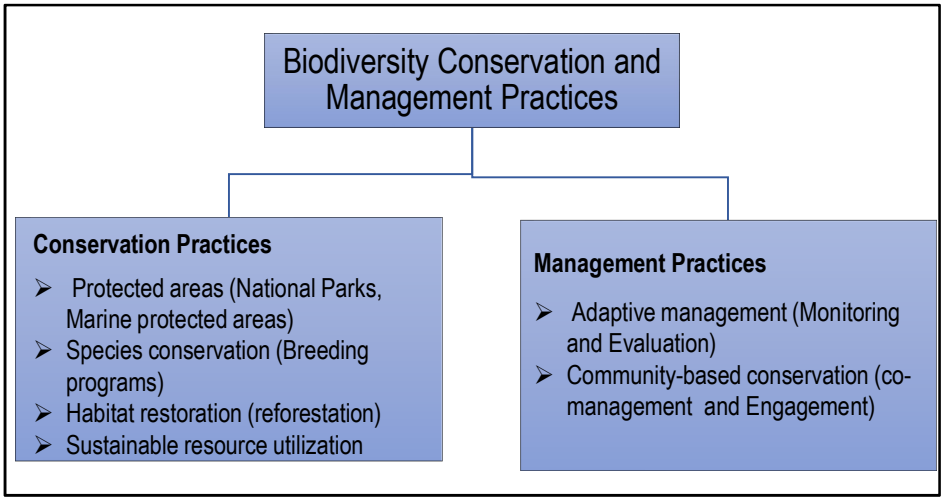
8.2.2. Conservation Practices

Various conservation methods such as protected areas, species conservation through breeding programs, habitat restoration and sustainable resource utilization have been adopted to preserve the ecosystem biodiversity as discussed below:

I. Protected Areas

Protected areas are the regions or zones where human interference is restricted to preserve the nature and biodiversity (Balmford et al., 2003). These are

- National Parks
- Wildlife reserves
- Marine protected Araes (MPAs)



II. **Species Conservation:** It is focused effort to protect the individual species especially those at verse of extinction. The conservation strategies include breeding programs, habitat restoration, and anti-pouching measures (involvement of a group of people that regularly patrol specific area to reduce or stop hunting or any other activities related to biodiversity loss). The government of India has adopted various species-based conservation programs as follow:

- Project Tiger
- Project Snow leopard
- Project Elephant
- Crocodile conservation
- Himalayan Musk Deer conservation programme

III. **Habitat restoration:** Habitat restoration is aimed at restore the destroyed and degrade habitats to their natural state**.** The method includes like reforestation, removal of invasive species and wetland restoration. There are three ecosystem

restoration project is going on to heal the degraded habitat due to human activities, climate change and urbanization. These are

- Sundarbans Mangrove Restoration (to protect the World's Largest Mangrove Forest, West Bengal, India)
- The Thol Lake Ecosystem restoration, Gujrat, India.
- Restoration of the forest landscape of Western Ghats, Maharashtra, India.

IV. Sustainable Use of Resources: Management of natural resources to meet current needs without negotiating the need of future generations. It includes sustainable forestry, agricultural, soil quality restoration, and fisheries management practices.

8.2.3. Management Practices

The goal of management practices of ecosystem is to manage the biodiversity and natural resources by maintaining the ecosystem functioning, processes, and services.

I. **Adaptive Management:** It is a systematic approach for enhancing resource management through the analysis of results subsequently adapting strategy with modification (Walters. 1986). The processes involved in adaptive management included monitoring, evaluation, and correcting management options based on generated information. It can be achieved by assessing the forest and wildlife species to monitor, evaluate and develop conservations and management strategies accordingly.

II. **Community-Based Conservation (CBC):** Comprehensive strategies for management of biodiversity and protection of natural resources to ensure its sustainable use by involving the local communities into the management and protection of natural resources. In conservation initiatives, this technique reinforces the value of indigenous knowledge and participatory governance by giving local populations the authority to manage their ecosystems. This approach harbor a coexistence between humans and nature for future generations by bridging the gap between conservation aims and socio-economic growth. There are five leading community-based conservation (CBC) projects with details are as follow:

- ***Bugunliocichla* Conservation:** *Bugunliocichla*is a native bird of Arunachal Pradesh with endangered conservation status. The Bugun tribe community form Singchung villages is playing important role for the conservation of this bird in the area.
- **Mangrove Forest Conservation:** The dominant biodiversity along the Indian coastline that which are adapted to grow in harsh environmental conditions likw inadequate soil oxygen. With due efforts of coastline states (Andhra Pradesh, Maharashtra, Gujarat, Goa, Tamil Nadu, Odisha, Karnataka and West Bengal), research institutions with major contribution of local communities, various mangrove restoration efforts have been successfully accomplished. Approximately, 2025 ha of destroyed mangrove have been restores in the coastline states which is only possible with the efforts of coastline communities.
- **Khasi Hills Community:** In Meghalaya, about 80% of forest is owned by indigenous communities especially the Khasi community. The Khasi Hill Community REDD+ project have been initiated in 2007 to protect and restore the forest along with the watersheds and sacred grooves.
- **Olive Ridley Turtle (ORT)** project established by Sahyadri Nisarga Mitra (SNM), Maharashtra to protect the eggs and Hatchlings of fa marine turtle.
- **Yaongyimchen Community Biodiversity Conservation (YCBCA) Project**, Nagaland established in 2012 with biggest achievement of complete cessation of hunting activities to protect the biodiversity.

III. **Integrated Coastal Zone Management (ICZM):** For the management of coastal areas to balance the environmental, social, economic and cultural aim. Major components of ICZM includes coastal planning, habitat preservation, pollution control, and community engagement (Cicin-Sain and Belfiore, 2005).

Challenges in Conservation and Management: Major challenges hinder the conservation and management program to executes are:

- Habitat Fragmentation
- Climate Change

- Overexploitation of resource
- Conflicting interests to balance conservation with social and economic needs.

Self-Assessment -1

Very short type answer type questions?

1. What does biodiversity encompass?
2. Which type of conservation focuses on protecting individual species at risk of extinction?
3. Name one of the primary causes of the biodiversity lose in India.
4. Which project in India focuses on the conservation of tigers?
5. What is the goal of adaptive management in ecosystem management?
6. What does community-based conservation (CBC) emphasize in biodiversity management?
7. Which conservation project aims to restore the mangrove forest in West Bengal?
8. What is the main objective of habitat restoration?
9. Which coastal management approach aims to balance environmental, social, economic, and cultural goals?

8.3. Traditional Ecological Knowledge

Traditional Ecological Knowledge (TEK) refers to the collected, existed knowledge and practices of indigenous and local communities concerning the environment. This knowledge is transferred orally through cultural practices like crafts, arts and ceremonies form generations to generation and strictly associated with cultural practices, traditions, and spiritual beliefs (Finn et al., 2017). It includes the understanding of ecosystems, conservation and management practices and species behavior that are often tailored to specific local environments. It includes the understanding of ecosystems, conservation and management practices and species behavior that are often tailored to specific local environments (Berkes, 2018).

Components of TEK

TEK denotes an inherently dynamic form of information which is continuously restructured or updated with successive generations (Berkes et al., 2000). The TEK of local communities is decreasing with this ongoing addition in long-term change. The drivers and

dynamics of TEK loss are multidimensional and complex. Globalization, the charm of westernization among indigenous communities and economic aspects are the major factors responsible for the widespread loss of cultural and language beliefs along with the destruction of traditional social-ecological systems (Turvey et al., 2018). However, the TEK is constituted with the following different components as discussed in Figure 1.

Importance of Traditional Ecological Knowledge (TEK)

The TEK and scientific knowledge altogether is very important to predict the impact near and long-term climate change effect. TEK is beneficial in various aspects as discussed below:

- TEK in climate change adaptation
- TEK in Natural resource management
- TEK in predicting future climatic conditions
- TEK in conservation of biodiversity

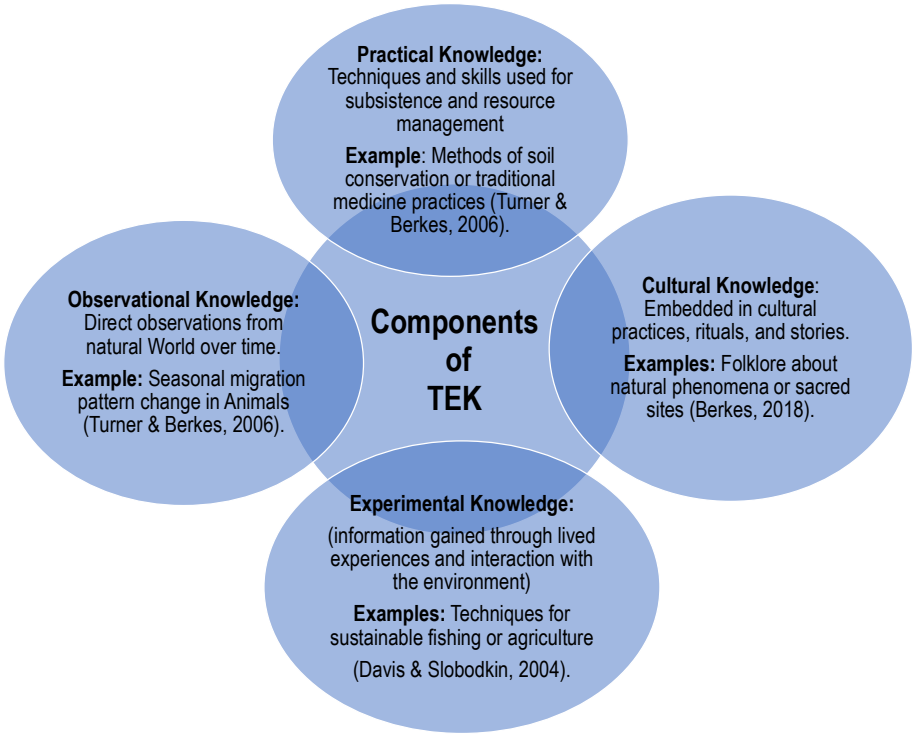


Figure 1. Components of Traditional Ecological Knowledge

Challenges with TEK

- Integration of TEK with scientificknowledge to enhance sustainable Environmental management strategies (Davis & Slobodkin, 2004).
- The knowledge of native communities must be appreciated and protected i.e., respect the Intellectual property(Turner & Berkes, 2006).
- The conservation and documentation to prevent loss due to cultural changes (Berkes, 2018).

8.4 Role of Traditional Knowledge

The wisdom, customs and abilitiescultured over many generations by indigenous and local communities are collectively referredas Traditional Knowledge (TK). This knowledge is typically transmitted orally or through practice and has its roots in cultural customs and traditions. It plays vital role in differentaspects of life such as cultural preservation, social cohesion,and environmental management (Figure 2). The significance of traditional knowledge in biodiversity conservation are discussed below:

Environmental Management: TK contributed significantly in sustainable natural resource management tailoredto local environmental conditions.

Preservation of culture: TK supports to conserve cultural practices, languages, rituals and traditional arts of the particular region.

Health and Medicine: Traditional knowledge is the basis of herbal, Unani and ayurvedic preparation and formulation for treating illness following holistic approach.

Agricultural Practices: TK involves traditional farming techniques for sustainable agriculture to improvecrop productivity, soil fertility, crop rotation, organic farming, and reduce soil erosion.

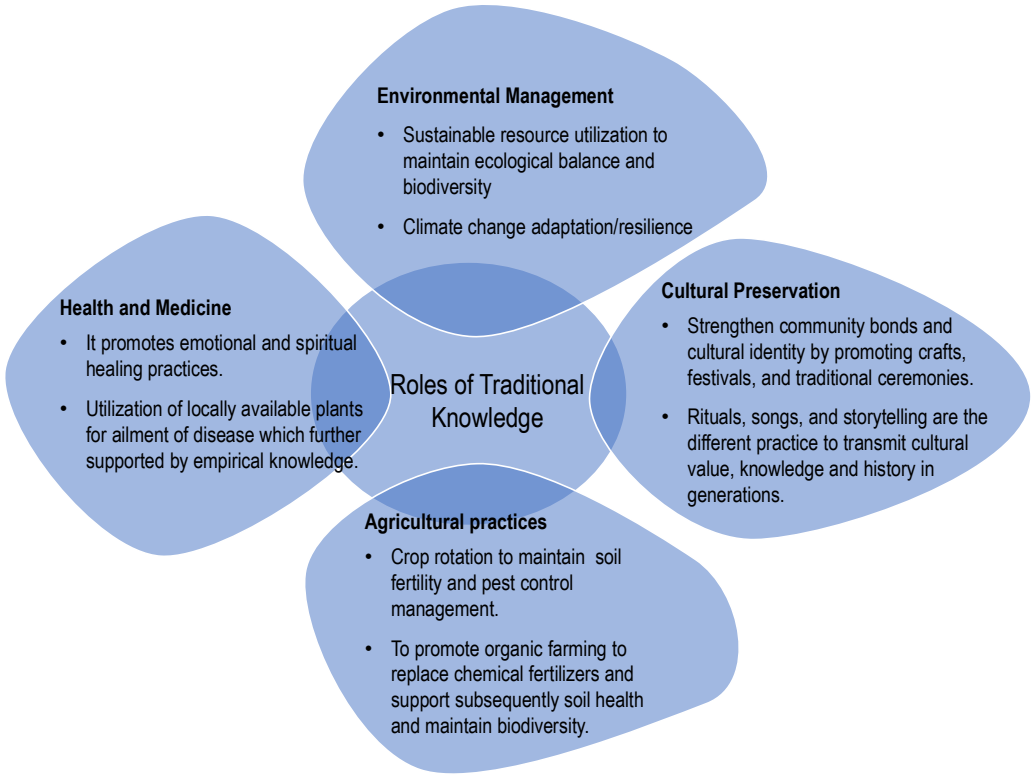


Figure 2. Importance of Tradition Knowledge

TK and Convention on Biological Diversity (CBD)

The Convention on Biological Diversity (CBD) is the principal international body that recognizes the importance of traditional knowledge, practices and innovations of indigenous communities in biodiversity conservation and its sustainable development. The Article 8(j) of the CBD is about preserving, maintaining and respecting the knowledge, practices and innovations indigenous and local communities. This article also encourages the wider application of such practices and the equitable sharing of benefits utilized from the innovations, knowledge and practices (Kannaiyan, 2007).

Biopiracy

The rights of traditional communities over their biological resources and associated knowledge are being violated. Biopiracy has both ethical and commercial ramifications: In order to get monopolistic control over biological resources, associated traditional knowledge, or commercial goods based on these resources or knowledge, one must

typically obtain intellectual property rights (IPRs) or plant breeders' rights (PBRs). This is done without the approval of, or benefiting from, the original holders of the resources or information. The original owners of traditional knowledge and biological resources are not entitled to a portion of the revenues from the commercialization of products manufactured using their resources. Additionally, they receive no credit for first creating and growing the resources and information (Kannaiyan, 2007).

Benefit sharing and Traditional Knowledge (TK)

The Arogyapacha case is the best illustration of benefit-sharing in India. A group of scientists discovered the Kani custom of consuming the seeds of the wild plant *Trichopus zeylanicus* to obtain energy in Western Ghats, Kerala. For many years, the Kani tribe has usedthe plant known locally as "Arogyapacha" to aid them during times of physical strain. After researching Arogyapacha, a standardized medication based on Kani was eventually created. In 1995, the medication known as "Jeevani" was approved for commercial manufacturing. As part of their agreement to transfer drug production technology to a pharmaceutical company, the Tropical Botanic Garden and Research Institute (TBGRI) decided to split the license fee 50/50. Moreover, the tribal community will receive 2% of the royalties from sales. After that, the Kani family received assistance in setting up a trust. The Kani tribe owns and operates this trust in its entirety. Approximately 60% of Kerala's Kani families (2,000) are currently beneficiaries of this trust (Kannaiyan, 2007).

Indian Acts for the protection of Traditional Knowledge (TK)

India implicated some new laws for protection of tradition/indigenous knowledge and bio-resources as follows:

- The Geographical Indications of Goods - Registration and Protection Act, 1999.
- The Protection of Plant Varieties and Farmer’s Rights Act, 2001.
- The Biological Diversity Act, 2002.
- The Patent (Second Amendment) Act, 2002.

Self-Assessment -2

True and False

1. Traditional Ecological Knowledge (TEK) is exclusively transferred through written documentation.
2. The loss of Traditional Ecological Knowledge (TEK) is solely due to environmental factors.
3. Traditional Knowledge (TK) is important for biodiversity conservation but not for environmental management.
4. Biopiracy involves the ethical and commercial exploitation of biological resources and associated traditional knowledge without the approval of the original holders
5. The Convention on Biological Diversity (CBD) does not address the preservation of traditional knowledge.
6. Biopiracy involves exploiting biological resources and traditional knowledge without proper approval or benefit-sharing with the original holders.
7. Traditional Knowledge (TK) has applications in health and medicine, including the use of herbal and ayurvedic preparations.
8. The Geographical Indications of Goods - Registration and Protection Act, 1999, is one of the Indian laws aimed at protecting traditional knowledge.
9. Traditional Knowledge (TK) includes modern scientific methods and techniques.
10. Traditional Ecological Knowledge (TEK) is inherently dynamic and continuously updated over time.

8.5. Traditionally conserved areas in India

Traditionally conserved areas can be defined as the landscapes and ecosystems managed by local or indigenous communities using age-old customs and cultural practices. These areas embody a harmonious blend of ecological stewardship and cultural heritage, reflecting a deep integration of historical knowledge with sustainable environmental management. Traditionally conserved zones have progressed over centuries through the collective understanding and practices of local and indigenouscommunities. These regions often direct a continuous historical tradition in land management, guided by traditional ecological knowledge (TEK) that encourages the sustainable use and conservation of natural resources. Traditional practices may include ritual protection of sacred spaces, sustainable resource harvesting methods, and the establishment of management rules

based on detailed observations of ecological patterns and species interactions. The management of these areas is governed by cultural norms and customary lawsthat regulate resource utilization and conservation efforts. These practices are based on a profound understanding of local ecosystems, encompassing species relationships, seasonal variation, and overall ecological dynamics. Policies employed in these areas frequently involve rotational resource utilization, designation of protected or sacred zones, and monitoring and enforcement through communities. Such approaches drive to conserve ecological balance and ensure the long-term sustainability of both cultural and natural systems.

India's rich cultural traditions and diverse ecologicalgive rise to a variety of traditionally conserved zones that are vital for conserving both its natural and cultural heritage. These conserved areas are managed through time-tested customs and practices that play a crucial role in maintaining the ecological balance of the country and cultural integrity.Traditionally protected areas in India are more than just natural resources; they are symbols of the underlying moral principles and religious convictions of the communities that manage them. They are a living example of how humans and the environment have historically interacted, providing a model for conservation that balances environmental stewardship with cultural reverence.In India, traditionally conserved areas include different types such as sacred groves, protected landscapes and community-managed forests. Sacred grovesare the forest areas preserved due to their association with local deities or spiritual entities. These groves, found throughout the Indian subcontinent, serve as crucial reservoirs of biodiversity, safeguarding numerous rare and threatened species. Their management is governed by strict cultural norms that prevent the exploitation of both plant and animal life, thereby significantly contributing to conservation efforts.In India, community-managed forests, sometimes referred to as Van Panchayats or Community Forest Management (CFM), are a group approach to resource management. Local laws and ordinances that support conservation and sustainable use control these forests. Using traditional ecological knowledge to preserve ecological balance and guarantee resource sustainability, indigenous and local communities are essential to the management and governance of these woods.

Sacred Groves

Sacred forests also known as sacred groves. Any forest that is valued as sacred or areas of forest that are guarded by the local people as a result of their long-standing cultural, religious, and traditional customs and beliefs. In India, religious beliefs and indigenous communities have a big impact on the natural world. Numerous tribes that reside in isolated villages rely solely on the resources found in the forest for their subsistence. Urbanization and development projects are altering the belief system of indigenous particularly about religion and customs, which is causing an alarming rate of deforestation and biodiversity loss, respectively.

Characteristics of sacred forest/groves

- Sacred grove is undisturbed forest that is traditionally protected by the indigenouscommunities as a whole or part and rich in biodiversity.
- The area of sacred groves may vary from few square meters to hectares.
- These sacred forests are dedicated to local divinities.
- People think that any kind of disruption will anger the local deity, which will result in illnesses, natural disasters, or crop failure.
- There are regional differences in the level of holiness assigned to the sacred groves. Even the dry leaves and fallen fruits remain untouchable in certain forests.
- The Wildlife (Protection) Amendment Act, 2002 established "community reserves," which provide legal protection for sacred groves.
- Within these patches, hunting and logging are typically strictly forbidden.

Significance of sacred groves

- The sacred grove is a traditional way for the tribal people to honor the local deities and preserve the forest.
- Many rare, endangered, and endemic species are protected by sacred groves.
- Sacred groves are significant repositories of diverse flora and fauna that have been sustainably preserved by nearby communities
- The vegetation covers in sacred groves reduces soil erosion and increases the soil stability.

- The holy groves are frequently connected to springs, ponds, or streams that fulfil the water demand of indigenous people therefore, the vegetation cover affect the as a result, sacred groves' vegetative cover aids in replenishing the aquifers.

There are many sacred groves found in India, some of them are mentioned below:

- Aravali Hills, Rajasthan
- Chanda and Bastar, Madhya Pradesh
- Khecheopalri Lake, Sikkim
- Khasi and Jaintia Hills, Meghalaya
- Western Ghats, Karnataka, Maharashtra

8.6. Case studies

Various traditional conservation efforts have been taken by indigenous people across India (Pathak, 2009). Some of them are discussed below:

State	Community/ Villages involved	Contribution to the conservation
Community conservation of Forest ecosystems		
Maharashtra	Gond tribal community of Mendha villages	The community started protection and de facto control over 1800 hectares of forest in the last 20 years.
Uttarakhand	Jardhargaon village	Preserved 600-700 hectares of forest, and revitalized various varieties of agricultural crops.
Uttarakhand	Makku van panchayat	Protecting around 10000 hectares of high-altitude pasture lands and forest.
Assam	Shankarghola village	Preserving the forests where the critically endangered golden langur lives
Nagaland	Various tribes of Khonoma village	They conserved the forest and wildlife reserves including a people's sanctuary for the endangered Blyth's tragopan.
Manipur	Ronmei tribe of Tokpa Kabui village	Preserved in the Loktak Lake catchment.
Community conservation of wetland, coastal and marine habitats		
Uttar Pradesh	Amakhera village, Aligarh district	Traditional wetlands conservation used for fishing and irrigation purposes
Uttar Pradesh	Sareli village, Kheri District	Protection of heronries birds by supporting nesting population of over 1000 openbill storks
Bihar	Patna Lake, Etah District	Community involved the protection of sacred

		pond for centuries
Karnataka	KokkareBellur	Villagers are safeguarding against poaching and unfair treatment, and occasionally even giving up their tamarind crop to prevent disturbing nesting birds.
Tamil Nadu	Local Communities around the Chittarangudi tank	Attracts migratory birds such as ibises, storks, egrets, cormorants and herons. The villagers forbid stealing or hunting of bird eggs. They stay away from commercial fishing and don't explode crackers during Diwali.
Orissa, Kerala and Goa	Coastal communities	Protecting critical habitat for coastal species including sea turtle breeding beaches in Orissa, Goa and Kerla, and Mangroves in Orissa.
Community conservation for protection of individual species		
Rajasthan	Bishnoi community	The communities famous for their long-standing conservation traditions and are renowned for their selfless defence of wildlife and forests. Because of the significance of the Bishnois for wildlife, they have been designated as the Abohar Sanctuary. Chinkara and blackbuck are common at all the Bishnoi sites.
Orissa	Buguda village, Ganjam District	For centuries, locals have been guarding blackbuck. The villages were also awarded a the Chief Minister's Award for wildlife conservation.
Rajasthan	Khichan village	Up to 10,000 demoiselle cranes spend their winters in the area, and the locals spend up to money every year feeding them grains.
Arunachal Pradesh	Buddhist Morpa community in Sangti Valley	in has co-existed with the endangered blacknecked cranes for generations, viewing them as a harbinger of better rice yields.
Kerala, Goa, and Orissa	Kolavipaalam (Kerla), Galgibag and Morjim (Goa), Rushikulya and Gokharkuda (Orissa)	Fisherfolk communities are protecting sea turtle eggs, hatchlings, and nesting sites.
Manipur	Youth clubs from the villages around Loktak Lake	have formed the Sangai Protection Forum to conserve the greatly endangered brow-antlered deer, which is endemic to this wetland. They take part in the management of the KeibulLamjao National Park, which forms the core of the lake.
Conservation sites for the protection of sacred groves		
Rajasthan	Sacred desert forests (orans)	The Gram Sabhas, or village assemblies,

		are normally in arid areas Rajasthan. Orans play a significant role in replenishing aquifers in arid regions, where each and every drop of water is valuable. The dominating tree, Khejari, is revered in most orans, especially in western Rajasthan, for its tremendous importance. The tree enhances soil nitrogen, and its bark is mixed with flour and consumed during famines and droughts.
Meghalaya (Khasi Hills)	Khasi tribe	The Khasi hills comprise with rivers, groves, trees, and forests, serve as the foundation for the region's nature worship rituals. The Khasi people hold that sacred creatures like tigers bring prosperity, happiness, and well-being, and that anyone who disturbs the forest will decease. The inhabitants of Thaianing think that because their ancestors destroyed their forest, "good luck"—the tiger—left, which resulted in hardship because there were insufficient amounts of wood, water, medicinal plants, and fertile soil.
Maharashtra	Bhimashankar, Ahupedeorai, Ajeevali village in Pune	Bhimashankar Wildlife Sanctuary, Harishchandragad Wildlife Sanctuaries manages a protected site for both spiritual and commercial reasons.
Sikkim	Rathong Chu/ Khangchendzonga valley	The entire valley are often considered as sacred regions to protect the biodiversity.

Self-Assessment 3

Multiple choice Questions:

1. What is a characteristic feature of sacred groves in India?

A) They are strictly commercial logging areas.

B) They are protected due to their association with local deities.

C) They are managed by the central government.

D) They are used exclusively for agricultural purposes.

