Uttar Pradesh Rajarshi Tandon Open University

M.Sc. Environmental Science

PGEVS-101 (N)

Ecosystem And Biodiversity Conservation

COURSE INTRODUCTION

This course is to provide knowledge of ecosystem and its components and different aspects of biodiversity conservation and management. We know the conservation of wildlife, biodiversity and its management is necessary for human being as well for sustainability of nature. The aspects of environment, structure and function of environment reflects by the present of diversity of species either plants or animal both have direct and indirect impact on regional environment. The definition, scope and types of ecosystems, ecological pyramid and energy flow model are mentioned in this course. However, the biodiversity, its types and conservations, loss of biodiversity, cause and effects of biodiversity losses are corporate in this course. Wild life and ecotourism, strategy of wild life conservation and management are also summarized. The course is organized into following blocks:

Block 1 covers the ecology and ecosystem

Block 2 deals the fundaments of biodiversity

Block 3 describes in conservation of biodiversity

Block 4 this block covers the wildlife protection and ecotourism

Block-1 **PGEVS-101N**

Rajarshi Tandon Open University, Prayagraj

Ecosystem And Biodiversity Conservation

Block- 1

Ecology and Environment

UNIT -1

Ecosystem

UNIT-2

Population Ecology

UNIT-3

Community Structure and Ecological Succession

Rajarshi Tandon Open University, Prayagraj

Ecosystem And Biodiversity Conservation

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Introduction

This first block of ecology and biodiversity conservation, this consists of following three units:

Unit-1: this unit covers the introduction, concept types, structure and function of ecosystem. The ecological pyramids, productivity, food chains and food webs, energy models, biogeochemical cycles also discussed in this unit.

Unit-2: This unit describes the population ecology in which Ecology and environment, basic concept of population ecology and environment discuss. The study of population characteristics, such as size, dispersion, age structure, natality, mortality, biotic potential and life table population mentioned here. The inter and intra-specific relation among population also summarized.

Unit-3: This unit covers the concept of species diversity, dominance, distribution pattern, and tropic level. In addition it's also discussed the concept of succession, process of succession monoclimax, polyclimax theory, ecological niche, and habitat. The competitive exclusion principle and ecological hierarchy also discussed.

Unit 1 – Ecology and ecosystem

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1.7. Food web

1.8. Energy flow Model

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1.11. Terminal questions

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1.1.Introduction

The environment refers to the things and conditions around the organisms which directly or indirectly influence the life and development of the organisms and their populations. An ecosystem refers to a community of living organisms (biotic) interacting with each other and their physical environment (abiotic) in a particular area. Ecosystems can vary greatly in size, from small ponds to vast forests or even entire biomes like deserts or coral reefs. The structure and function of an ecosystem are intricately connected and contribute to its overall stability and productivity. All organisms are always in the state of perfect balance with the environment with two non-separable factors. Organisms interact with each other and also with the physical conditions that are present in their habitats. According to Clarke, 1954, "the organisms and the physical features of the habitat form an ecological complex or more briefly an ecosystem.

Objectives

After studies this unit, leaner will able to known:

- the concept of ecosystem
- the structure and function of ecosystem
- the ecological pyramid and energy flow model in ecosystem
- the biogeochemical cycles in ecosystem

1.2.Concept of Ecosystem

In the nature, the living and non living environmental interrelate and interact with each other, keeping these things in his mind, A.G. Tansley (1935) gives the term ecosystem. According to A.G. Tansely, the system resulting from the interaction of all the living things and non living things of environment is called ecosystem. However, the basic concept of ecosystem is that at any place, where organism lives there is a continuous reaction between living and non living components. Thus the ecosystem not only includes organism but also the whole complex of physical factor forming the environment.

Ecosystem is the major ecological unit that is also known as structural and functional units of biosphere consisting of living being and physical environment, both interacting and exchange material between them. The structure is related to species diversity where as function is related to transfer of energy and cycling of materials through structural components of the ecosystem. However, unit ecosystems are simply separated from each other with time and space, but functionally they all linked with other and forming as integrated whole According to Woodbury (1954), ecosystem is a complex in nature in which habitat, plants and animals are considered as one interacting unit, the materials and energy of one passes in and out of the others.

According to E.P. Odum, the ecosystem is the basic functional unit of organisms and their environment, interacting with each other and with their own components. An ecosystem may be conceived and studied in the habitats of various sizes, e.g., one square meter of grassland, a pool, a large lake, a large tract of forest, balanced aquarium, a certain area of river and ocean. All the ecosystems of the earth are connected to one another, e.g., river ecosystem is connected with the ecosystem of ocean, and a small ecosystem of dead logs is a part of large ecosystem of a forest. A complete self-sufficient ecosystem is rarely found in nature but situations approaching self-sufficiency may occur.

Structure and function of ecosystem

Ecosystem structure is a network of interactions between **abiotic and biotic components** of the system **and ecosystem functioning** reflects the collective life activities of plants, animals and microbes. These life activities (e.g., feeding, growing, moving, excreting waste) related with the physical and chemical conditions of their environment. The relationship between the abiotic components and the biotic components of the ecosystem is termed '**holocoenosis'**. There are two major aspects of ecosystem as structure and functions.

Structure of ecosystem:

i. Composition of biological community- the biological community includes species, number, biomass, life form history and distribution.
ii. Quantity and distribution of non living martial- it includes water, nutrients, space, etc.
iii. Condition gradient of existence – its includes light, temperature, moisture humidity, etc.

Functions of ecosystem:

i. Rate of biological energy flow, likely respiration and production rate of community, the flow the energy from producers to consumers and decomposers. Producers capture sunlight as radiant energy and convert it into chemical energy, the process is known as photosynthesis, which is then transferred through various trophic levels as organisms are consumed.
ii. It maintains the rate of nutritional and martial cycle because the decomposers break down organic matter, releasing nutrients that are taken up by plants and reused in the ecosystem. This cycling of nutrients is essential for the functioning and productivity of ecosystems.
iii. Biological or ecological regulation including, both, respiration of organism by environment [Photorespiration] and regulation of environment by organism [nitrogen fixing organism]
iv. Ecosystems provide habitats for a wide variety of species. The interactions between different species contribute to biodiversity, which enhances the stability and resilience of ecosystems.

v. Ecosystems provide numerous services that are valuable to humans, such as water purification, air quality regulation, pollination, climate regulation, and provision of food and natural resources.

vi. Ecosystems undergo a process of change over time called ecological succession. This involves the gradual replacement of one community of species by another, leading to changes in structure and function of the ecosystem.

Components of ecosystem:

Components of an ecosystem can be categorized into two main types: biotic and abiotic components.

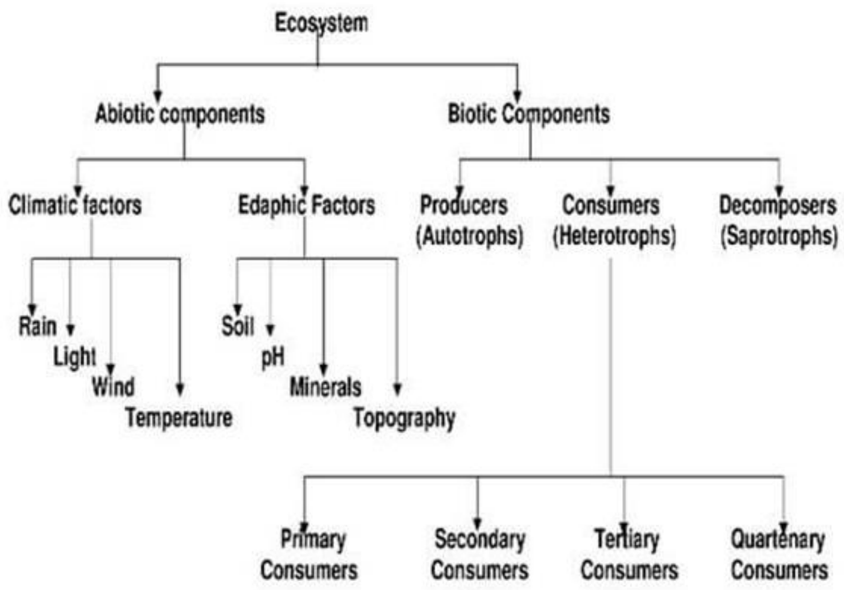


Fig 1.1: Components of Ecosystem

Biotic Components:

Biotic components are the living organisms within an ecosystem. These include:

a) Producers/Autotrophs:

Producers are organisms capable of converting inorganic substrate like CO_2, and N_2O into energy-rich organic compounds in presence of sunlight through processes known as photosynthesis (in plants and algae) or chemosynthesis (in certain bacteria). They form the base of the food chain by producing food for other organisms.

b) Consumers/Heterotrophs:

Those living members of ecosystem consume the food synthesized by producers are called consumers. This category included all kinds of animals that are found in an ecosystem. There are different classes or categories of consumers, such as:

(a) Consumers of the first order or primary consumers,

(b) Consumers of the second order or secondary consumer

(c) Consumers of the third order or tertiary consumers, and

(d) Quaternary consumers.

(a) Primary consumers:

These are purely herbivorous animals that are dependent for their food on producers or green plants. Insects, rodents, rabbit, deer, cow, buffalo, goat are some of the common herbivores in the terrestrial ecosystem, and small crustaceans, molluscs, etc. in the aquatic habitat. Elton (1939) named herbivores of ecosystem as “key industry animals”. The herbivores serve as the chief food source for carnivores.

(**b) Secondary consumers:**

These are carnivores and omnivores. Carnivores are flesh eating animals and the omnivores are the animals that are adapted to consume herbivores as well as plants as their food. Examples of secondary consumers are sparrow, crow, fox, wolves, dogs, cats, snakes, etc.

(c) Tertiary consumers:

These are the top carnivores which prey upon other carnivores, omnivores and herbivores. Lions, tigers, hawk, vulture, humans etc. are considered as tertiary or top consumers. Both secondary and tertiary consumers must hunt for their food, so collectively referred to as predators. Human is an omnivore.

(d) Quaternary consumers:

Quaternary consumers are often top predators within the environment, and they eat the tertiary consumers. Examples of quaternary consumers include lions, wolves, polar bears, humans, and hawks.

2. Decomposers and transformers:

Decomposers and transformers are the living components of the ecosystem and they are fungi and bacteria. Decomposers attack the dead remains of producers and consumers and degrade the complex organic substances into simpler organic substance. The simple organic matters are then attacked by another kind of bacteria, the transformers, which change this organic substance into the inorganic forms that are suitable for reuse by producers or green plants. The decomposers and transformers play very important role in maintaining the dynamic nature of ecosystems.

From nutrition point of view, the biotic components can be grouped into three basic components:

1 **Autotrophic components-**Autotrophs (from Greek, auto – self, trophos – feeder) are called **producers, transducers or converters,** as well. These are photosynthetic plants, they normally bear chlorophyll, which synthesizes, a high-energy rich complex organic compound (or food) from the inorganic raw materials utilizing the sunlight, by the process of photosynthesis. Autotrophs form the core of all biotic systems. In terrestrial ecosystems, autotrophs are usually rooted plants. Whereas in the aquatic ecosystems, the floating plants referred to as phytoplankton and the shallow water rooted plants – macrophytes – are the main producers.

2 **Heterotrophic components-** Heterotrophs (from Greek, heteros – other, trophs – feeder) are the **consumers**. The consumers are also referred to as phagotrophs (phago – to swallow or ingest) while macro consumers are normally herbivores and carnivores

3 **Saprotrophs-** Saprotrophs (from Greek again: sapros – rotten; trophies – feeder) are called the **reducers or decomposers**. They break the complex organic compounds present in a dead matter (dead plants and animals). Decomposers don't ingest the food. Instead, they secrete a digestive enzyme in the dead, decaying plant or animal remains and digest this organic material. These enzymes act on the complex organic compounds in the dead matter. Decomposers absorb a bit of the decomposition products which provide themselves nourishment. The remaining substance is added as minerals in the soil mainly. The released minerals are utilized or reused as nutrients by plants, the producers.

Abiotic Components of ecosystem:

The abiotic components of an ecosystem include the water, the air, the temperature, the rocks and minerals that make up the soil. The biotic components of the ecosystem both, live, on and interact with the abiotic components. Abiotic factors are classified as-

a. **Climatic factors** include the climatic regime of an area with physical factors in the environment such as light, atmospheric temperature, wind, humidity, etc (fig.6.1):
   - **Sunlight:** Sunlight is the primary source of energy for most of ecosystems. It fuels the process of photosynthesis, allowing producers to convert light energy into chemical energy. Most living tissue is composed of a very high percentage of water, up to and even exceeding 90%. The protoplasm of a very few cells can survive, if their water content drops below 10%, and most are killed, if it is less than 30-50%.
   - **Temperature:** Temperature affects the metabolic rates, growth, and reproduction of organisms. Different species have specific temperature ranges within which they can survive.
   - **Water:** Water is essential for the survival of all living organisms. It is required for various physiological functions, such as, hydration, nutrient transport and waste removal. Availability of water influences the distribution and abundance of species in an ecosystem.
   - **Air:** The composition of air, including gases like oxygen, carbon dioxide, and nitrogen, is crucial for respiration, nitrogen fixation and photosynthesis. Air also plays a role in seed dispersal and pollination.
   - **Atmosphere:** The atmosphere provides living condition to organisms found within ecosystems, with carbon dioxide for photosynthesis and oxygen for respiration. The processes of evaporation, transpiration and precipitation cycle of water occurs between the atmosphere and the Earth’s surface.

b. **Edaphic factors:** which relate to the composition and structure of the soil, like its chemical and physical properties – like the soil type, soil profile, soil organic matter (humus), minerals, soil water and soil organisms. Inorganic substances like water, carbon, sulfur, nitrogen, phosphorus and so on and organic substances like proteins, lipids, carbohydrates, humid substances etc, also present in soil.

Types of ecosystem:

Ecosystems can be classified into various types based on their characteristics, geographical location, and dominant organisms. Here are some common types of ecosystems:

Terrestrial Ecosystems:

a. **Forest Ecosystems:** These ecosystems are characterized by a dense growth of trees and various understory plants. Examples include tropical rainforests, temperate forests and boreal forests.
b. **Grassland Ecosystems:** Grasslands are dominated by grasses and herbaceous plants with few or scattered trees. They can be further divided into savannas, prairies, and steppes.
c. **Desert Ecosystems:** Deserts are arid regions with minimal rainfall and sparse vegetation. They can be hot or cold deserts, such as the Sahara Desert or the Gobi Desert.
d. **Tundra Ecosystems:** Tundras are cold and treeless regions and characterized by low temperatures and a short growing season. They are found in the Arctic and high mountain regions.
e. **Wetland Ecosystems**: Wetlands include marshes, swamps, bogs and other water-saturated areas. They support unique plant and animal species adapted to wet conditions.
f. **Aquatic Ecosystems:**
   a) **Freshwater Ecosystems:** These ecosystems include- rivers, lakes, ponds and streams. They are home to a wide variety of aquatic organisms, such as, fish, amphibians and water plants.
   b) **Marine Ecosystems:** Marine ecosystems are oceans, seas, coral reefs and estuaries. They support diverse marine life, including fish, coral, whales and various other aquatic organisms.
   c) **Estuarine Ecosystems:** Estuaries are transitional areas, where freshwater rivers meet the saltwater of the ocean. They are characterized by fluctuating salinity levels and support a unique mix of marine and freshwater species.
   d) **Coastal Ecosystems:** Coastal ecosystems are found along coastlines and include beaches, dunes, mangroves and salt marshes. They are influenced by tides and provide habitat for a variety of plants and animals.
g. **Artificial ecosystem**
   a) **Urban Ecosystems:** Urban ecosystems are human-made environments, characterized by cities, towns, and urban areas. They include buildings, parks, gardens and other modified landscapes.

b) **Agricultural Ecosystems:** Agricultural ecosystems consist of cultivated fields, pastures and farmland where crops are grown and livestock is raised.

c) **Industrial Ecosystems:** Industrial ecosystems are associated with human industrial activities, such as factories, mines, and industrial complexes. They can have a significant impact on the surrounding environment.

Each type of ecosystem has its unique set of environmental conditions, species composition, and ecological processes. Understanding these different ecosystems is important for conservation efforts, management practices and maintaining biodiversity.