2. Which of the following regions is NOT mentioned as having sacred groves?

A) Aravali Hills

B) Khasi and Jaintia Hills

C) Himalayan Mountains

D) Western Ghats

3. Which Indian state is known for the community-managed forests called "Van Panchayats"?

A) Maharashtra

B) Uttarakhand

C) Assam

D) Tamil Nadu

4. The Wildlife (Protection) Amendment Act, 2002 in India established which of the following?

A) National Parks

B) Wildlife Sanctuaries

C) Community Reserves

D) Marine Protected Areas

5. Which community in Rajasthan is renowned for its long-standing conservation traditions and defense of wildlife?

A) Buguda

B) Bishnoi

C) Gond

D) Ronmei

6. Match the following Indian states (List I) with their traditional conservation practices (List II) and select the correct option:

List I	**List II**
A. Maharashtra	**I.** Sacred groves in arid regions
B. Meghalaya	**II.** Protection of sacred forests
C. Sikkim	**III.** Community-managed forests
D. Rajasthan	**IV.** Sacred valley conservation

A) A- I; B – II, C = III, D = IV

B) A- II; B – I, C = IV, D = III

C) A- I; B – II, C = IV, D = III

D) A- I; B – III, C = II, D = IV

7. Match the following communities (List I) with their conservation efforts (List II) and choose the correct option

List I	List II
A. Ronmei tribe	1) Preservation of Loktak Lake
B. Bishnoi community	2) Protection of blackbuck
C. Khasi tribe	3) Conservation of sacred groves
D. Youth clubs around Loktak Lake	4) Protection of endangered species

A) A- III; B – I, C = II, D = IV

B) A- II; B – I, C = IV, D = III

C) A- I; B – II, C = III, D = IV

D) A- I; B – III, C = II, D = IV

8. **Assertion:** Sacred groves in India are considered highly important for biodiversity conservation.

Reason: Sacred groves are protected by cultural norms that prevent exploitation, which helps in preserving rare and endangered species.

A) Both Assertion and Reason are correct, and Reason is the correct explanation for Assertion.

B) Both Assertion and Reason are correct, but Reason is not the correct explanation for Assertion.

C) Assertion is correct, but Reason is incorrect.

D) Assertion is incorrect, but Reason is correct.

9. **Assertion:** Community-managed forests in Uttarakhand are managed using Traditional Ecological Knowledge (TEK).

Reason: This approach promotes sustainable resource use and conservation by involving local communities in decision-making.

A) Both Assertion and Reason are correct, and Reason is the correct explanation for Assertion.

B) Both Assertion and Reason are correct, but Reason is not the correct explanation for Assertion.

C) Assertion is correct, but Reason is incorrect.

D) Assertion is incorrect, but Reason is correct.

Summary

- This chapter delves into conservation strategies and the value of traditional ecological knowledge in India, with a focus on the country's diverse biological resources, which are critically endangered by deforestation and habitat loss. The rich array of plant and animal species in India is essential for both sustainable development and the sustenance of rural communities. Immediate and comprehensive conservation measures are crucial to protect these vital resources for future generations.
- The primary objectives of conservation and management are to safeguard biodiversity, sustain ecosystem services, mitigate habitat loss, and promote the sustainable utilization of natural resources. Biodiversity conservation strategies encompass the establishment of protected areas, execution of species-specific breeding programs, habitat restoration initiatives, and the adoption of sustainable resource management practices.
- Protected areas are defined zones with restricted human activity aimed at preserving natural ecosystems and biodiversity, encompassing categories such as national parks, wildlife reserves, and marine protected areas (MPAs). In India, significant initiatives include Project Tiger, Project Snow Leopard, Project Elephant, Crocodile Conservation, and the Himalayan Musk Deer Conservation Program.
- Habitat restoration focuses on rehabilitating degraded and destroyed ecosystems to their natural conditions. This process involves techniques such as reforestation, removal of invasive species, and wetland restoration. Currently, three significant ecosystem restoration projects are addressing habitat degradation caused by human activities, climate change, and urbanization.
- Ecosystem conservation management aims to maintain biodiversity and natural resources by safeguarding ecosystem functions and services through various key practices. **Adaptive Management** involves a systematic process of monitoring,

evaluating, and adjusting strategies based on new data to improve conservation outcomes. **Community-Based Conservation (CBC)** engages local communities in managing and protecting natural resources, integrating indigenous knowledge and participatory governance, as demonstrated by projects like the BugunLiocichla Conservation and mangrove restoration efforts. **Integrated Coastal Zone Management (ICZM)** balances environmental, social, economic, and cultural objectives in coastal areas through holistic planning and community engagement.

- Traditional Ecological Knowledge (TEK) encompasses the accumulated wisdom and practices of indigenous and local communities related to the environment, transmitted orally through cultural traditions and spiritual beliefs.
- Traditional Knowledge (TK), passed down through generations, is integral to environmental management, cultural preservation, health and medicine, and agricultural practices, providing sustainable resource management, cultural continuity, holistic healthcare, and effective farming techniques tailored to local conditions.
- Sacred groves, or sacred forests, are forested areas protected by local communities in India due to cultural, religious, and traditional beliefs passed down through generations. These groves, varying in size from small patches to extensive areas, are dedicated to local deities, and disturbances are believed to invoke divine displeasure, leading to natural calamities or crop failures. Sacred groves are vital for preserving biodiversity, protecting rare and endemic species, reducing soil erosion, and replenishing water sources. They are legally recognized under the Wildlife (Protection) Amendment Act, 2002, and examples include sacred groves in the Aravali Hills, Chanda and Bastar, Khecheopalri Lake, Khasi and Jaintia Hills, and the Western Ghats.

Terminal Questions

1. Explain Conservation and Management practices?
2. What is individual species conservation program? Discuss.
3. How can we restore any degraded habitat? Discuss.
4. What is Community- based Conservation? Explain with the help of examples.
5. What are the challenges in Conservation and Management Practices?
6. Discuss the Traditional Ecological Knowledge.

7. What isthe importance of traditional knowledge?
8. Define the sacred groves and its importance.

Answer Keys

Self-Assessment 1: 1 - Biodiversity encompasses genetic, species, and ecosystem variation; 2 - Species conservation; 3 - Deforestation; 4 - Project Tiger; 5 - The goal of adaptive management is to enhance resource management by analyzing results and adapting strategies accordingly; 6 - CBC emphasizes involving local communities in the management and protection of natural resources; 7 - Sundarbans Mangrove Restoration; 8 - The main objective of habitat restoration is to return destroyed and degraded habitats to their natural state; 9 - Integrated Coastal Zone Management (ICZM).

Self-Assessment 2: 1 – False; 2 – False; 3 - False; 4 - True; 5 – False; 6 – False; 7 – True; 8 – True; 9 – False; 10 – True

Self -Assessment 3: 1 – B; 2 - C; 3 – B; 4 – C; 5 – B; 6 – C; 7 – C; 8 – A; 9 - A

References

Balmford, A., Rodrigues, A. S. L., Walpole, M., & L. M. (2003). Global variation in terrestrial protected area coverage. *Global Ecology and Biogeography*, 12(4), 223-230.

Berkes F, Colding J, Folke C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications*, 10, 1251–1262.

Berkes, F. (2018). Sacred Ecology: Traditional Ecological Knowledge and Resource Management. Routledge.

Cicin-Sain, B., & Belfiore, S. (2005). Linking marine protected areas with integrated coastal and ocean management. *Marine Policy*, 29(3), 221-232.

Davis, M. A., &Slobodkin, L. B. (2004). The Science and Management of Traditional Ecological Knowledge. *Ecological Applications*, 14(1), 123-132.

Finn, S., Herne, M. and Castille, D., (2017). The value of traditional ecological knowledge for the environmental health sciences and biomedical research. *Environmental Health Perspectives*, 125(8), p.085006.

https://thinkwildlifefoundation.com/5-leading-community-based-conservation-projects-in-india/IUCN Protected Area Categories (International Union for Conservation of Nature).

Kannaiyan, S. (2007). Biological diversity and traditional knowledge. In Paper circulated for discussion at the National Consultation Workshop on Agro biodiversity Hotspots and Access and Benefit Sharing (pp. 19-20).

Pathak, N., (2009). Community conserved areas in India: an overview. Community Conserved Areas in India: a Directory, pp.45-94.

Turner, N. J., & Berkes, F. (2006). Local Ecological Knowledge and Resource Management: A Case Study of the Gitga'at First Nation. *Environmental Science & Policy*, 9(1), 20-28.

Turvey, S.T., Bryant, J.V. and McClune, K.A., (2018). Differential loss of components of traditional ecological knowledge following a primate extinction event. *Royal Society Open Science,* 5(6), p.172352.

Walters, C.J. (1986). Adaptive Management of Renewable Resources. Macmillan.

Unit 9: Biodiversity and Climate Change

Unit Structure

9.0 Learning Objectives

On completion of this unit you should be able to understand about:

- Biodiversity and climate change
- Biodiversity's vulnerability to climate change
- Significance of biodiversity in mitigation and adapting to climate change
- Impacts on seasonal life cycle events due to climate change
- Management approaches to the consequences of climate change on biodiversity

9.1 Introduction

As is well known, climate has a significant impact on many aspects of human existence and acts as the primary source of several biological processes that span from people to ecosystems. As a result, the biological and societal systems might be significantly and probably severely influenced by climate change. The biosphere and biodiversity in terrestrial and marine conditions are changing due to climate change, which additionally impacts ecosystem functioning and ecosystem resistance to change. The benefits that people receive from ecosystems are impacted by this. Reducing the important ecological

and socioeconomic effects of biodiversity loss brought on by climate change is a matter of critical importance.

There is a relationship between biodiversity and climate change. Considering their relationship, it appears that mitigating climate change and biodiversity loss will be major concerns for mankind in the twenty-first century. Although biodiversity is negatively impacted by climate change, which has an adverse effect on human well-being, biodiversity also plays a significant role in mitigating and adapting to climate change through ecosystem services. On the other side, there is a substantial impact of climate change on biodiversity, including evolution, restructuring, regional adjustments, and events of extinction. Thus, an effective approach on biodiversity and climate change is required to ensure that:

(i) There is a decrease of an impact of climate change on biodiversity.

(ii) Ecosystems and biodiversity combined can offer options for mitigating and adapting to climate change.

(iii) Modifications in land management brought about by climate change adaptation and mitigation strategies do not adversely affect biodiversity.

Keeping above in view, this unit explores how vulnerable biodiversity is to the effects of climate change, how these effects are linked to one another, and how biodiversity contributes to climate change mitigation and adaptation.

9.2 Biodiversity and Climate Change

Considering that biodiversity is impacted by climate change and that changes in biodiversity have an impact on climate change, the problems of biodiversity and climate change are interrelated.

It additionally indicates that minor adjustments to terrestrial and marine emission sources and sinks can have significant effects on atmospheric CO_2 concentrations. In addition to reducing ocean sinks, anthropogenic climate change, which is primarily caused by the accumulation of greenhouse gases in the atmosphere from land use changes and fossil fuels, may cause the overall natural carbon cycle to shift towards annual net carbon dioxide emissions from terrestrial sinks. Therefore, even slight variations in the ocean's

and land's CO_2 sources and sinks may have a significant impact on the amount of CO2 in the atmosphere.

As previously stated, ecosystems serve an extensive variety of goods and services like food and fiber, regulating floods and climate change, cultural like recreation and aesthetics, and sustaining like soil formation functions. These essential services include safety and security, social cooperation, food and nutritional security, human wellness, and means of subsistence. Even though ecosystems are naturally more biologically diverse and carbon thick, many ecosystems are degrading to the point where their capability to accumulate and sequester carbon is being significantly decreased. This leads to increased greenhouse gas emissions and a loss of genetic, species, and ecosystem biodiversity.

Ecosystems are under continual strain as a result of climate change, which also contributes to the adverse effects of other challenges including pollution, excessive use, invasive species, degradation and loss of habitat, and pressure from population growth. Through the decline of biodiversity, climate change is continuously changing the biosphere on both large and small scales in terrestrial and marine environments. It is leading to changes in ecosystems' and species' geographic distribution as well as increased risks of mortality. On the other hand, biodiversity increases the resilience of ecosystems and helps in adaptation and mitigation of climate change.

The occurrence of important life events is one way that observed changes in temperature are already affecting biodiversity at the species and ecosystem levels. Changes in temperature have led biodiversity to adapt, either by modifying lifecycles, relocating habitats, or evolving new physical characteristics. One emerging field that focuses on these changes is called "climate change biology." As a result of climate change, species' ranges are expanding. It has changed species interactions that are responsible for the most significant biotic changes associated with climate change. A few of them are:

(i) All tropical reefs have seen bleaching, which is a change in the symbiotic interaction between corals and their algae brought on by increased water temperatures.

(ii) A shift in bark beetle appearance caused by temperature has resulted in severe tree mortality linked to outbreaks of the insect. Therefore, species range alterations or the effects of shifting relationships or phenology have reorganized whole ecosystems.

Climate change increased the following trends:

- Range changes from pole to upslope, leading to the growth and extinction of new ecosystems.
- Loss of habitat spread of invasive species, and opening and closure of pathways.
- Significant losses to marine and freshwater ecosystems; alterations to the timing of biological processes.
- An increase in sensitivity to pests, catastrophes caused by nature, and alterations in habitat.

Furthermore, the potential of biodiversity to provide ecosystem services would be negatively impacted by climate change. Additionally, the local economy and way of life will be affected as a result of climate change. Many development goals will be hampered by these negative effects, which are likely to have an adverse effect on the well-being of the poor and other vulnerable groups including women, local and indigenous communities, and biodiversity.

According to the Intergovernmental Panel on Climate Change (IPCC) Working Group II (WGII) on Impacts, Adaptation, and Vulnerability's Fifth Assessment Report (AR5), "recent modifications to the climate have had adverse impacts on natural and human systems on every continent and in all oceans in the world." This conclusion is unambiguous. According to the research, natural systems exhibit the most consistent and complete evidence of the implications of climate change.

However, healthy ecosystems and biodiversity are also essential assets for boosting resiliency and mitigating the risks and losses related to the adverse effects of climate change. They can act as naturally occurring resistance against severe climate and weather conditions including shifting rainfall patterns, droughts, storms, and other calamities. There are additional alternatives for adjusting to a changing environment in industries that are

interconnected and diverse. Production methods built on ecosystems minimize greenhouse gas emissions and dependency on artificial inputs. In the face of climate change, it will be crucial to create fish, cattle, and plant species resistant to disease, drought, and salt.

In addition to benefiting biodiversity, initiatives to preserve and restore ecosystems also provide practical, affordable ways to mitigate the effects and adjust to climate change. Globally large carbon reserves are found in ecosystems such wetlands, agriculture, peat soils, forests, and grazing lands. As a result, they are essential to achieving the Paris Agreement under the United Nations Framework Convention on Climate Change, which is a worldwide commitment to reducing the risk of hazardous alterations to the Earth's atmospheric climate and temperature system. Their conservation, restoration, and sustainable use have been included in many Intended Nationally Determined Contributions.

Self-Assessment -1

Multiple choice Questions:

1. What is the primary source of biological processes that climate affects?
   A) Economic factors
   B) Human activities
   C) Climate
   D) Technology

2. How does climate change primarily impact biodiversity?
   A) By enhancing species adaptation
   B) By increasing species interactions
   C) By leading to extinction events
   D) By promoting ecosystem stability

3. Which of the following is NOT a service provided by ecosystems mentioned in the text?
   A) Climate regulation
   B) Aesthetic enjoyment
   C) Food security
   D) Genetic engineering

4. What does "climate change biology" study?
A) The effects of climate on human health
B) The adaptation of species to climate changes
C) Economic impacts of climate change
D) Technological solutions for climate change

5. Which of the following is a consequence of climate change mentioned in the text?
A) Changes in species' geographic distribution
B) Decreased water temperatures
C) Increased biodiversity
D) Enhanced ecosystem services

6. Match the following Ecosystem services (List I) with its benefits (List II) and choose the correct option

List I	List II
A) Flood regulation	I. Provides food for communities
B) Nutritional security	II. Enhances community well-being
C) Cultural aesthetics	III. Prevents loss of land
D) Soil formation	IV. Supports agricultural productivity

A) A= I; B= II, C = III, D = IV
B) A= III; B= I, C = II, D = IV
C) A= I; B= II, C = IV, D = III
D) A= I; B= III, C = II, D = IV

7. Match the following Climate change effect (List I) with its consequence (List II) and choose the correct option

List I	List II
A) Increased temperatures	I. Altered species interactions
B) Invasive species spread	II. Increased drought risk
C) Changes in precipitation	III. Altered species interactions
D) Habitat loss	IV. Ecosystem restructuring

A) A = I; B = II, C = III, D = IV
B) A = III; B = I, C = II, D = IV
C) A = IV; B = I, C = II, D = III
D) A = I; B = III, C = II, D = IV

8. **Assertion:** Biodiversity plays a significant role in mitigating climate change.
   Reason: Ecosystems can provide services that help absorb carbon dioxide.
   A) Both assertion and reason are true, and the reason is the correct explanation for the assertion.
   B) Both assertion and reason are true, but the reason is not the correct explanation for the assertion.
   C) The assertion is true, but the reason is false.
   D) The assertion is false, but the reason is true.

9. **Assertion:** Healthy ecosystems are crucial for reducing the risks of climate change.
   Reason: Climate change has no impact on human systems.
   A) Both assertion and reason are true, and the reason is the correct explanation for the assertion.
   B) Both assertion and reason are true, but the reason is not the correct explanation for the assertion.
   C) The assertion is true, but the reason is false.
   D) The assertion is false, but the reason is true.

10. **Assertion:** Ecosystem degradation leads to increased greenhouse gas emissions.
    Reason: Biodiversity loss does not affect climate systems.
    A) Both assertion and reason are true, and the reason is the correct explanation for the assertion.
    B) Both assertion and reason are true, but the reason is not the correct explanation for the assertion.
    C) The assertion is true, but the reason is false.
    D) The assertion is false, but the reason is true.

9.3 Biodiversity's vulnerability to climate change and its impact assessment

Climate change is already having an effect on biodiversity, particularly in some of its most vulnerable environments. In order to provide an overview of how climate change is influencing biodiversity and ecosystem services globally, the second AHTEG on

biodiversity and climate change reviewed the body of scientific literature that is currently accessible, including reports from the Intergovernmental Panel on Climate Change (IPCC). The Fifth Assessment Report (AR5) is the most recent report published by the IPCC. According to the AR5, all continents and oceans have experienced effects from climate change, with ecosystems suffering the most. Below are some examples of certain expected impacts on species and ecosystems: (source: IPCC (2014 a, b)

- Several terrestrial plant and animal species are experiencing changes in abundance, range growth, and periodic activity.
- A significant number of freshwater and terrestrial species will be more vulnerable to extinction.
- Sea level rise makes coastal habitats more vulnerable to erosion, floods, and sinking.
- Rises in ocean temperatures have led to significant shifts in the distribution patterns of several species and affected the composition of ecosystems.
- Cloud forests, mangroves, coral reefs, alpine and Arctic ecosystems, and freshwater aquatic habitats and wetlands are some of the ecosystems that are most impacted by the effects of climate change.
- It has been determined that endemic and montane species are more vulnerable due to their small geographic and climatic ranges, lack of options for variation, and severity of other stresses.

According to the report of the Second AdHoc Technical Expert Group on Biodiversity and Climate Change, natural ecosystems and species have already been negatively affected by changes in atmospheric CO_2 levels and climate. A 0.75ºC increase in the average worldwide temperature at the surface from before the Industrial Revolution is a modest amount of climate change compared to the 2.0–7.5ºC predicted changes by 2100 in the absence of aggressive mitigation measures. However, several species and ecosystems have shown the ability to adapt naturally, while others have begun to demonstrate negative impacts.

According to data from the Intergovernmental Panel on Climate Change's Fourth Assessment Report (IPCC AR4), "within the range of probable future scenarios based in impacts assessments (typically <5°C global temperature rise), approximately 10% of species assessed at this point will be at an increasingly serious threat of extinction for every 1°C rise in global mean temperature." Extended climate change will have serious negative effects on many ecosystems and the services they provide, effects that are frequently irreversible and have a significant negative social, cultural, and economic impact. It is yet unresolved though, how quickly and to what degree climate change will affect ecosystem services and biodiversity, as well as the points beyond which ecosystems may forever shift.

Self-Assessment - 2

Fill in the blanks with appropriate answers.

1. Climate change is already having an effect on biodiversity, particularly in some of its most _____ environments.
2. The second AHTEG on biodiversity and climate change reviewed the body of scientific literature from the _____.
3. The Fifth Assessment Report (AR5) is the most recent report published by the _____.
4. According to the AR5, all continents and oceans have experienced effects from climate change, with _____ suffering the most.
5. A significant number of freshwater and terrestrial species will be more vulnerable to _____.
6. Sea level rise makes coastal habitats more vulnerable to _____, floods, and sinking.
7. Rises in ocean temperatures have led to significant shifts in the distribution patterns of several species and affected the composition of _____.
8. Endemic and montane species are more vulnerable due to their small geographic and climatic _____.

9. A 0.75ºC increase in the average worldwide temperature at the surface is considered a modest amount of climate change compared to the _____ predicted changes by 2100.
10. Approximately _____ of species assessed will be at an increasingly serious threat of extinction for every 1°C rise in global mean temperature.

9.4 The Significance of Biodiversity in Mitigation and Adapting to Climate Change

Both mitigating and adapting to climate change may be significantly helped by biodiversity. Attempts to mitigate the adverse consequences of climate change can be enhanced by biodiversity. Because conserved or restored ecosystems store carbon, they can mitigate climate change by removing carbon dioxide from the atmosphere. One way to mitigate the catastrophic consequences of climate change, including floods and hurricanes, is to conserve whole ecological systems, like mangroves. Increased ecological structural resistance to environmental changes, including protracted droughts, can be attributed to biodiversity.

However, several kinds of recent climatic changes, including as rising temperatures and an increase in the frequency of major floods and droughts, are affecting biodiversity throughout a wide range of taxonomic groups and biomes, including mountains, oceans, and forests. It has frequently been demonstrated that modifications to the environment and disturbances to ecosystems, such as the loss of biodiversity, boost the probability of viral and other developing diseases, as well as wildlife species that pose threats to people, livestock, and crops. Hunting is one example of a direct human activity that may accelerate how climate change affects biodiversity.

Ecological and socioeconomic elements associated with the issue must be understood for sustainable management to be effective, and all governmental levels must have policies that make sense. A thoughtful restoration project, community-based initiatives that benefit the local economy or other factors, and/or suitable incentives to promote more sustainable land-use practices are examples of potential solutions.

Specifically, maintaining biodiversity and its sustainable use can boost resilience to natural disasters by protecting coastlines, controlling flooding, and protecting ecosystem services and goods like food, clean water, and raw materials. For instance, adaptation related to agricultural biodiversity is predicted to prevent 10–15% of the yield declines that are anticipated as a result of changing climatic scenarios. It is vital to take care of biodiversity and ecosystem services against the adverse consequences of climate change, as their degradation will ultimately end in more costly and less sustainable adaptation attempts.

Ecosystem-based approaches for adaptation to climate change (EBA) are an important means of connecting the conservation, restoration, and sustainable use of biodiversity and ecosystem services with climate change adaptation. These links are among the numerous ones that exist between biodiversity and climate change. According to the Second Ad Hoc Technical Expert Group (AHTEG) on Biodiversity and Climate Change, "use of ecosystem services and biodiversity integrated into an overall adaptation strategy can be economically viable and generate social, economic, and cultural additional advantages and contribute to the conservation of biodiversity."

It is generally accepted that living things have a part in the creation and absorption of greenhouse gases. General circulation models already account for the effects of climate change, such as shifts in the volume of tropical forests and phytoplankton in the oceans. Ecologists accept that the global biota is already altering due to climate change. It has an impact on the amount and distribution of different species, the timing of plant and animal reproduction, the migration patterns of wildlife and birds, and the frequency and severity of pest and disease outbreaks. It is the movement of species from lower latitudes to higher elevations. There is danger for immovable species.

In the meanwhile, ecosystems' capacity to adjust to climate change is being impacted by shifts in the global biota due to many factors. The adaptability of many ecosystems has been reduced when they are streamlined to make them more "useful" to humans. Humans have decreased the ability of many ecosystems to function in the event that climatic circumstances change through the elimination of species that are "overlapping" with present climatic conditions and their present usage.

Self -Assessment - 3

Very short answers type questions?

1. How does biodiversity help mitigate climate change?
2. What role do mangroves play in climate change mitigation?
3. What are the recent climatic changes affect biodiversity?
4. How does biodiversity loss affect disease risks?
5. What are proposed solutions for sustainable biodiversity management?
6. How can agricultural biodiversity aid climate adaptation?
7. What are ecosystem-based approaches for adaptation?
8. How does climate change impact species distribution?

9.5 Impacts on Seasonal Life Cycle Events due to Climate Change

The environment has a significant impact on ecosystems through the climate. Several factors, including climate change, influence the ecosystems. For example, rising temperatures may compel certain species to shift to higher altitudes or latitudes where survival conditions are better. The same is true for freshwater systems; when sea levels rise, saltwater intrusion may drive some important species to move or go extinct, eliminating important predators or prey from the current food chain.

Ecosystems and species are not the only things that are directly impacted by climate change; it also interacts with other human stresses like development. According to the IPCC (2014), stressors can have significant ecological effects even when they only have a little effect when they operate alone.

Many species' annually life cycles, including migration, flowering, and reproduction, are influenced by the environment in which they reside or spend in an area of the year. In certain regions of the country, the timing of these occurrences has impacted due to shorter and warmer winters:

- On the US East Coast, early springs have caused 28 migrating bird species to nest earlier (IPCC, 2014).

- As stated by CCSP (2008) in compared to a century ago, birds from the Northeast are returning north 13 days before in the spring after spending the winter in the southern United States.
- Around 16 out of 23 butterfly species changed the time of their migration and arrived earlier, according to a California research (CCSP, 2008).

The different capabilities of species to adapt might lead to asynchronies, which increase the vulnerability of both species and ecosystems. Mistakes in the timing of mating, migration, avoiding pests, and food availability are a few examples of these asynchronies. Migrants that arrived at an area either before or after food supplies become available have a decreased chance of growth and survival (CCSP, 2008 and USGCRP, 2014).

Many North American species are shifting northward and upward in their home ranges as temperatures rise. Plants and animals have migrated to higher altitudes in both terrestrial and aquatic environments in recent decades at a median keeping up of 36 feet (0.011 kilometers) each decade, and to higher latitudes at a median rate of 10.5 miles (16.9 kilometers) per decade. Some species may see an expansion of their range as a result, but others may experience a reduction in their range, migration into less hospitable habitat, or increased competition. Some species may even become extinct as a result of living at the top of a mountain or at the northernmost point of land which is suitable for their habitat (USGCRP, 2014 and USGCRP, 2009). In certain places, these forces cause localized extinctions of both flora and animals. Consequently, by 2100, it is predicted that the ranges of vegetative biomes would shift across 5–20% of the US territory (USGCRP, 2014).