2.1.Ecological Pyramid

An ecological pyramid is a graphical representation of the relationship between different organisms in an ecosystem. Each of the bars that make up the pyramid represents a different trophic level and their order, which is based on who eats whom and represents the flow of energy.

It can be observed that these pyramids are in the shape of actual pyramids with the base being the broadest, which is covered by the lowest trophic level, i.e., producers. The next level is occupied by the next trophic level, i.e., the primary consumers and so on.

All the calculations for construction of each type of ecological pyramids must take into account all the organisms in a particular trophic level, because a sample space of a few numbers or a few species will end up giving a huge level of errors.

Types of Ecological Pyramid

Three types of ecological pyramid exist. They are as follows:

A. Pyramid of Numbers

B. Pyramid of Energy

C. Pyramid of Biomass

A. Pyramid of Numbers:

In this type of ecological pyramid, the number of organisms in each trophic level is considered as a level in the pyramid. The pyramid of numbers is usually **upright** except for some situations, like that of the detritus food chain, where many organisms feed on one dead plant or animal (**Fig.**1.2).

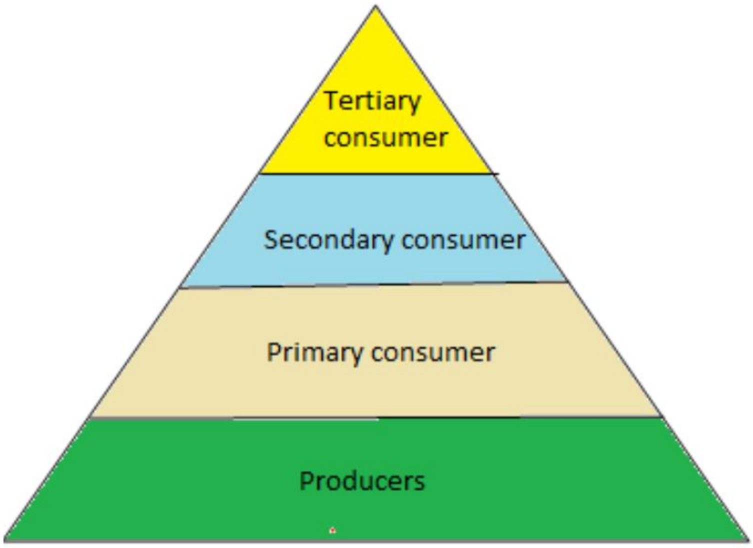


Fig. 1.2: Pyramid of Numbers

B. Pyramid of Biomass:

In this particular type of ecological pyramid, each level takes into account the total amount of biomass, produced by each trophic level. The pyramid of biomass is also **upright,** except for that observed in oceans where large numbers of zooplanktons depend on a relatively smaller number of phytoplanktons(**Fig.**1.3).

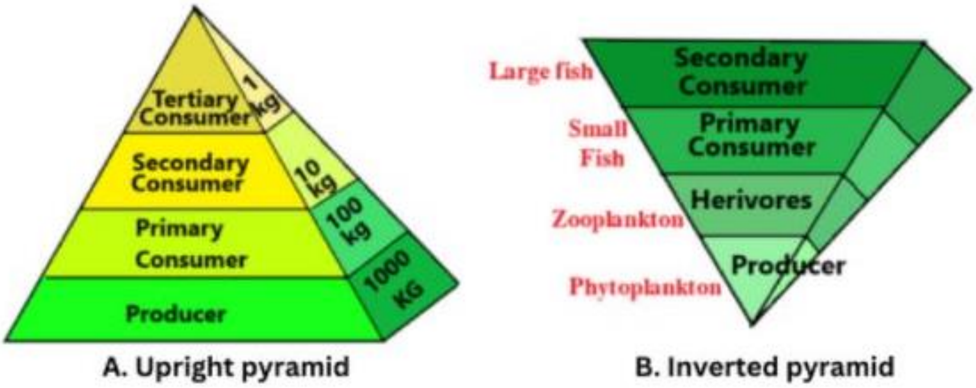


Fig.1.3: Pyramid of Biomass

Pyramid of Energy:

Pyramid of energy is the only type of ecological pyramid, which is **always upright** as the energy flow in a food chain is always unidirectional. Also, with every increasing trophic level, some energy is lost into the environment (Fig.1.3).

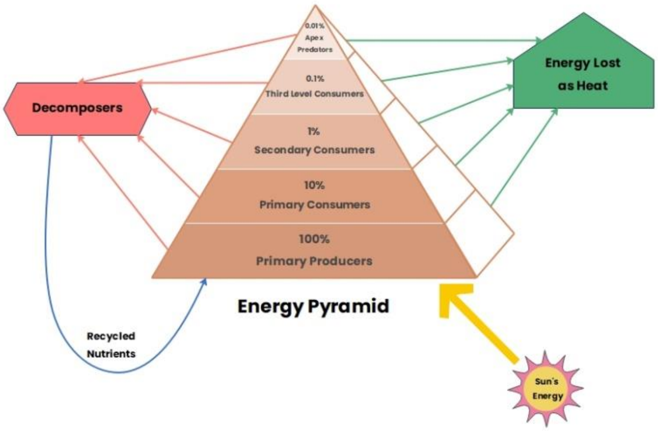


Fig. 1.4. Pyramids of energy

Importance of Ecological Pyramid

The importance of ecological pyramid can be explained in the following points:

1. They show the feeding of different organisms in different ecosystems.
2. It shows the efficiency of energy transfer.
3. The condition of the ecosystem can be monitored, and any further damage can be prevented.

Limitations of the Ecological Pyramid

1. More than one species may occupy multiple trophic levels as in case of the food web. Thus, this system does not take into account food webs.
2. The saprophytes are not considered in any of the pyramids, even though they form an important part of the various ecosystems.
3. These pyramids are applicable only to simple food chains, which usually do not occur naturally.
4. These pyramids do not deliver any concept in relation to variations in season and climate.
5. They do not consider the possibility of the existence of the same species at different levels**.**

2.2.Productivity

Productivity, measured by gross and net primary productivity, is defined as the amount of energy that is incorporated into a biomass. Productivity within an ecosystem can be defined as the percentage of energy entering the ecosystem incorporated into biomass in a particular trophic level. Biomass is the total mass in a unit area (at the time of measurement) of living or previously-living organisms within a trophic level. Ecosystems have characteristic amounts of biomass at each trophic level. There are two main types of productivity in an ecosystem:

Primary Productivity:

Primary productivity is the rate at which autotrophic organisms (producers) convert solar energy into organic compounds through photosynthesis or chemosynthesis. It is typically measured in terms of biomass, produced per unit area per unit time, such as, grams of organic matter per square meter per year ($g/m^2/year$). The productivity of the primary producers is especially important in any ecosystem because these organisms bring energy to other living organisms by photoautotrophy or chemoautotrophy. **Photoautotrophy** is the process by which an organism (such as a green plant) synthesizes its own food from inorganic substances using light as a source of energy (**chemoautotrophy**) on the other hand, is the process by which simple organisms (such as bacteria or archaea) derive energy from chemical processes rather than photosynthesis. **The rate at which photosynthetic primary producers incorporate energy from the sun is called gross primary productivity (G.P.P.)**. Because all organisms need to use some of this energy for their own functions (such as respiration and resulting metabolic heat loss), scientists often refer to the **net primary productivity (N.P.P.)** of an ecosystem. Net primary productivity is the energy that remains in the primary producers after accounting for the organisms' respiration and heat loss. The net productivity is then available to the primary consumers at the next trophic level.

Factors affecting primary productivity include:

- **Sunlight availability:** Adequate sunlight is required for photosynthesis to occur.
- **Temperature:** Optimal temperature ranges vary for different plant species.
- **Water availability:** Sufficient water is essential for plant growth and photosynthesis.
- **Nutrient availability**: Adequate nutrients like nitrogen, phosphorus potassium etc; are necessary for plant growth.

Primary productivity is highest in ecosystems with abundant sunlight, moderate temperatures, and ample water and nutrient availability. Examples of highly productive ecosystems include tropical rainforests, temperate forests and coral reefs.

Secondary Productivity:

Secondary productivity refers to the rate at which consumers (heterotrophic organisms) convert the energy obtained from consuming producers or other consumers into their own biomass. It measures the energy transfer between trophic levels in an ecosystem.

Factors affecting secondary productivity include:

- Availability of food resources: Sufficient quantities of food are necessary for consumers to grow and reproduce.
- Efficiency of energy transfer: Energy is lost as heat during metabolic processes, so the efficiency of energy transfer between trophic levels affects secondary productivity.
- Secondary productivity is influenced by the primary productivity of an ecosystem. Ecosystems with high primary productivity can support a greater biomass and diversity of consumers, leading to higher secondary productivity. For example, a diverse and productive grassland can support a larger population of herbivores and, in turn, a larger population of carnivores.

Understanding productivity in ecosystems is crucial for assessing the health and sustainability of ecological systems. It provides insights into energy flow, trophic interactions and the potential carrying capacity of an ecosystem. Productivity also influences nutrient cycling, biodiversity and the overall functioning of ecosystems.

Net productivity in ecosystem:

Net productivity in an ecosystem refers to the amount of energy or biomass that remains after the energy expended in cellular respiration by producers is subtracted from the total energy captured through photosynthesis. It represents the energy available for growth, reproduction, and biomass accumulation in the ecosystem.

Net productivity can be divided into two main components:

Gross Primary Productivity (GPP):

Gross primary productivity is the total amount of energy or biomass produced by autotrophic organisms (producers) through photosynthesis or chemosynthesis. It represents the total energy captured by producers from sunlight or inorganic compounds.

Respiration (R):

Respiration is the process by which organisms, including producers, break down organic compounds to release energy for their own metabolic needs. This energy is used for various life processes, such as cellular maintenance, growth and reproduction.

Net Productivity (NP) can be calculated using the following formula:

Net Productivity (NP) = Gross Primary Productivity (GPP) - Respiration (R)

In other words, net productivity is the surplus energy or biomass, available for consumers (heterotrophs) at higher trophic levels, after accounting for the energy expended by producers in their own metabolic activities.

The net productivity of an ecosystem is influenced by factors such as, environmental conditions, nutrient availability, temperature, water availability and the efficiency of energy transfer between trophic levels. Understanding net productivity helps in assessing the overall energy budget and dynamics within an ecosystem, as well as the potential for supporting higher trophic levels and maintaining ecosystem stability.

Transfer of Energy between Trophic Levels

The transfer of energy between trophic levels in an ecosystem refers to the movement of energy from one level of the food chain to another. Trophic levels represent different positions in the food chain, starting with primary producers (autotrophs) and progressing through various levels of consumers (heterotrophs) that feed on each other.

Energy transfer between trophic levels occurs primarily through the consumption and digestion of organisms. Here's a general overview of how energy moves through various trophic levels:

Primary Producers (Autotrophs): Primary producers, such as plants or algae, convert solar energy into chemical energy through photosynthesis. They are at the base of the food chain and form the primary source of energy for all other trophic levels.

Primary Consumers (Herbivores): Herbivores are organisms that consume primary producers. They obtain energy by feeding on plants or algae. Energy is transferred from primary producers to herbivores when the latter consume and digest plant material.

Secondary Consumers (Carnivores/Omnivores): Secondary consumers are organisms that feed on primary consumers. They can be carnivores, which consume other animals, or omnivores, which consume, both plants and animals. Energy is transferred from primary consumers to secondary consumers when they consume and digest the herbivores.

Tertiary Consumers and Higher Trophic Levels: The process of energy transfer continues as organisms at higher trophic levels consume and digest lower trophic level organisms. This can extend to tertiary consumers (carnivores that consume secondary consumers), quaternary consumers (carnivores that consume tertiary consumers), and so on.

It's important to note that energy transfer between trophic levels is not 100% efficient. Some energy is lost as heat during metabolic processes and not all energy consumed by an organism is converted into biomass. This is known as the ecological efficiency or trophic efficiency.

In biological systems, this means a great deal of energy is lost as metabolic heat when the organisms from one trophic level are consumed by the next level. The measurement of energy transfer efficiency between two successive trophic levels is termed the **trophic level transfer efficiency** (TLTE) and is calculated by the following formula:

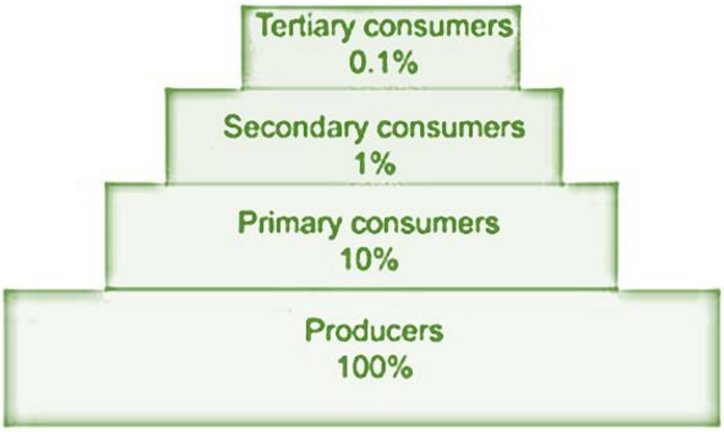
$$(\mathbf{TLTE}) = \frac{\text{Energy transferred to next level}}{\text{Energy recived during transfer}} \text{X } 100$$

On an average, the ecological efficiency is estimated to be around 10% in each trophic level. This means that only about 10% of the energy from one trophic level is converted into biomass and passed on to the next trophic level. The remaining energy is lost as heat or used for metabolic activities.

The transfer of energy between trophic levels has significant implications for the structure and functioning of ecosystems. It shapes population dynamics, species interactions, and the flow of matter and energy throughout the food web. Understanding energy transfer between trophic levels is crucial for studying ecosystem productivity, stability, and the impacts of disturbances or environmental changes on ecosystem dynamics.

The 10% Law of Energy Flow

In general, only about 10% of energy is transferred from one trophic level to the next, and this number can vary from 5-20%, depending on the ecosystem. This means that 90% of obtained energy is lost at each trophic level, greatly affecting the maximum number of possible levels in the ecosystem. For example, if an ecosystem received 600,000 Kcal of solar energy from the sun, primary producers would pass on only 60,000 Kcal to herbivores, which would pass only 6,000 Kcal to secondary consumers, 600 Kcal to tertiary consumers and 60 Kcal to quaternary consumers at the top of the food chain. An apex predator like a wolf- needing an average of 2000 Kcal per day would need to consume a very high quantity of secondary or tertiary consumers to meet its calorie quota per day (Fig.1.5).



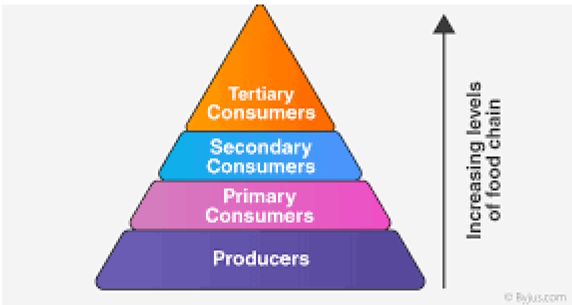


Fig.1.5: Ecological Pyramid: Energy flow

Net production efficiency

The concept of net production efficiency refers to the efficiency with which energy is converted into biomass by organisms within an ecosystem. It quantifies the proportion of energy assimilated by organisms that is converted into new organic matter or biomass. Net production efficiency (NPE) allows ecologists to quantify how efficiently organisms of a particular trophic level incorporate the energy they receive into biomass. Net production efficiency is typically calculated using the following formula:

$$\text{Net Production Efficiency} = \frac{\text{Secondary Production}}{\text{Assimilation}}\ 100$$

Secondary production refers to the energy or biomass accumulated by organisms through growth and reproduction. It represents the increase in biomass over a given period of time. Assimilation refers to the energy intake or consumption by organisms, which is usually measured as the difference between the energy ingested and the energy lost through excretion and respiration. Net consumer productivity is the energy content available to the organisms of the next trophic level. Assimilation is the biomass (energy content generated per unit area) of the present trophic level after accounting for the energy lost due to incomplete ingestion of food, energy used for respiration, and energy lost as waste. By dividing secondary production by assimilation and multiplying the result by 100, we obtain the net production efficiency expressed as a percentage. A higher net production efficiency indicates a more efficient utilization of assimilated energy for growth and reproduction. Assessing net production efficiency in ecology can provide insights into the energy flow and efficiency of energy transfer between trophic levels in an ecosystem, which in turn contributes to our understanding of ecosystem dynamics and functioning.

The inefficiency of energy use by warm-blooded animals has broad implications for the world's food supply. It is widely accepted that the meat industry uses large amounts of crops to feed livestock. Because the NPE is low, much of the energy from animal feed is lost. For example, it costs about $0.01 to produce 1000 dietary calories (kcal) of corn or soybeans, but approximately $0.19 to produce a similar number of calories growing cattle for beef consumption. The same energy content of milk from cattle is also costly, at approximately $0.16 per 1000 kcal. Much of this difference is due to the low NPE of cattle. Thus, there has been a growing movement worldwide to promote the consumption of non-meat and non-dairy foods so that less energy is wasted feeding animals for the meat industry.

2.3.**Food Chain**:

In an ecosystem, every organism depends on other organisms for food material and all organisms are (herbivores to carnivores) arranged in a series in which food energy is transferred through a repeated series of eating and being eaten. It is called **food chain**.

- In the food chain, energy flow is in the form of food.
- In a food chain, food material or food energy transfer from one trophic level to the next trophic level.
- Four trophic levels are present in the ecosystem because level of energy decreases during the flow of energy from one trophic to another trophic level.
  1. First trophic level [T1] = Producers
  2. Second trophic level [T2] = Primary consumers
  3. Third trophic level [T3] = Secondary consumers
  4. Fourth trophic level [T4] = Top consumers

There are five trophic levels found in highly complex ecosystem in which tertiary consumer is present in between the secondary consumers and top consumers. Then the fifth trophic level (T5) is formed by the top consumer.

- Shorter food chains will provide greater energy.
- Generally the decomposers (bacteria and fungi) are not included in the food chain but when included then there are at as the last tropic level.

Types of Food Chains found in an Ecosystem

In nature, **three** types of food chains are present: Grazing food chain, parasitic food chain and detritus food chain.

1. Grazing Food Chains or Predatory Food Chain:

Most of the food chain in nature is of this type.This food chain begins with producers (plants) and in successive order it goes from small organism to large organism.

Aquatic ecosystem

$$\begin{array}{ccccccc}
\text{Producer} & & \text{Primary consumer} & & \text{Secondary consumer} & & \text{Top consumer} \\
\uparrow & & \uparrow & & \uparrow & & \uparrow \\
\text{Phytoplankton} & \rightarrow & \text{Zooplankton} & \rightarrow & \text{Largefish} & \rightarrow & \text{Smallfish} \\
\downarrow & & \downarrow & & \downarrow & & \downarrow \\
T_1 & & T_2 & & T_3 & & T_4
\end{array}$$

Grassland ecosystem

$$\begin{array}{ccccccc}
\text{Producer} & & \text{Primary consumer} & & \text{Secondary consumer} & & \text{Top consumer} \\
\uparrow & & \uparrow & & \uparrow & & \uparrow \\
\text{Grass} & \rightarrow & \text{Rabbit} & \rightarrow & \text{Fox} & \rightarrow & \text{Lion} \\
\downarrow & & \downarrow & & \downarrow & & \downarrow \\
T_1 & & T_2 & & T_3 & & T_4
\end{array}$$

2. Parasitic Food Chain

This food chain also starts from producers but in successive order it goes, from big organism to the smaller organism.

Tree ecosystem

$$\begin{array}{ccccc}
\text{Tree} & \rightarrow & \text{Birds} & \rightarrow & \text{Parasites} \\
\downarrow & & \downarrow & & \downarrow \\
T_1 & & T_2 & & T_3
\end{array}$$

Both, grazing and parasitic food chains are directly dependent on solar radiation (as a primary source of energy), and have rapid energy flow.

3. Detritus Food Chain or Saprophytic Food Chain

- This food chain begins with decomposition of dead organic matter by decomposers, so it is also known as saprophytic food chain.
- In this food chain, primary consumers are bacteria and fungi.
- In mangrove vegetation, this food chain goes up to big organism.

  Dead mangroves leaves → Bacteria & fungi → Amphipods, molluscs, crabs, nematodes → Small fishes → Fish eating birds.

- In detritus food chain, energy flow is rather very slow yet magnitude of energy is great because vast number of decomposers is involved.
- Detritus food chain does not depend on light.

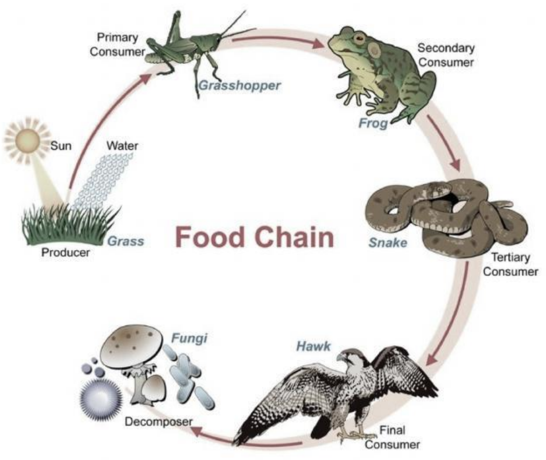


Fig.1.6: Food Chain

Significance of food chain:

1. The study of food chains helps in understanding the feeding relationship and the interaction between organisms in any ecosystem.
2. They also help us to understand the energy flow mechanism and matter circulation in an ecosystem and understand the movement of toxic substances in the ecosystem.
3. The study of food chain helps us to understand the process of bio-magnifications**.**

1.7.Food Web

Food web is an important ecological concept. Basically, food web represents feeding relationships within a community (Smith and Smith 2009). It also implies the transfer of food energy from its source in plants through herbivores to carnivores (Krebs 2009).

- In a food web, transfer of food energy is unidirectional but from many different alternative pathways.
- In a food web, members of a particular trophic level obtain their food according to their choice and taste. It means they have more than one option or alternative for getting food.
- As much as food web is complex, the ecosystem is more permanent or stable, such type of ecosystem is not destroyed naturally and continues for a long time. This ecosystem is not affected by loss of any organism of any particular trophic level. Those ecosystems which have simple food web are not very stable it means that they can be finished at any time, if there is a change in any particular trophic level.
- A food web (or food cycle) is the natural interconnection of food chains and a graphical representation (usually an image) of what-eats-what in an ecological community. Another name for food web is **consumer-resource system.** Ecologists can broadly classified all life forms into one of two following categories (1) Autotrophs, and (2) Heterotrophs.
- Many interconnected food chains make up a food web. When you look at the larger picture, a food web shows a realistic representation of the energy flow through different organisms in an ecosystem.

Sometimes, a single organism gets eaten by many predators or it eats many other organisms. This is when a food chain doesn't represent the energy flow in a proper manner because there are many trophic levels that interconnect. This is where a food web comes into place. It shows the inter-relationship of energy flow between different organisms in an ecosystem. The following diagram shows the energy flow between various organisms through a food web.

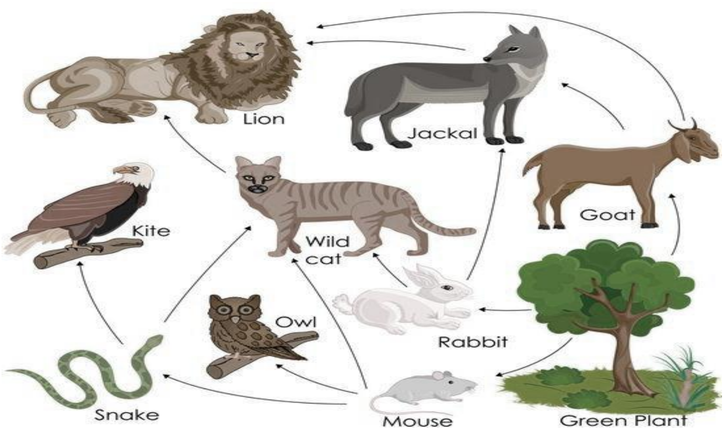


Fig. 1.7: Food Web

1.8.Energy Flow Model

Energy flow in an ecosystem occurs in unidirectional way so that behavior of energy in ecosystem is termed as energy flow. The energy flow in an ecosystem is essential because producer utilizes solar energy and it's converted into chemical energy. The total input of energy in the form of food and its efficiency of assimilation is determined in an ecosystem.

The energy flow takes place via the food chain and food web. During the process of energy flow in the ecosystem, plants being the producers utilize sunlight with the help of the chloroplasts and a part of it's transformed into chemical energy in the term of organic compounds by the process of photosynthesis. The simple organic substances, like CO_2, and H_2O also participate in this process as raw materials.

The flow of energy in ecosystems is vitally important to the thriving of life on Earth. Nearly, all of the energy in Earth's ecosystems originates with the help of the Sun. Once this solar energy reaches Earth surface, it is distributed among ecosystems in an extremely organized complex manner. A simple way to analyze this distribution is through a food chain or food web.

Energy flow is the flow of energy through living things within an ecosystem. All living organisms can be organized into producers and consumers, and those producers and consumers can further be organized into a food chain. Each of the levels within the food chain is a trophic level.

How Organisms Acquire Energy in a Food Web

All living things require energy in one form or another since energy is required by most, complex, metabolic pathways (often in the form of ATP), life itself is an energy-driven process. Living organisms would not be able to assemble macromolecules (proteins, lipids, nucleic acids and complex carbohydrates) from their monomeric subunits without a constant energy input.

It is important to understand how organisms acquire energy and how that energy is passed from one organism to another through food webs and their constituent food chains. Food webs illustrate how energy flows directionally through ecosystems, including how efficiently organisms acquire it, use it, and how much remains for use by other organisms of the food web. Energy is acquired by living things in three ways: photosynthesis, chemosynthesis, and the consumption and digestion of other living or previously-living organisms by heterotrophs.

Photosynthetic and chemosynthetic organisms are grouped into a category known as autotrophs: organisms capable of synthesizing their own food (more specifically capable of using inorganic carbon as a carbon source). Photosynthetic autotrophs (photoautotrophs) use sunlight as an energy source, whereas chemosynthetic autotrophs (chemoautotrophs) use inorganic molecules as an energy source. Autotrophs act as producers and are critical for all ecosystems. Without these organisms, energy would not be available to other living organisms and life itself would not be possible.

Photoautotrophs, such as plants, algae and photosynthetic bacteria, serve as the energy source for a majority of the world's ecosystems. These ecosystems are often described by grazing food webs. Photoautotrophs harness the solar energy of the sun by converting it in to chemical energy in the form of ATP (and NADP). The energy stored as ATP is used to synthesize complex organic molecules, such as glucose.

Chemoautotrophs are primarily bacteria that are found in rare ecosystems where sunlight is not available, such as, in those associated with dark caves or hydrothermal vents at the bottom of the ocean. Many chemoautotrophs in hydrothermal vents use hydrogen sulfide (H2S), which is released from the vents, as a source of chemical energy. This allows chemoautotrophs to synthesize complex organic molecules, such as glucose, for their own energy and in turn supplies energy to the rest of the ecosystem.

Heterotrophs function as consumers in the food chain; they obtain energy in the form of organic carbon by eating autotrophs or other heterotrophs. They break down complex organic compounds produced by autotrophs into simpler compounds, releasing energy by oxidizing carbon and hydrogen atoms into carbon dioxide and water, respectively. Unlike autotrophs, heterotrophs are unable to synthesize their own food. If they cannot eat other organisms, they will die.

1.9.Biogeochemical Cycle

Biogeochemical cycles in ecosystems refer to the pathways through which essential elements, such as carbon, nitrogen, phosphorus and water, are circulated and recycled between the living (biotic) and non-living (abiotic) components of the environment. These cycles involve complex interactions between organisms, the atmosphere, soil, water bodies, and geological processes. However, the matter that makes up living organisms is conserved and recycled. The six most common elements associated with organic molecules (carbon, nitrogen, hydrogen, oxygen, phosphorus, and sulfur) take a variety of chemical forms and may exist for long periods in the atmosphere, on land, in water or beneath the earth's surface.

The components of organic molecules are constantly being stored and recycled as part of their biogeochemical cycle. Water, which contains hydrogen and oxygen, is essential to all living processes. The hydrosphere is the area of the earth where water movement and storage occurs. Water can be liquid on the surface and beneath the surface or frozen (rivers, lakes, oceans, groundwater, polar ice caps and glaciers) or exist as water vapor in the atmosphere. Carbon, found in all organic macromolecules, is an important constituent of fossil fuels. Nitrogen, a major component of our nucleic acids and proteins, is critical to human agriculture. Phosphorus, a major component of nucleic acid (along with nitrogen), is one of the main ingredients in artificial fertilizers, used in agriculture and their associated environmental impacts on our surface water. Sulfur, critical to the 3–D folding of proteins (as in disulfide binding), is released into the atmosphere by the burning of fossil fuels, such as coal.

The cycling of all of these elements is interconnected. For example, the movement of water is critical for the leaching of nitrogen and phosphate into rivers, lakes and oceans. Furthermore, the ocean itself is a major reservoir for carbon. Thus, mineral nutrients are cycled, either rapidly or slowly, through the entire biosphere, from one living organism to another, and between the biotic and abiotic world.

1.9.1. The Water (Hydrologic) Cycle

The water cycle, also known as the hydrological cycle, describes the continuous movement of water on, above and below the Earth's surface. It involves processes, such as, evaporation, condensation, precipitation, runoff, infiltration, and transpiration. Most of the water of the world about 97%, is found in oceans but because of high salt content it cannot be used for municipal, agricultural or most industrial needs. Water serves as a pool for many dissolved and suspended materials. It is a vital component for all living cells and for various biochemical processes. In water cycle, water interconvert's in all the three states, i.e., liquid form, vapor form and solid form. The water cycle is a key in environmental dynamic, for all types of processes, physical, chemical, and biological and had been in existence ever since oceans came into being, i.e., more than two billion years ago.

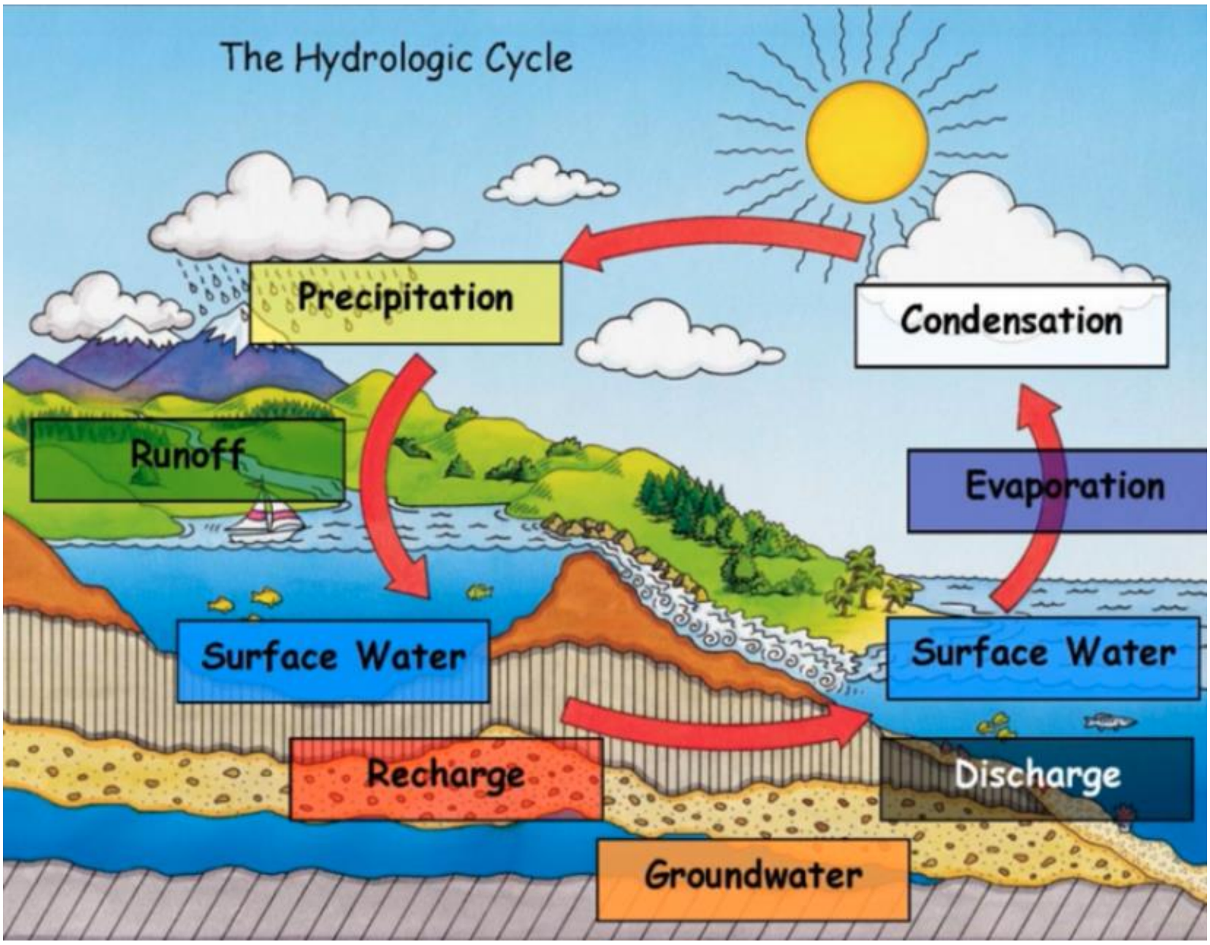


Fig. 1.8: Water cycle and its various processes

The movement of water on the earth's surface and through the atmosphere is known as hydrologic cycle. Figure 5 displays the water cycle and its various processes. The water cycle can be either a long cycle or various short cycles.