As an example, the invasion of tundra by boreal forests restricts the habitat for several rare species, such caribou, arctic foxes, and snowy owls, which are depend on this environment. Additional changes observed in the United States consist of a shift in the boundaries between temperate broadleaf and conifer forests in Vermont's Green Mountains, a shift in the boundaries between shrub land and conifer forests in New Mexico, and an upward shift in the boundaries between temperate mixed and conifer forests in Southern California.

9.6 Management Approaches to the Consequences of Climate Change on Biodiversity

The distributions, dynamics, and interconnections of species and ecosystems will alter significantly as a result of climate change and how it relates with human biosphere alterations.

It is important to find out how human or natural systems might be adapted or adjusted. Examples of such systems include protected areas, common conservation techniques, and the interdependent nature of land and marine environments. To emphasise the advantages of maintaining ecosystems for the fundamental services they offer to humans, the concept of ecosystem-based adaptation is developed and explored.

The structure, function, and availability of services in ecosystems may experience significant changes due to the rise of invasive species. In this case, the introduction of the jellyfish-like carnivorous ctenophore *Mnemiopsis leidyi* to the Black Sea resulted in the extinction of 26 important fishery species and has been linked, among other things, to the subsequent expansion of the oxygen-depleted "dead" zone.

Reversing deforestation and appropriately implementing reforestation could make significant contributions to climate mitigation and protection of biodiversity. Major reductions in greenhouse gas emissions and improved. The Reduced Emissions from Deforestation and Degradation (REDD+) program has significant potential in mitigating greenhouse gas emissions resulting from deforestation in tropical and subtropical regions. The direct consequences of climate change on biodiversity must be taken into account, as well as the beneficial indirect benefits of REDD + and the adverse indirect effects of producing biofuels.

Reducing non-climatic challenges together with conservation, restoration, and sustainable management techniques can increase biodiversity's ability to resist climate change. While some of the negative effects of climate change should be mitigated by conservation and management measures that protect and restore biodiversity, there will be some rates and scales of climate change for which natural adaptability will become more challenging. In

the face of increased climate change, options to improve species' and ecosystems' ability for adaptation include:

- Minimizing non-climatic stresses including pollution, excessive usage, invasive species, habitat loss, and fragmentation.
- Increased use of sustainable use and conservation techniques, especially by fortifying protected area networks.
- Enhancing monitoring and evaluation frameworks to support adaptive management.
- Assisted migration, reproduction in captivity ex-situ germplasm storage, and relocation may all help to maintain a species' ability to adapt.

Self -Assessment - 4

True or False

1. Rising temperatures due to climate change may force some species to move to higher altitudes or latitudes.
2. Sea level rise has no impact on freshwater systems.
3. According to the IPCC, human stressors can amplify ecological effects of climate change.
4. Birds in the Northeast United States are nesting later in the spring compared to a century ago.
5. A study in California found that 16 out of 23 butterfly species migrated earlier due to climate change.
6. All species are equally capable of adapting to climate change, preventing any asynchronies in life cycles.
7. By 2100, it is expected that the ranges of vegetative biomes in the US may shift across 5–20% of the territory.
8. The introduction of invasive species can have beneficial effects on native ecosystems.
9. The REDD+ program aims to reduce greenhouse gas emissions resulting from deforestation.

10. Increasing pollution is a non-climatic stress that can help biodiversity adapt to climate change.

Summary

- This unit has covered biodiversity and climate change, as well as their interactions. Additionally, management techniques for reducing the effects on biodiversity and climate change were covered.
- The richness and variety of life, including organisms, genetic material, and ecosystems, is referred to as biodiversity. People can obtain essential ecosystem products and services from biodiversity. In addition to services like nutrient cycling, erosion management, climate adjustment, and air and water purification, it offers commodities like food, fibre, and medication.
- Additionally, biodiversity is crucial to the economic sectors of forestry, fisheries, tourism, and agriculture that stimulate growth. Human livelihoods are dependent on forests, non-timber forest products (such as fruit from trees), marine and coastal biodiversity, and forests.
- In order to provide for their families, a large number people primarily rely on the availability of productive land, water, plants, and animals. Ecosystem services vital to human well-being, including food production, clean water, pest management, and erosion prevention, are made possible by biodiversity. Wetlands, forests, and other ecosystems provide as significant carbon storage facilities.
- Biodiversity can aid in the adaptation of ecosystems and humans to climate change by enhancing ecosystem resilience. Maintaining biodiversity and fixing ecosystems are therefore crucial components of mitigating and adapting to climate change. Measures must be taken to address climate change and biodiversity loss simultaneously in order to avoid the loss of species and their habitats and to discourage an endless cycle of ecosystem degradation.

Terminal Questions

1. What do you understand by climate change?

2. Discuss the impacts of climate change on biodiversity?
3. What are the contributing factors for climate change? Discuss.
4. What are the outcomes based on Fifth Assessment Report (AR5) published by the IPCC? Discuss.
5. How the biodiversity contributed in mitigation of climate change impact? Discuss.
6. What is the ecosystem- based approaches for adaptation to climate change? Discuss.
7. How climate change contributes in rising of sea level? Discuss.
8. What is shifting of species due to climate change? Elaborate.
9. What are the Management approaches to mitigate the impact of climate on biodiversity?
10. What is the role of Reduced Emissions from Deforestation and Degradation (REDD+) program?

Answer Keys

- **Self -Assessment 1:** 1 – C; 2 - C; 3 –D; 4 – B; 5 – A; 6 – B; 7 – C; 8 – A; 9 – C; 10 – C.
- **Self -Assessment 2:** 1- vulnerable; 2- Intergovernmental Panel on Climate Change (IPCC); 3 – IPCC; 4 – Ecosystem; 5 – extinction; 6 – erosion; 7 – ecosystems; 8 – ranges; 9 - 2.0–7.5ºC; 10 – 10%
- **Self -Assessment 3:** 1- It enhances carbon storage in ecosystems; 2- They help mitigate floods and hurricanes; 3 - Rising temperatures and increased floods and droughts; 4 - It increases the likelihood of emerging diseases; 5 - Restoration projects and community initiatives; 6 - It can prevent 10–15% of yield declines; 7 - They connect biodiversity conservation with climate adaptation; 8 - Species are shifting to higher elevations and latitudes.
- **Self -Assessment 4:** 1 – True; 2 – False; 3 – True; 4 – False; 5 – True; 6 – False; 7 – True; 8 – False; 9 – True; 10 - False

References

CCSP (2008). The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States . A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Backlund, P., A. Janetos, D. Schimel, J. Hatfield, K. Boote, P. Fay, L. Hahn, C. Izaurralde, B.A. Kimball, T. Mader, J. Morgan, D. Ort, W. Polley, A. Thomson, D. Wolfe, M. Ryan, S. Archer, R. Birdsey, C. Dahm, L. Heath, J. Hicke, D. Hollinger, T. Huxman, G. Okin, R. Oren, J. Randerson, W. Schlesinger, D. Lettenmaier, D. Major, L. Poff, S. Running, L. Hansen, D. Inouye, B.P. Kelly, L Meyerson, B. Peterson, and R. Shaw. U.S. Environmental Protection Agency, Washington, DC, USA.

D.C. Dobson, A.P., 1996, Conservation and Biodiversity. Scientific American Library, New York, NY.

Egyankosh: https://egyankosh.ac.in/bitstream/123456789/91207/1/Unit-6.pdf

Gaston, K J. and J.I. Spicer, 1998, Biodiversity: An Introduction. Blackwell Science, London, UK.

Groom bridge, B., and M. Jenkins, 2000, Global Biodiversity: Earth's Living Resources in the 21 st Century. World Conservation Press, Cambridge, UK. IUCN, 2004,

https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-ecosystems_.html

https://www.cbd.int/climate/intro.shtml

IPCC (2014). Settele, J., R. Scholes, R. Betts, S. Bunn, P. Leadley, D. Nepstad, J.T. Overpeck, and M.A. Taboada. Terrestrial and Inland Water Systems. In: *Climate Change 2014: Impacts, Adaptation and Vulnerability*. Part A: Global and Sectoral Aspects. *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.) Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC, (2014) Climate Change2014: Impacts, Adaptation and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y .O. Estrada, R.C. Genova, B.

Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp1132.

IPCC, (2014b) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panelon Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P .R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, N Y, USA, pp688.

Primack, R.B., 2002, Essentials of Conservation Biology, 3 rd Edn. Sinauer Associates, Sunderland, Ma. USA Wilson, Edward, 1993, Diversity of Life. Harvard University Press, Cambridge, MA.

USGCRP (2009). Global Climate Change Impacts in the United States. “Climate Change Impacts by Sectors: Ecosystems.” Karl, T.R., J.M. Melillo, and T.C. Peterson (eds.). United States Global Change Research Program. Cambridge University Press, New York, NY, USA.

USGCRP (2014). Groffman, P. M., P. Kareiva, S. Carter, N. B. Grimm, J. Lawler, M. Mack, V. Matzek, and H. Tallis, 2014: Ch. 8: Ecosystems, Biodiversity, and Ecosystem Services. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 200-201.

USGCRP (2014). Horton, R., G. Yohe, W. Easterling, R. Kates, M. Ruth, E. Sussman, A. Whelchel, D. Wolfe, and F. Lipschultz, 2014: Ch. 16: Northeast. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 16-1-nn.

Unit 10: Biodiversity Conservation and Human Health

Unit Structure

10.0 Learning Objectives

On completion of this unit you should be able to understand about:

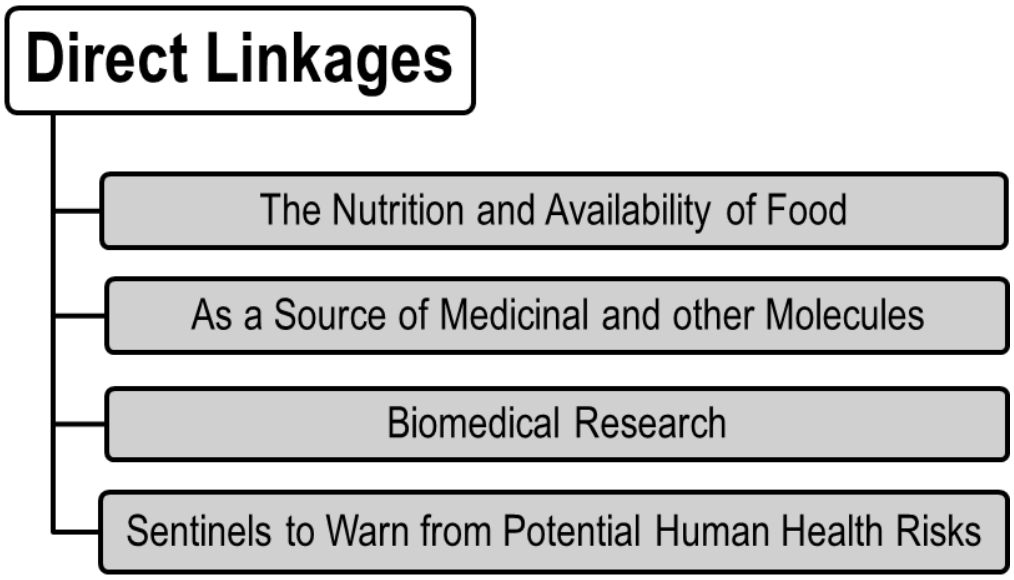
- Direct and indirect linkages of biodiversity and human health
- Biodiversity and rural livelihoods
- Development and Biodiversity
- Conflicts between Human Health and Biodiversity Conservation,

10.1 Introduction

The ecosystem provides a wide range of products and services and services and these ecosystem goods and services are essential to human well-being. Human health is considered to be both directly and indirectly dependent upon the goods and services that provided through the environment, or by the biodiversity, and as therefore, their loss may have negative consequences. The World Health Organization (WHO) recognized that, the connections between biodiversity and human health have received a lot of attention lately since the goods and services received through biodiversity are essential for sustaining human health and have turned into a conservation issue (A. Gómez and E. Nichols., 2010). Thus, taking into account all the above aspects the present unit elaborates the

direct and indirect linkages of biodiversity and human health, biodiversity and rural livelihoods, development and biodiversity and conflicts between human health and biodiversity conservation.

10.2 Direct Linkages



10.2.1 The Nutrition and Availability of Food

According to Waltner-Toews and Lang (2000), humans utilise controlled, partially wild and wild ecosystems for a consistent supply of food. Sustaining the daily energy and nutrient intake necessary for essential human health depends on a sufficient supply and diversity of nutritional resources. Food insecurity is a serious hazard to physical and mental well-being that can result from decreases in the supply and consistency of food resources.

There are two main ways that food directly influences human health and biodiversity. To put it simply, everything we consume (including a large number of vital nutrients and minerals) comes from an animal, fungi, or plant species. People consume a mix of cultivated and wild foods depending on their daily energy and nutritional needs. Both industrialized and developing nations utilize wild food sources, although the nutritional needs of the rural regions frequently depend significantly on wild edible species (WRI et al., 2005).

Globally significant food sources, including freshwater and marine fisheries, as well as wild mammals, are under risk due to overexploitation, climate change, and biodiversity loss (Abramovitz, 1996; Orensanz et al., 1998; Baum et al., 2003; Jerozolimski and Peres, 2003; Marshall et al., 2006). Therefore, fishing, collecting, and hunting for less-preferred food sources have become common activities for many human cultures (de Merode et al., 2004).

In some cases, a food item's consequent unavailability (such a wide range of seafood) has increased their value and increased collection pressure. Second, wild species serves as a genetic resource for future plant and animal choices that will be more compatible with agricultural habitats that change constantly, which is why they are vital to the human food chain. Furthermore, a higher level of resilience to plant diseases and insect-pests is frequently supplied by increasing genetic variety within the agricultural sector (Lavelle et al., 2004). These insect-pests and diseases might otherwise affect wide regions when only one vulnerable species has been introduced (Zhu et al., 2000).

10.2.2 As a Source of Medicinal and other Molecules

Since prehistoric times, the primary sources of traditional medicine have been vascular plant species and their extracts, along with lichen, microbes, and components from animals. The value of Mother Nature as a source of healing molecules and other pharmaceuticals has not decreased over time; many of these substances are now utilized to treat stress, high blood pressure, discomfort, a high temperature (Fever), and cardiac disorders. There is always a chance that nature has the answer to curing diseases that are now untreated or that are becoming more widespread.

Natural substances might provide unique defences against cancer, resilient bacterial strains, and illnesses like HIV/AIDS. Due to the development of antimicrobial-resistant bacteria brought about by years of widespread use (and overuse) of antibiotics, bacterial infections remain an extremely major threat to the wellness of humans (Gomez and Nichols., 2010). It is true that certain varieties of the bacteria are sensitive to more than one antibiotic, and that a few varieties are even resistant to the most recent medicines available. Sustaining an abundant treatment inventory is essential, and unique antibiotic compounds originating from natural resources have been developed recently that may be

able to combat infections caused by these antibiotic-resistant strains (Wang et al., 2006). The loss of biodiversity and possibly valuable chemicals correlates with the extinction of a species.

In addition to providing new medications, biomolecules have additional advantageous effects on human well-being. The polymerase chain reactions, for example, was developed from a set of molecules produced by a type of bacteria discovered in thermal waters in Yellowstone National Park (USA) and has been vital in the diagnosis of both genetic disorders and viral illnesses as well as the synthesis of several replicates of DNA molecules (Chien et al., 1976). Additionally, newly developed and safer pesticides and insecticides are made possible by molecules obtained from plants (like neem trees) and animals (like spiders). The medicinal substances found in nature have great societal importance. Indeed, according to estimates, at least 80% of the world's population gets the majority of their medical treatment from substances derived mostly from plants (Fabricant and Farnsworth, 2001; Kumar, 2004).

10.2.3 Biomedical Research

In the field of biomedical research, species from a wide variety of taxa are and will always be vital. Biodiversity improves human health by contributing enormously to our knowledge of human behavior, physiological mechanisms, and illness. Research findings that would not have been able to be acquired in any other way have been obtained primarily to the usage of these models. Some organisms have special characteristics in their ability to represent a disease; nine-banded armadillos, for example, are valuable in the study concerning human leprosy (Gomez and Nichols., 2010).

Animal model experiments became the foundation for early medical research and instructional resources. Animals remain frequently utilized in many nations to teach medical students about fundamental anatomy and surgical techniques. Furthermore, animal models are utilized in assessing the effectiveness of new vaccinations, anesthetics, and other compounds having possible medical applications (Gomez and Nichols., 2010). Before conducting human trials, these new medications must first be shown to be harmless and efficient in vertebrate models, such as rat, mice, pets, and monkeys.

Understanding the metabolism of specific organs or the body as a whole under particular environmental conditions is another purpose for medical models. Species that are as diverse as plants and the yeasts are frequently used as models in order to improve our knowledge of molecular processes like gene expression and mutagenesis and to obtain knowledge regarding human health concerns like tumor development and ageing. Lastly, the study of animal cell and tissue cultures advances our understanding of how particular illnesses affect human cells, tissues, and organs. Both mice and rats are frequently used as lab animals. However, a few uncommon species have been used in biomedical research, such as sea squirts (to investigate kidney stone production), cone snails (to investigate the physiological functions of cellular receptors, neurons, and ionic pathways), and horseshoe crabs (to study anatomy).

10.2.4 Sentinels to Warn from Potential Human Health Risks

The distribution, abundance, and health of certain species can be studied to learn more about environmental stresses that may pose a health risk to humans, such as toxic substances or the presence of infections. Due to their ability to alert us to potential threats to human health, these species are known as sentinels. A wide range of species can act as sentinels, as mosses to dolphins; however, non-domesticated animals are usually used as sentinels of infectious agents as well as chemical and physical threats (Rabinowitz et al., 2005). The presence or absence of a particular environmental stressor in an ecosystem can be determined from the distribution and abundance of key species. As an example, the disappearance of a particular species of algae might act as an indicator of the threshold at which water pollution becomes harmful (Funes et al., 2006). In other circumstances, the identification of certain physiological changes in sentinel species may indicate that harmful health impacts are being caused by several causes of climate change operating simultaneously. According to Aguirre and Lutz (2004), the development of tumors in sea turtles could indicate several causes of anthropogenic environmental change in the world's oceans. These examples highlight how biodiversity may improve human health by empowering communities to recognize and respond to challenges that would otherwise harm their health.

Self-Assessment -1

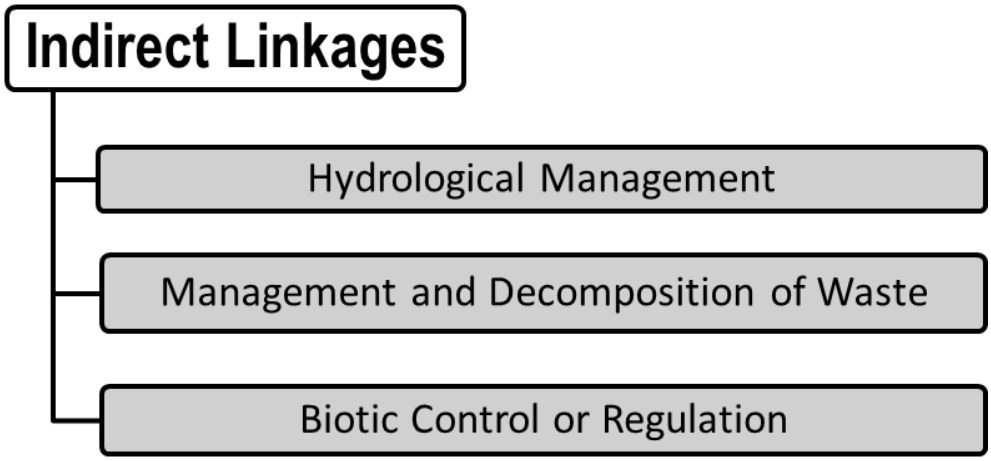
Ture and False

1. Human health is directly and indirectly linked to biodiversity.
2. Food insecurity can negatively impact physical and mental well-being.
3. Wild edible species are primarily consumed in industrialized nations.
4. Biodiversity loss can lead to a decline in medicinal resources.
5. Animal models are not used in biomedical research.
6. Sentinel species can help identify potential human health risks.
7. Ecosystem functions like pollination and pest control have no impact on human health.
8. Wetlands can help regulate hydrology and reduce flood risks.
9. Biodiversity plays a role in waste decomposition.
10. The extinction of a species has no effect on disease transmission cycles.

10.3 Indirect Linkages

Our dependence on the natural world extends not only to the final goods and products provided by nature (ecosystem services), but also to the ecosystem processes provided by large-scale ecosystem interactions. Ecosystem functions, such as pollination, pest control, soil creation and maintenance, nitrogen fixation, and a host of aquatic processes, support all productive ecosystems. Pollination by diverse groups of wild, unmanaged species and domesticated pollinators such as the European honeybee (*Apis mellifera*) (Kremen et al., 2002) enables the production of approximately one third of the average human daily caloric intake (McGregor, 1976; Buchmann and Nabhan, 1997).

Natural biological control of plant pests may help preserve crop yields without the use of artificial chemicals, which have detrimental (and frequently unknown) effects on both human and animal health (Shetty, 2002). Nutrient cycling is essential for the survival of both natural and wild ecosystems (John et al., 2007) and is facilitated by a wide and diverse variety of bacteria, protozoa, fungus, and invertebrates. These processes are examples of the numerous natural processes that can be indirectly linked to human health. The degree of the data supporting these links, however, varies, and there is frequently little direct study linking losses in these services to corresponding declines in human health.



10.3.1 Hydrological Management

Water purification, which involves the capture and gradual filtration of water through naturally vegetated watersheds, reduces sediment and organic component loads. While it is commonly accepted that the preservation of natural vegetation in watersheds is linked to the supply of safe drinking water downstream, the mechanisms behind these ecological functions are only poorly understood. Flood control is one method for regulating hydrology. Floods are the most common natural disaster in the world, as well as the most costly in terms of money and human health. Intact wetlands, for example, are valued for their potential to reduce the frequency and size of flooding episodes at local watershed scales (Andreassian, 2004) by storing soil sediment and boosting or maintaining soil porosity and infiltration capacity (Bronstert et al., 2000;)

Intact ecosystems help to mitigate flood events and, as a result, the primary and indirect effects of floods on human health, such as physical destruction, water- and vector-borne disease epidemics, and water and soil contamination (Ahern et al., 2005). Floods raise the risk of vector-borne (e.g., malaria, dengue, West Nile Fever), water-borne (e.g., cholera, leptospirosis), and non-epidemic, water-borne infection (e.g., wound infections, dermatitis).

10.3.2 Management and Decomposition of Waste

A variety of macro invertebrates, such as dung beetles, termites, and earthworms, remove excrement from animals, wildlife, and humans (especially in rural regions with poor

hygiene). Dung beetles may have an impact on human health by suppressing dung-breeding fly populations (Horgan and Fuentes, 2005) and reducing the transmission of end parasites and protozoa through contact with contaminated dung (Bryan, 1973; Nichols et al., 2008).

The breakdown of dead organic materials by living entities is an important ecological function performed by numerous species from various taxa, but mostly by bacteria and fungus. The phrase "bioremediation" refers to the technology that uses biological processes to eliminate pollutants from the environment.

The term refers to methods for facilitating the establishment, growth, and reproduction of the organisms involved, as well as technologies used to improve the efficiency of the removal processes (including genetic engineering) (Kulkarni and Chaudhari, 2007; Padmavathiamma and Li, 2007; Saier, 2007; Zhuang et al., 2007).

10.3.3 Biotic Control or Regulation

Biodiversity can operate as a disease buffer, regulating the populations of vectors and hosts involved in disease transmission cycles. In general, the extinction of any species or functional group that plays a regulatory role in an ecosystem would result in a dramatic rise in the abundance of the species it normally controls. For example, the loss of carnivorous predators might result in an expansion in prey populations and the illnesses for which they are hosts (Packer et al., 2003; Ostfeld and Holt, 2004; Stronen et al., 2007).

Self-Assessment -2

Fill in the blanks with appropriate answers.

1. Humans utilize _____, partially wild, and wild ecosystems for food.
2. _____ is a serious hazard to physical and mental well-being.
3. Natural substances can provide unique defenses against _____ and _____ bacteria.
4. Animal models are used in _____ research to study diseases.
5. _____ can help reduce the frequency and size of flooding episodes.
6. _____ is a technology that uses biological processes to eliminate pollutants.

7. Disease buffer can regulate the populations of _____ and _____ involved in disease transmission.
8. _____ is essential for the survival of both natural and wild ecosystems.
9. Biodiversity can operate as a _____, regulating the populations of vectors and hosts involved in disease transmission cycles.

10.4 Biodiversity and Livelihoods

Biodiversity composed of the variety of genetic, species and ecosystems diversity, is basically linked to the livelihoods and well-being of rural communities around the world. The complex and interdependent relationship between biodiversity and the socioeconomic realisms of rural inhabitants deliberating the crucial role that natural resources play in sustaining the rural livelihoods. Importance of biodiversity with respect to livelihood includes food security and rural incomes. Effective agricultural systems provide ecosystem services such as pollination, nutrient cycling, and pest control which are key for improving crop yields and sustainable food production. Furthermore, collecting and selling of wild goods such as fibers, medicinal plants and food items from various ecosystems frequently acts as an essential safety net contributing in economy and fulfilling the dietary gaps in rural communities particularly during food insecurity. The dependence on wild resources is even more evident in many rural areas that lack market access and basic infrastructure, with biodiversity acting as both a means of subsistence and a gateway to the cash economy (Israr et al., 2014).

Beyond its obvious utilitarian value, biodiversity is essential for forming the cultural significance and customs of rural populations. Since people have always had a deep connection to nature, protecting biodiversity has significant intrinsic and moral value in addition to being important from an ecological and economic standpoint (Díaz et al., 2006). This connection has been a fundamental part of the human experience for millennia.

The complex relationship between biodiversity and rural livelihoods, however, is threatened by various factors, such as overexploitation, habitat destruction, and climate change. The loss of regional biodiversity and the traditional knowledge that goes along

with it presents serious difficulties to the sustainable strengthening of food production in rural areas as the world's food systems increasingly converge towards homogenization (Dannenberg et al., 2024; Dawson et al., 2019). A comprehensive multidisciplinary strategy that allows the various roles that biodiversity plays in sustaining the livelihoods and general well-being of rural communities is needed to address these issues. Though the value of biodiversity for rural livelihoods is often underestimated, and the fast standardization of the global food systems is significant threat to the survival of these valued natural resources. To maintain the sustainable rural livelihoods required to pay attention by acquiring experts and policymakers to develop holistic approach considering vital role of biodiversity for encouraging the conservation and sustainable use of biodiversity along with incorporation a variety of agricultural practices and raising the value of goods collected from the wild (Frison et al. 2011; Dawson et al., 2019; Dannenberg et al., 2024).

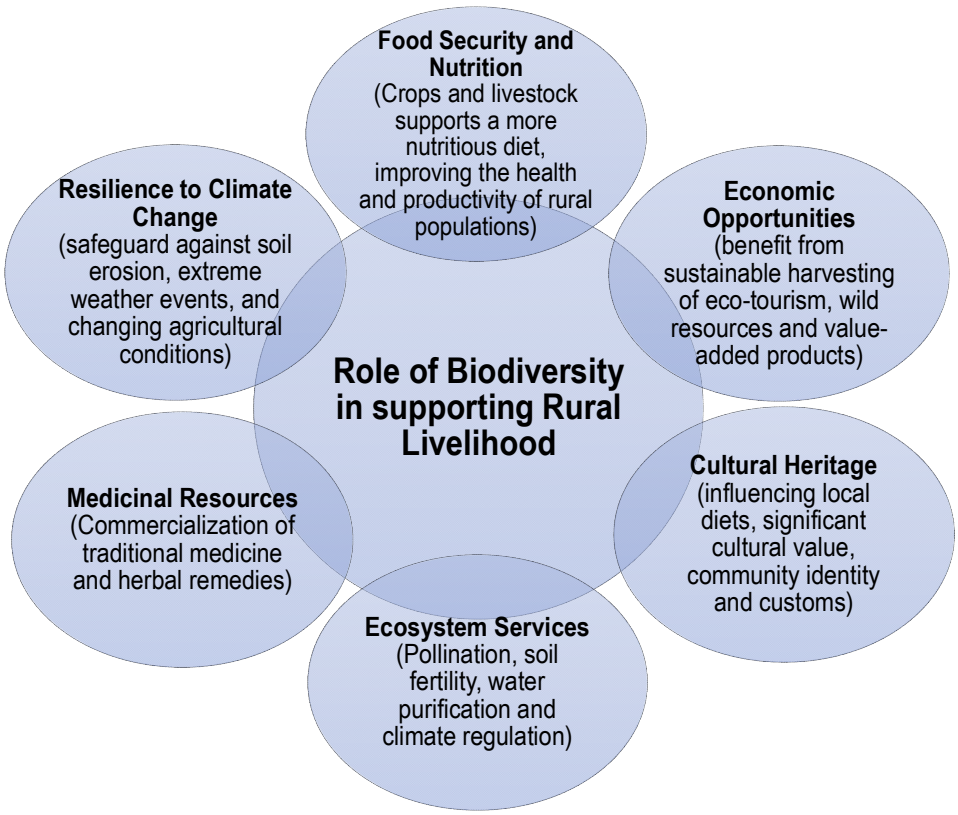


Figure. Significant role of biodiversity in supporting Rural livelihood.

10.5 Conflicts between Human Health and Biodiversity Conservation

It appears that human health and biodiversity are related based on the facts provided so far. However, some ecological events may determine the overall impact of climate change on the risk of human health. Several types of environmental alteration may be harmful to human health even while they are beneficial for biodiversity. For example, the regeneration of abandoned cropland in the United States is linked to a higher chance of Lyme disease (Telford III, 2002), but in Sudan, it was found that forest regeneration was related with a higher possibility of leishmaniosis (Gratz, 1999). The occurrence of parasitic infections in fish and human beings has surprisingly increased as a result of some marine mammal conservation initiatives (McCarthy and Moore, 2000; Olson et al., 2004).

In other scenarios, the manmade alterations that cause the most adverse environmental effects could also pose the least threats to human health. When compared to selective extraction, clear-cut logging results in minimal human- wildlife interaction and so refers to a lower risk of disease development (Wolfe et al., 2005).

A further challenge to the conservation of biodiversity may come from newly emerging viral diseases in humans. A large number have reservoirs in wild animals, making them zoonotic. Eliminating animals may be the only viable option because humans are at danger of getting illnesses from close interactions with these animals. While there has been debate regarding the effectiveness of eliminating wildlife reservoirs and the need for alternative approaches for preventing spread of diseases, the elimination of wildlife species remains a viable approach in these kinds of prevention and control initiatives (Donnelly et al., 2006).

When thinking about the topic of pathogen conservation, it is also important to take into consideration possible conflicts between the purposes of biological conservation and public health. Pathogens are important agents in processes related to ecology and evolution. In the development of interactions between diseases and their hosts, complicated ecosystems have developed. Pathogens influence the variety of other organisms in the ecosystem through influencing the distribution and abundance of their

hosts, functioning as effective selection agents and genetic diversity producers in their hosts. Pathogen species have different evolutionary lineages and comprise a significant portion of the planet's diversity. These arguments have been made by some conservation scientists to support the necessity of pathogen species protection (Gompper and Williams, 1998; Windsor, 1998).

Self-Assessment -3

Multiple choice Questions:

1. What is the primary relationship between biodiversity and rural livelihoods, according to the text?
    A) Biodiversity is a threat to rural livelihoods.
    B) Rural livelihoods are independent of biodiversity.
    C) Biodiversity is essential for sustaining rural livelihoods.
    D) Rural livelihoods have a negative impact on biodiversity.
2. How does biodiversity contribute to food security in rural areas?
    A) By reducing crop yields.
    B) By providing ecosystem services like pollination and nutrient cycling.
    C) By increasing dependence on wild resources.
    D) By promoting unsustainable agricultural practices.
3. Which of the following is NOT a threat to biodiversity and rural livelihoods?
    A) Overexploitation
    B) Habitat destruction
    C) Climate change
    D) Sustainable agricultural practices
4. What is the cultural significance of biodiversity for rural populations?
    A) It has no cultural significance.
    B) It is a source of conflict.
    C) It is deeply connected to their way of life.
    D) It is irrelevant to their daily lives.
5. How can the regeneration of abandoned cropland impact human health?
    A) It always has a positive impact.

B) It always has a negative impact.

C) It can have both positive and negative impacts depending on the region.

D) It has no impact on human health.

6. What is the main challenge posed by emerging viral diseases to biodiversity conservation?

A) The need to protect wildlife reservoirs.

B) The potential for human-wildlife conflict.

C) The difficulty in developing vaccines.

D) The lack of public awareness.

7. Why do some conservation scientists argue for the protection of pathogen species?

A) Because they are harmful to human health.

B) Because they play a crucial role in ecosystems.

C) Because they are easy to eradicate.

D) Because they have no impact on biodiversity.

8. **Assertion:** Biodiversity is a valuable asset for rural communities.

Reason: It provides essential ecosystem services and contributes to livelihoods.

A) Both Assertion and Reason are true, and Reason is the correct explanation of Assertion.

B) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.

C) Assertion is true, but Reason is false.

D) Assertion is false, but Reason is true.

9. **Assertion:** The conservation of biodiversity can sometimes conflict with public health concerns.

Reason: Some wildlife species can act as reservoirs for harmful pathogens.

A) Both Assertion and Reason are true, and Reason is the correct explanation of Assertion.

B) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.

C) Assertion is true, but Reason is false.

D) Assertion is false, but Reason is true.

10. **Assertion:** The loss of biodiversity poses a significant threat to the sustainability of rural livelihoods.

    Reason: Biodiversity provides essential resources and services that support rural communities.

A) Both Assertion and Reason are true, and Reason is the correct explanation of Assertion.

B) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.

C) Assertion is true, but Reason is false.

D) Assertion is false, but Reason is true.

Summary

- Our common ecological challenges are ultimately responsible for connecting the health of humans with the welfare of every other species on the earth. Thus, health offers a special perspective from which we can look at and try to make sense of the impacts of human behavior. We showed the connections, both direct and indirect, between biodiversity and human health. The physical and psychological well-being of humans may suffer as a result of human actions that cause biodiversity to become extinct.
- The effects of these connections on conservation biology practice are not always clear-cut, though. More investigation is required for a complete understanding the relationships between conservation of biodiversity and human health. We should specifically look at its universality and strength. Furthermore, it is highly probable that not all biodiversity will be beneficial to human health overall based on our present understanding of these linkages (i.e., biodiversity can potentially have a neutral impact, and some species and ecological functions might even have an adverse overall effect on human beings). Establishing an accurate relationship between biodiversity and the supply of goods and services would improve our ability of assessing biodiversity's significance in relation to human health and to develop and carry out appropriate conservation plans. The complex relationship of environmental,

social, economic, and public health parameters influences human health, and how much importance each of these elements varied geographically and historically. In order to better understanding of the social and environmental causes of human health risks, collaborative efforts including the disciplines of biomedical science, public health, biological conservation, social sciences, anthropology, ecology, and environmental science are necessary. This is because the dynamic balance we refer to as "health" is multifaceted.

- The occurrence of illnesses that are not infectious and a decline of ecosystem resilience are two ways that anthropogenic changes to the environment can have a negative impact on human health. Deforestation and fossil fuel emissions, for example, may accelerate the destructive effects of extreme weather events by triggering global climate change. It is possible that human actions are the associated cause of the higher health risks rather than biodiversity loss being the primary factor.
- Variations in health risks, biodiversity loss, and environmental modification have a complicated interaction with unknown causal relationships. Significantly adverse impacts on human health are thought to be mostly caused by anthropogenic environmental change. As an example, human interaction is frequently associated with the development of infectious diseases in plants, animals, and humans.
- The advantages and services associated with biodiversity may accumulate at chronological and geographical dimensions that are unsustainable for ongoing conservation efforts, even if we are aware of the direct and indirect connections between biodiversity and human health. For example, activities occurring throughout the course of evolution result in the biochemical compounds commonly found in nature, and even at the local level, the regulatory functions provided by biodiversity frequently depend on interactions between events occurring at distant locations. In the larger context of conservation, the circumstances in which conserving biodiversity may have negative impacts on human health should be carefully assessed. However, the negative effects of biodiversity loss on human health should be taken into account when developing policies regarding the environment, and the connections between

biodiversity and health will probably always be significant motivations for conservation efforts.

Terminal Questions

1. What are direct linkages of biodiversity and human health? Discuss.
2. Discuss how biodiversity contributed as a source of medicinal values?
3. Discuss the indirect linkages of biodiversity and human health? Discuss
4. What are the effects of floods on human health?
5. What is bioremediation? Explain.
6. How biodiversity support rural livelihood?
7. What is the conflict between human health and Biodiversity conservation?

Answer Keys

Self-Assessment 1: 1 - True; 2 - True; 3 -False; 4 - True; 5 - False; 6 – True; 7 – False; 8- True; 9 – True; 10 – True

Self-Assessment 2: 1- controlled**;** 2- Food insecurity; 3- cancer and antibiotic-resistant**;** 4- Biomedical**;** 5 – Wetlands; 6 – Bioremediation**;** 7 -7 vectors and hosts; 7 - Nutrient cycling; 9 - disease buffer

Self-Assessment 3: 1- C; 2 - B; 3- D; 4 – C; 5 - C; 6 – B; 7- B; 8- A; 9 – A; 10 – A

References

Abramovitz, J. N. 1996. Imperiled waters, impoverished future: the decline of freshwater ecosystems. Page 80. Worldwatch Paper, Washington, D.C.

Aguirre, A. A. and P. A. Lutz. 2004. Marine turtles as sentinels of ecosystem health: is fibropapillomatosis an indicator? EcoHealth 1:275-283.

Ahern, M., R. S. Kovats, P. Wilkinson, R. Few, and F. Matthies. 2005. Global health impacts of floods: epidemiologic evidence. Epidemiologic Reviews 27:36-46.

Andreassian, V. 2004. Waters and forests: from historical controversy to scientific debate Journal of Hydrology 291:1-27.

Baum, J. K., R. A. Myers, D. G. Kehler, B. Worm, S. J. Harley, and P. A. Doherty. 2003. Collapse and conservation of shark populations in the Northwest Atlantic. Science 299:389.

Bronstert, A., A. Jaeger, A. Guntner, N. Hauschild, P. Doll, and M. Krol. 2000. Integrated modelling of water availability and water use in the semi-arid Northeast of Brazil. Physics and Chemistry of the Earth Part B: Hydrology Oceans and Atmosphere 25:227-232.

Bryan, R. P. 1973. The effects of dung beetles activity on the numbers of parasitic gastrointestinal helmintic larvae recovered from pasture samples. Australian Journal of Agricultural Research 24:161-168.

Buchmann, S. and G. Nabhan 1997. The Forgotten Pollinators. Island Press, Washington DC.

Chien, A., D. B. Edgar, and J. Trela. 1976. Deoxyribonucleic acid polymerase from the extreme thermophile Thermus aquaticus. Journal of Bacteriology 174:1550-1557.

Dannenberg, P., Braun, B., Greiner, C., Follmann, A., Haug, M., et al. (2024). Eight arguments why biodiversity is important to safeguard food security. *Plants, People, Planet*, *6*(3), 604-610.

Dawson, I. K., Park, S. E., Attwood, S. J., Jamnadass, R., Powell, W., Sunderland, T., & Carsan, S. (2019). Contributions of biodiversity to the sustainable intensification of food production. *Global Food Security*, *21*, 23-37.

de Merode, E., K. Homewood, and G. Cowlishaw. 2004. The value of bushmeat and other wild foods to rural households living in extreme poverty in Democratic Republic of Congo. Biological Conservation 118:573-581.

Díaz, S., Fargione, J., Chapin III, F. S., & Tilman, D. (2006). Biodiversity loss threatens human well-being. *PLoS biology*, *4*(8), e277.

Donnelly, C. A., R. Woodroffe, D. R. Cox, F. J. Bourne, C. L. Cheeseman, R. S. Clifton-Hadley, G. Wei, G. Gettinby, P. Gilks, H. Jenkins, W. T. Johnston, A. M. Le Fevre, J. P. McInerney, and W. I. Morrison. 2006. Positive and negative effects of widespread badger culling on tuberculosis in cattle. Nature 439:843-846.

Fabricant, D. S., and N. R. Farnsworth. 2001. The value of plants used in traditional medicine for drug discovery. Environmental Health Perspectives 109:69-75.

Frison, E. A., Cherfas, J., & Hodgkin, T. (2011). Agricultural biodiversity is essential for a sustainable improvement in food and nutrition security. *Sustainability*, *3*(1), 238-253.

Funes, V., J. Alhama, J. I. Navas, J. Lopez-Barea, and J. Peinado. 2006. Ecotoxicological effects of metal pollution in two mollusc species from the Spanish South Atlantic littoral. Environmental Pollution 139:214-223.

Gómez A and Nichols E 2010. Biodiversity Conservation and Human Health. Synthesis. Center for Biodiversity and Conservation of the American Museum of Natural History, Lessons in Conservation. Available at http://ncep. amnh.org/linc.

Gompper, M. E. and E. S. Williams. 1998. Parasite conservation and the black-footed ferret recovery program. Conservation Biology 12:730-732.

Gratz, N. G. 1999. Emerging and resurging vector-borne diseases. Annual Review of Entomology 44:51-75.

Horgan, F. G. and R. C. Fuentes. 2005. Asymmetrical competition between Neotropical dung beetles and its consequences for assemblage structure. Ecological Entomology 30:182-193.

Israr, M., Khan, H., Jan, D., & Ahmad, N. (2014). Livelihood diversification: A strategy for rural income enhancement. *Journal of Finance and Economics*, *2*(5), 194-198.

Jerozolimski, A., and C. Peres. 2003. Bringing home the biggest bacon: a cross-site analysis of the structure of hunterkill profiles in Neotropical forests. Biological Conservation, 111.

John, R., J. W. Dalling, K. E. Harms, J. B. Yavitt, R. F. Stallard, M. Mirabello, S. P. Hubbell, R. Valencia, H. Navarrete, M. Vallejo, and R. B. Foster. 2007. Soil nutrients influence spatial distributions of tropical tree species. Proceedings of the National Academy of Sciences 104:864-869.

Kremen, C., N. Williams, and R. Thorp. 2002. Crop pollination from native bees at risk from agricultural intensification. Proceedings of National Academy of Sciences USA 99:16812-16816.

Kulkarni, M. and A. Chaudhari. 2007. Microbial remediation of nitro-aromatic compounds: An overview. Journal of Environmental Management 85:496-512.

Kumar, P. 2004. Valuation of medicinal plants for pharmaceutical uses. Current Science 86:930-937.

Lavelle, P., M. Blouin, J. Boyer, P. Cadet, D. Laffray, A. T. Pham-Thi, G. Reversat, W. Settle, and Y. Zuily. 2004. Plant parasite control and soil fauna diversity. Comptes Rendus Biologies 327: 629-638.

Marshall, A. J., Nardiyono, L. M. Engstrom, B. Pamungkas, J. Palapa, E. Meijaard, and S. A. Stanley. 2006. The blowgun is mightier than the chainsaw in determining population density of Bornean orangutans (*Pongo pygmaeus* morio) in the forests of East Kalimantan. Biological Conservation 129:566-578.

McCarthy, J. and T. A. Moore. 2000. Emerging helminth zoonoses. International Journal for Parasitology 30:1351-1360.

McGregor, S. E. 1976. Insect Pollination of Cultivated Crop Plants in C. H. B. R. Center, editor. USDA.

Nichols, E., S. Spector, J. Louzada, T. Larsen, S. Amezquita, M. Favila, and the Scarabaine Research Network. 2008. Ecological functions and ecosystem services provided by Scarabaeine dung beetles. Biological Conservation.

Olson, R. E., J. R. Pierce, K. C. Jacobson, and E. M. Burreson. 2004. Temporal changes in the prevalence of parasites in two Oregon estuary-dwelling fishes. Journal of Parasitology 90:564-571.

Orensanz, J. M. L., J. Armstrong, D. Armstrong, and R. Hilborn. 1998. Crustacean resources are vulnerable to serial depletion - the multifaceted decline of crab and shrimp fisheries in the Greater Gulf of Alaska. Reviews in Fish Biology and Fisheries 8:117-176.

Ostfeld, R. S. and R. D. Holt. 2004. Are predators good for your health? Evaluating evidence for top-down regulation of zoonotic disease reservoirs. Frontiers in Ecology and the Environment 2:13-20.

Packer, C., R. D. Holt, P. J. Hudson, K. D. Lafferty, and A. P. Dobson. 2003. Keeping the herds healthy and alert: implications of predator control for infectious disease. Ecology Letters 6:797-802.

Padmavathiamma, P. K. and L. Y. Li. 2007. Phytoremediation technology: Hyper-accumulation metals in plants. Water Air and Soil Pollution 184:105-126.

Rabinowitz, P. M., Z. Gordon, R. Holmez, B. Taylor, M. Wilcox, D. Chudnov, P. Nadkarni, and F. J. Dein. 2005. Animals as sentinels of human environmental health hazards: An evidence-based analysis. EcoHealth 2:26-37.

Saier, M. H. 2007. Beneficial bacteria and bioremediation. Water Air and Soil Pollution 184:1-3.

Shetty, P. K. 2002. Ecological implications of pesticide use in agro-ecosystems in India. Page 7. National Pesticide Stewardship Alliance, Bangalore.

Stronen, A. V., R. K. Brook, P. C. Paquet, and S. McLachlan. 2007. Farmer attitudes toward wolves: Implications for the role of predators in managing disease. Biological Conservation 135:1-10.

Telford III, S. R. 2002. Deer tick-transmitted zoonoses in the Eastern United States in A. A. Aguirre, R. Ostfeld, G. M. Tabor, C. House, and M. C. Pearl, editors. Conservation medicine: ecological health in practice. Oxford University Press, New York.

Waltner-Toews, D. and T. Lang. 2000. A new conceptual base for food and agricultural policy: the emerging model of links between agriculture, food, health, environment and society. Global Change & Human Health 1:116-130.

Wang, J., S. M. Soisson, K. Young, W. Shoop, S. Kodali, A. Galgoci, R. Painter, G. Parthasarathy, Y. S. Tang, R. Cummings, S. Ha, K. Dorso, M. Motyl, H. Jayasuriya, J. Ondeyka, K. Herath, C. Zhang, L. Hernandez, J. Allocco, Ã. n. Basilio, J. R. Tormo, O. Genilloud, F. Vicente, F. Pelaez, L. Colwell, S. H. Lee, B. Michael, T. Felcetto, C. Gill, L. L. Silver, J. D. Hermes, K. Bartizal, J. Barrett, D. Schmatz, J. W. Becker, D. Cully, and S. B. Singh. 2006. Platensimycin is a selective FabF inhibitor with potent antibiotic properties. Nature 441:358-361.

WHO, World Health Organization. 2006. Ecosystems and health.

Windsor, D. A. 1998. Equal rights for parasites. Bioscience 48:244-244.

Wolfe, N. D., P. Daszak, A. M. Kilpatrick, and D. S. Burke. 2005. Bushmeat hunting deforestation, and prediction of zoonoses emergence. Emerging Infectious Diseases 11:1822-1827.

WRI, U. N. D. Programme, U. N. E. Program, and W. Bank. 2005. The Wealth of the Poor: Managing Ecosystems to Fight Poverty. WRI, Washington DC.

Zhu, Y. Y., H. R. Chen, J. H. Fan, Y. Y. Wang, Y. Li, J. B. Chen, J. X. Fan, S. S. Yang, L. P. Hu, H. Leung, T. W. Mew, P. S. Teng, Z. H. Wang, and C. C. Mundt. 2000. Genetic diversity and disease control in rice. Nature 406:718-722.

Zhuang, P., Q. W. Yang, H. B. Wang, and W. S. Shu. 2007. Phytoextraction of heavy metals by eight plant species in the field. Water Air and Soil Pollution 184:235-242.

Unit 11: Endemic Species of India

Unit Structure

11.0 Learning Objectives

After going through this unit you will be able to:

- Describe various types of Endemism
- Understand different type of habitat for Endemics
- Explain theories of endemism
- Explain status of endemism in India
- Describe the endemic species of India

11.1 Introduction

The concept of endemism is central to the study of biogeography. The term 'endemism' was coined by A.P. de Candolle (1855) for the distribution of an organism (plant, animal or microorganism) in a limited geographical area. In Ecological terms, it states that a plant or an animal life only in a particular location, such as a specific island, habitat type, nation or other defined zone. It is the association of a biological taxon with a unique and well-defined geographic area. The cosmopolitan distribution or cosmopolitan is the antithesis of endemic, and refers to a taxon which is extremely widespread in many world regions. For example, highest numbers of endemic taxa are found in Australian region. All important islands and mountain chains (except isolated piece of the country like Italy) from 48º N to

South wards possess endemics. Maximum proportion of endemism is found in West Australia and South African regions. All the southern land masses have great number of species confined to themselves i.e. endemism is higher in old landmasses than in young e. g. land of northern hemisphere, which are covered by the Pleistocene ice sheets have lower number of endemics.

Types of Endemism: Two general classes of endemism are widely recognized: Paleoendemism and Neoendemism.

I. **Paleoendemic species:** Paleoendemics means "ancient endemics" these are the organisms (animals or plants) that are restricted to an area because they have died out elsewhere. A fossil record elsewhere is the best evidence for paleoendemism (e.g., in *Sequoia*, *Sequoiadendron*, *Lyonothamnus*). These are also described as those species which used to live in a large area in the past, but now live only in a smaller area. These species are often systematically isolated taxa, whose distribution areas represent the remnants of originally larger distribution ranges that have been reduced due to environmental changes. For example, species A is widely distributed throughout the whole mountain range. Any change occurring in the environmental conditions of the region, leads to a reduction of the distribution of species A. Species A does not extinct entirely; it survives in a small area at the periphery of its former distribution range. Now, species A is a known as paleoendemic species of that area.

II. **Neoendemic species:** Neoendemism means that a species has recently appeared which is closely related to the main species or one that has formed following hybridization and is now classified as a separate species. This is a common process in plants especially those which exhibit polyploidy. These species result from the divergent adaptation to differing environmental conditions, thereby, leading to the formation of new species that are locally distributed. The evolution of neoendemic plant species is often triggered by polyploids. The endemic species may have a higher ploidy level then its related taxa (apoendemics), or it may be diploid while its related taxa have a higher ploidy level (patroendemics). In cases where the endemic taxon and its related taxa are of equal ploidy level, the endemic species are called

schizoendemics. Apopatro and schizoendemics are further subdivisions of neoendemic. For example, species B immigrates to an area and colonizes the upper region of mountain chain. As a result, the population of species B gets separated and the two subpopulations are isolated from each other. Since the environmental conditions of the two subpopulations are not identical they show different adaptations. The divergent evolution in the subpopulation may lead to the formation of new species or subspecies that are locally distributed andare called as neoendemic species.

11.2 Habitat for Endemics

The biological organisms have different patterns of distribution where they live on the globe. The territory where a species lives is called its distribution, it describes that where in the worldthat species naturally occurs. Therefore, based on their habitat of distribution on entire globe species can be cosmopolitan, endemic or disjunct **(Figure 1).** For example, the distribution ofpolar bears restricted to Arctic region and lemurs occur naturally only in the Island of Madagascar region is consider as the endemic species of that particular region. Another example of endemic species is Bay checkerspot butterfly i.e. *Euphydryas editha bayensis* occurring in only one region in the San Francisco Bay area. In contrast to this, brown rats (i.e.*Rattus norvegicus*), occurring everywhere, are considered as cosmopolitan species.

11.3 Characters of endemism

They are localized in distribution because of their narrow ecological amplitude and are unable to invade in fresh areas. They lack potentially to migrate because of saturate genomes. Real endemics never migrate while Neo-endemics have the potential to migrate. The dispersal propagules are not able to sustain during migration to other area. It may be due to physical barriers.

Self-Assessment -1

Multiple choice Questions:

1. What does the term 'endemism' refer to?
   A) Widespread distribution of species
   B) Species living only in a specific geographic area
   C) Migration of species across continents
   D) Fossils found in multiple regions

2. Who coined the term 'endemism'?
   A) A.P. de Candolle
   B) Charles Darwin
   C) Gregor Mendel
   D) Alfred Wallace

3. Which of the following describes neoendemic species?
   A) Species that have been restricted to a smaller area over time
   B) Species that are ancient and have fossil records
   C) Species that have recently formed and are locally adapted
   D) Species that are found in multiple regions

4. Paleoendemic species are best described as:
   A) Recently evolved species with a high ploidy level
   B) Ancient species restricted to a specific area
   C) Species that migrate frequently to new habitats
   D) Cosmopolitan species found globally

5. Where is the highest number of endemic taxa found?
   A) North America
   B) Australian region
   C) European region
   D) Arctic region

6. Match the following types of Endemism (List I) with their Descriptions (List II) and choose the correct option

List I		List II	
A.	Paleoendemic	**I.**	Ancient species restricted to a limited area
B.	Neoendemic	**II.**	Recently formed species through adaptation
C.	Apoendemic	**III.**	Endemic species with equal ploidy level as related taxa
D.	Schizoendemic	**IV.**	Endemic species with a higher ploidy level than related taxa

A) A- I; B – II, C = III, D = IV

B) A- II; B – I, C = IV, D = III

C) A- I; B – II, C = IV, D = III

D) A- I; B – III, C = II, D = IV

7. Match the following Organisms (List I) with their Distribution (List II) and choose the correct option

List I		List II	
A.	Polar Bear	**I.**	Cosmopolitan
B.	Bay Checkerspot Butterfly	**II.**	Endemic to Madagascar
C.	Lemurs	**III.**	Endemic to San Francisco Bay area
D.	Brown Rat	**IV.**	Restricted to Arctic region

A) A- I; B – II, C = III, D = IV

B) A- II; B – I, C = IV, D = III

C) A- I; B – II, C = IV, D = III

D) A- IV; B – III, C = II, D = I

8. **Assertion (A):** Endemic species have a narrow ecological amplitude.
   Reason (R): They are unable to invade new areas due to their specialized habitat requirements.
   A) Both A and R are true, and R explains A.
   B) B) Both A and R are true, but R does not explain A.
   C) A is true, but R is false.
   D) A is false, but R is true.