Short Cycle: It involves only evaporation and immediate condensation and so on. The reservoir for short cycle could be any water body.

Long Cycle: It involves various processes like evaporation, condensation, transpiration, infiltration and interception, run off, stream off and subsurface flow.

There are various processes that occur during the cycling of water, which include the following:

- evaporation / sublimation
- condensation /precipitation
- subsurface water flow
- surface runoff /snowmelt
- stream flow

Evaporation is the process by which water changes from a liquid state to a gaseous state. Heat from the sun causes water bodies, such as oceans, lakes and rivers, to evaporate, converting liquid water into water vapor. For example, when sunlight heats a lake's surface, water molecules gain enough energy to break their bonds and escape into the air as water vapor. Transpiration is the release of water vapor from plants and trees through their leaves. Plants absorb water from the soil through their roots, and this water is transported up to the leaves, where it evaporates through small openings called stomata. Transpiration is often considered a part of the water cycle because it returns water vapor to the atmosphere. For instance, a tree draws up water from the soil through its roots, and the excess water is released as vapor through the stomata in its leaves. Condensation is the process in which water vapor cools and changes back into liquid form. When the temperature cools, water vapor in the atmosphere condenses into tiny water droplets or ice crystals, forming clouds. Condensation also occurs when warm air meets a cool surface, leading to the formation of dew or fog. For example, when warm, moist air rises and encounters colder temperatures at higher altitudes, the water vapor condenses to form clouds. Precipitation occurs when condensed water droplets or ice crystals in the clouds become too heavy and fall back to the Earth's surface. It can take various forms, such as rain, snow, sleet or hail, depending on the atmospheric conditions. Precipitation provides a vital source of freshwater to replenish water bodies, recharge groundwater and nourish plants and ecosystems. For instance, rainfall replenishes rivers and lakes, and snowfall contributes to snowpack in mountainous regions. Runoff refers to the flow of water over the land surface during heavy rainfall, eventually reaching rivers, lakes, and oceans. When the ground becomes saturated or unable to absorb all the precipitation, excess water flows over the surface of earth, and reach to water bodies, such as, pond, lake, sea, oceans and rivers. Runoff also transports nutrients, sediments and pollutants, influencing the quality of water bodies. For example, after heavy rainfall, water may flow over the land surface, gathering in streams and flowing into a river. Infiltration is the process by which water seeps into the ground and enters the soil and underlying layers, replenishing groundwater. It occurs when the ground is not saturated and can absorb water. Infiltrated water may be stored in the soil, travel horizontally as groundwater, or contribute to the recharge of aquifers. For instance, when it rains, water may seep into the soil, replenishing the underground water resources. Sublimation is the process by which ice or snow changes directly into water vapor without becoming a liquid first. It occurs when the temperature and atmospheric conditions favor the conversion of ice or snow directly into water vapor. Melting, on the other hand, is the process in which solid ice changing into liquid water as temperatures rise. Both, sublimation and melting contribute to the water cycle by transforming ice into water vapor. These examples demonstrate the various processes involved in the water cycle, highlighting how water moves through different forms and reservoirs in the Earth's systems. The water cycle plays a crucial role.

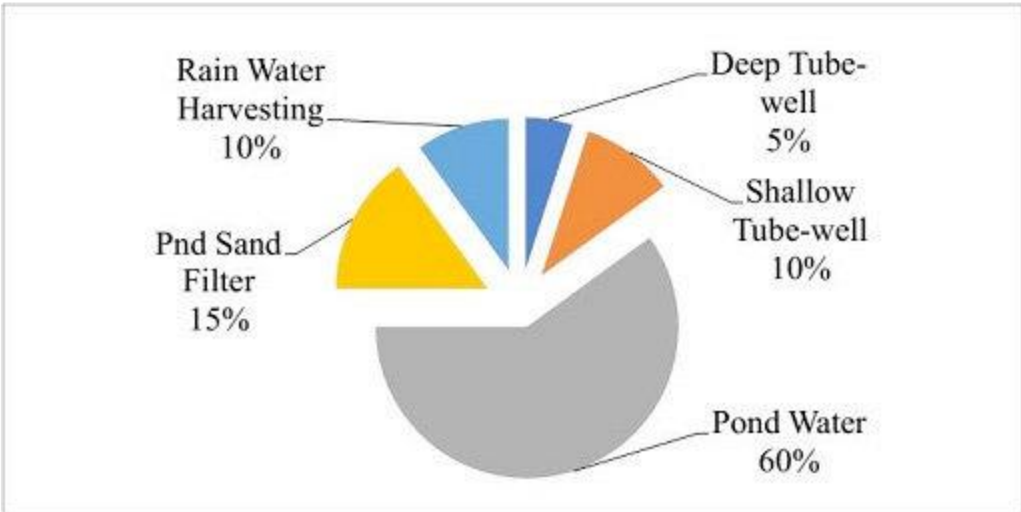


Fig.1.9: Water availability

Water cycling is extremely important to an ecosystem dynamics as it has a major influence on climate and, thus, on the environments of ecosystems. For example, when water evaporates, it takes up energy from its surroundings, cooling the environment. When it condenses, it releases energy, warming the environment. The evaporation phase of the water cycle purifies water, which then replenishes the land with fresh water. The flow of liquid water and ice transports minerals across the globe. It is also involved in reshaping the geological features of the earth through processes including erosion and sedimentation. The water cycle is also essential for the maintenance of most life and ecosystems on the planet. Most of the water on earth is stored for long periods in the oceans, underground, and as ice. Residence time is a measure of the average time an individual water molecule stays in a particular reservoir. A large amount of the earth's water is locked in place in these reservoirs as ice, beneath the ground, and in the ocean, and, thus, is unavailable for short-term cycling (only surface water can evaporate).

1.9.2. The Carbon Cycle

The carbon cycle is a biogeochemical cycle that describes the movement of carbon between the atmosphere, land, water bodies and living organisms. It involves various processes, including photosynthesis, respiration, decomposition and the combustion of fossil fuels. Carbon enters the atmosphere in the form of inorganic carbon as **carbon dioxide** via the carbon cycle and returns to organic carbon as carbohydrate (glucose) via **photosynthesis**. Carbon, the **second most abundant element** in living organisms, is present in all organic molecules. Its role in the structure of macromolecules is of primary importance to living organisms. Plants, algae and some bacteria perform photosynthesis, a process where they use sunlight, carbon dioxide (CO_2), and water to produce glucose (a simple sugar) and oxygen is evolved as by product. This process removes carbon dioxide from the atmosphere and converts it into organic matter. For example, a tree absorbs carbon dioxide through its leaves and, using sunlight, converts it into glucose for energy storage. All living organisms, including plants, animals and microorganisms, engage in respiration. During respiration, organic matter (glucose) is broken down to release energy, and carbon dioxide is produced as a byproduct. This process returns carbon dioxide back to the atmosphere. For instance, animals breathe by utilizing oxygen and release carbon dioxide as a waste product through respiration. When organisms die, their organic matter is broken down by decomposers, such as, bacteria and fungi. During decomposition, carbon from dead part of plants and animals is released back into the atmosphere as carbon dioxide. For example, when a fallen tree decomposes, microorganisms break down its organic matter and release carbon dioxide into the surrounding environment. The combustion of fossil fuels, such as, coal, oil and natural gas, releases carbon dioxide into the atmosphere. Human activities, such as burning fossil fuels for energy production, transportation, and industrial processes, contribute to the increase in atmospheric carbon dioxide levels. For instance, burning gasoline in cars, releases carbon dioxide, adding to the atmospheric carbon pool. Some carbon is stored for long periods in carbon sinks, which can include forests, soils and the oceans. Trees and plants, for example, act as carbon sinks by absorbing atmospheric carbon dioxide during photosynthesis and storing it as carbon in their tissues. The oceans also absorb and store large amounts of carbon dioxide from the atmosphere. The oceans play a significant role in the carbon cycle by absorbing and releasing carbon dioxide. Carbon dioxide dissolves in seawater, forming carbonic acid, which reacts with other compounds to form bicarbonate and carbonate ions. This process, known as oceanic carbon sequestration, helps regulate atmospheric carbon dioxide levels. Over millions of years, dead plants and animals can become buried under sediment and undergo fossilization. This process converts the organic carbon into fossil fuels, such as coal, oil, and natural gas, which are rich in carbon. When these fossil fuels are burned, carbon dioxide is released back into the atmosphere, contributing to increased greenhouse gas concentrations. These examples illustrate the various processes involved in the carbon cycle, highlighting how carbon is exchanged, transformed, and stored in different reservoirs within the Earth's systems. The carbon cycle plays a crucial role in regulating Earth's climate and supporting life on the planet. Human activities that release excessive amounts of carbon dioxide can disrupt the carbon cycle and contribute to climate change.

The Biological Carbon Cycle

Living organisms are connected in many ways, even between ecosystems. A good example of this connection is the **exchange of carbon between autotrophs and heterotrophs**. Carbon dioxide is the basic building block that **most autotrophs use to build multi-carbon, high-energy compounds, such as glucose**.

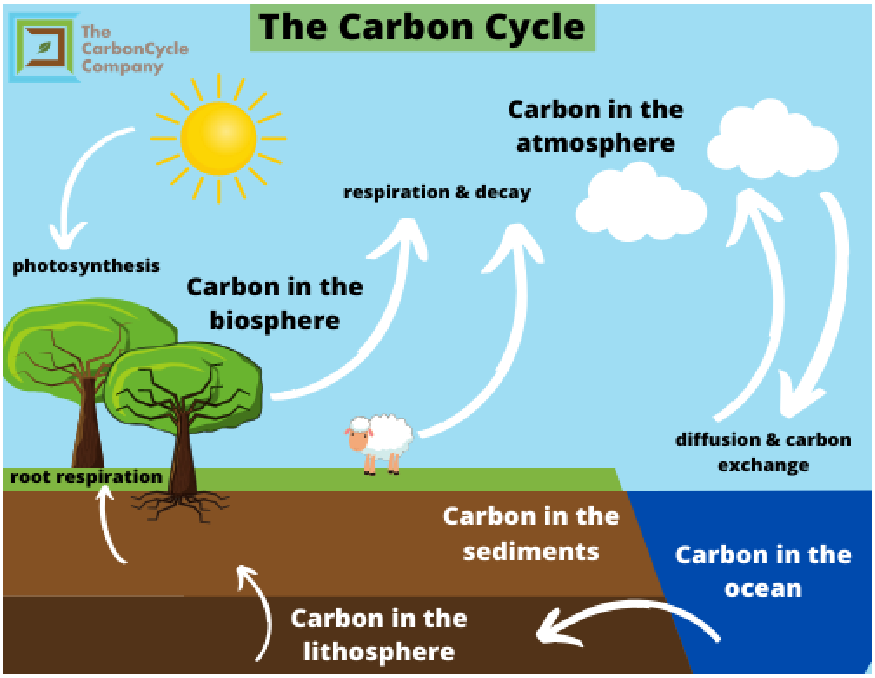


Fig.1.10: **Carbon cycle**:

Heterotrophs require the high-energy carbon compounds from the autotrophs by consuming them and breaking them down by respiration to obtain cellular energy, such as, ATP. The most efficient type of respiration, aerobic respiration, requires oxygen obtained from the atmosphere or dissolved in water. Thus, there is a constant exchange of oxygen and carbon dioxide between the autotrophs (which need the carbon) and the heterotrophs (which need the oxygen for respiration). Gases exchange through the atmosphere and water is one way that the carbon cycle connects all living organisms on Earth.

1.9.3. The Nitrogen Cycle

Nitrogen, the most abundant gas in the atmosphere, is cycled through the biosphere via the multi-step process of nitrogen fixation, which is carried out by nitrogen fixing bacteria.

Getting nitrogen into the living world is difficult. Plants and phytoplankton are not equipped to incorporate nitrogen from the atmosphere (which exists as tightly-bonded, triple-covalent as N_2), even though this molecule comprises approximately 78 percent of the atmosphere. Nitrogen enters the living world via free-living and symbiotic bacteria, which incorporate nitrogen into their macromolecules through nitrogen fixation (conversion of N_2). Cyanobacteria live in most of aquatic ecosystems, where sunlight is present; they play a key role in nitrogen fixation. Cyanobacteria are able to use inorganic sources of nitrogen to “fix” nitrogen. Rhizobium bacteria, able to fixed nitrogen live symbiotically in the root nodules of legumes (such as peas, beans, and peanuts), providing them the organic nitrogen they need. Free-living bacteria such as Azotobacter are also important nitrogen fixers.

Organic nitrogen is especially important to the study of ecosystem dynamics as many ecosystem processes, such as primary production and decomposition, are limited by the available supply of nitrogen. The nitrogen that enters living systems by nitrogen fixation is successively converted from organic nitrogen back into nitrogen gas by bacteria. This process occurs in three steps in terrestrial systems: ammonification, nitrification, and denitrification. First, the ammonification process converts nitrogenous waste from living animals or from the remains of dead animals into ammonium (NH_4^+) by certain bacteria and fungi. Second, the ammonium is converted to nitrites (NO_2^-) by nitrifying bacteria, such as Nitrosomonas, through nitrification. Subsequently, nitrites are converted to nitrates ($NO3^-$) by similar organisms. Third, the process of denitrification occurs, whereby bacteria, such as Pseudomonas and Clostridium, convert the nitrates into nitrogen gas, allowing it to re-enter the atmosphere.

Human activity can release nitrogen into the environment by two primary means: the combustion of fossil fuels, which releases different nitrogen oxides, and the use of artificial fertilizers in agriculture, which are then washed into lakes, streams and rivers by surface runoff. Atmospheric nitrogen is associated with several effects on earth’s ecosystems, including the production of acid rain (as nitric acid, HNO_3) and greenhouse gas (as nitrous oxide, N_2O), potentially causing climate change. A major effect from fertilizer runoff is saltwater and freshwater eutrophication: a process whereby nutrient runoff causes the excess growth of microorganisms, depleting dissolved oxygen levels and killing ecosystem fauna. A similar process occurs in the marine nitrogen cycle, where the ammonification, nitrification, and denitrification processes are performed by marine bacteria. Some of this nitrogen falls to the ocean floor as sediment, which can then be moved to land in geologic time by uplift of the earth’s surface, becoming incorporated into terrestrial rock. Although the movement of nitrogen from rock directly into living systems has been traditionally seen as insignificant compared with nitrogen fixed from the atmosphere, a recent study showed that this process may indeed be significant and should be included in any study of the global nitrogen cycle.