9. Why do real endemics have limited migration capabilities?
   A) They have high genetic diversity
   B) They lack the ability to adapt
   C) They have saturate genomes
   D) They thrive in various environments

10. Which factor is primarily responsible for the isolation of paleoendemic species?
   A) Climate change
   B) Environmental changes
   C) Human activity
   D) Migration of other species

11.4 Theories of endemism

There are two main theories of Endemism.

I. The first theory believes that the last survivors of once flourishing flora which is now declining are the relics or epibiotics which are endemics.

II. However, second theory believes that these are recent and youthful forms in course of gradual extinction. According to Willis age-and-area hypothesis, most endemic species are considered to be youthful i.e. youngsters rather old relic. The concept of endemism includes two types of organisms whose areas are confined to a single regions: endemics (which are relatively youthful species), and epibiotics (which are relatively old relic species). The theory is also known as Age and Area hypothesis. The first theory is supported by Geographers e.g., *Sequoia*

semipenirens of the central Valley of California and Oregon and *S. gigantea* of Sierra Nevada which are endemic to their respective native homes, were extensively distributed in Cretaceous and Tertiary periods. The supporters of second theory have the examples of *Primula, Impatiens* and *Rhododendron* etc. According to this theory, Area is directly proportional to its age in the scale of evolution. So, a small area of distribution shows relatively young in age e.g., *Coleus* is distributed on the summit of the dry Ritigala mountains in Sri Lanka, with two species *C. elongatus* and *C. barbatus*. *C. elongatus* is endemic and *C. barbatus* is widely distributed in tropical Asia and Africa. Willis believed *C. elongatus* to be derived from *C. barbatus*.

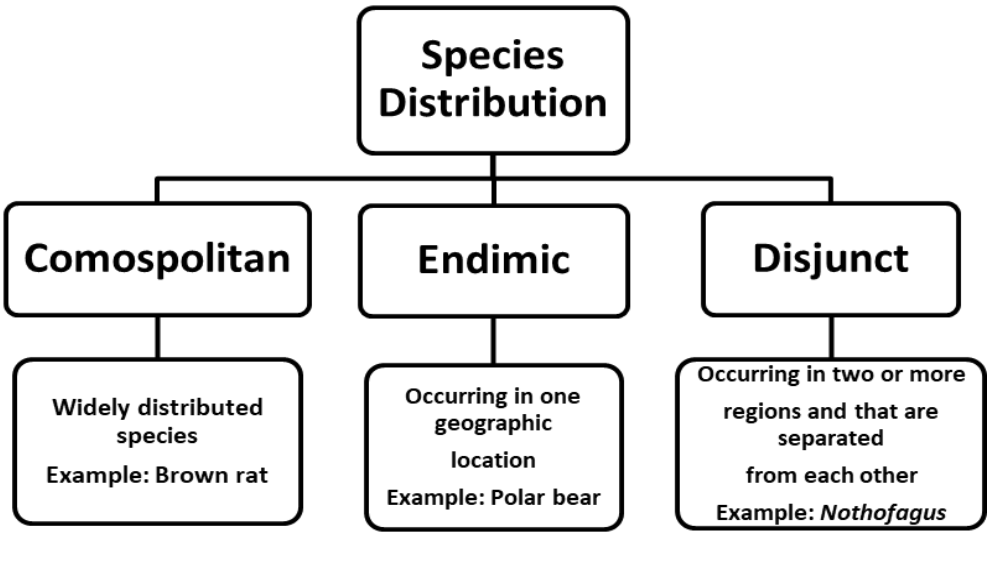


Figure 1: Based on species distributional range of species they can be categorized into various types.

11.5 Factors Responsible for Endemism

Factors responsible for the production of endemics are natural crossing among the closely related plants growing under favorable conditions and Mutations. If the condition of isolation is developed the effect becomes more pronounced.

- Endemism is found in isolated e.g., islands, isolated areas etc. Mountains also have more endemic species as they are isolated e.g., 70% sp. of Himalayas is endemic.
- Climate also is one of the factors e.g., North of Himalaya is dry plateau of Tibet and South Himalayan range has alluvial fertile soil. According to Chatterjee the percentage of endemic species of Dicot plants in India is more than 50. Maximum endemic plants are found in the Himalayas and South India. Indo-Gangetic plains have a very small number of endemic species.

Stebbins, (1942) has given a genetic explanation for the endemic. He told that such taxa have depleted their store of genetic variation (biotype depletion) and they are unable to expand their range.

There are multiple causes of rarity and endemism. Three primary factors describe the distribution of endemics:

- Geographical area
- Ecological role of species
- Isolation

Stebbins (1980) has given the gene pool/ niche interaction theory to explain origin of rarity and endemism. "According to theory, the primary cause of localized or endemic distribution patterns is adaptation to a combination of ecological factors that are themselves localized. Factors of soil texture and chemical composition are the most important but by no means the only ones. Next to the climatic and edaphic factors, those inherent into the gene pool of the population are of critical importance. They include the total amount of variability, the amount of variability that can be released at any one time, and the amount of variation that can be generated with respect to those particular characteristic that affect most strongly the establishment of new population"

Self -Assessment - 2

Very short answer type questions?

1. What are the two main theories explaining endemism?
2. How does the age-and-area hypothesis relate to endemism?

3. What factors contribute to the creation of endemic species?
4. Where endemics are often found?
5. How does climate influence endemism?
6. What genetic explanation did Stebbins propose for endemism?
7. What factors determine the distribution of endemic species?
8. What drives localized endemic patterns?
9. What factors impact the establishment of new populations?
10. Why do endemic species often have limited distribution?

11.6 Endemism in India

India is a tropical country that is one of the mega-diversity centers, with only 2.4% of the world's land area, accounts for 7-8% of all recorded species, including over 45,000 species of plants and 91,000 species of animals. It is situated at the trijunction of the Afrotropical, Indo- Malayan and Palaearctic realms, all of which support rich biodiversity. Being one of the 17 identified mega diverse countries; India has 10 biogeographic zones and is home to 8.58% of the mammalian species documented so far, with the corresponding figures for avian species being 13.66%, for reptiles 7.91%, for amphibians 4.66%, for fishes 11.72% and for plants 11.80%. Four of the 34 globally identified biodiversity hotspots, namely the Himalaya, Indo- Burma, the Western Ghats-Sri Lanka and Sunderland, are represented in India. The diverse physical features and climatic conditions have resulted in a variety of ecosystems such as forests, grasslands, wetlands, and desert, coastal and marine ecosystems which harbor and sustain high biodiversity and contribute to human well-being. In India, there are following four mega endemic centers:

I. Indo-Burma covering Mizoram, Manipur, Nagaland, Meghalaya, Tripura and Andaman Islands.
II. Himalaya covering Jammu & Kashmir, Himachal Pradesh, Uttarakhand, northern part of West Bengal (Darjeeling), Sikkim, northern part of Assam and Arunachal Pradesh.

III. Western Ghats falls within the states of Tamil Nadu, Kerala, Karnataka, Goa, Maharashtra and Gujarat.

IV. The Sunderland covering the Nicobar Islands.

Peninsular India is the richest endemic centre. It harbors nearly 82% of the total endemic genera of the country. Peninsular India has a high concentration of endemic genera (40 genera). There is no endemic family in India. There are only 49 genera endemic to India, of which 36 are unspecific. Hill tops provide a good environment for endemism next to islands. The species richness and high endemism in the Western Ghats is due to varied latitudinal and altitudinal gradients with varied rainfall and temperature. India has large number of endemic species.

Endemic: The term "endemic" is used to denote a species, genus or other group confined to a small area like Single Island, a group of islands, a mountain chain or a comparatively small country like South Africa or West Australia, largely bounded by sea or by a marked alteration of climate.

Endemic species (ES)

An "Endemic Species" is one that is only found in a particular region and nowhere else in the world. Since these species are not widespread and may be confined to only one or two protected areas, they are of great conservation concern. A plant may be said to endemic to a certain state, to a country or to a continent. Although, there is no country or islands that have all its species endemic, yet it is very common to find genera with all their species endemic.

11.7 Endemic species of India

The numbers of endemic plant under different plant groups mentioned in the fifth report of convention of Biological Diversity (CBD) 2014 reported by Botanical survey of India are given in Table 1. According to this report data, nearly about 4045 species of flowering plants (angiosperms) endemic to India are distributed amongst 141 genera belonging to 47 families.

These are concentrated in the floristically rich areas of North-east India, the Western Ghats, the North-west Himalaya and the Andaman and Nicobar Islands. Some examples

of endemic plant species of India are *Rhododendron* sp. (Ericaceae), *Beaumontia grandiflora* (Apocynaceae), *Eleusine coracana* (Poaceae), *Caryota urens* (Arecaceae), *Aegle marmelos* (Rutaceae), *Crotolaria juncea* (Fabaceae), *Ficus religiosa* (Moraceae), and *Seasamum indicum* (Pedaliaceae) and other plant species belong to families like Rubiaceae (6 genera), Rosaceae, Asteraceae, Primulaceae and Acanthaceae etc. Some examples of the endemic animal species found in India are Lion-tailed macaque, Nilgiri Langur, Brown palm civet and Nilgiri Thar.

Table 1: Endemism in different plant groups of India

S.No.	Plant Group	Total no of species in India	Number of Endemic species	Percentage (%)
1.	Angiosperms	17, 926	4, 045	22.57
2.	Gymnosperms	74	8	10.81
3.	Pteridophytes	1, 267	196	15.47
4.	Bryophytes	2, 504	642	25.64
5.	Algae	7, 244	1, 949	26.91

Source: BSI (2013)

Self-Assessment - 3

Fill in the blanks with appropriate answers.

1. India is a mega-diversity center with…… of the world's land area.
2. The…… are the four mega endemic centers in India.
3. **……** percent of the total endemic genera of the country are harbored by Peninsular India.
4. The term "endemic" refers to a species, genus, or group confined to a……area.
5. An "Endemic Species" is one that is only found in a …… region.
6. Nearly …… of flowering plants are endemic to India.

Summary

- Endemism is a key concept in biogeography, referring to organisms (plants, animals, or microorganisms) confined to a specific geographic area. It contrasts with cosmopolitan species, which are widespread. Notably, Australia has a high number of endemic taxa, with old landmasses generally exhibiting greater endemism compared to younger regions.

- Endemism is categorized into two types: Paleoendemism and Neoendemism. Paleoendemic species are those that once had a broader distribution but are now limited due to environmental changes, evidenced by fossil records. Neoendemic species have recently emerged, often due to hybridization or adaptations to new environments, particularly among plants exhibiting polyploidy.

- Variation in species distribution occurs globally as with some being endemic to specific regions, such as polar bears in the Arctic and lemurs in Madagascar. Others, like the Bay checkerspot butterfly are limited to localized areas, contrasting with cosmopolitan species like brown rats.

- Endemic species typically have a narrow ecological range and limited migratory ability. Real endemics do not migrate, while neo-endemics may have some migratory potential. Dispersal barriers often inhibit the movement of these organisms.

- There are two main theories regarding endemism: 1. Endemics are relics of once widespread species that have declined; 2. Endemics are relatively young species facing extinction. The age and area hypothesis relates a region's age to its endemic species, with older areas showing more endemic relics.

- Endemism arises from factors like isolation (e.g., islands and mountains), climate differences, and genetic variability. Genetic depletion and localized ecological conditions restrict species range and contribute to endemism.

- India, a mega-diversity hotspot, hosts about 7-8% of the world's species in just 2.4% of its land area. It features four major endemic centers, with peninsular India being particularly rich in endemic genera. The varied ecosystems support high biodiversity, with significant concentrations in the Western Ghats and Himalayas.

- According to a 2014 report, India has approximately 4,045 endemic flowering plant species, particularly in regions like Northeast India and the Western Ghats. Examples include *Rhododendron* and *Beaumontia* species. Endemic animals include the lion-tailed macaque and Nilgiri langur, emphasizing the need for conservation of these unique species.

Terminal Questions

1. Define the term endemism, endemic and endemic species.
2. Discuss Paleoendemism and Neoendemism with examples.
3. What are the characteristics for endemic habitat?
4. What are the theories of endemism? Discuss.
5. What are the factors responsible for endemism?
6. Discuss the endemism in India.
7. Write five endemic plant and animal species found in India.

Answer Keys

Self -Assessment 1: 1 – B; 2 - A; 3 – C; 4 – B; 5 – B; 6 – C; 7 – D; 8 – A; 9 – C; 10 – B

Self -Assessment 2 - 1: The relic theory and the youth theory; 2: It suggests most endemic species are young; 3: Natural crossing and mutations; 4: Isolated areas like islands and mountains; 5: It shapes ecological niches; 6: Depleted genetic variation; 7: Geographical area, ecological role, and isolation; 8: Localized ecological factors; 9: Genetic variability and ecological factors; 10: Specific adaptations to localized conditions.

Self -Assessment 3: 1: 2.4%; 2: Indo-Burma, Himalaya, Western Ghats-Sri Lanka, and Sunderland; 3: 82%; 4: small; 5: particular; 4045 species.

References

BSI (2013) Official communication from Botanical Survey of India, Kolkata, India.

EPG Pathshala: Subject: Environmental Sciences; Paper No: 03 Biodiversity and Conservation; Module 26: Endemic Species of India (Content Writer: Prof. Daizy Batish).

Irwin, S.J. and Narasimhan, D. (2011). Endemic genera of Angiosperms in India: A Review. Rheedea21: 87-105.

Kruckeberg, A.R. and Rabinowitz, D. (1985). Biological Aspects of Endemism in Higher Plants. Annual Review of Ecology and Systematics. 16: 447-479.

Malik, V. (2015). Endemism: An Overview. Global Journal for Research Analysis X: 104-105.

Mitra, S. and Mukherjee, S. K. (2007). Reassessment and diversity of endemic Angiospermic genera of India. Journal of Economic and Taxonomic Botany31: 163 – 176.

Willis, J.C. (1922). Age and area. A study in geographical distribution and origin of species. Cambridge, University Press.

Unit 12: Biodiversity conservation-Legal aspects

Unit Structure

12.0 Learning Objectives

After going through this unit you will be able to:

- Appreciate the importance of legislations in application of conservational plans
- Define various national legislations for biodiversity conservation
- Describe the need of Indian Forest Act 1927, Biodiversity Act 2000, Biosafety Act and Wildlife (Protection) Act 1972
- Explain what is endangered species act
- Define federal role in wildlife preservation

12.1 Introduction

In order to protect wildlife (flora and fauna) from various environmental problems and prohibition of degrading the environment, several legislations have been enacted at national and international levels. We will discuss some important environmental legislations which are enacted to protect biodiversity. The Indian legislations are called acts and international legislations are in form of conventions. India is one of 12 Mega diversity country of the world. There are innumerable species, whose potential are not

known till date. Biodiversity has direct consumption value in agriculture, medicine and industry. Legislation is needed in order to prevent waste and destruction and destructive harvesting of wild life resources for commercialization and profit are the major threat to wildlife conservation. To curve destructive practice by scrupulous people and mafia group effective legislation is necessary to protect and conserve the biodiversity. Legislation also serves as a valuable tool for educating masses.

There is Constitutional provision in India for biodiversity conservation. The constitution (forty second Amendment) Act of 1976 has made it fundamental duty to protect and improve the natural environment by Clause (g) to Article 51A. The Department of Environment was established in India in 1980 to ensure a healthy environment for the country. This later became the Ministry of Environment and Forests in 1985. This Ministry has overall responsibility for administering and enforcing environmental legislations and policies.

12.2 Legal instruments relevant to biological diversity in India

The constitution of India ensures the concept of environmental protection. It has a new section on Directive Principles of State Policy, setting out the duties for the States and all the citizens through Article 48A and Article 51A (g) and explaining that "the State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife in the country" and to protect and improve the natural environment, including forests, lakes and rivers and wildlife, and to have compassion for living creatures. A legal and policy framework has been developed which relates specifically to biological diversity. The Forest Act of 1927, the Forest (Conservation) Act of 1980 (amended in 1988), the Wildlife (Protection) Act of 1972 (amended in 1983, 1986 and 1991) and the Environment (Protection) Act of 1986 are supported by State Laws and Statutes relating to forests and other natural resources.

The National Conservation Strategy of 1992 outlines the policy action required to give greater attention to biodiversity conservation. The National Forest Policy, as amended in 1988, stresses the sustainable use of forests, and the need for greater attention to ecologically fragile (but biologically rich) areas such as the mountain and island ecosystems. The National Wildlife Action Plan of 1973 lays down priorities in the area of wildlife conservation. One of the major considerations in Environmental Impact

Assessment carried out by the Ministry of Environmental and Forests is the protection of habitats and valuable ecosystems.

12.2.1 Forest Protection Act

First Forest Act was enacted in 1927. This is one of the many surviving colonial legislations. It was enacted to consolidate the law related to forest, the transit of forest produce and the duty liveable on timber and other forest produce. Subsequently, the Forest (Conservation) Act was promulgated in 1980 to make certain reforms over the preceding Act of 1927. The 1927 Act deals with the four categories of the forests, namely reserved forests, village forests, protected forests and private forests. A state may declare forest lands or waste lands as reserved forest and may sell the produce from these forests. Any unauthorized felling of trees quarrying, grazing and hunting in reserved forests is punishable with a fine or imprisonment, or both. Reserved forests assigned to a village Community is called village forests. The state governments are empowered to designate protected forests and may prohibit the felling of trees, quarrying and the removal of forest produce from these forests. The preservation of protected forests is enforces through rules, licenses and criminal prosecutions. Forest officers and their staff administer the Forest Act. Alarmed at India's rapid deforestation and resulting environmental degradation, Centre Government enacted the Forest (Conservation) Act in 1980. Under the provisions of this Act, prior approval of the Centre Government is required for diversion of forestlands for non-forest purposes. An Advisory Committee constituted under the Act advises the Centre on these approvals.

Self-Assessment 1

(A) Multiple choice questions

1. What is the main purpose of environmental legislation in India?

a) To increase industrial production

b) To protect and conserve biodiversity

c) To promote urban development

d) To regulate international trade

2. Which amendment to the Indian Constitution made it a fundamental duty to protect and improve the natural environment?

a) The 44th Amendment

b) The 42nd Amendment

c) The 50th Amendment

d) The 60th Amendment

3. In which year was the Department of Environment established in India?

a) 1970

b) 1980

c) 1990

d) 2000

4. Which article of the Indian Constitution focuses on environmental protection and conservation of forests and wildlife?

a) Article 48A

b) Article 51A (g)

c) Article 21

d) a and b both

5. What role does the Ministry of Environment and Forests play in India?

a) It promotes industrial growth.

b) It administers and enforces environmental legislation and policies.

c) It manages international trade relations.

d) It regulates agricultural production.

6. What does the National Wildlife Action Plan of 1973 focus on?

a) Economic growth and development

b) Priorities in wildlife conservation

c) Urban expansion

d) Industrial pollution control

7. Assertion: The Forest (Conservation) Act of 1980 was enacted to control deforestation in India.

Reason: The Act requires prior approval from the Central Government for the diversion of forestlands for non-forest purposes.

Answer:

a) Both the assertion and the reason are correct, and the reason is the correct explanation for the assertion.

b) Both the assertion and the reason are correct, but the reason is not the correct explanation for the assertion.

c) The assertion is correct, but the reason is incorrect.

d) The assertion is incorrect, but the reason is correct.

8. Assertion: The establishment of the Department of Environment in 1980 was a key step in India's environmental policy framework.

Reason: The Department was later upgraded to the Ministry of Environment and Forests in 1985 to strengthen environmental administration.

Answer:

a) Both the assertion and the reason are correct, and the reason is the correct explanation for the assertion.

b) Both the assertion and the reason are correct, but the reason is not the correct explanation for the assertion.

c) The assertion is correct, but the reason is incorrect.

d) The assertion is incorrect, but the reason is correct.

12.2.2 Wildlife Protection Act

According to the Wildlife Protection Act, 1972, “Wildlife” includes any animal, bees, butterflies, crustacea, fish and moths; and aquatic or land vegetation which forms part of any habitat. “All beings are found of themselves, they like pleasure, they hate pain, they shun destruction, they like pleasure, they like life and want to live long. To all, life is dear, hence their life should be protected” – Mahavira. The Wildlife Protection Act was passed by the Indian Parliament in the year 1972 to protect India’s wildlife. However, in the 20 year s that has passed since the Act came into force, the number of wild animals is going down alarmingly, despite of government efforts to protect them. With the increase in population, there is greater pressure on land. Forests are being

destroyed as human habitations expand, thereby shrinking the habitats of our wildlife. There is also the clandestine international trade in wildlife and wildlife products which is a major cause for their needless destruction. Meanwhile, the growing consumer society and the increasing emphasis on luxury and vanity items have also caused the exploitation of wildlife in the name of industrial progress. The major task of protecting the wildlife cannot be handled by the Government machinery alone through its limited officials but should be the duty of every individual. This was one of the reasons why a new provision, Article 51 A (g), was inserted into our Constitution, making it the fundamental duty of every citizen to protect and improve the natural environment, including forests, lakes, rivers and wildlife, and to have compassion for living creatures.

12.2.3 Biodiversity Act 2000

India's richness in biological resources and indigenous knowledge relating to them is well recognized. One of the major challenges is in adopting an instrument which helps realize the objectives of equitable benefit sharing enshrined in the Convention. Towards this, legislation on biodiversity was developed following an extensive consultative process. The legislation aims at regulating access to biological resources so as to ensure equitable sharing of benefits arising from their use. The Biological Diversity Bill, which was introduced in the Parliament in 15TH May, 2000, was referred to the Department related Parliamentary Standing Committee for Science, Technology, Environment & Forests for examination and report. After examination of witnesses and recording evidences, the Standing Committee approved the Bill with some amendments. The Cabinet approved the proposal for moving the official amendments based upon the recommendations of the Committee. The Biological Diversity Bill 2002 has been passed by the Lok Sabha on 2nd December, 2002 and by the Rajya Sabha on 11th December, 2002.

Salient features of the Biodiversity Legislation are as follows:

- The main intent of this legislation is to protect India's rich biodiversity and associated knowledge against their use by foreign individuals and organizations without sharing the benefits arising out of such use, and check biopiracy.
- The Act provides for setting up of a National Biodiversity Authority (NBA), State Biodiversity Boards (SBBs) and Biodiversity Management Committees

(BMCs) in local bodies. NBA and SBB are required to consult BMCs in decisions relating to use of biological resources/related knowledge within their jurisdiction and BMCs are to promote conservation, sustainable use and documentation of biodiversity.

- All foreign nationals/organizations require prior approval of NBA for obtaining biological resources and/or associated knowledge for any use. Indian individuals/entities require approval of NBA for transferring results of research with respect to any biological resources to foreign nationals/organizations.
- Collaborative research projects and exchange of knowledge and resources under these projects are exempted provided they are drawn as per the policy guidelines of the Central Government and have its approval the objectives of conservation, sustainable use and benefit sharing.
- However, Indian citizens/entities/local people including vaids and hakims to have free access to use biological resources within the country for their own use, medicinal purposes and research purposes.
- While granting approvals, NBA will impose terms and conditions to secure equitable sharing of benefits. Before applying for any form of IPRs in or outside India for an invention based on research or information on a biological resource obtained from India, prior approval of NBA will be required.
- There is an enabling provision for setting up a framework for protecting traditional knowledge.
- The monetary benefits, fees, royalties as a result of approvals by NBA to be deposited in National Biodiversity Fund, which will be used for conservation and development of areas from where resource has been accessed, in consultation with the local self government concerned and Provision for notifying National Heritage Sites important from standpoint of biodiversity by State Governments in consultation with local self government.
- Provision for notifying items, areas for exemption provided such exclusion does not violate other provisions. This is to exempt normally traded commodities so as not to adversely affect trade.

12.2.4 Biosafety Act (Biosafety Framework: Rules and Institutions)

Genetically modified organisms are regulated in India under the Indian Environment (Protection) Act of 1986 (henceforth the EP Act). The objective of the EP Act is the protection and improvement of the environment. To meet this objective, the act calls for regulation of "environmental pollutants" which are defined as "any solid, liquid or gaseous substance present in such concentration as may be, or tend to be, injurious to the environment". The ministry of environment and forests used this broad definition of 'environmental pollutant' in 1989 to issue a set of legally binding rules to govern use of genetically engineered organisms under the EP Act. The 1989 'Rules for the Manufacture, Use, Import, Export and Storage of Hazardous Microorganisms, Genetically Engineered Organisms or Cells' (henceforth 1989 Rules) constitute the legally binding regulatory framework for genetically modified organisms in India (Rules 1989). As required by the 1989 Rules, biosafety guidelines were first issued by the department of biotechnology under the ministry of science and technology in 1990. These guidelines were revised and expanded in 1994 and 1998 (DBT 1994, 1998). I address below, first, the scope of this regulatory framework (that is, what it covers) and second, how it allocates decision-making authority for biosafety.