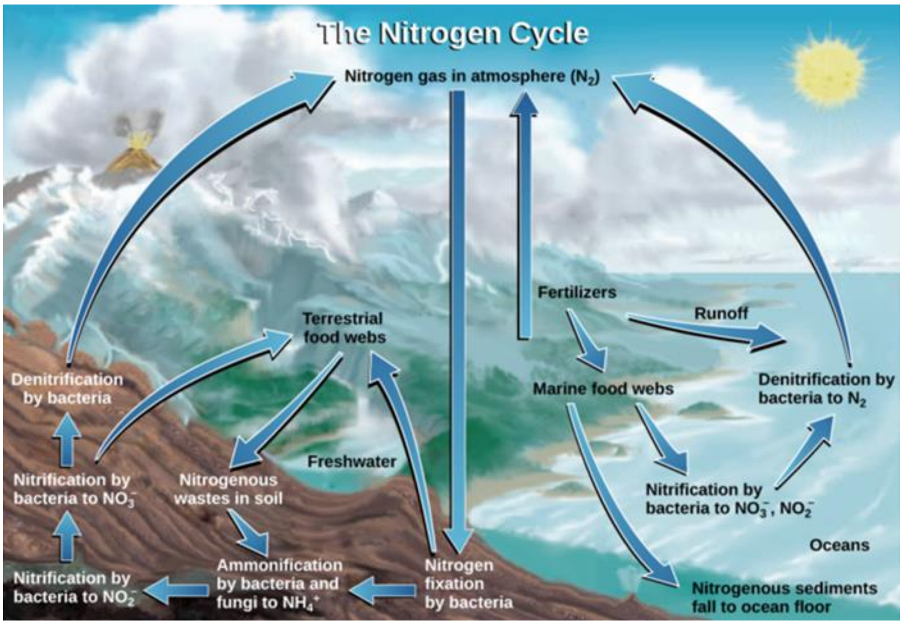


Fig. 1.11: Nitrogen fixation

Nitrogen enters the living world from the atmosphere via nitrogen-fixing bacteria. This nitrogen and nitrogenous waste from animals is then processed back into gaseous nitrogen by soil bacteria, which also supply terrestrial food webs with the organic nitrogen they need.

1.9.4. The Phosphorus Cycle

The phosphorus cycle is a biogeochemical cycle that describes the movement of phosphorus through the lithosphere (rock and soil), water bodies and living organisms. Phosphorus is an essential element for life, involved in processes such as DNA and RNA synthesis, energy transfer, and in the formation of bones and teeth. Phosphorus is an essential element of living being but, in excess, it can cause damage to ecosystems.

The phosphorus cycle begins with the weathering of rocks, primarily phosphate-rich rocks, such as apatite. Over time, weathering processes, including erosion, temperature changes, and the action of water and wind, break down these rocks, releasing phosphorus into the soil. Phosphorus occurs in nature as the phosphate ionPO_3^{4-}. In addition to it phosphate runoff as a result of human activity, natural surface runoff occurs when it is leached from phosphate-containing rock by weathering, thus sending phosphates into rivers, lakes and the ocean. This rock has its origins in the ocean. Phosphate-containing ocean sediments form primarily from the bodies of ocean organisms and from their excretions. However, in remote regions, volcanic ash, aerosols and mineral dust may also be significant phosphate sources. This sediment then is moved to land over geologic time by the uplifting of areas of the earth's surface.

Phosphorus is also reciprocally exchanged between phosphate dissolved in the ocean and marine ecosystems. The movement of phosphate from the ocean to the land and through the soil is extremely slow, with the average phosphate ion having an oceanic residence time between 20,000 and 100,000 years.

Excess phosphorus and nitrogen that enters these ecosystems from fertilizer runoff and from sewage causes excessive growth of microorganisms and depletes the dissolved oxygen, which leads to the death of many ecosystem fauna, such as shellfish and finfish. This process is responsible for dead zones in lakes and at the mouths of many major rivers.

Over time, phosphorus can be transported by water and accumulate in sedimentary rocks at the bottom of lakes, rivers and oceans. This process, known as sedimentation, locks phosphorus away in geological formations. Through, geological processes, such as uplift, weathering, and erosion, these phosphate-rich sedimentary rocks can resurface and contribute to the phosphorus cycle once again.

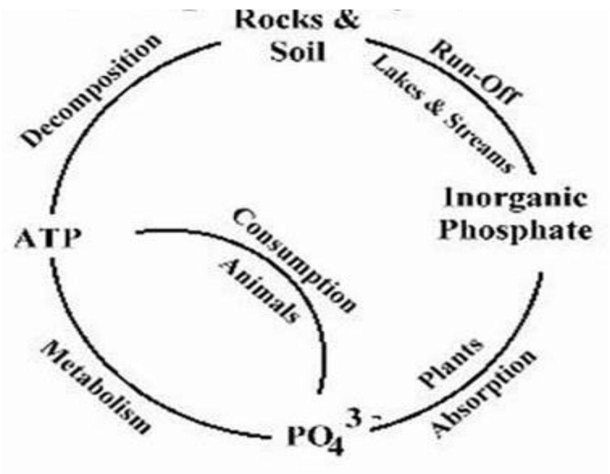


Fig.1.12: Phosphorus cycle

Phosphorus and Plants

Phosphorus can be stored in sedimentary rocks for long periods of time. Geological processes, such as uplift and erosion, gradually expose these rocks to weathering, releasing phosphorus back into the soil and restarting the cycle over geological timescales. This slow release ensures a long-term supply of phosphorus to sustain the ecosystems.

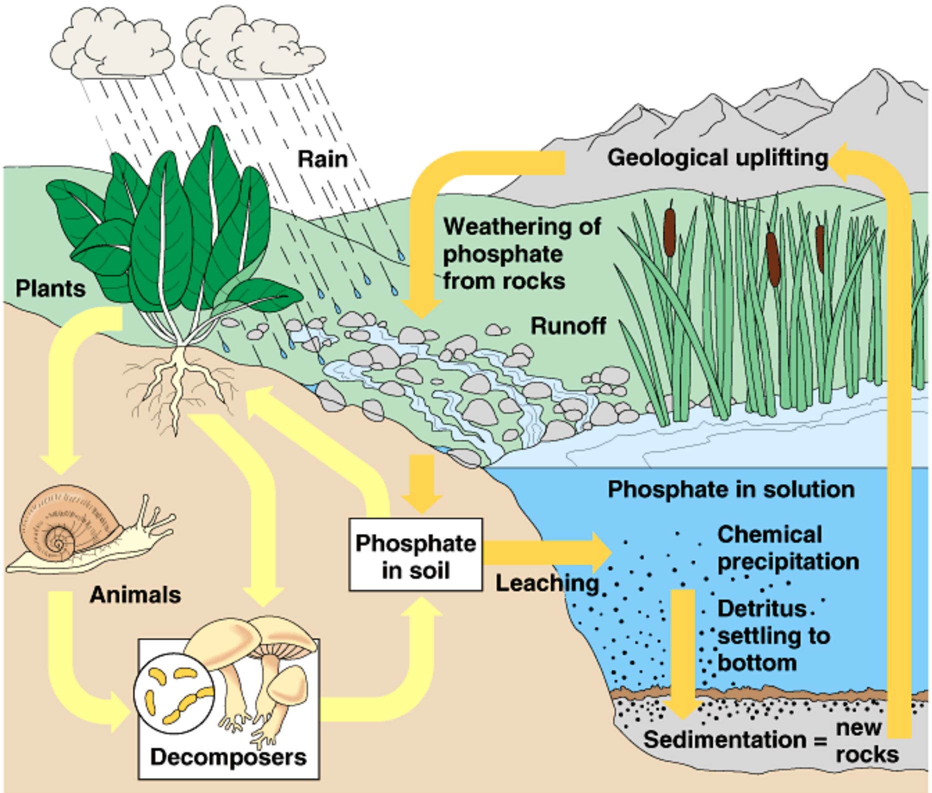


Fig.: 1.13: Phosphorus cycle

Phosphorus compounds reside primarily in rocks. Phosphorus does not go through an atmospheric phase, but rather, phosphorus-laden rocks release phosphate (PO_4^{-3}) into the ecosystem as the result of weathering and erosion. To plants, phosphorus is a vital nutrient (second only to nitrogen). Plants absorb phosphates through their root hairs. Phosphorus then passes on through the food chain when the plants are consumed by other organisms.

1.9.5. The Sulfur Cycle

Sulfur is deposited on land as precipitation, fallout and rock weathering, and reintroduced when organisms decompose. Sulfur is an essential element for the macromolecules of living things. As a part of the amino acid Cystine, it is involved in the formation of disulfide bonds within proteins, which help to determine their 3-D folding patterns and, hence, their functions. Sulfur cycles exist between the oceans, land and atmosphere.

On land, sulfur is deposited in four major ways: precipitation, direct fallout from the atmosphere, rock weathering and decomposition of organic materials. Atmospheric sulfur is found in the form of sulfur dioxide (SO_2). As rain falls through the atmosphere, sulfur is dissolved in the form of weak sulfuric acid (H_2SO_4), creating acid rain. Sulfur can also fall directly from the atmosphere in a process called fallout. The weathering of sulfur-containing rocks also releases sulfur into the soil. These rocks originate from ocean sediments that are moved to land by the geologic uplift. Terrestrial ecosystems can then make use of these soil sulfates (SO_4^{2-}). Upon the death and decomposition of these organisms, sulfur is released back into the atmosphere as hydrogen sulfide (H_2S) gas. Sulfur may also enter the atmosphere through geothermal vents.

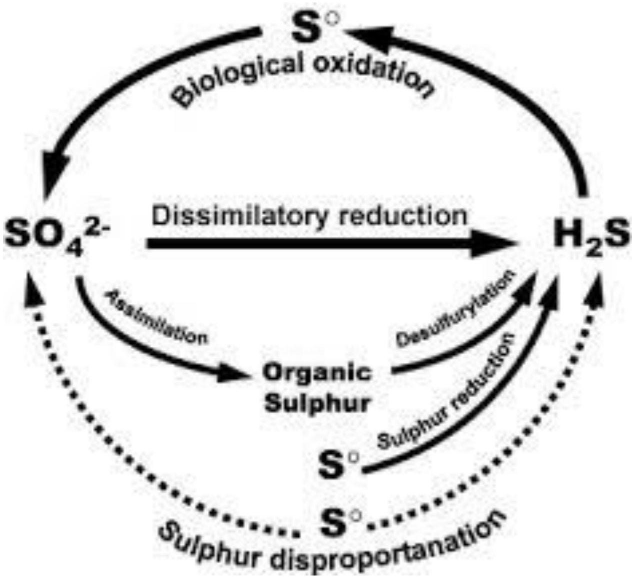


Fig.1.14 Sulfur cycle

Human activities have played a major role in altering the balance of the global sulfur cycle. The burning of large quantities of fossil fuels, especially from coal, releases large amounts of hydrogen sulfide gas into the atmosphere, creating acid rain. Acid rain is corrosive rain that causes damage to aquatic ecosystems and the natural environment by lowering the pH of lakes, which kills many of the resident fauna, it also affects the human-made environment through the chemical degradation of buildings. For example, many marble monuments such as the Lincoln Memorial in Washington, DC, have suffered significant damage from acid rain over the years. These examples show the wide-ranging effects of human activities on our environment and the challenges that remain for our future. Sulfur dioxide from the atmosphere becomes available to terrestrial and marine ecosystems when it is dissolved in precipitation as weak sulfuric acid or when it falls directly to the earth as fallout. Weathering of rocks also makes sulfates available to terrestrial ecosystems. Decomposition of living organisms returns sulfates to the ocean, soil and atmosphere.

1.10. Summary

Ecology is the scientific study of the interactions between organisms and their environment. It encompasses the study of the distribution, abundance and relationships of living organisms as well as their interactions with the physical and biological components of their environment. Ecosystems, on the other hand, are dynamic systems formed by the interactions between living organisms (biotic components) and their physical surroundings (abiotic components). A pond, lake, desert, grassland, meadow, forest etc. are common examples of ecosystems. Each ecosystem has two main components :1) Abiotic (2) Biotic A food chain is a linear sequence of organisms through which nutrients and energy pass as one organism eats another. Food webs consist of many interconnected food chains and are more realistic representation of consumption relationships in ecosystems. Ecosystems can vary in size and complexity, from small freshwater ponds to vast forests or entire biomes. Energy flows through ecosystems in the form of food chains and food webs, as organisms require energy by consuming other organisms or by converting sunlight through photosynthesis. Nutrients, such as carbon, nitrogen, and phosphorus, cycle within ecosystems, being recycled and reused by different organisms. Ecosystems provide numerous ecosystem services, including the provision of food, water, clean air, climate regulation, nutrient cycling, and cultural and aesthetic values.

1.11. Terminal Questions

Q.1: Describe in brief the components of an ecosystem

Answer:……………………………………………………………………………………
…………………………………………………………………………………………….

Q.2: What is difference between a food chain and food web?

Answer:……………………………………………………………………………………
…………………………………………………………………………………………….

Q.3: What is the importance of food chain and food web?

Answer:……………………………………………………………………………………
…………………………………………………………………………………………….

Q.4: What are the three types of ecological pyramids?

Answer:……………………………………………………………………………………
………………………………………………………………………..

Q.5: Explain the path of the hydrologic cycle and its importance.

Answer:……………………………………………………………………………………
………………………………………………………………………..

Q.6: What are the three steps of the nitrogen cycle?

Answer:………………………………………………………………………………………
…………………………………………………………………..

1.12.Suggested further readings

1 Ecology: Theories and Applications (4th Edition) by Peter Stiling; Prentice Hall.

2 Biodiversity: a beginner's guide, john I. spicer, Oneworld Publications.

3 Atmosphere, Weather and Climate, Barry, R. G. 2003, Routledge Press, UK.

4 Environmental Science, Subhas Chandra Santra, new central book agency, 3rd Edition, 2011

5 A text Book of Environment Studies, Asthana, D. K. and Asthana, M. 2006, S. Chand & Co

Unit-2: Population Ecology

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2.1. Introduction

Population ecology, study of the processes that affect the distribution and abundance of animal and plant populations. Population ecology is a sub-field of ecology that deals with the dynamics of species population and how these populations interest with the environment, such as birth and deaths rates, and by immigration and emigration. A population consists of all the organisms of a given species that live in a particular area. The statistical study of populations and how they change over time is called demography. The two important measures of a population are population size, population size represents the total number of individuals in a habitat and population density, refers to how many individuals residue in particular area. Population size is represented by the letter N and it equals the total number of individuals in a population. Population size is the numbers of individuals in a population density is the average number of individuals per unit of area or volume.

Within any population, individuals are born and individuals die. If there are more individuals begin born than dying, the population grows in size, while if more individuals are dying than being born, the populations shrinks. Individuals may also enter or leave a population, which is referred to as immigration and emigration. To better understand population growth, ecologists have created models to study how birth, death, immigration and emigration affect population size. The simplest model is called the exponential growth model.

Some ecologists recognized following two types of populations:

1. **Monospecific population** is the population of individuals of only one species and,

2. **Mixed or polyspecific population** is the population of individuals of more than one species.

The basic characteristic of a population is its **size or density** which is affected by four primary population parameters such as **natality** (births), **mortality** (deaths), **immigration** and **emigration.** In addition to these attributes, one can derive secondary characteristics of a population, such as its **age distribution, genetic composition** and **pattern of distribution** (distribution of individuals in space).

Objectives:

After studying this unit you will be able to known:

- about the characteristics of population
- about the regulation of population density
- about interaction among population

2.2. Ecology and Environment

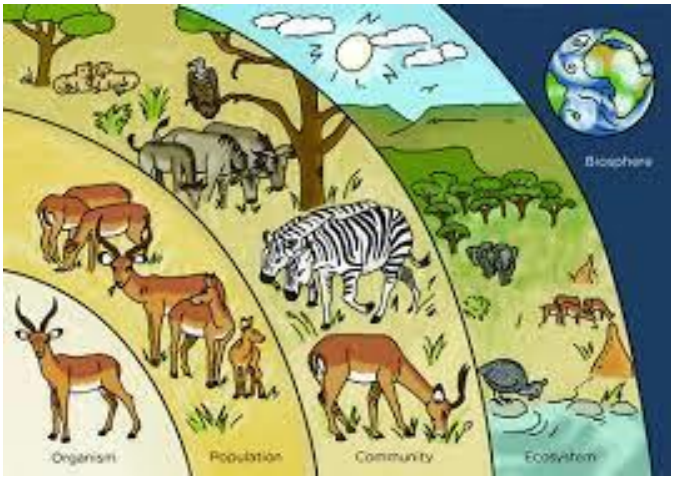
Ecology and the environment are closely related fields of study that focus on understanding the relationships between living organisms and their surroundings. Ecology is the study of how living organisms interact with each other and their environment, while the environment refers to the physical and biological surroundings in which living organisms exist. Ecology encompasses a wide range of topics, including the study of ecosystems, biodiversity, biogeochemical cycles, population dynamics and food webs. Ecologists study these topics to better understand how living organisms interact with each other and with their environment, and to develop strategies for conservation and management of natural resources. The environment includes the physical and biological components of the Earth's systems, including the atmosphere, hydrosphere, lithosphere and biosphere. Environmental science focuses on the study of the environment and the impact of human activities on natural systems. This includes the study of air and water pollution, climate change, land use, and resource management. The environment includes the physical and biological components of the Earth's systems, including the atmosphere, hydrosphere, lithosphere and biosphere. Environmental science focuses on the study of the environment and the impact of human activities on natural systems. This includes the study of air and water pollution, climate change, land use, and resource management. Here are some examples of ecology and the environment:

- **Ecosystems:** An ecosystem is a community of living organisms and their non-living environment. For example, a forest is an ecosystem consisting of trees, animals, and microorganisms, along with soil, water, and air. Biodiversity:
- **Biodiversity**: refers to the variety of living organisms in an ecosystem. For example, a coral reef has high biodiversity with many different species of fish, coral and other marine organisms.
- **Climate Change:** Climate change refers to long-term changes in the Earth's climate. Climate change is caused by natural and by human activities , including greenhouse gas emissions, deforestation and changes in land use.
- **Pollution:** Pollution refers to the release of harmful substances into the environment. For example, air pollution from industrial emissions can cause respiratory problems in humans and animals, and water pollution from oil spills can harm marine life.

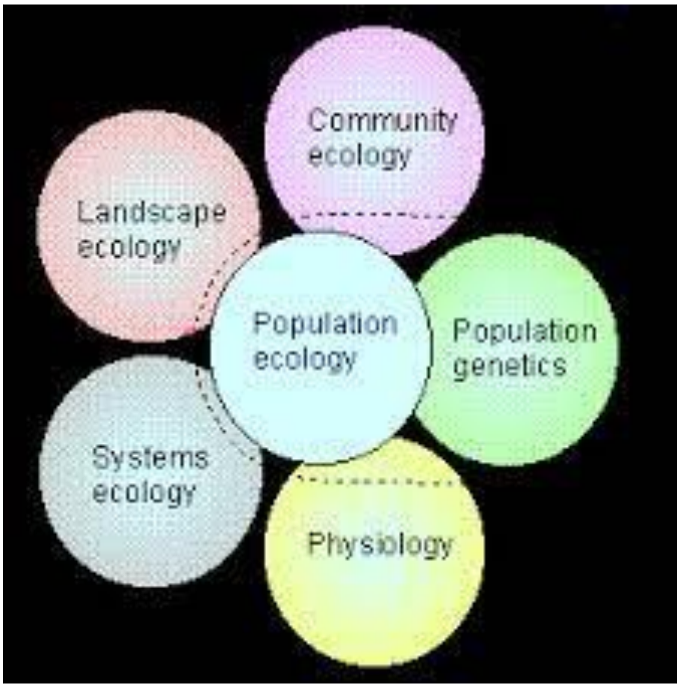
- Conservation: Conservation refers to the protection and management of natural resources. For example, efforts to protect endangered species like the bald eagle or the black rhinoceros are examples of conservation.
- **Renewable Energy:** Renewable energy refers to energy sources that are replenished naturally, such as solar, wind, and hydro power. The use of renewable energy can help to reduce greenhouse gas emissions and combat climate change.

2.3. Concept of Population ecology

A population is defined as a group of individuals of the same species living and interbreeding within a given area. Members of a population often rely on the same resources, are subject to similar environmental constraints and depend on the availability of other members to persist over time.



In ecology, a population is a group of organisms of the same species who inhabit the same particular geographical area and are capable of interbreeding. The area of a sexual population is the area where inter-breeding is possible between any pair within the area and more probable than cross-breeding with individuals from other areas. In ecology, the population of a certain species in a certain area can be estimated using the Lincoln index to calculate the total population of an area based on the number of individuals observed.



Population, a group of organisms of one species that interbreed and live in the same place at the same time (e.g., human population, the population of apple trees, total population of deer in a forest). It is a subset of total individuals of a species that occupy a certain geographic area in the world. A species can be randomly or schematically distributed throughout the different parts of the world, countries, cities, forests, ecosystems, *etc*. But a defined set living in a "*very*" specific geographic dimension is called a *population*.

2.4. Characteristics of Population

The ecological study of populations includes the following three main aspects;

a. Population characteristics;
b. Population dynamics;
c. Regulation of population.

Population characteristics in ecology refer to the various attributes and features of a population that are used to describe and understand its dynamics within an ecosystem. These characteristics provide insights into the size, structure, distribution and behavior of populations. The population has the following characteristics:

2.4.1. Population Size:

Population size refers to the total number of individuals in a population at a given time. It is an essential characteristic that provides a baseline for understanding population dynamics. Population size can influence resource availability, competition, and other ecological processes. Total size is generally expressed as the number of individuals in population. More informative are estimates of **density**, the number per unit area (or volume) of environment. The population size (N) at any given place is determined by the processes of birth (B), death (D), new arrivals from outside or **immigration (I)** and going out or **emigration (E)**. Therefore, change in population size between an interval of time Nt+1 is Nt (initial stage) +B-D+I-E.

2.4.2. Population Density:

Population density is the number of individuals per unit area or volume. It indicates how crowded or dispersed the population is within its habitat. High population density can lead to increased competition for resources and greater interactions among individuals. Density may be numerical density (number of individuals per unit area or volume) or biomass density (biomass per unit area or volume). When the size of individuals in the population is relatively uniform, as mammals, birds or insects then density is expressed in terms of number of individuals (numerical density). But, when the size of individuals is variable, such as true of fishes, trees or mixed populations (biomass density).

The patterns of distribution of organisms in nature are different it becomes important to distinguish between **crude density** and **specific (ecological) density**.

1. **Crude density.** It is the density (number or biomass) per unit total space.
2. **Specific** or **ecological** or **economic density.** It is the density (number or biomass) per unit of habitat space i.e. available area or volume that can **actually** be colonized by the population.
3. **Dispersion:** Dispersion is the spatial pattern of individuals in a population relative to one another. The three basic types of dispersion are:
    a. **Regular Dispersion:** The individuals are more of less spaced at equal distance from one another. Animals with territorial behavior tend towards this dispersion.
    b. **Randam Dispersion:** The position of one individual is unrelated to the positions of its neighbors'. This is also relatively rare in nature.
    c. **Clumped Dispersion:** Most populations exhibit this dispersion to some extent with individuals aggregated into patches interspersed with no or few individuals. Such aggregations may result from social aggregations.

2.4.3. Age structure

Age structure describes the distribution of individuals in different age groups within a population. It provides insights into the reproductive status, survival rates and potential for future population growth. Age structure can be categorized into three main groups: pre-reproductive (young), reproductive and post-reproductive (old). In most types of populations, individuals are of different age. The proportion of individuals in each age group is called age structure or age distribution of the population.

Age distribution is important, as it influence both, natality and mortality of the population. The ratio of the various age groups in a population determine the current reproductive status of the population, thus anticipating, its future, From an ecological view point there are three major ecological ages (age groups) in any population. These are prereproductive, reproductive and post reproductive.

Age pyramids. The model representing geometrically the proportions of different age groups in the population of any organism is called age pyramid. The three hypothetical pyramid types are:

a) **A pyramid with broad base.** It indicates a high percentage of young individuals only few old individuals. Thus in rapidly growing young population, birth rate is high and population growth may be exponential as in housefly, Paramecium, etc
b) **A bell-**shaped polygon. It indicates a stationary population having an equal number of young and middle aged individuals. It indicates a moderate proportion of young to old. As the rate growth becomes slow and stable, i.e., the prereproductive and reproductive age groups becomes more or less equal in size, post reproductive group remaining as the smallest, there results a bell-shaped structure.
c) **Urn-shaped** structure. It indicates a low percentage of young individuals. It shows a declining population. Such an urn-shaped figure is obtained when the birth rate is drastically reduced; the pre-reproductive group dwindles in proportion to the other age groups of the population.

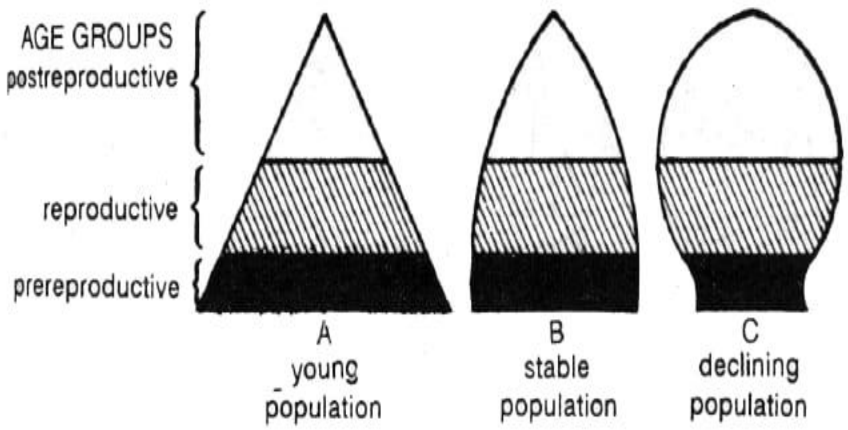


Fig. 2.1- Showing different types of age pyramid

2.4.4. Sex Ratio:

Sex ratio refers to the proportion of males to females in a population. It is an important characteristic for understanding reproductive dynamics and potential breeding success. Deviations from a balanced sex ratio can affect mating opportunities and genetic diversity.

2.4.5. Distribution Pattern:

Distribution pattern describes how individuals are spatially arranged within a population's habitat. It can be clumped, uniform, or random. The distribution pattern is influenced by resource availability, social behavior and environmental factors.

2.4.6. Pattern of population dispersion

Dispersal refers to the movement of individuals from their birthplace to establish in new areas. It affects the distribution and genetic diversity of populations. Dispersal can occur through migration, active movement, or passive transportation by external factors such as wind or water.

2.4.7. Natality

Natality is a broader term covering the production of new individuals by birth, hatching, germination or fission. The natality rate may be expressed as the number of organisms born per female unit time. In human population, the natality rate is equivalent to the 'birth-rate'/ **Natality (birth rate).** There are distinguished two types of natality:

1. **Maximum (absolute** or **potential** or **physiological) natality.** It is the theoretical maximum production of new individuals under ideal conditions (i.e. no ecological limiting factors, reproduction being limited only by physiological factors). It is a constant for a given population. This also called **fecundity rate**.
2. **Ecological or relished natality.** It is also known simply as natality, which refers to population increase under an actual, existing specific condition. Thus, it takes into account all possible existing environmental conditions. This is also designated as **fertility rate**.

Natality is expressed as

$\Delta N_n/\Delta t$ = the absolute natality rate (B)

$\Delta N_n/N\Delta t$ =the specific natality rate (b) (natality rate per unit of population)

Where, N = initial number of organisms

n = new individuals in the population

t= time

Further the rate at which females produce offspring's is determined by the following three population characteristics:

1. Clutch size or the number of young produced on each occasion;
2. The time between one reproductive event and the next, and
3. The age of first reproduction.

Thus natality usually increases with the period of maturity and then falls again as the organism gets older. But there are some trees which continue to increase fruit production as they get older. Natality patterns differ in tropical and temperate populations.

2.4.8. Mortality (death rate):

Mortality means the rate of death of individuals in the population. It is a negative factor for population growth. A birth-death ratio ($100\times\frac{births}{deaths}$) is called **vital index.** For a population, the important thing is not which members die but which members survive. Thus survival rates are of much interest than the death rates. Survival rates are generally expressed by survivorship curves. Like natality, mortality may be of following types:

1. **Minimum mortality:** It is also called specific or potential mortality. Minimum mortality represents the theoretical minimum loss under ideal or non-limiting conditions. It may be constants for a population.
2. **Ecological mortality.** It is also called realized mortality. It is the actual loss of individuals under a given environmental condition. Ecological mortality is not constant for a population and varies with population and environmental conditions, such as predation, disease and other ecological hazards.

2.4.9. Survivorship curves:

There are following three types of survivorship curves which represent the different nature of survivors in different types of population:

a) **<u>Highly convex curves.</u>** (Pattern 1) in the figure, is characteristic of the species in which the population mortality rate is low until near the end of the life span thus, such species tend to live throughout their life span , with low mortality. Many species of large animals as deer, mountain sheep, man etc. show such curves.

b) **Highly concave curve**. This type of curve (pattern III) is the charaterists of such species where mortality rate is high during the young stages. Some birds, blacktail deer, oysters, sheel fish, oak trees, etc., exhibit pattern III type curve.

c) **Diagonal straight-line curve.** This type of curve (pattern IIb) indicates an age specific constant survivorship, i.e. a constant rate of mortality occurs at every age. Some animals such as hydra, gull, American robin, etc. exhibit this type of curve.

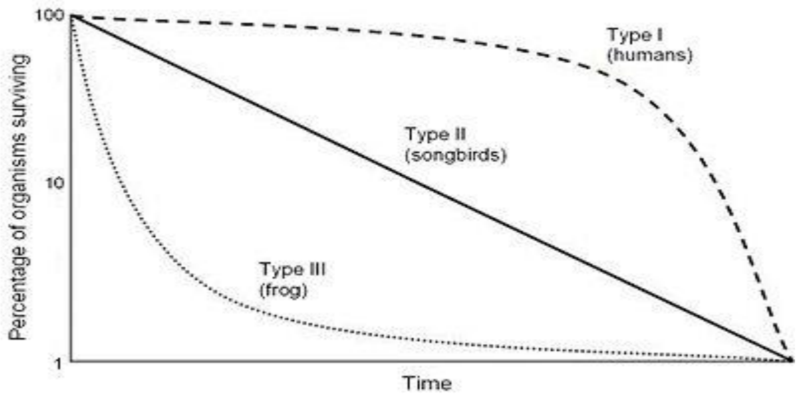


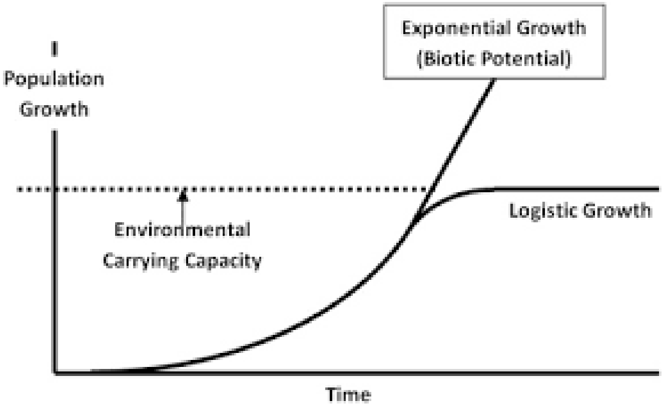
Fig. 2.2. Survivorship curve

In fact, no population in the real world has a constant age-specific survival rate throughout the whole life span. Thus a slightly concave or sigmoid curve is characteristic of many birds, mice and rabbits. In them the mortality rate is high in the young but lower and almost constant in the adult (1 year or older). In some holometabolous insects (i.e. insects with complete metamorphosis), such as butterflies, the survival rate differs in successive life history stages and the curve becomes the stair-step type survivorship curve the initial, middle and final steep segments represent the egg population and short lived adult stages, and the two middle flatter segments represent larval and pupal stages which exhibit less mortality.

The survivorship curve of human population is highly convex. This has become possible because of increased medical care, better hygiene, and improved nutrition and so on.