The Indian biosafety regulatory framework, comprising the 1989 Rules and the 1990, 1994 and 1998 DBT guidelines, covers the entire spectrum of activities relating to genetically modified organisms. This includes "research involving genetically modified organisms, as well as genetic transformations of green plants, rDNA technology in vaccine development, and large-scale production and deliberate/accidental release into the environment of organisms, plants, animals and products derived from rDNA technology" (DBT 1990:1). Production facilities such as distilleries and tanneries that use genetically modified organisms are also covered (Rules 1989, Article 1). The 1990 'Recombinant DNA Safety Guidelines' and 1994 'Revised Guidelines for Safety in Biotechnology' provide guidance on containment and safe laboratory practices for GMOs in the agricultural and pharmaceutical sectors (DBT 1990, 1994). They also, however, contain an important change from the 1989 Rules in their treatment of deliberate release of GMOs. While the 1989 Rules effectively banned such releases (permitting them only under special circumstances), the 1990 guidelines permit them, with a shift to assessing and managing ecological and health risks that might result. The 1998 'Revised Guidelines for Research in Transgenic Plants and Guidelines for

Toxicity and Allergenicity Evaluation of Transgenic Seeds, Plants and Plant Parts' add to the regulatory architecture by calling for toxicity and allergenicity data for ruminants, such as goats and cows, from consumption of transgenic plants (DBT 1998). Biosafety regulators claim that Indian risk assessment is "even stricter than the best models elsewhere" in pointing to such requirements, which are portrayed as relevant to the Indian context. Another key addition in the 1998 guidelines is the requirement to generate data on comparative economic benefits of a modified plant (DBT 1998). Thus, the 1998 guidelines call for a demonstration that a transgenic crop is both "environmentally safe and economically viable" (DBT 1998: 6). An agronomic evaluation of the transgenic crop to determine economic advantage to farmers is seen as an integral component of the transgenic crop approval process, along with the biosafety evaluation. Thus, when the government granted permission for large-scale field-testing of transgenic cotton in India in July 2000 (the first crop to receive such approval), mandatory data to be generated included "cost of transgenic seed, projected demand, and the area to be covered under transgenic cotton cultivation" (GoI 2000).

12.2.5 Environment Protection Act (EPA)

In the wake of the Bhopal tragedy, the government of India enacted the Environment (Protection) Act of 1986. The purpose of the Act is to implement the decisions of the United Nations Conference on the Human Environment of 1972, in so far as they relate to the protection and improvement of the human environment and the prevention of hazardous to human beings, other living creatures, plants and property. The Act is an "umbrella" legislations designed to provide a framework for Central Government Coordination of the activity of various central and state authorities established under previous Acts, as the Water Act and the Air Act. In this Act, main emphasis is given to "Environment" defined to include water, air and land and the inter -relationships which exist among water, air and land and human beings and other living creatures, plants, micro-organisms and property. "Environmental pollution" is the presence of pollutant, defined as any solid, liquid, or gas substance present in such a concentration as may be or may tend to be, injurious to the environment.

Intellectual Property Rights

The *Intellectual Property Rights* (IPR's) include copyrights, trademarks, trade secrets and patents. *Patents* vest exclusive monopoly ownerships rights over the patented

matter i.e. the patent holder has due right to exclude others from using, making and selling the patented subject matter for a certain period of time. IPR's and patents have become a matter of concern because of mega mergers of multinational companies in the life science industry which involves commercial sale of seeds, pesticides, food and pharmaceuticals. Thus, multinational companies can monopolise and control the supply of these products. This essentially means an increase in their prices. In addition, the control on essential resources such as seeds, drugs and food indirectly means a control over the fundamental rights of access to food, health and nutrition.

WTO agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) was negotiated during the Uruguay Round. Article 27.3(b) relates the provision of TRIPS to biodiversity. It envisages the protection of plant varieties either by patents or by effective *Sui Generis* (unique or of its own kind) system or by a combination thereof. The two main issues involved being the patenting of life forms and the protection of plant varieties. The patenting of life forms is related to bio-piracy i.e. the theft of biological resources and traditional knowledge from developing countries. A US patent on the use of turmeric for healing wounds is an example of bio -piracy. The issue of IPR protection of the genetically engineered crops is also very important.

The protection of plant varieties is important for commercial plant breeders. The international Union for Protection of New Varieties of Plants (UPOV) held its first convention in 1961 which promotes the protection of breeder’s rights over the new plant varieties. The UPOV convention has been revised many times. Under 1991 revision, the breeders who register rights over varieties can claim full commercial control over the seed or propagating materials of their protected varieties. Thus, the farmers can’t sell the seeds from their harvest and they have to pay royalty even for the seeds that they save from their harvest for use in the next plantation. Recently, there was another development which could be used to exercise control and ownership over the biodiversity. With the help of new genetic engineering techniques, it is possible to create sterile plants with infertile seeds that can't be replanted. Thus, the seeds are killed after one generation. This technology is known as terminator technology. It forces the farmers to purchase seeds for every growing season. Hence, this technology offers an inbuilt protection without the needs of patents. The schedule for implementing TRIPS obligations for various categories of countries is as follows:

Developed Countries	1st January, 1996
Developing Countries	1st January, 2000
Least Developed Countries	1st January, 2006

The issue of patents and IPRs is a matter of concern for developing countries, as the private monopolisation of life and of biological resources would adversely affect the development, food security, livelihood of farmers and the environment. Such patents are also being opposed by the people on ethical and moral grounds.

Table 12.1: Rules of patent and plants

International Law	India	National Law	Domestically
WTO TRIPS	Member since 1995	Amendments in Patents Act, 1970 to make it TRIPS compliant	Introduces product patents
UPOV	India's membership application pending with the UPOV Council	Protection of Plant Varieties & Farmers' Rights Act, 2001 with elements of UPOV Act of 1978	Establishes IPR on plant varieties through grant of breeder rights
CBD	Party since 1994	Biological Diversity Act, 2002	Regulates access and screens patent applications on Indian bioresources & knowledge
ITPGR	Ratified in 2002		Binds the country to grant facilitated access to a negotiated selection of 35 food crops and 29 forages

Sources: Survey of Environment 2004, The Hindu

A case study: Controversial patent of neem, basmati and turmeric

Another treaty of relevance in this area is the recently concluded International Treaty on Plant Genetic Resources for Food and Agriculture (PGRFA Treaty), adopted on November 3, 2001, which incorporates, to a large extent, the philosophy of the CBD. India is a party to all the three treaties. Recent controversy in India over the controversial patents granted by the US Patent Office and the EPO on *turmeric, basmati* and *neem* (all were based on the knowledge widely shared in India, another important case of biopiracy is the patent sought on *Phyllanthus niruri* (commonly known as Bhadharti in Sanskrit and Jaramla in Hindi) for the cure of jaundice or viral

hepatitis. Use of *Phyllanthus niruri* for treatment of jaundice has been an ancient and well-recorded innovation in the Indian system of medicine. The Fox Chase Cancer Centre of Philadelphia has applied to the EPO for its use in curing viral hapatitis B., has brought the issue of biopiracy to the centre-stage in all the legislative efforts undertaken by the Government of India to comply with its international obligations under these treaties. Though *turmeric* and *neem* patents have been revoked in the US and the EU respectively, these cases have highlighted certain gaps in the whole procedure of granting and revoking patents on bio-products, and the very issue of IPRs has become very controversial in India. On turmeric the patent was granted to the University of Mississippi Medical Centre in December 1993 on its use in normal healing, particularly in chronic and acute wounds, which was successfully challenged by the Indian Council of Scientific and Industrial Research (CSIR), on the ground that the alleged invention was part of public domain knowledge in India. On the basis of documented evidence, the patent was cancelled. Similarly, *neem* patent, granted to W.R. Grace of the U.S., was revoked by the European Patent Office (EPO) after representations made by certain NGOs.

Self assessment 2

1. True/false

i) The Wildlife Protection Act of 1972 aims to protect only land-based animals and does not cover aquatic life**.** **True / false**

ii) The Biosafety Act in India was enacted to regulate genetically modified organisms (GMOs) under the Indian Environment (Protection) Act of 1986. **True / false**

iii) The Environment (Protection) Act of 1986 was enacted in response to the Bhopal gas tragedy. . **True / false**

iv) Under the WTO TRIPS Agreement, developing countries were required to implement its obligations by January 1, 1996. . **True / false**

v) The patent granted to the University of Mississippi Medical Centre for the use of turmeric in healing wounds was successfully challenged by the Indian Council of Scientific and Industrial Research (CSIR). **True / false**

2. Match the following:

List I	List II
A) Wildlife Protection Act, 1972	**i.** Regulates the use of genetically modified organisms and includes guidelines for their safety and environmental impact.
B) Biodiversity Act, 2002	**ii.** Aims to protect India's rich biodiversity and ensure equitable benefit sharing from biological resources.
C) Environment (Protection) Act, 1986	**iii.** Established in response to the Bhopal gas tragedy, it provides a framework for environmental protection and pollution control.
D) Biosafety Act (1989 Rules and guidelines)	**iv.** Provides legal protection for wildlife and their habitats across India, including both land and aquatic species.

a) A-ii, B-i, C-iii, D-iv

b) A-i, B-ii, C-iii, D-iv

c) A-ii, B-i, C-iv, D-iii

d) A-iv, B-ii, C-iii, D-i

3. Match the following:

List I	List II
A) Patent	**i.** Provides exclusive rights to creators of original works of authorship, such as books, music, and software.
B) Copyright	**ii.** Grants exclusive rights to an inventor to exclude others from making, using, or selling an invention for a certain period of time.
C) Trademark	**iii.** Protects symbols, names, and slogans used to identify goods or services and distinguish them from others.
D) Trade Secret	**iv.** Refers to confidential business information that provides a competitive edge, such as formulas or processes.

a) A-ii, B-i, C-iii, D-iv

b) A-i, B-ii, C-iii, D-iv

c) A-ii, B-i, C-iv, D-iii

d) A-iv, B-ii, C-iii, D-i

12.3 Endangered species act

12.3.1 History

Calls for wildlife conservation in the United States increased in the early 1900s because of the visible decline of several species. One example was the near-extinction of the bison, which used to number in the tens of millions. Similarly, the extinction of the passenger pigeon, which numbered in the billions, also caused concern. The whooping crane also received widespread attention as unregulated hunting and habitat loss contributed to a steady decline in its population. By 1890, it had disappeared from its primary breeding range in the north central United States. Scientists of the day played a prominent role in raising public awareness about the losses. For example, George Bird Grinnell highlighted bison decline by writing articles in Forest and Stream.

12.3.2. Endangered Species Preservation Act of 1966

Despite these treaties and protections, many populations still continued to decline. By 1941, only an estimated 16 whooping cranes remained in the wild. By 1963, the bald eagle, the U.S. national symbol, was in danger of extinction. Only around 487 nesting pairs remained. Loss of habitat, shooting, and DDT poisoning contributed to its decline. The U.S. Fish and Wildlife Service tried to prevent the extinction of these species. Yet, it lacked the necessary Congressional authority and funding. In response to this need, Congress passed the Endangered Species Preservation Act on October 15, 1966. The Act initiated a program to conserve, protect, and restore select species of native fish and wildlife. As a part of this program, Congress authorized the Secretary of the Interior to acquire land or interests in land that would further the conservation of these species. The Department of Interior issued the first list of endangered species in March 1967. It included 14 mammals, 36 birds, 6 reptiles, 6 amphibians, and 22 fish. A few notable species listed in 1967 were the grizzly bear, American alligator, Florida manatee, and bald eagle. The list included only vertebrates at the time because of the Department of Interior's limited definition of "fish and wildlife." The Endangered Species Preservation Act was repealed by the Endangered Species Act.

12.3.3. Endangered Species Conservation Act of 1969

The Endangered Species Conservation Act of 1969 amended the Endangered Species Preservation Act of 1966. It established a list of species in danger of worldwide

extinction. It also expanded protections for species covered in 1966 and added to the list of protected species. While the 1966 Act only applied to 'game' and wild birds, the 1969 Act also protected mollusks and crustaceans. Punishments for poaching or unlawful importation or sale of these species were also increased. Any violation could result in a $10,000 fine or up to one year of jail time. Notably, the Act called for an international convention or treaty to conserve endangered species. A 1963 IUCN resolution called for a similar international convention. In February 1973 a meeting in Washington, D.C. was convened. This meeting produced the comprehensive multilateral treaty known as CITES or the Convention on International Trade of Endangered Species of Wild Fauna and Flora. The Endangered Species Conservation Act of 1969 provided a template for the Endangered Species Act of 1973 by using the term "based on the best scientific and commercial data." This standard is used as a guideline to determine if a species is in danger of extinction.

12.3.4 Endangered Species Act 1973

The Endangered Species Act of 1973 aims to conserve species listed as endangered or threatened under the act. Under the ESA, it is the policy of Congress that all federal agencies shall seek to conserve threatened and endangered species, use their authorities in furtherance of the ESA, and cooperate with state and local agencies to resolve water resource issues in concert with conserving endangered species. The ESA is administered by the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS). Under the ESA, domestic and foreign species of animals (both vertebrate and invertebrate) and plants can be listed as either endangered or threatened, according to an assessment of the risk of their extinction. Once a species is listed, the act provides tools to aid the species' conservation and recovery and to protect its habitat. The ESA and its predecessors have been in place since 1966. Since enactment, these acts have led to the listing of over 2,400 species as threatened or endangered. As of October 2020, 2,363 species were listed, the majority of which (71%) were listed in the United States; the remaining 29% were foreign species. Of all listed species in October 2020, 79% were endangered and 21% were threatened. As of October 2020, 91 species had been delisted under the ESA since it was enacted in 1973, which is approximately 3.7% of the total number of species ever listed under the act.

12.4 Federal role in wildlife preservation

Many people are under the impression that India does not have strong wildlife conservation laws. On the contrary, we have some of the most stringent legislations to protect wildlife and habitats. It is imperative that all conservationists familiarize themselves with these laws, so that they can contribute effectively. It is also vital to understand which institutions control land in India before any conservation interventions can be attempted in any landscape. The legal status of the land must first be ascertained so that one can engage with the correct authorities or agencies. The Government of India has introduced various types of legislation in response to the growing destruction of wildlife and forests. The Wildlife (Protection) Act, 1972 (Last amended in 2006) The WLPA provides for several categories of Protected Areas/Reserves:

i) National Parks

ii) Wildlife Sanctuaries

iii) Tiger Reserves

iv) Conservation Reserves

v) Community Reserves

National parks and Tiger Reserves are by law more strictly protected, allowing virtually no human activity except that which is in the interest of wildlife conservation. Grazing and private rights are disallowed in National Parks but can be allowed in sanctuaries at the discretion of the Chief Wildlife Warden. The amended WLPA does not allow for any commercial exploitation of forest produce in both national parks and wildlife sanctuaries, and local communities can collect forest produce only for their bona fide needs. No wild mammal, bird, amphibian, reptile, fish, crustacean, insects, or coelenterates listed in four Schedules of the WLPA can be hunted either within or outside protected areas. On conviction, the penalty for hunting is imprisonment for a period ranging from a minimum of three to a maximum of seven years with fines not less than 10,000 rupees.

Community reserves and conservation reserves are two new categories of protected areas that have been included under the WLPA. These two categories provide a greater role for local communities, stakeholders and civil society as well as the

opportunity to protect many areas of conservation value that cannot be designated under strict categories such as wildlife sanctuaries or national parks. The statute prohibits the destruction or diversion of wildlife and its habitat by any method unless it is for improvement or better management and this is decided by the state government in consultation with the National and State Boards for Wildlife. The WLPA contains elaborate procedures for dealing with legal rights in proposed protected areas and acquisition of any land or interest under this law is deemed as an acquisition for a public purpose. However, with the enactment of The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, compliance of various provisions relating to tenurial and community rights must be ensured.

Apart from protected area establishment, other important aspects of the WLPA include procedures for the appointment of state wildlife authorities and wildlife boards, the regulation of trade in wildlife products and the prevention, detection and punishment of violations of the WLPA. The 2006 amendment introduced a new chapter for establishment of the National Tiger Conservation Authority and notification of Tiger Reserves (before this amendment, Tiger Reserves were not defined under the law, but were merely administrative designations to enable funding under Project Tiger). The Wildlife Crime Control Bureau (WCCB) was constituted vide the 2006 amendment to monitor and control the illegal trade in wildlife products. The WLPA provides for investigation and prosecution of offences in a court of law by authorized officers of the forest department and police officers.

Summary

In this unit we have discussed various aspects of biodiversity. So far you have learnt that:

- The various national and international legislations, which have been framed to stop environmental degradation.
- India is one of the few countries of the world that have made specific reference in the constitution to the need for environmental protection and improvement. The Central Government State Governments have utilized this provision to pass various Acts in order to protect the environment from destruction.

- The Endangered Species Act, enacted in 1973, aims to conserve species listed as endangered or threatened by protecting their habitats and fostering recovery efforts.
- In India, various governmental bodies, including the National and State Boards for Wildlife, play critical roles in implementing conservation laws, regulating trade, and managing protected areas.

Terminal Questions

1. What is Forest Protection Act and how does it helps in protecting the Forest?

2. What is Biodiversity Act 2000?

3. Describe Environmental Protection Act (EPA).

4. Though India has forest protection act with several amendments but even then the forest cover is shrinking. Why it so?

5. Explain Endangered Species Act?

Answer keys

Self assessment 1: 1-b; 2-b; 3-b; 4-d; 5-b; 6-b;7-a; 8-a.

Self assessment 2: 1- i) F; ii) T; iii) T; iv) F; v) T; **2-**d**; 3-**a**.**

Reference

This unit is compiled from eGyanKosh (https://egyankosh.ac.in/) and other open sources.

Internet Sites

http://www.unep.ch/conventions/geclist.htm

http://www.epw.org.in

http://www.cites.org/eng/disc/what.shtml

https://en.wikipedia.org/wiki/Endangered_Species_Act_of_1973

https://crsreports.congress.gov/product/pdf/R/R46677

https://www.conservationindia.org/resources/the-legal-framework-for-wildlife-conservation-in-india-2

Unit 13. Conservation and Sustainable use of Biodiversity I

Unit Structure

13.0. Learning Objectives

After you have studied this unit, you should be able:

- Understand about Wildlife Protection Act 1972.
- Various Forest & Environment Conservation Acts.
- Biological diversity act 2002.

13.1. Wildlife (Protection) Act, 1972

The Wild Life (Protection) Act of 1972 creates a legislative framework for safeguarding various species of wild animals and plants, maintaining their habitats, and regulating and restricting commerce in wild animals, plants, and products produced from them.
• The legislation determines which plants and animals receive government protection and supervision, with varying levels.

• The Wildlife Act permitted India's membership in CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora).

•Previously, Jammu and Kashmir was not protected by the 1972 Wildlife Protection Act. As a result of the reorganization legislation, the Indian Wildlife Protection act now has jurisdiction over Jammu and Kashmir.

13.1.1. Constitutional Provisions for the Wildlife Act:

• Forests and Protection of Wild Animals and Birds (42nd Amendment Act of 1976) was moved from the State to Concurrent List.

• According to Article 51 A (g) of the Constitution, residents have a responsibility to preserve and improve the natural environment, including forests and wildlife.

• According to Article 48 A of the Directive Principles of State Policy, the state is responsible for maintaining and improving the environment, especially forests and wildlife.

13.1.2. Schedules under the Act:

Wildlife protection act 1972 divided into following 6 schedules (Fig. 1):

Schedule I:

- It includes endangered species that require strict protection.
- A person who violates the law under this Schedule faces the severe punishment.
- Species listed in this Schedule are prohibited from being hunted across India, save in cases when human life is threatened or a disease is incurable.

- Some of the creatures in Schedule I include the Black Buck, Snow Leopard, Himalayan Bear, and Asiatic Cheetah.

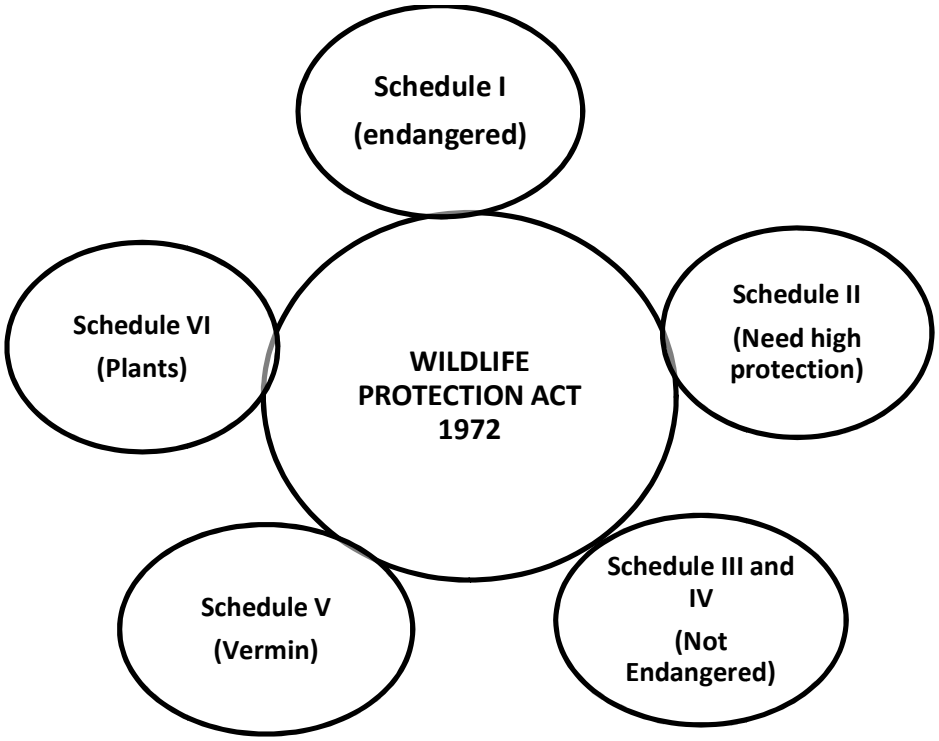


Fig. 1. Diagrammatic representation of different schedules

Schedule II:

- Animals on this list are also given special protection, as their trade is prohibited.
- Schedule II animals include the Assamese Macaque, the Himalayan Black Bear, and the Indian Cobra.

Schedule III and IV:

- Species that are not endangered are listed in Schedule III and IV.
- This includes protected species, with hunting forbidden, but the penalty for any infraction is lower than in the first two schedules.
- Chital (spotted deer), Bharal (blue sheep), Hyena, and Sambhar (deer) are all Schedule III protected animals.

- Flamingos, Hares, Falcons, Kingfishers, Magpies, and Horseshoe Crabs are among the animals protected by Schedule IV.

Schedule V:

- Schedule V includes vermin (small wild creatures that spread disease and destroy plants and food). These animals can be hunted.
- It has only four types of wild animals: common crows, fruit bats, rats, and mice.

Schedule VI:

- Schedule VI regulates the cultivation of specific plants and restricts their ownership, sale, and transit.
- The cultivation and commerce of specific plants can only take place with the prior consent of the competent authority.
- Beddomes' Cycad (Native to India), Blue Vanda (Blue Orchid), Red Vanda (Red Orchid), Kuth (Saussurealappa), Slipper orchids (Paphiopedilum spp.), and Pitcher plant (Nepenthes khasiana) are among the plants protected under Schedule VI.

13.1.3. Bodies Constituted under the Act:

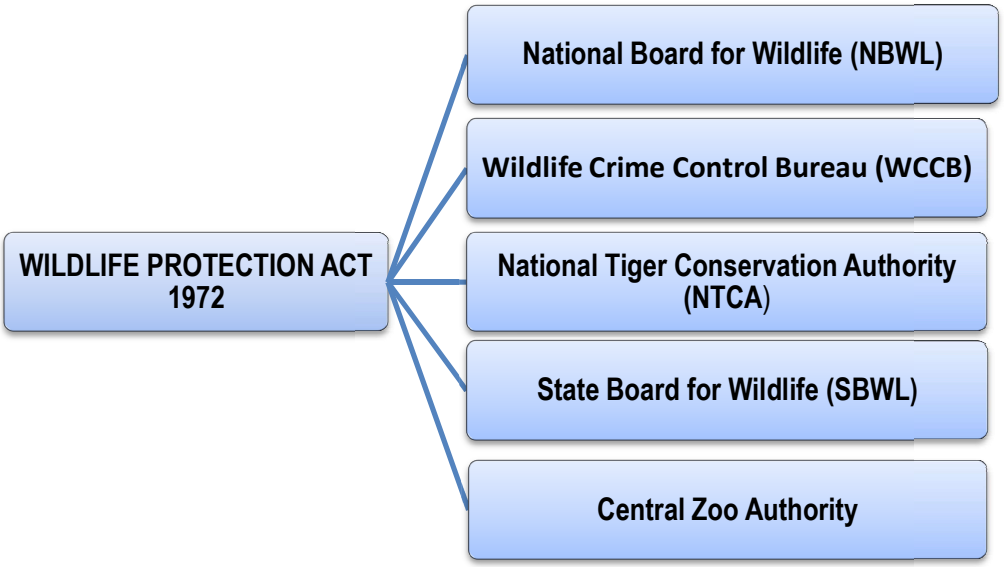


Fig 2. Different Bodies constituted under Wildlife Protection Act 1972

I. NBWL serves as an apex body for the review of all wildlife-related matters and for the approval of projects in and around national parks and sanctuaries (Fig. 2).
II. The Chief Minister of the state/UT is the chairperson of the State Board for Wildlife (SBWL).
III. The Central Zoo Authority consists of a total 10 members including the Chairperson and a Member-Secretary.
IV. The Central Zoo Authority provides recognition to zoos and is also tasked with regulating the zoos across the country.
V. It lays down guidelines and prescribes rules under which animals may be transferred among zoos nationally and internationally.
VI. National Tiger Conservation Authority (NTCA) was constituted in 2005 for strengthening tiger conservation.
VII. The Union Environment Minister is the Chairperson of NTCA and the State Environment Minister is the Vice-Chairperson.
VIII. The Central Government on the recommendations of NTCA declares an area as a Tiger Reserve.
IX. The constitution of Wildlife Crime Control Bureau (WCCB) to combat organized wildlife crime in the country.
X. There are five types of protected areas under the Act which are: Sanctuary, National Parks, Conservation Reserves, Community Reserves and Tiger Reserves.

13.1.4. Important Amendments:

I. Wildlife (Protection) modification Act of 1991: This modification increased the penalties and punishments for wildlife-related acts while also including provisions for the protection of endangered species.

II. The Wildlife (Protection) Amendment Act of 2002: established the concept of community reserves and conservation reserves as protected regions.

III. The Wildlife (Protection) Amendment Act of 2006 addressed the issue of human-wildlife conflict and established the National Tiger Conservation Authority (NTCA) to

monitor and safeguard tiger reserves. It also provided for the establishment of a Tiger and Other Endangered Species Crime Control Bureau to address wildlife-related offences.

IV. Wildlife (Protection) Amendment Act, 2022: The Act aims to increase the number of species protected by law and implement CITES. The number of schedules has decreased to four:

• Schedule I includes animal species with the highest level of protection.

• Schedule II covers animal species with less protection.

• Schedule III for protected plant species.

• Schedule IV for scheduled specimens under CITES.

1. The Act allows the use of elephants for religious or other reasons.
2. Penalties for offences against both general and specially protected species have been enhanced.