2.4.10. Biotic potential:

The term of biotic potential, one is able to put together natality, mortality and age distribution. Chapman (1928) proposed the term biotic potential to designate maximum reproductive power. Biotic potential refers to the maximum reproductive capacity of a population under ideal conditions, assuming no limitations from resources, predation, competition, or other environmental factors. It represents the intrinsic capacity of a species to produce offspring and increase its population size. He defined it as “the inherent property of an organism to reproduce, to survive, i.e. to increase in numbers. It is sort of the algebraic sum of the number of young produced at each reproduction, the number of reproduction in a given period of time, the sex ratio and their general ability to survive under given physical conditions".



Each population has the inherent power to grow but growth rate (i.e. the population growth rate per individual) becomes constant and maximum for the existing environmental conditions. The value of the growth rate under these favorable conditions is maximal, is characteristic of a particular population age structure, and is a single index of the inherent power of a population to grow. It may be designed by the symbol r, which is the exponent in the differential equation for population growth in an unlimited environment under specific physical conditions.

The index r is actually the difference between the instantaneous specific natality rate (b), (i.e, rate per time per individual) and the instantaneous specific death rate (d), and may thus be expressed as

$$r=b-d$$

The overall population growth rate under unlimited environment conditions (*r*), depends on the age composition and the specific growth rates due to reproduction of component age groups. In a population with a stable age distribution, the reproductive capacity or growth rate is called the intrinsic and represented by symbol r. Thus, there may be several values of *r* for a species depending upon population structure. The maximum values of *r* are often called by the less specific but widely used expression **biotic potential** or reproductive potential. Here are some examples of species with different biotic potentials:

Bacteria: Bacteria have a high biotic potential due to their ability to reproduce rapidly through binary fission. Under favorable conditions, a single bacterium can divide and produce two daughter cells every 20 minutes. With exponential growth, the population can increase exponentially within a short period of time.

Insects: Insects often have high biotic potentials due to their short generation times and large numbers of offspring produced. For example, a female mosquito can lay hundreds of eggs at a time, and many insect species can produce multiple generations within a single year.

Rodents: Many rodent species have high biotic potentials. They typically have short gestation periods and can produce multiple litters per year. For example, a female house mouse can have a litter of 5-10 pups every 3-4 weeks, allowing their populations to increase rapidly.

Small Fish: Some small fish species, such as certain species of minnows, have high biotic potentials. They reproduce in large numbers, and their offspring mature quickly, leading to rapid population growth under favorable conditions.

Plants: Many plants have high biotic potentials due to their ability to produce numerous seeds or reproduce asexually through methods like runners or bulbs. For example, dandelions produce numerous wind-dispersed seeds, and some invasive plant species can spread rapidly and colonize new areas.

It's important to note that biotic potential represents the maximum reproductive capacity of a species, but actual population growth is limited by various factors such as resource availability, predation, competition, and environmental conditions. These factors determine the populations realized or actual growth rate and can influence the species' success and abundance in different ecosystems.

2.5. Life table Population

A life table is a tool used in ecology to study population dynamics, which provides a summary of the probabilities of survival and reproduction of individuals in a population at different stages of their life cycle. Life tables are used to analyze the age structure and growth rates of populations, as well as to make predictions about future population size and composition. Raymond Pearl, (1921) first used life table for the population of Drosophila reared in the laboratory.

Life tables are commonly used to study insect populations, which are characterized by high reproductive rates and short life spans. For example, ecologists may use life tables to examine the survival rates of individual butterflies at different stages of their life cycle, from egg to adult. Life tables can also be used to study marine mammal populations, such as whales, dolphins, and seals. These populations have longer life spans than insects, and their life tables may include information on survival rates, reproductive rates, and age at first reproduction. Human life tables may include information on survival rates at different ages, age-specific fertility rates and age-specific mortality rates.

Constructing a life table is often a simple method for keeping track of births, deaths, and reproductive output in a population of interest. Basically, there are two types of life table:

1) the cohort life table follows a group of same-aged individuals from birth (or fertilized eggs) throughout their lives

2) the period or static life table is made from data collected from different aged individuals at one particular time

2.5.1. Components of a life table

1. First column x in the life table provides age intervals of the individuals in time units suitable according to the species.
2. Second column n_x gives number of individuals surviving at that particular age interval.
3. Third column lx gives proportion surviving. It can start with one thousand individuals that enter in the first age group and gives the remaining number at the beginning of each subsequent age interval. It is calculated by the formula:

$$l_x = l_{x1}/n_{x1} X\, n_{x2}$$

4. Fourth column dx represents number of individuals dying at each age interval from the initial group of 1000 individuals. It is calculated by:

$$d_x = l_x - 1(x+1)$$

5. Fifth column ex denotes life expectancy. It determines the total expected survival of an individual of a given age beyond its present age. It can be calculated by following three steps;

a. Lx is average number of individuals alive. Calculate the proportion of survivors at the mid-point of each time interval.

$$L_x = l_x + 1(x+1)/2$$

b. Lx is total life time remaining for all the individuals attaining the age. Sum all the Lx values from the age of interest upto the oldest age:

$$Lx = \Sigma Lx$$

$$ex = Tx/lx$$

2.5.2. Construction of the cohort life table

A cohort life table can be constructed from counts of all the individuals of a population (or estimate the population size from samples) as it progresses through the growing season. The easiest way to think of this to consider an insect with a determinant number of instars; for example, a typical caddisfly with a life history of eight distinct stages (egg, 1st–5th instar larva, pupa, and adult).

The construction of life table for this simple life history can be done by counting the population size at each life stage. The first column (x) denotes the age class and second column (nx) specify the number of individuals survived at the beginning of each age. These data can be used to calculate several other life history parameters, such as the proportion surviving at each life stage (lx), proportion of individuals dying at each age (dx) and agespecific mortality rate (qx) dying at each age which is helpful in locating the points where mortality is most intense **(table: 2.1 .** For constructing life table, the first step is to decide age interval in which data can be placed. For instance, human and tree can be grouped at interval of five years; for birds or deer population, interval can be of one year; and for rodents (field mice) or annual plants the interval can be of one months. By making the age interval shorter, we can analyze the mortality scenario in more details. The rate of mortality (qx) is expressed as a rate for the time interval between successive census stages of the life table. For example in the table, 78% of song sparrow died before reaching to age group one.

Table 2.1: Cohort life table of song sparrow on Mandarte Island, British Columbia

(Source: Smith 1988)

Age in yrs (x)	**Observed No. birds alive each year (nx)**	**Proportion surviving at Start of Age Interval x (lx)**	**No. dying within Age interval x to x + 1 (dx)**	**Rate of mortality (qx)**
0	115	1.0	90	0.78
1	25	0.217	06	0.24
2	19	0.165	07	0.37
3	12	0.104	10	0.83
4	2	0.017	1	0.50
5	1	0.009	1	1.0
6	0	0.0	--	--

2.5.3. Construction of static life table

The static is a less accurate, this method also known as vertical or period life table. The static table compares population size from different cohorts, across the entire range of ages, at a single point in time. Static tables make two important assumptions: (1) the population has a stable age structure that is, the proportion of individuals in each age class does not change from generation to generation, and (2) the population size is nearly stationary.

The construction of static life tables is done by estimating age of the individuals at the time of death in a given population. This can be a useful technique for secretive large mammals (e.g., moose) from temperate regions where it is difficult to sample the living members. Because the highest mortality of large herbivores occurs during the winter, an early spring survey of carcasses from starvation and predator kills can yield useful information in constructing a life table. Keeping in mind; however, all static tables suffer from the same two assumptions stated above. Because, we keep good birth and death records of humans, static life tables can also be used to answer questions concerning our populations. For instance, we know that females today have a larger mean life expectancy than men. But, was this true for our population 100 years ago? We can use data, collected from cemetary grave markers to construct a static life table and reveal interesting features of human populations from past generations. The following data were collected from a random sample of 30 females and 30 males off grave markers located in an Ann Arbor cemetary:

Table: 2.2. Static life table for the human female population of individuals born prior to 1870. (Source G. Belovsky, unpubl.).

Age at death	Females	Males
0–5	1	2
6–10	0	0
11-15	1	0
16-20	2	1
21-25	1	1
26-30	0	2
31-35	0	0
36-40	1	2
41-45	1	0
46-50	2	1
51-55	1	0
56-60	2	3
61-65	0	4
66-70	0	4

71-75	1	3
76-80	6	1
81-85	4	1
86-90	7	3
91-95	0	0
96-100	0	2

2.5.4. Application of life table:

- Life tables can be used to understand the patterns and causes of mortality of the individuals in a population.
- It can also be used to predict the growth or decline of future populations and also help in protecting the populations of endangered species.
- It can also be used in the field of species conservation efforts.
- It can be used to calculate the average longevity of a population for determining the age composition of a population.
- It can used to indicate critical stages in the life cycle of a species at which mortality rate is very high to make the differences between species

2.6. Inter and intra-specific relation among population

Organisms do not live alone, all the time they are influenced by their neighbors and show a response to this influence. In ecology, this is known as species interaction and is defined as the relation between species that live together in a community. Species interactions are basis for many features of community and ecosystem. The nature of these interactions can vary depending on the evolutionary context and environmental conditions in which they occur, as a result, ecological interactions between individual organisms and entire species are often difficult to define and measure and are frequently dependent on the scale and context of the interactions. The living organism has two types of integration that is inter and intra specific integration. The inter specific interaction occurs between two different organism or species while intra specific interaction occurs between to same organism or species.

2.6.1. Inter-specific relationships

Inter-specific relationships refer to the interactions between different species in an ecosystem. These relationships can be positive, negative, or neutral, and can have significant impacts on the population dynamics and ecology of the species involved. Here are some examples of inter-specific relationships among populations in ecology:

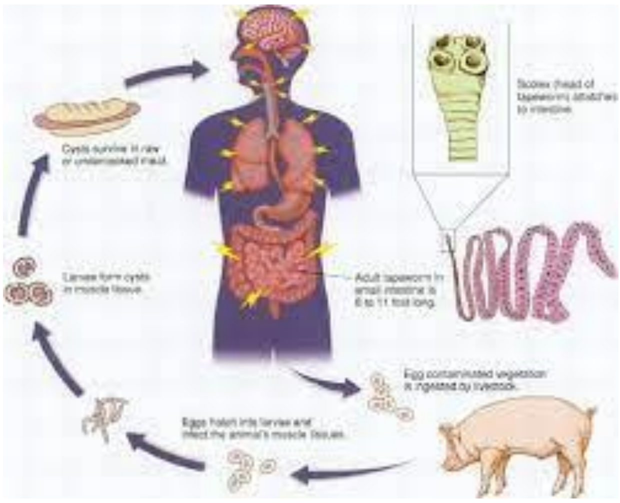
- **Predation:** Predation is a type of ecological relationship in which one species (the predator) kills and eats another species (the prey) for sustenance. It is a common phenomenon in the natural world, and can have significant impacts on the population dynamics and ecology of the species involved. Predation is a natural phenomenon in ecology that plays an important role in regulating populations and maintaining ecological balance.

Predation can have significant impacts on the population dynamics and ecology of the species involved, and is a key aspect of food webs and ecosystems. Sharks are top predators in many marine ecosystems and feed on a wide range of prey, including fish, squid, and marine mammals, another examples is Spiders are predators that use webs or traps to catch their prey, which are usually small insects such as flies or mosquitoes. In addition, Killer whales are apex predators in their ecosystems, and they feed on a variety of prey, including seals, sea lions, and fish.

- **Mutualism:** Mutualism is a type of ecological relationship in which both species benefit from each other's presence. This relationship is common in nature and can have significant impacts on the population dynamics and ecology of the species involved. Pollinators, such as bees, butterflies, and hummingbirds visit flowers to feed on nectar and pollen, and in doing so, they inadvertently transfer pollen between flowers, allowing the plants to reproduce. This relationship benefits both the pollinators and the plants, as the pollinators get food and the plants can reproduce.

Another examples is Symbiotic relationships occur when two species live in close association with each other, and both benefited from the relationship. For example, lichens are a symbiotic relationship between fungi and algae, where the fungi provide structure and protection to the algae, while the algae provide nutrients for the fungi. Nitrogen-fixing bacteria live in the roots of legume plants is also examples of symbolic relationship, where they convert atmospheric nitrogen fixed into a form that the plants can use it for growth. The bacteria benefited from the nutrients provided by the plants, while the plants benefited from the nitrogen provided by the bacteria. In addition, Mycorrhizal fungi form a mutualistic relationship with plant roots, where they help the plants to absorb nutrients and water from the soil, and in return, the plants provide sugar to the fungi.

- **Parasitism:** Parasitism is a type of ecological relationship in which one species (the parasite) benefited at the expense of another species (the host). The parasite benefited from the relationship by gaining nutrients, shelter or protection, while the host is harmed. Parasitism is a common ecological relationship in which one species benefits at the expense of another. This relationship can have significant impacts on the population dynamics and ecology of the species involved, and can result in coevolution between the parasite and host species. Tapeworms are internal parasites that live in the digestive tract of vertebrates, such as fish, birds, and mammals.



The tapeworms benefited from the nutrients in the host's food, while the host may suffer from digestive problems or malnutrition. Cuckoo birds are brood parasites that lay their eggs in the nests of other bird species, such as warblers and dunnocks. The cuckoo bird benefited from having its offspring raised by another species, while, the host bird may suffer from reduced reproductive success or abandonment of its own eggs.

- **Competition**: competition is an ecological relationship in which two or more species compete for the same resources, such as food, water or habitat. Examples include lions and hyenas competing for prey, and plants competing for sunlight and nutrients in the soil. In a forest, plants compete for sunlight as they grow taller to reach the sunlight. Trees growing in the understory of the forest may not receive enough sunlight to grow as tall as trees growing in areas with more direct sunlight.

Many animals compete for food, either by consuming the same type of food or by hunting the same prey. For example, wolves and coyotes both hunt for similar prey such as rabbits and deer, and may compete with each other for access to these preys.

- **Commensalism:** Commensalism is an ecological relationship in which one species benefited from the presence of another species, while, the other species is not affected. These relationships can be important for the survival and success of species in a variety of ecosystems.

Epiphytes are plants that grow on other plants, such as trees, without harming them. The epiphytes benefit from the height and exposure to sunlight provided by the host tree, while, the tree is not affected. Another example is Remora fish are small fish that attach themselves to sharks and other large fish using a suction disc on their head. The remoras benefit from being carried by the host fish and feeding on scraps of food left by the host, while the host fish is not affected.

2.6.2. Intraspecific relation

Intraspecific relations refer to interactions among individuals of the same species in a population. However, the intraspecific relations are important for understanding population dynamics and the behavior of individuals within a species. These relations can affect the growth, survival and evolution of populations over time.

Individuals within a population may compete with each other for some resources such as food, water and shelter. This competition can limit the growth and survival of individuals, particularly in times of scarcity. Intraspecific relations also include interactions related to mating and reproduction. This can include competition for mates, courtship rituals and territorial behavior. Some species exhibit cooperative or social behavior among individuals in the same population, such as bees working together to build a hive, or wolves hunting together in packs. An intraspecific relation is important for understanding population dynamics and the behavior of individuals within a species. These relations can affect the growth, survival, and evolution of populations over time. Here are some examples of intraspecific relationships in ecology

- **Cooperation:** Many species cooperate with each other, such as social insects like bees, ants, and termites, which work together to maintain their colonies. Wolves and lions also cooperate in packs to hunt prey. Cooperation can increase the chances of survival and reproductive success for individuals and can benefit the group as a whole.
- **Competition**: Competition can occur between individuals of the same species for resources such as food, water, and mates. For example, male elephant seals compete for access to females during breeding season. Competition can also occur between members of the same sex, such as female mountain gorillas competing for access to the dominant male for mating opportunities.
- **Territoriality:** Many animals defend territories against other members of the same species to ensure access to resources such as food, water, and mates. For example, male songbirds establish territories during the breeding season and defend them against other males.
- **Agonistic behavior**: Agonistic behavior refers to aggressive interactions between members of the same species, which can involve fighting, threat displays, or other forms of aggression.
- Social hierarchies: Many animal species have social hierarchies in which individuals establish dominance and submissive roles. Dominance hierarchies can be based on factors such as age, size, or strength and can influence access to resources and mating opportunities.