13.1.5. Initiatives of Wildlife Development under Wildlife Protection Act, 1972:

Since the formation of Jim Corbett National Park in 1930, India has been conducting wildlife conservation projects. The Government of India has started a huge number of projects to save animal biodiversity and avert extinction. Wildlife conservation aims to safeguard endangered animal and plant species, as well as their natural habitats. The conservation efforts include:

1. Project Tiger
2. Project Elephant.
3. Project Hangul
4. Project Snow Leopard
5. One Horn Rhino
6. Project Ganges Dolphin
7. Project Crocodile:
8. Cheetah Project

9. Project Sea Turtle

10. Conservation for Vultures

1. Project Tiger Conservation: Project Tiger Conservation aims to conserve tigers' populations. The project, launched in 1973, is now running with the aid of the Ministry of Environment, Forests, and Climate change.

2. **Project Elephant:** Project Elephant was established by the central government in 1992 to protect and conserve elephants. The Act identified a total of 88 corridors.

3. Wildlife Corridors: These corridors connect protected areas and allow animals to migrate freely without interfering with human populations. The first urban wildlife corridor in India, connecting New Delhi and Haryana, has recently been planned. The corridor is located near the Asola Bhatti wildlife reserve and provides safe passage for wildlife species such as leopards and other animals.

13.1.6. Major Challenges in Wildlife Protection Act, 1972

1. Lack of Awareness: Despite being in place for more than 50 years, the Act has failed to reach the general public adequately. Many individuals remain uninformed of the significance of wildlife conservation and the rules governing it.

2. Human-Wildlife Conflict: As human populations grow and wildlife habitats are encroached upon, human-wildlife conflict has increased. This frequently results in the slaughter of wildlife, which is forbidden under the WPA.

3. Illicit Wildlife trafficking: India has seen a huge increase in illicit wildlife trafficking, which poses a serious threat to the country's wildlife. Despite strict restrictions, poaching and illegal wildlife trade continue to thrive.

4. Lack of Coordination: The forest department frequently fails to coordinate with other government agencies such as the police, customs, and revenue departments.This makes it difficult to adequately enforce the WPA and prevent the illegal wildlife trade.

5. Inadequate Penalties: The penalties for wildlife crimes under the WPA are insufficient to serve as deterrence. Fines and punishments are sometimes inadequate to discourage criminals.

6. Lack of community participation: Local people must be involved in conservation effort s for them to be effective.

However, there is sometimes a lack of community involvement in wildlife conservation initia tives.

7. Climate Change: Climate change poses a serious hazard to wildlife habitats and is expected to introduce new challenges to current wildlife. The WPA must consider the impact of climate change on wildlife and their habitats.

Self-Assessment 1

A. Multiple Choice Questions (MCQs)

1. What year was the Wildlife Protection Act enacted in India?

A) 1965

B) 1972

C) 1980

D) 1991

2. Which of the following is NOT a protected area under the Wildlife Protection Act?

A) National Parks

B) Wildlife Sanctuaries

C) Biosphere Reserves

D) Agricultural Land

3. What is the primary objective of the Wildlife Protection Act?

A) To promote tourism

B) To protect wildlife and their habitats

C) To enhance agricultural production

D) To regulate fishing

4. The first amendment to the Wildlife Protection Act was made in which year?

A) 1986

B) 1991

C) 2002

D) 2013

5. Which Schedule of the Wildlife Protection Act lists endangered species?

A) Schedule I

B) Schedule II

C) Schedule III

D) Schedule IV

B. True/False Statements

1. The Wildlife Protection Act allows for the hunting of all wildlife species in India.

2. The Act provides for the establishment of national parks and wildlife sanctuaries.

3. The Wildlife Protection Act has been amended multiple times to strengthen wildlife conservation efforts.

4. The Act includes provisions for the rehabilitation of wildlife.

5. Only the central government can enforce the Wildlife Protection Act, and states have no role.

13.2. Various Forest & Environment Conservation Acts

Forests are an important part of the environment and contribute to the quality of life. During the British rule in India, forest laws were regarded as necessary to control and protect the country's forests and resources. The Indian Forest Service was established in 1864 to work on the formulation of the Indian Forest Act of 1865. The Act was revised twice, once in 1878 and again in 1927.

Forest Conservation

The Forest Conservation Act of 1980 was established to help preserve the country's forests. It strongly prohibits and regulates the de-reservation of forests and the use of forest land for non-forest purposes without prior consent from the Central Government. To

this objective, the Act specifies the requirements for diverting forest land for non-forest purposes. The Indian Forest Act of 1927 consolidates the laws governing forests, the transportation of forest produce, and the duty levied on timber and other forest produce.

13.2.1. History of Forest policies in India

• In 1850, British authorities appointed the first Inspector- General of Forests, and the Forest Department was founded in 1864.

• The Forest Act of 1865 divided woods into reserved and unclassified categories to increase revenue.

• In 1878, the Forest Act removed communal rights to woods and replaced them with privileges that required payment.

• In 1894, the first Forest Policy was developed, with an emphasis on agriculture rather than forests.

• The Forest Act was updated in 1927, tightening laws and further restricting people's rights

• The Forest Policy of 1952 resulted in the acquisition of extensive forest territory from princely entities and "zamindaris". The initiative recommended that 33% of India's land be covered by forests or trees. It provided thorough directions for managing and preserving forests and wildlife.

• The Forest Conservation Act, passed in 1980, aims to maintain and conserve the country's forests.

• The National Forest Policy of 1988 revised the previous National Forest Policy of 1952.

• The Scheduled Tribes and Other Traditional Forest inhabitants (Recognition of Forest Rights) Act was passed in 2006 to remedy historical injustices against forest inhabitants.

13.2.2. Indian Forest Act (1865, 1878, and 1927)

The British implemented the Indian Forest Act to govern the local use of forests. It was a watershed moment that granted the state the authority to manage the rights to utilise forests and regulate the use of timber and other forest products. It also found to charge taxes on timber and other forest-based goods, which would generate cash for the government. The Indian Forest Act of 1927 was created to improve and strengthen existing Indian forest legislation implemented by the British.

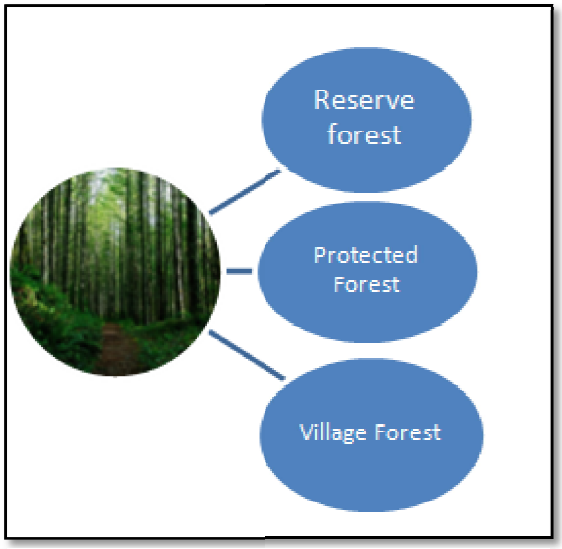


Fig. 3. Types of Forest under Indian forest act

Types of Forest Land under the Indian Forest Act

The Indian Forest Act classified the forests into three types – reserved forests, protected forests and village forests.

Reserved forests are the strongest types of woods, designated by the government to protect species and natural resources. In these forests, hunting and tree-cutting are absolutely forbidden unless there is a good reason and permission from higher authorities. Chapter 2 of the Indian Forest Act of 1927 covers reserve forests.

Protected Forest: The government has designated certain forests as protected forests in order to promote conservation and preservation. The state government does not have any reservations in these woods. The State Government has the authority to designate specific tree species for revenue-raising reasons and to impose regulations and limits on the use of these forests. The Forest Department oversees the management of these woods.

Village Forests: Village forests are those over which specific village communities with property designated as a reserved forest are granted ownership rights by the State Government. Village forests give nearby people a chance to sustainably manage their own

resources. Village forests are covered by Section 28 of the Indian Forest Act, which also provides guidelines for their establishment and management.

13.2.3. Forest Conservation Act, 1980

The Forest (Conservation) Ordinance, 1980 was enforced by the President of India to conserve forests, which was later repealed by the Forest (Conservation) Act, 1980. For centuries, people living in and around forests have had a symbiotic relationship with their environment. However, during colonial times this relationship shifted from local communities using forests as a resource to State resources for commercial interests. Further, with the increasing human population, forests were being depleted at an alarming rate. These led to the enactment of the Forest Conservation Act, 1980 which ensures their protection and sustainable use.

Features of the Forest Conservation Act 1980

The Forest Conservation Act of 1980 supplanted the Indian Forest Act of 1927, which was designed to preserve the British Empire's business interests in India. The law applies to all of India and was revised in 1988. It aims to safeguard forests and ensure their long-term usage by limiting the use of forests for non-forest activities. The Act not only prohibits deforestation, but also requires that any alterations made to existing forests be done properly and with due regard for the environment.

The Act also prohibits the state government and other authorities from making decisions without the Central government's authorization, and it imposes penalties for infractions of its provisions. This act has been vital in conserving India's forests and animals for decades, making it one of the most important pieces of environmental law in the country today.

13.2.4. Forest (Conservation) Amendment Act 2023

- Included a 'preamble' highlighting India's commitment to preserving forests, biodiversity, and addressing climate change problems.

- Changing the name of the Act to Van (Sanrakshan Evam Samvardhan) Adhiniyam (translated as Forest Conservation and Augmentation) from the current Forest (Conservation) Act.
- The Act only applies to lands designated as 'forest' in official records on or after 1980.
- Exemptions: The Act does not apply to notified forest land that was legally diverted for non-forest use between 1980 and 1996.
- Forest land located 100 km from international borders for "strategic projects of national importance" or • Land of 5-10 hectares for security and defense projects.
- The Act allows some operations in forests, including erecting checkpoints, fencing, and bridges.
- The Bill also enables the operation of zoos, safaris, and eco-tourism facilities.
- The state government requires prior approval from the central government before assigning forest land to a private entity.
- The Bill expands this to include all entities and allows for assignment based on the central government's stipulated terms and conditions.

13.2.5. National Forest Policy

The National Forest Policy was initially established in 1952. The Indian Parliament changed the policy in 1988, replacing the previously adopted policy of 1952. The primary goal of this strategy was to guarantee that forests are managed in a sustainable manner, and that local/tribal communities are empowered and participate in their conservation and development. One direct result of this approach was the formation of Joint Forest Management (JFM). This strategy aimed to maintain environmental stability, restore ecological balance, protect natural heritage including flora and fauna, avoid soil erosion, floods, and droughts, and increase forest cover through afforestation initiatives.

The National Forest Policy also aimed to promote the efficient use of forest resources for meeting fundamental human requirements such as fuelwood, fodder, and small timber,

while ensuring that these activities did not contribute to deforestation or degradation. It also emphasized the need of biological variety conservation, namely the protection of endangered species and the preservation of genetic variation. Furthermore, it proposed strategies to increase production through scientific management approaches such as silviculture and agroforestry.

The policy establishes an overarching structure and direction for the management and regulation of forests in the country. The new strategy is also an essential step towards addressing the challenge of climate change in India, with the goal of bringing at least one-third of the country's entire geographical area under forest cover through scientific interventions and tight laws to safeguard dense cover.

13.2.6. Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006

The Scheduled Tribes and Other Traditional Forest inhabitants (Recognition of Forest Rights) Act of 2006 was passed to remedy historical injustices against forest inhabitants. This legislation was enacted to establish a balance between their right to the environment and their right to life and livelihood. The Indian Forest Act of 1927 allowed for the settlement of rights, although it was rarely executed. The National Forest Policy of 1988 recognized the symbiotic relationship between forests and forest-dwelling communities, prompting the passage of this law.

The Act acknowledges the right of forest-dwelling tribal people and other traditional forest dwellers to access and utilize traditional forest resources.

It also guarantees rights to self-cultivation, dwelling, grazing, fishing, access to water bodies, habitat rights for especially vulnerable tribal groups (PVTGs), traditional seasonal resource access for nomadic and pastoral populations, and so on. It also assigns the Gramme Sabha the task of conserving and protecting biodiversity, wildlife, forests, and other environmentally sensitive regions.

The Act protects forest residents from unlawful evictions and provides essential development services such as education, health care, nutrition, and infrastructure.

13.2.7. Forest Conservation Rules, 2022

The Forest Conservation Rules 2022 are a set of regulations issued by the Ministry of Environment, Forests, and Climate Change (MoEFCC) to ensure efficient forest conservation management. The rules establish an Advisory Committee and a Project Screening Committee in each state/UT to advise or recommend on forest conservation issues. The committees have been given precise timetables for considering non-mining projects ranging from 5 to 40 hectares and mining projects within 75 days. For larger projects, the committee has more time to review.

The guidelines also allow private developers to destroy forests without first obtaining authorization from the forest dwellers, as well as clearing a forest without telling its legitimate residents. Applicants are seeking to divert forest land in hilly or mountainous states with green cover covering more than two-thirds of the geographical area, or in a state/UT with forest cover covering more than one-third of the geographical area, may engage in compensating afforestation in other states.

Forest Conservation Rules 2022 being criticized?

• State governments are now responsible for obtaining forest dwellers' consent before approving projects, allowing private developers to tear down forests without consulting them.

• The Union Government can clear forests without alerting residents. This goes against the Scheduled Tribes and Other customary Forest Dwellers (Recognition of Forest Rights) Act of 2006, which requires governments to get the free, prior, and informed permission of forest dwellers before approving a project on their customary lands.

• The Forest Conservation Act 1980 was revised in 1988 to encompass the entire country. This implies that all forests in India are now subject to these new regulations, which allow private developers to clear them without consulting the people who live there or rely on

them for a living. This has outraged individuals who rely on these trees for a living, as they are left with little choice but to accept it. This is considered as an attack on indigenous rights, and many impacted are extremely distressed.

13.3. History of environmental laws in India

The detailed and developed framework for environmental protection emerged during the 1972 United Nations Conference on the Human Environment in Stockholm. In 1972, the Science and Technology Department established the National Council for Environmental Policy and Planning. This was set up to create a regulatory body to oversee environmental issues and concerns. This council was later reorganized as the Ministry of Environment and Forests.

Environmental Laws in India

The government of India has made numerous acts to protect the environment and biodiversity. The important and impactful environmental laws and acts are listed and explained below.

- The Water (Prevention and Control of Pollution) Act, 1974,
- The Water (Prevention and Control of Pollution) Cess Act, 1977,
- The Forest (Conservation) Act, 1980,
- The Air (Prevention and Control of Pollution) Act, 1981,
- The Environment (Protection) Act, 1986,
- The Public Liability Insurance Act, 1991

13.3.1. The Water (Prevention and Control of Pollution) Act, 1974

The main objective of water act is:

- To prevent and regulate water contamination. Maintaining or restoring the wholesomeness and cleanliness of water from various sources.
- It grants regulatory jurisdiction to the Centre Pollution Control Boards (CPCBs) and State Pollution Control Boards (SPCBs).

- CPCB and SPSB are statutory bodies established under the Water Act of 1974. It allows the CPCB and SPCB to develop and enforce effluent standards for factories that discharge pollutants into water bodies.
- CPCB serves the same functions for union territories, as well as developing policies to avoid water pollution and coordinating the actions of several SPSBs.
- SPCB regulates sewage and industrial effluent discharge by authorising, denying, and consenting to discharge.

13.3.2. The Air (Prevention and Control of Pollution) Act, 1981

- The act attempts to manage and prevent air pollution in India, with the following key objectives: prevention, control, and abatement.
- To establish boards at the national and state levels to implement the act.
- CPCB and SPCB were given the authority.
- It states that sources of air pollution, such as internal combustion engines, industry, vehicles, and power plants, are not permitted to exceed the predetermined limit for particulate matter, lead, carbon monoxide, sulphur dioxide, nitrogen oxide, volatile organic compounds (VOCs), or other toxic substances.
- It authorizes the state government to identify air pollution hotspots.

13.3.3. The Environment (Protection) Act, 1986

This act was enacted under Article 253 (legislation to give effect to international accords). This was passed in the aftermath of the Bhopal gas disaster in December 1984. It was passed to implement the Stockholm Declaration of the 1972 United Nations Conference on the Human Environment. The MoEFCC notifies eco-sensitive zones or ecologically fragile regions in accordance with the EPA, 1986, which establishes 10-kilometer buffer zones surrounding protected areas.

Statutory bodies under the EPA, 1986:

- Genetic Engineering Appraisal Committee

- National Coastal Zone Management Authority (later converted to National Ganga Council under the Ministry of Jal Sakthi)
- The ozone-depleting substances (regulation and control) rules, 2000

It established deadlines for the phase-out of certain Ozone Depleting Substances (ODSs) and regulated the manufacture, sale, import, and export of ODS-containing products. These regulations restrict the use of CFCs, halons, ODSs including carbon tetrachloride and methyl chloroform, and SFCs except in metered-dose inhalers and for other medical applications.

13.3.4. Coastal Regulation Zone Notification 2018

- It was notified in accordance with the Shailesh Nayak Committee's recommendations.
- To promote sustainable development while accounting for natural threats such as rising sea levels due to global warming.
- To conserve and protect biodiversity while also providing livelihood security for local residents, notably fishers. CRZs are grouped into four zones for regulation:

1. **CRZ I** includes ecologically fragile habitats such mangroves, coral reefs, salt marshes, turtle nesting grounds, and the intertidal zone.
2. **CRZ II** refers to built areas along the shore.
3. **CRZ III-** Coastal areas that are not heavily developed, including rural coastal areas.
4. **CRZ IV** refers to the water area between the Low Tide Line (LTL) and India's territorial waters.

- It was enacted to increase energy efficiency and reduce waste. It sets energy consumption guidelines for equipment and appliances.
- It establishes energy consumption guidelines and requirements for consumers. It establishes energy-efficient building codes for commercial buildings.
- The Bureau of Energy Efficiency (BEE) is a statutory entity created by the act.

13.3.5. The National Green Tribunal Act, 2010

Established in 1992 during the Rio Summit to provide legal and administrative remedies for victims of pollution and environmental damage. Consistent with Article 21 of the constitution, which guarantees citizens the right to a healthy environment. The NGT must resolve cases within 6 months of receiving appeals. The NGT has original jurisdiction over environmental issues. NGT deals with the civil cases under the 7 acts related to the environment:

1. Water (Prevention And Control Of Pollution) Act, 1974
2. Air (Prevention And Control Of Pollution) Act, 1977
3. Forest Conservation Act, 1980
4. Environmental Protection Act, 1986
5. Public Liability Insurance Act 1991
6. Biological Diversity Act, 2002

Two acts have been kept out of the jurisdiction of NGT:

1. Wildlife Protection Act, 1972
2. Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 (FRA)

The decisions of the NGT can be challenged in High Courts and the Supreme Court.

13.3.6. Compensatory Afforestation Fund Act, 2016

The CAF Act was adopted to administer monies collected for compensatory afforestation, which were previously controlled by the ad hoc Compensatory Afforestation Fund Management and Planning Authority (CAMPA). Compensatory afforestation means that every time forest land is diverted for non-forest purposes such as mining or industry, the user agency pays for planting forests on an equal area of non-forest land or twice the extent of degraded forest land if such land is unavailable. According to the rules, 90% of the CAF money is to be distributed to the states, with the remaining 10% held by the Centre.

The funds can be used for catchment area treatment, assisted natural generation, forest management, wildlife protection and management, village relocation from protected areas, human-wildlife conflict resolution, training and awareness-raising, the supply of wood-saving devices, and other related activities.

Self-Assessment 2

A. Multiple choice Questions:

1. Which act is primarily focused on the conservation of forests and their resources in India?

A) Wildlife Protection Act, 1972

B) Forest (Conservation) Act, 1980

C) Environment Protection Act, 1986

D) Biological Diversity Act, 2002

2. What is the main objective of the Environment Protection Act, 1986?

A) To regulate hunting of wild animals

B) To protect and improve the environment

C) To conserve forests

D) To promote sustainable agriculture

3. Which of the following is NOT a provision of the Forest (Conservation) Act, 1980?

A) Prior approval of the central government for diversion of forest land

B) Protection of wildlife habitats

C) Conservation of biodiversity

D) Compensatory afforestation

4. Which section of the Forest (Conservation) Act, 1980, deals with the procedure for approval for forest land diversion?

A) Section 2

B) Section 3

C) Section 4

D) Section 5

5. The National Forest Policy of India was formulated in which year?

A) 1988

B) 1976

C) 1991

D) 2000

6. What does the term "compensatory afforestation" refer to in the context of forest conservation?

A) Planting trees in urban areas

B) Planting trees in place of those that have been cut down

C) Restoring degraded forest land

D) Conservation of existing forests

13.4. Biodiversity Act, 2002

13.4.1. Background

Biodiversity refers to the variability among living organisms from all sources and the ecological complexity of which they are a part, including variation within species, between species, and within ecosystems. Plants, animals, and microorganisms or sections of them, as well as their genetic material and byproducts (excluding value-added products), having present or potential use or value, are considered biological resources. The Biological Diversity Act, 2002, originated from India's attempt to realize the goals set in the United Nations Convention on Biological Diversity (CBD) 1992, which recognizes states' sovereign rights to use their own biological resources.

13.4.2. The Biological Diversity Act, 2002

The act, established in 2002, aims to conserve biological resources, manage their sustainable use, and enable fair and equitable sharing of benefits resulting from the use and knowledge of biological resources with local populations.

Key Features of the Act

The Act prohibits the following activities without prior approval from the National Biodiversity Authority:

• Obtaining biological resources in India for research or commercial use.

• Transferring research results from India.

• Claiming intellectual property rights on inventions based on biological resources.

The act proposed a three-tier framework to control access to biological resources:

1. The National Biodiversity Authority (NBA).

2. State Biodiversity Boards (SBB)

3. Local Biodiversity Management Committees (BMCs)

The National Biodiversity Authority (NBA)

The Central Government formed the National Biodiversity Authority (NBA) in 2003 to administer India's Biological Diversity Act (2002).

It is a statutory body that facilitates, regulates, and advises the Government of India on the conservation and sustainable use of biological resources.

The NBA's headquarters are in Chennai and Tamil Nadu, India.

Structure of the NBA

The National Biodiversity Authority consists of the following members, who will be selected by the federal government:

- **A chairperson:** Three ex officio members: one from the Ministry of Tribal Affairs and two representing the Ministry of Environment and Forests.

- **Seven ex-officio members** will represent the Central Government Ministries responsible for :
    - Agricultural Research and Education
    - Biotechnology
    - Ocean Development
    - Agriculture and Cooperation
    - Indian Systems of Medicine and Homoeopathy
    - Science and Technology
    - Scientific and Industrial Research;

Five non-official members: to be appointed from amongst specialists and scientists having special knowledge and experience in the required matters.

Functions of the NBA

- Providing an enabling environment as needed to encourage biodiversity conservation and sustainable use.
- Advising the central government, regulating activities, and giving guidelines for access to biological resources and fair and equitable benefit sharing under the Biological Diversity Act of 2002.
- Taking the necessary steps to prevent the unauthorised grant of intellectual property rights in any nation other than India on any biological resource obtained from India or information related with such biological resources.
- Advising state governments on the selection of biodiversity-rich regions to be designated as heritage sites, as well as proposing management strategies.

State Biodiversity Boards (SBBs)

The SBBs are established by state governments in accordance with Section 22 of the Act. All members of the SBB are appointed by their respective state governments. The State Biodiversity Board has the following members:

- A chairperson.

- Not more than five ex officio members to represent the relevant Departments of the State Government.
- Not more than five members drawn from among experts in biological diversity conservation, sustainable use of biological resources, and equitable distribution of benefits derived from biological resource usage.

Functions of SBBs

- Advise the State Government on conservation, sustainable usage, and equitable benefit sharing, subject to any recommendations set by the Central Government.
- Regulate by giving approvals or other requests for commercial exploitation, bio-survey, and bio-utilisation of any biological resource by humans.
- There are no State Biodiversity Boards established for Union territory.
- The National Biodiversity Authority has the authority and functions of a State Biodiversity Board for the UTs.

Biodiversity Management Committees (BMCs)

- Section 41 of the Act requires local bodies to establish a Biodiversity Management Committee (BMC) to promote conservation, sustainable use, and documentation of biological diversity. This includes preserving habitats, landraces, folk varieties and cultivars, domesticated stocks and breeds of animals, microorganisms, and chronicling knowledge about biological diversity (Structure).
- It shall be composed of a chairperson and no more than six members nominated by the local body.
- A BMC's membership should consist of at least one-third women and at least 18% Scheduled Castes/Tribes.

- The Chairperson of the Biodiversity Management Committee will be elected from among the committee members at a meeting presided over by the local body's Chairperson.
- In the event of a tie, the local body's chairperson will cast the deciding vote.

Functions

- The BMC's primary role is to prepare the People's Biodiversity Register in conjunction with local residents.
- The register must include detailed information about the availability and knowledge of local biological resources, as well as any therapeutic or other uses for them.

People's Biodiversity Registers (PBR):

The PBRs aim to document local biodiversity, traditional knowledge, and practices through participatory documentation. The registers provide detailed information on biological resources, their medicinal uses, and associated traditional knowledge. They are important legal documents for establishing local people's rights over biological resources and traditional knowledge.

Biodiversity Heritage Sites (BHS)

Under Section 37 of Biological Diversity Act, 2002 the State Government in consultation with local bodies may notify the areas of biodiversity importance as Biodiversity Heritage Sites. The Biodiversity Heritage Sites are the well defined areas that are unique, ecologically fragile ecosystems - terrestrial, coastal and inland waters and, marine having rich biodiversity comprising of any one or more of the following components:

- Richness of wild as well as domesticated species or intra-specific categories
- High endemism
- Presence of rare and threatened species
- Keystone species

- Species of evolutionary significance
- Wild ancestors of domestic/cultivated species or their varieties
- Past preeminence of biological components represented by fossil beds

Having significant cultural, ethical or aesthetic values; important for the maintenance of cultural diversity (with or without a long history of human association with them)

Areas having any of the following characteristics may qualify for inclusion as BHS.

Some of the Biodiversity Heritage Site (BHS) are as follows:

- **Nanda Devi Biosphere Reserve, Uttarakhand**: Known for its diverse flora and fauna, including endangered species.
- **Kumarakom Bird Sanctuary, Kerala**: A vital habitat for migratory birds, promoting eco-tourism and conservation efforts.
- **Bhitarkanika Mangroves, Odisha**: A critical site for mangrove conservation and home to saltwater crocodiles.
- **Western Ghats**: A UNESCO World Heritage Site, this region boasts high levels of endemic species and rich biodiversity.
- **Sundarbans, West Bengal**: Famous for its unique mangrove forests and the Royal Bengal Tiger.

Summary

The WPA 1972 has been in existence for more than 50 years, but it faces several challenges. Addressing these challenges will require a concerted effort from the government, civil society, and the public. Effective enforcement, community participation, and awareness-raising campaigns are some of the steps that can be taken to protect India's wildlife and their habitats.

Answer key:

Self-Assessment 1: A- 1-B; 2-D; 3-B; 4-A; 5-A. **B-** 1-F; 2-T; 3-T; 4-T;5-F.

Self-Assessment 2: 1-B; 2-B; 3-B, 4-A; 5-A; 6-B.

Terminal Questions:

A. Multiple choice question

1. What is the main objective of the Biodiversity Act, 2002?

A) To promote industrial development

B) To conserve biological diversity and ensure sustainable use of its components

C) To regulate fishing practices

D) To manage water resources

Answer: B) To conserve biological diversity and ensure sustainable use of its components

2. Which authority is established under the Biodiversity Act, 2002, to oversee biodiversity management?

A) Central Environmental Authority

B) National Biodiversity Authority (NBA)

C) State Forest Department

D) Ministry of Agriculture

Answer: B) National Biodiversity Authority (NBA)

3. The Biodiversity Management Committees (BMCs) are formed at which level?

A) National level

B) State level

C) Local level

D) District level

Answer: C) Local level

4. The Act mandates the preparation of a People's Biodiversity Register. What is its purpose?

A) To document species richness

B) To record traditional knowledge related to biodiversity

C) To assess economic benefits of biodiversity

D) To promote eco-tourism

Answer: B) To record traditional knowledge related to biodiversity

5. If a particular plant species is placed under Schedule VI of the Wildlife Protection Act, 1972, what is the implication? (2020)

A) A licence is required to cultivate that plant.

B) Such a plant cannot be cultivated under any circumstances.

C) It is a Genetically Modified crop plant.

D) Such a plant is invasive and harmful to the ecosystem.

Ans: (a) A licence is required to cultivate that plant.

6. At the national level, which ministry is the nodal agency to ensure effective implementation of the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006?

A) Ministry of Environment, Forest and Climatic Change.

(B) Ministry of Panchayat Raj

C) Ministry of Rural Development

D) Ministry of Tribal Affairs

Answer: (d) Ministry of Tribal Affairs

B. True/False type Questions

1. The Biodiversity Act, 2002, allows for the commercialization of biological resources without any regulation.

Answer: False

2. The National Biodiversity Authority (NBA) has the authority to grant approval for accessing biological resources.

Answer: True

3. The Biodiversity Act, 2002, focuses only on the conservation of flora, ignoring fauna.

Answer: False

4. Local communities have no role in the implementation of the Biodiversity Act, 2002.

Answer: False

5. The Act emphasizes the need for benefit-sharing with local communities who conserve biodiversity.

Answer: True

C. Short /Answer type question

Q1. What is Zoo safari?

Answer: A zoo safari is a commercial drive-in tourist attraction where visitors can drive their own vehicles or ride in vehicles provided by the facility to observe freely roaming animals. Safari parks are larger than zoos and smaller than game reserves.

Q2. What is Forest Advisory Committee (FAC)?

Answer: The Forest Advisory Committee (FAC) is a statutory body established under the Forest Conservation Act (FCA) of 1980.

Unit 14. Conservation and Sustainable Use of Biodiversity II

Unit Structure

14.0. Learning Objectives

After you have studied this unit, you should be able to understand about:

- International Environmental Conventions
- Ramsar and world Heritage convention
- Role of Corporate Social Responsibility (CSR) in Environment and Biodiversity Management
- Convention on Migratory species

14.1. International Initiatives: Major International Conventions

Conference: A conference is a formal consultation; a type of discussion with a wide theme. In a conference, the principal bodies are formed to conduct further deliberations on the broad issue for which the conference is called.

Convention: A convention is a conference or gathering to develop or reflect on a generally recognized principle, a framework in which the parties choose the fundamental parameters. Occasionally the line between conference and convention is very thin, and

occasionally they are interchangeably used since the outcome document of the convention arrives at the conference.

Protocol: A protocol to the convention is an agreement developed and signed by diplomatic negotiators as the foundation for a final convention in which the parties establish specified goals or legal duties. Typically, when an important provision is to be integrated into the convention's regulations, a protocol is called among the countries that signed and accepted the original convention.

The IUCN was one of the few non-governmental organizations (NGOs) directly participating in the preparations for the 1972 United Nations Conference on the Human Environment in Stockholm. The Stockholm Conference ultimately resulted in three new international conventions, with IUCN involved in their draughting and implementation:

- In 1961, the IUCN assisted in establishing the World Wildlife Fund, today known as the World Wide Fund for Nature (WWF), to ensure a permanent financial foundation for its operations.
- The IUCN conducts technical evaluations and monitoring for The Convention on the Protection of World Cultural and Natural Heritage (1972).
- CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) (1974) IUCN is a signing party, and the CITES secretariat was first filed with IUCN.
- Ramsar Convention on Wetlands of International Importance (1975). The secretariat is still run from the IUCN's headquarters.
- In 1975, IUCN started collaborating on the World Conservation Strategy.

Some of the major International Conventions are:

Convention Name	**Year**
RAMSAR Convention on Wetlands	1971
Stockholm Conference	1972

Convention Concerning the Protection of World Cultural and Natural Heritage	1972
CITES	1973
Convention on Migratory Species of Wild Animals	1979
World Conservation Strategy	1980
Nairobi Declaration	1982
Vienna Convention for Ozone Layer	1985
Montreal Protocol for ODS	1987
Basel Convention on Hazardous wastes	1989
Earth Summit	1992
UNFCCC	1992
CBD	1992
UN Convention on Desertification	1994
Kyoto Protocol	1997
Stockholm Convention on POPs	2000
Johannesburg Declaration	2002
UN World Summit	2005
Bali Summit on Climate Change	2007

Self-Assessment -1

Multiple choice Questions

1.Which of the following conventions is specifically aimed at reducing greenhouse gas emissions?

A) Convention on Biological Diversity

B) United Nations Framework Convention on Climate Change (UNFCCC)

C) Ramsar Convention on Wetlands

D) Montreal Protocol

2.The Kyoto Protocol, adopted in 1997, focuses on which of the following?

A) Protecting endangered species

B) Controlling ozone-depleting substances

C) Establishing legally binding commitments for industrialized countries to reduce greenhouse gas emissions

D) Conserving marine biodiversity

3. The Convention on Biological Diversity (CBD) was adopted at which international event?

A) Earth Summit in Rio de Janeiro, 1992

B) Kyoto Conference, 1997

C) Stockholm Conference, 1972

D) Paris Agreement, 2015

14.2. Convention on Migratory Species, 1979 (BONN Convention)

The Convention on the Conservation of Migratory animals of Wild Animals, generally known as the Convention on Migratory Species (**CMS) or the Bonn Convention**, is an international agreement that seeks to protect migratory animals across their entire range1. The convention was held in **Bonn, Germany, in 1979.**The Convention went into effect in 1983. As of September 2020, the Convention has 131 member states. The Government of the Federal Republic of Germany serves as the depositary. This treaty includes conservation efforts for Marine Turtles, Siberian and Dugongs in India. The main objectives of the convention are:

1. The convention aimed to reach an agreement on the management of wild animals that move "cyclically and predictably" across international borders.

2. The Convention promotes accurate protection measures for endangered migratory species, multilateral conservation agreements, and collaborative research initiatives.

The Convention has two appendices:

- **Appendix I** include a list of endangered migratory species that require urgent international cooperation to resolve.
- **Appendix II** identifies other species that require or would benefit from international agreements under the Convention.
- India held the **13th Conference of Parties (COP)** of the Convention on the Conservation of Migratory Species of Wild Animals (CMS) in Gandhinagar, Gujarat, from February 17th to 22nd, 2020.
- The COP 13 logo was inspired by 'Kolam', a traditional art form in Southern India depicting key migratory species such as Amur Falcons and Marine Turtles.
- The logo emphasised the importance of ecological connectivity in protecting migratory wildlife and habitats.
- COP 13 recommends protecting ten new species under CMS.

• There are seven proposed species, including the Little Bustard (EU Nations), Urial (Tajikistan, Iran, Uzbekistan), Jaguar (Costa Rica, Argentina, Bolivia, and Paraguay), White tip Shark (Brazil), Antipodean Albatross (New Zealand, Australia, Chile), Smooth Hammerhead Shark (Brazil), and Tope Shark (EU Nations). Three Indian species: Asian Elephant, Bengal Florican, and Great Indian Bustard are proposed for protection.

• Risks to biodiversity, habitat loss, fragmentation, destruction, degradation, and climate change were identified at COP 13.

Self-Assessment -2

Multiple choice Questions

1.What is the primary goal of the Convention on Migratory Species (CMS)?

A) To regulate international trade in wildlife

B) To conserve migratory species and their habitats

C) To promote eco-tourism

D) To develop marine protected areas

2. Which of the following species are included in Appendix I of the CMS?

A) Species that need international agreements for conservation

B) Species threatened with extinction

C) Species that are abundant and not endangered

D) Species that are endemic to a single country

3. What are range states in the context of CMS?

A) Countries with the largest populations of migratory species

B) Countries through which migratory species travel or breed

C) Countries that import wildlife

D) Countries that are members of CITES

4. Which of the following best describes the nature of CMS?

A) Legally binding international treaty

B) Non-binding agreement among countries

C) National legislation for wildlife protection

D) Research initiative on animal behavior

5. In which year was the Convention on Migratory Species adopted?

A) 1972

B) 1979

C) 1987

D) 1992

14.3. CITES

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) is an international agreement between states with the goal of preserving the planet's plants and animals by guaranteeing that international trading in their specimens does not jeopardize their survival. It was adopted in 1963 and went into effect in 1975.

The 19th Conference of the Parties to the Convention on International Trade in Endangered Species of Wild Fauna and Flora, or CITES COP19, was held in Panama City (November 14th to 25th, 2022). India presented three applications to CITES COP19 for stricter protection of its natural species, including the Jeypore Indian gecko, the red-crowned roofed turtle, and the Leith's softshell turtle.

- CITES was conceived in 1963 at a meeting of the International Union for Conservation of Nature. It was established in 1975 and currently has 183 member countries who comply with CITES standards by enacting legislation within their own borders to enforce such regulations.
- The Convention of Parties to CITES is the Convention's top decision-making body, made up of all of its Parties.
- Although CITES is legally binding for the Parties, it does not replace national legislation. Rather, it provides a framework that must be followed by each Party, which must pass its own domestic law to ensure that CITES is implemented on a national scale.

14.3.1. CITES Appendix

Plants and animals are classified into three groups under CITES based on their threat level. CITES protects around 5,600 animal species and 30,000 plant species from overexploitation in international trade. Species are categorized into three appendices based on their level of protection needed:

Appendix I: Species in danger of extinction. Commercial trading is forbidden. Permits are necessary for import and export. There are 931 species on the list. Examples include Asiatic lions and tigers (tiger skin trade), sea turtles, gorillas, lady slipper orchids (most species), and so on.

CITES Appendix II

Species that are not in danger of extinction but should be monitored to ensure that any trade does not pose a harm. trading permits are obtained lawfully, and only if the origin country guarantees that harvesting and trading will not impair the species' chances of survival. There are 34,419 species on the list. For example, American alligators (skin trade), paddlefish, mahogany, corals, and so on.

Appendix III: Species protected in at least one country. The regulations for these species vary, but normally the country that sought the listing can give export licenses, whereas exports from other countries require a certificate of origin. There are 147 species in the list. Honey badgers (for medicinal or bush meat purposes), walruses, map turtles, specific bugs, and so forth. CITES has several key features:

Permits and Certificates: International trade of listed species requires permits that ensure compliance with CITES regulations.

Parties and Governance: The treaty is enforced by member countries, known as Parties, which are responsible for implementing the provisions domestically.

Regular Reviews: CITES conducts periodic reviews and updates of species listings based on scientific data and conservation status.

Capacity Building: The convention provides resources and support for developing countries to strengthen their ability to manage wildlife trade.

Cooperation and Coordination: CITES promotes collaboration among member countries and with other international organizations to address wildlife trafficking and conservation.

Non-Compliance Measures: There are mechanisms to address non-compliance by member countries, including potential trade sanctions.

Self-Assessment- 3

Multiple choice Questions

1. What is the primary objective of CITES?

A) To protect all species from extinction

B) To regulate international trade in endangered species

C) To establish national parks

D) To promote sustainable tourism

2. CITES classifies species into how many appendices?

A) One

B) Two

C) Three

D) Four

3.Which Appendix of CITES includes species threatened with extinction, where trade is generally prohibited?

A) Appendix I

B) Appendix II

C) Appendix III

D) Appendix IV

4. What is required for the international trade of species listed in Appendix II of CITES?

A) No restrictions

B) Export permits to ensure sustainability

C) Complete ban on trade

D) Special permits for only government agencies

5.Which of the following is a key feature of CITES?

A) It is a legally binding international treaty for all countries.

B) It encourages parties to implement measures to prevent over-exploitation.

C) It only addresses terrestrial species.

D) It excludes plant species from its provisions.

6. Which of the following statements is true regarding CITES?

A) CITES is only focused on animals and does not cover plants.

B) CITES operates independently of national laws.

C) CITES provides financial penalties for illegal trade.

D) CITES requires permits for international trade of listed species.

14.4. Ramsar Convention

- The Ramsar Convention is an intergovernmental convention that guides national and international efforts to conserve and responsibly use wetlands and their resources.
- The Convention was adopted at **Ramsar, Iran, in 1971** and entered into force in 1975 after UNESCO, the Convention's depositary, received the instruments of accession from governments.
- The RAMSAR Secretariat is located at the headquarters of the International Union for the Conservation of Nature (IUCN) in Gland, Switzerland.
- **World Wetlands Day** is observed on **February 2nd**.

14.4.1. Criteria for choosing a RAMSAR site:

• **Criteria 1:** The site must be a representative, uncommon, or unique example of a natural or near-natural wetland type occurring in the relevant biogeographic region.

• **Criterion 2:** Supports vulnerable, endangered, or severely endangered species or threatened ecological communities.

• **Criterion 3:** Supports plant and/or animal species that contribute to the ecological diversity of a certain biogeography region.

•**Criterion 4:** Supports plant and animal species during vital stages of their life cycles or provides refuge from harsh conditions.

• **Criterion 5:** sustains 20,000 or more water birds on a consistent basis.

• **Criterion 6:** Supports 1% of a single species or subspecies of water bird.

• **Criteria 7:** Supports indigenous fish subspecies, species, families, life-history stages, species interactions, and populations that represent wetland advantages and values, contributing to global biological diversity.

• **Criterion 8:** whether it serves as a food source, breeding place, nursery, or migration path for fish stocks, both within and outside the wetland.

• **Criterion 9:** Supports 1% of a wetland-dependent non-avian animal population.

The Montreux Record

The **Montreux Record is a register of wetland areas** on the List of Wetlands of International Importance that have undergone or are expected to undergo ecological changes due to technological advancements, pollution, or human meddling. It is included in the Ramsar List.

Ramsar Sites in India

The Ramsar list's primary objective is "to develop and maintain an international network of wetlands which are important for the conservation of global biological diversity and for sustaining human life through the maintenance of their ecosystem components, processes and benefits".

• The convention went into effect in India on **February 1, 1982.**

• India has **46 Ramsar sites**, including Chilika Lake in Odisha, Keoladeo National Park in Rajasthan, Harike Lake in Punjab, Loktak Lake in Manipur, and Wular Lake in Jammu and Kashmir. • Keoladeo National Park and Loktak Lake are listed in the Montreux record, while Chilka Lake was designated but removed in 2002.

Self-Assessment- 4

A) Multiple choice Questions

1.What is the main purpose of the Ramsar Convention?

A) To protect the rights of indigenous peoples

B) To conserve wetlands and promote their sustainable use

C) To regulate international trade in endangered species

D) To address climate change impacts

2. In which year was the Ramsar Convention adopted?

A) 1971

B) 1982

C) 1992

D) 2000

3. Which of the following is considered a "wetland" under the Ramsar Convention?

A) Only marshes and swamps

B) Lakes, rivers, and coastal areas

C) Deserts and grasslands

D) Only man-made reservoirs

4. The Ramsar Convention encourages parties to promote the conservation and sustainable use of wetlands. Which of the following is a key aspect of this?

A) Only focusing on species protection

B) Involving local communities in wetland management

C) Limiting access to wetlands

D) Reducing agricultural activities

B) True/False Type Questions:

5. The Ramsar Convention is legally binding for all member countries.

6. Wetlands are important for biodiversity, water purification, and flood control.

7. The Ramsar Convention only applies to freshwater wetlands.

14.5. World Heritage Convention

- The Convention emphasizes the importance of maintaining a balance between humans and nature.
- The Convention defines the types of natural or cultural sites eligible for UNESCO World Heritage listing.
- The World Heritage Centre, established in 1992, manages the Convention on a daily basis. The 1972 World Heritage Convention is notable for combining the principles of nature protection and cultural property preservation into a single text. The Convention

recognizes how people interact with nature and the critical necessity to maintain the balance between the two.

India currently **hosts 40 World Heritage Sites.** According to the organization's selection criteria, 32 are cultural, seven are natural, and one is mixed (fulfilling both cultural and natural characteristics). India has the sixth-largest number of sites worldwide. **Khangchendzonga National Park (2016)** is the only **Mixed World Heritage** Site

The list of UNESCO Natural World Heritage sites in India is given below:

Natural World Heritage Site	State	Year of Notification
Kaziranga National Park	Assam	1985
Keoladeo Ghana National Park	Rajasthan	1985
Manas Wildlife Sanctuary	Assam	1985
Nanda Devi National Park and Valley of Flowers	Uttarakhand	1988, 2005
Sundarbans National Park	West Bengal	1987
Western Ghats	Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala	2012
Great Himalayan National Park	Himachal Pradesh	2014

The list of UNESCO Cultural World Heritage sites in India is given below:

Cultural World Heritage Site	State	Year of Notification
Agra Fort	Uttar Pradesh	1983
Ajanta Caves	Maharashtra	1983
Archaeological Site of Nalanda Mahavihara (Nalanda University)	Bihar	2016
Buddhist Monuments at Sanchi	Madhya Pradesh	1989
Champaner-Pavagadh Archaeological Park	Gujarat	2004
Chhatrapati Shivaji Terminus	Maharashtra	2004
Churches and Convents of Goa	Goa	1986
Dholavira	Gujarat	2021
Elephanta Caves	Maharashtra	1987
Ellora Caves	Maharashtra	1983
Fatehpur Sikri	Uttar Pradesh	1986

Great Living Chola Temples	Tamil Nadu	1987
Group of Monuments at Hampi	Karnataka	1986
Group of Monuments at Mahabalipuram	Tamil Nadu	1984
Group of Monuments at Pattadakal	Karnataka	1987
Hill Forts of Rajasthan	Rajasthan	2013
Historic City of Ahmedabad	Gujarat	2017
Humayun's Tomb, Delhi	Delhi	1993
Jaipur City	Rajasthan	2020
Kakatiya Rudreshwara (Ramappa) Temple	Telangana	2021
Khajuraho Group of Monuments	Madhya Pradesh	1986
Mahabodhi Temple Complex at Bodh Gaya	Bihar	2002
Mountain Railways of India	Tamil Nadu	1999
Qutb Minar and its Monuments, Delhi	Delhi	1993
Rani-Ki-Van	Gujarat	2014
Red Fort Complex	Delhi	2007
Rock Shelters of Bhimbetka	Madhya Pradesh	2003
Sun Temple, Konarak	Orissa	1984
Taj Mahal	Uttar Pradesh	1983
The Architectural Work of Le Corbusier, an Outstanding Contribution to the Modern Movement	Chandigarh	2016
The Jantar Mantar	Rajasthan	2010
Victorian and Art Deco Ensemble of Mumbai	Maharashtra	2018

Self-Assessment-5

Multiple choice Questions

1. In which year was the World Heritage Convention adopted?

A) 1965

B) 1972

C) 1980

D) 1992

2. What is the primary purpose of the World Heritage Convention?

A) To promote international tourism

B) To protect and preserve cultural and natural heritage sites of outstanding value

C) To regulate the trade of artifacts

D) To create national parks

3. Which organization is responsible for implementing the World Heritage Convention?

A) UNESCO

B) WWF

C) IUCN

D) The World Bank

4. What is the World Heritage List?

A) A list of all tourist attractions worldwide

B) A list of sites recognized for their cultural and natural significance

C) A list of protected species

D) A list of countries with UNESCO membership

14.6. Role of CSR in Environment and Biodiversity Management

The concept of corporate social responsibility, or CSR, holds that companies have responsibilities to society as a whole in addition to their shareholders and should behave in an environmentally and socially responsible manner. This is frequently called the "triple bottom line," as it considers and manages revenues in addition to social and environmental concerns.

The "three Ps" of the triple bottom line are profit, people, and the environment. Businesses that prioritize people take into account all parties involved, including clients, staff members, and the communities in which their operations have an impact. Businesses pledge to lessen their environmental effect by putting the planet first.

14.6.1. CSR Approaches for the Environment

Corporate social responsibility refers to the practice of evaluating a company's success based on its ability to manage its social and environmental implications in addition to its financial performance. Although the idea of companies "doing good" is not new, the current form of corporate social responsibility (CSR) took shape in the 1950s and changed during the 1960s as a result of social movements for environmental protection, labour rights, and racial justice. The environment became as a major focal point over time.

Businesses and industry have a significant impact on the environment because they use a lot of natural resources and release dangerous pollutants into the air. Nowadays, a lot of businesses pursue environmental sustainability as a moral and business opportunity in addition to a legal need.

I. Carroll's Pyramid of CSR

Archie B. Carroll (1991) a management specialist, published one of the most famous CSR frameworks in 1991. It is a simple pyramid with four domains: economic, legal, ethical, and discretionary. Together, these areas provide a framework for enterprises to negotiate societal duties.

In the economic sphere, quite simply, firms must make a profit in order to continue operating, but they must do so within the law. The ethical realm entails acting in ways that protect stakeholders' (not only investors') rights: the need to "do no harm." The discretionary domain encompasses anything relating to corporate giving, including donations, volunteerism, and other forms of "doing good."

II. Circularity

Many firms are attempting to incorporate the "circular economy" into at least portion of their operations. Circularity aims to reduce waste by implementing the old motto "reduce, reuse, recycle" as well as actions such as renting rather than owning and mending rather than discarding broken things. As a result, production becomes a closed-loop system, with outdated or undesired products avoiding the garbage.

III. Reducing Pollution

Many products either contain or emit harmful compounds during the production process. However, several companies are minimising hazardous pollutants. Many businesses that practise CSR work to decrease or remove hazardous compounds in the air, land, and water, from apparel companies moving to non-toxic dyes to restaurants replacing single-use plastics with biodegradables. Cradle-to-cradle design is one reliable way to reduce the pollution footprints.

IV. Mitigating Climate Change

Some firms specifically aim to reduce greenhouse gas emissions that contribute to climate change by restricting energy usage, producing sustainable energy, or offsetting their emissions with carbon credits. This can also include harvesting carbon or methane for reuse, which is another form of circularity.

V. Land and Biodiversity Conservation

Businesses leave a significant environmental footprint, whether through raw material procurement or the location of manufacturing plants and office buildings. Companies can offset their impacts by funding projects that restore or maintain biodiversity.

Sometimes this takes the shape of preservation. It could also include supporting Indigenous-led land management approaches that preserve biodiversity. It may include cleaning up a former mine and restoring the habitat. Other approaches to coexistence include regenerative silvopastoral systems, which integrate crops, cattle, and trees to conserve biodiversity and natural resources.

VI. Concerns

Reducing immoral and environmentally detrimental actions are admirable goals, yet there are often significant gaps between intentions and outcomes. While most businesses now identify CSR and some type of environmental preservation as goals, many lack the desire and vision to effect true systemic change.

Examples: There are numerous examples of firms being called out for inadequate sustainability plans and greenwashing. Fiji Water faced a class action lawsuit after labelling their bottled water as carbon negative, which the plaintiffs said was based on

questionable carbon accounting. H&M, the worldwide clothing retailer, has an amazing sustainability portfolio, yet it still manufactures resource-intensive fast-fashion items.

Self-Assessment- 6

Multiple choice Questions

1. Which of the following is a primary goal of CSR initiatives related to the environment?

A) Maximizing shareholder profits

B) Reducing operational costs

C) Enhancing the company's public image

D) Promoting sustainable practices and reducing environmental impact

2. How can companies contribute to biodiversity management through CSR?

A) By avoiding regulations

B) By developing eco-friendly products and practices

C) By only focusing on profit maximization

D) By ignoring community feedback

3. Which of the following activities would be considered a CSR initiative focused on environmental conservation?

A) Conducting annual employee performance reviews

B) Supporting local reforestation projects

C) Offering discounts to increase sales

D) Reducing employee benefits

4. Why is stakeholder engagement important in CSR initiatives for biodiversity?

A) To comply with legal requirements

B) To gather insights and build partnerships for more effective conservation efforts

C) To improve financial performance

D) To increase media coverage

Answer Key

Self-Assessment-1: 1 - B; 2 - C; 3 –A

Self-Assessment-2: 1 - B; 2 - B; 3 – B; 4 – B; 5 – B

Self-Assessment -3: 1 - B; 2 - C; 3 – A; 4 – B; 5 – B; 6 – D

Self-Assessment -4: **A)** 1 - B; 2 - A; 3 – B; 4 – B; **B)** 5 – False; 6 – True; 7 – False

Self-Assessment -5: 1 - B; 2 - B; 3 – A; 4 – B

Self-Assessment -6: 1 - D; 2 - B; 3 – B; 4 – B

References

Carroll, Archie B. "The Pyramid Of Corporate Social Responsibility: Toward The Moral Management Of Organizational Stakeholders." Business Horizons, vol. 34, no. 4, 1991, pp. 39-48., doi:10.1016/0007-6813(91)90005-g

"U.S. Outdoor Clothing Brand Patagonia Wins UN Champions Of The Earth Award." UN Environment Programme, 2019.

Ash, Michael, and James K. Boyce. "Measuring Corporate Environmental Justice Performance." Corporate Social Responsibility And Environmental Management, vol. 18, no. 2, 2011, pp. 61-79., doi:10.1002/csr.238

Lejano, Raul P. et al. "The Hidden Disequities Of Carbon Trading: Carbon Emissions, Air Toxics, And Environmental Justice." Frontiers In Environmental Science, vol. 8, 2020, doi:10.3389/fenvs.2020.593014

Basic Documents of International Environmental Law. Boston: Graham & Trotman, 1992.

Effectiveness of International Environmental Agreements: A Survey of Existing Legal Instruments. Cambridge, England: Grotius, 1992.