2.7. Aggression and dominance

Aggression and dominance are important aspects of both inter- and intraspecific interactions in ecology. Aggression and dominance is important for understanding the dynamics of populations in different ecosystems. These behaviors can affect the success of individuals in passing on their genes to future generations, and can also shape the characteristics of populations over time. Here are some examples of aggression and dominance in ecology.

- **Aggression between individuals**: In many species, individuals may engage in aggressive behavior towards each other, in order to establish dominance or defend resources. This can involve physical displays of aggression, such as fighting or threatening gestures.
- **Dominance hierarchies:** Many social species, such as primates and some bird species, establish dominance hierarchies within their groups. This can involve individuals establishing their rank through physical contests or by using non-physical displays of dominance such as vocalizations or posturing.
- **Territorial behavior:** Some species use aggression to defend their territory from other members of their species or from different species. This can involve physical confrontations or displays of aggression that signal a willingness to defend the territory.
- **Resource competition:** Many species compete for some resources such as food, water or shelter. This competition can lead to aggressive behavior and the establishment of dominance hierarchies in order to ensure access to resources.
- **Predation and defense:** Some species use aggression and dominance as a means of defense against predators. For example, some bird species may mob predators to drive them away from their nesting sites

2.8: Mating and reproduction behavior

Mating and reproductive behavior is an important aspect of intraspecific interactions in ecology. For example, male birds may sing complex songs, display colorful feathers, or perform dances to attract female birds. Some species use territorial behavior to attract mates and protect their offspring. For example, male birds may defend a territory that contains good nesting sites or food sources, in order to attract females and ensure the survival of their offspring. However, the parents provide care for their offspring in order to ensure their survival. This can involve feeding, protecting, or teaching offspring, and can be exhibited by both male and female parents. In addition, different species exhibit different reproductive strategies, depending on their environment and ecological niche. For example, some species may produce large numbers of offspring with little parental care, while others may produce fewer offspring with greater parental investment.

2.9. Kin selection and altruism

Kin selection and altruism are important concepts in ecology that help to explain certain behaviors in organisms, particularly in social species. Kin selection is a form of natural selection that favors the evolution of traits, that benefit relatives of the individual with those traits. Altruism is a behavior that benefits others at a cost to the individual performing the behavior. In some species, such as birds and mammals, individuals may help care for the offspring of related individuals. This behavior benefits the offspring and increases their chances of survival, and it also benefits the individual performing the behavior by increasing the survival and reproductive success of their relatives. Some animals, such as ground squirrels and meerkats, use alarm calls to warn other members of their group about potential predators.

This behavior benefits the group as a whole, but it also puts the individual performing the behavior at risk. However, if the individuals in the group are closely related, the benefits to their relatives may outweigh the costs to the individual performing the behavior. Many social insect species, such as bees, ants and termites, have specialized roles within their colonies. Some individuals may perform tasks that benefit the group as a whole, such as caring for the young or defending the colony, even if it means sacrificing their own reproductive potential. This behavior benefits their relatives, who are also members of the colony and share their genes. Kin selection and altruism is important for understanding the evolution of social behavior in different populations and ecosystems. These behaviors can have significant impacts on the survival and growth of populations, as well as the characteristics of individuals within those populations. Here are some examples of kin selection and altruism in different organisms:

Social Insects: Social insect colonies, such as bees, ants and termites, exhibit remarkable examples of altruism through kin selection. Workers within these colonies often forego their own reproduction and dedicate their lives to supporting the reproduction of their close relatives, particularly the queen. By helping the queen produce offspring, which share a large proportion of their genes, the workers indirectly pass on their genetic material. This cooperative behavior increases the inclusive fitness of the workers and enhances the survival and reproduction of genetically related individuals.

Ground Squirrels: In certain ground squirrel species, individuals take turns acting as sentinels, scanning the surroundings for predators, while others for forage. The sentinel squirrels put themselves at risk by drawing attention to potential threats, but they provide an early warning system that benefits their relatives. This behavior can be explained by kin selection, as the relatives of the sentinel squirrel have a higher chance of survival, increasing the overall fitness of the family group.

Vampire Bats: Vampire bats are known to regurgitate blood meals to feed unrelated individuals who were unsuccessful in finding food. This behavior is considered altruistic because the donor bat incurs a cost by giving away its food, but it increases the chances of survival for the recipients. Vampire bats form social bonds and engage in reciprocal altruism, where individuals help each other over time, and the favour is returned in the future.

These examples illustrate how kin selection can drive the evolution of altruistic behaviors. By assisting close relatives, individuals increase the chances of passing on their shared genetic material, even if they themselves incur some costs. Kin selection provides a mechanism for understanding the evolution of altruism and cooperative behaviors in diverse species.

2.10. Summary

Population ecology is a branch of ecology that focuses on the study of populations, or groups of individuals of the same species living in the same geographic area. A population is generally a group of individuals of a particular species occupying a particular area at a specific time. Some of the ecologists, however recognize two types of population. Monospecific population and Mixed or polyspecific population. Populations can grow or shrink depending on factors, such as birth rates, death rates, immigration, and emigration. Life tables are used to track the survival and reproductive rates of individuals within a population. Within a population, individuals can interact with each other in a variety of ways, including cooperation, aggression, and dominance. The availability of resources such as food, water and shelter can have a significant impact on the growth and survival of populations. Population ecology is important for understanding the dynamics of ecosystems and the factors that contribute to the growth and survival of populations over time. It can also help inform conservation efforts and management strategies to protect endangered species and ecosystems.

2.11. Terminal Questions

Q.1: Define a population. Give a coincise account of various characteristics of a population of organisms.

Answer: --

Q.2: Discuss in brief the various factors that regulate the population growth.

Answer: --

Q.3: Explain the theory of population growth. How far this is applicable to real population growth in nature.

Answer: --

Q.4: Explain Age structure and Life tables

Answer: --

Q.5: What is known about Biological Potential?

Answer: --

Q.6: Explain inter and intra specific relationship among population.

Answer: --

2.12. Further suggested readings

1 Environmental Science, Subhas Chandra Santra, new central book agency, 3rd Edition, 2011

2 A text Book of Environment Studies, Asthana, D. K. and Asthana, M. 2006, S. Chand & Co

3 Atmosphere, Weather and Climate, Barry, R. G. 2003, Routledge Press, UK.

4 Ecology: Theories and Applications (4th Edition) by Peter Stiling; Prentice Hall.

5 Biodiversity: a beginner's guide, john I. spicer, One world Publications.

Unit-3: Ecological Succession

3.1. Introduction

Objectives

3.2. Concept of community

3.3. Characteristic of community

3.4. Ecological succession

3.4.1. Causes of Succession

3.4.2. Process of Succession

3.4.3. Types of Succession

3.4.3.1. Hydrosere - Succession in water- Plenty of water present

3.4.3.2. Xerosere- Succession on dry situation-

3.4.3.3. Moisture is present in minimal amount

3.5. Monoclimax

3.6. Polyclimax theory

3.7. Ecological niche

3.8. Habitat

3.9. Competitive exclusion principle

3.10. Ecological hierarchy

3.11. Summary

3.12. Terminal Questions

3.13. Further suggested readings

3.1. Introduction

The occurrence of relatively definite sequence of communities over a period of time in the same area is known as ecological succession. The concept of succession was largely developed by Warming (1909) and Cowles (1899). It has been further elaborated by Clements (1916, 1936) who proposed a theory of plant succession and community development called the mono-climax. Later on Tansely (1939) and Daubenmire (1966) proposed the poly-climax hypothesis. Ecological succession is a gradual process by which ecosystem change and develops overtime. Nothing remains the same and habitats are constantly changing. The species living in a particular place gradually change over time as does the physical and chemical environment with in that area. Succession take place because of growing and reproducing living organisms interact with each and affected by the environment within an area.

Objective:

After studying this unit you will be able to know-

- Causes and process of Succession.
- Types of Succession
- Succession in water
- Succession on land

3.2. Concept of community

Different types of population in a given habitat are studied under community ecology. Same kind of species constitute population but when different populations (different kind of species) interacts together with beneficial and mutual adjustments sharing same environment and habitat, the association is called Community. Examples of community include grassland, a pond, or a forest where different animal organism (population) interacts with plants (another population) in a natural area and sharing environment. Thus, community includes only interacting biotic components of ecology i.e. living organisms.

While walking in a forest we not only see different types of plants/trees like pine tree, or maple tree but also get glimpse of deer or squirrel or spider sometimes indicating a collection of different kind of species constituting populations (different) in that natural area sharing uniform environment. These different populations are adapted to the same environment and influence each other through their associations either positive or negative and thus, shaping/forming a biotic community.

Fig.3.1: A forest community depicting different interacting population

A community is a diverse group of organisms that interact in a common natural environment i.e. particular location. For instance, a forest, inhabited by animals and various species of plants, as well as soil bacteria and fungi constitutes a biological community. There are many factors that contribute to a biological community.

The factors include diversity (the number different types of species), abundance (number of individuals in each species), and the interactions among the various species. These interactions include predation, mutualism, parasitism, and competition. When these communities change over time, the phenomenon is called ecological succession. In a community, except for autotrophs (mostly plants), most organisms depends up on other organisms for food. This interdependence on other organisms can be represented by a food chain, and each organism occupying a particular place in a food chain called the trophic level.

A common definition of community emerged as a group of any size of people living an area with some common characteristics who are linked by social ties, (have a common cultural and historical heritage) share common perspectives, and engage in joint action in geographical locations or settings. Community is a spatial concept dependent on landscape pattern while the continuum is an environmental concept referring to an abstract space. When applying niche theory to plants, the mechanisms of competition are ill-defined and the assumption of bell-shaped response curves for species unrealistic. community ecology, also known as synecology, examines interactions between species in groups over a wide range of temporal and spatial scales, including distribution, population dynamics, structure, abundance, and demography.

3.3. Characteristic of community

Community ecology's main characteristics include diversity of species, growth form and structure, dominance, self-reliance, relative abundance, and trophic structure. Natural communities include a desert, a forest, and a pond. A community is unique in terms of its structure, development, and behaviors. All the communities are governed by similar forces for their maintenance and share common and certain general characteristics. Instead of being sharply defined by the boundaries, these communities tend to overlap on each other, thus forming a gradient. Seasonal variations and other type of variations or disturbances causes frequent shifting of the animals between the communities. Communities are broadly separated but similar types of animals are found in the communities with similar kind of prevailing environmental factors. Some of the common characteristics shared by all the ecological communities are given below:

3.3.1. **Stratification: Vertical and Zonation/horizontal stratification:**

Stratification refers to the division of a community population into distinct groups based on certain characteristics, such as age, gender, income, education level, occupation, and race or ethnicity. These groups or strata often have different levels of access to resources and opportunities, which can lead to disparities in health outcomes, education, and economic status. Stratification can occur naturally within a community as people tend to associate with others who share similar characteristics. However, it can also be perpetuated by social structures and policies that reinforce existing inequalities. For example, discrimination in housing or employment can limit opportunities for certain groups, perpetuating their disadvantage.

3.3.2. Ecotone:

An ecotone is a transition zone, where two or more different ecosystems meet and interact each other Ecotones are characterized by a mixture of species from adjacent ecosystems and often support a unique community of plants and animals. Here are some examples of ecotone such as, Wetland-Forest ecotone, Grassland-Forest ecotone, Mountain-Forest ecotone and Coastal-Marine ecotone. In Coastal-Marine ecotone the boundary between a coastal habitat and the marine environment is an ecotone that can support a unique community of plants and animals. For example, mangrove forests and salt marshes are coastal habitats that transition to the marine environment, supporting to species adapted to both land and water. Thus we can say that the ecotones play an important role in maintaining biodiversity and promoting ecological resilience, as they provide a buffer zone where species can adapt to changing environmental conditions.

3.3.3. Species diversity:

Species diversity refers to the variety and abundance of different species in a given area or ecosystem. It can be measured by the number of species present, their relative abundance, and their distribution within the ecosystem. Different creatures, including plants, animals, bacteria, and others, constitute each community. They are also taxonomically distinct from one another. The species diversity could be local or regional.

3.3.4. Species abundance:

Species abundance refers to the number of individuals of a particular species present in a given area or ecosystem. Abundance can be measured in a variety of ways, such as the total number of individuals, the density of individuals per unit area or the biomass of individuals. Species abundance is an important factor in determining the structure and function of ecosystems, as it can impact the distribution and interactions between different species. In general, species with high abundance are more likely to have a greater impact in on the ecosystem than species with low abundance. For example, in a forest ecosystem, the abundance of different tree species can impact the composition of the forest understory and the abundance of other organisms such as birds and insects. Species with high abundance may provide important resources, such as food or habitat for other organisms, while species with low abundance may be more vulnerable to extinction or may have less impact on the ecosystem. Measuring species abundance is an important tool for monitoring changes in biodiversity over time, as changes in the abundance of particular species can provide insights into broader ecological trends. For example, declines in the abundance of certain species may indicate the presence of environmental stresses or other threats to an ecosystem health. Overall, understanding species abundance is important for understanding the structure and function of an ecosystems as well as for identifying and addressing threats to biodiversity and ecosystem health.

3.3.5. Ecological dominance:

Ecological dominance refers to the ability of a particular species or group of species to exert a significant influence on the structure and function of an ecosystem. This influence can be positive or negative and can occur through a variety of mechanisms, such as predation, competition, or habitat modification. Ecological dominants can be keystone species, which have a disproportionate impact on the ecosystem relative to their abundance or they can be simply highly abundant or widely distributed species. Dominants can be plants, animals, or even microorganisms, and they can operate at different trophic levels within the ecosystem. The concept of ecological dominance is important because it helps us to understand how ecosystems function and how they respond to environmental change. By identifying the species that are ecological dominants, we can better predict how changes in their populations or behavior will affect the rest of the ecosystem. Elephants are ecological dominants in the African savanna ecosystem. They are important seed dispersers, clearing large areas of vegetation and allowing new growth to occur. They also create pathways through dense vegetation that other animals can use. Humans are ecological dominants on a global scale. Through our use of technology and our ability to modify the environment, we have significantly altered ecosystems around the world. We have also caused the extinction of many species and caused significant changes to the global climate.

3.3.6. Diurnal and seasonal variations:

Durational and seasonal variations are two types of variation in linguistic studies that are used to describe the way language changes over time and across different contexts. Durational variation refers to variation in the length of speech sounds or syllables, and can be affected by factors such as stress, intonation, and speaking rate. For example, in English, the duration of the vowel sound in the word "beat" may be longer or shorter depending on the context in which it appears (e.g. "beat" vs. "beating"). Sessional variation, on the other hand, refers to variation in language use that occurs in different contexts or situations. This can include variation in word choice, sentence structure, and communicative style, among other factors. For example, a person may use different vocabulary or speaking style when communicating with friends versus when speaking in a formal business setting.

3.3.7. Pattern Diversity:

Pattern diversity refers to the variety of different patterns or arrangements that can be observed in a given system or ecosystem. Here are some examples of pattern diversity: Vegetation Patterns: In many ecosystems, such as grasslands or forests, vegetation patterns can vary depending on factors such as soil type, moisture levels, and grazing pressure. For example, in the African savanna, vegetation patterns can range from open grasslands to densely packed clusters of trees, creating a diverse array of habitats for different animal species. Pattern diversity is important for understanding the complexity and diversity of natural systems, and can provide valuable insights into the processes that shape and influence the world around us.

3.3.8. Periodicity:

Periodicity in ecology refers to the regular occurrence of natural events or phenomena at fixed intervals of time, such as daily, seasonal, or annual cycles. Here are some examples of periodicity in ecology:

- **Seasonal Migration:** Many animal species exhibit seasonal migration patterns, where they travel to different habitats in response to changes in temperature, food availability, or breeding cycles. For example, some bird species migrate to warmer climates during the winter months, while others migrate to breeding grounds during the summer.
- **Plant Phenology:** Plant species also exhibit seasonal cycles, with changes in growth, reproduction, and dormancy occurring at regular intervals throughout the year. For example, deciduous trees in temperate climates lose their leaves, enter in dormancy during the winter and then begin new growth in the spring.
- **Annual Cycles:** Some natural phenomena occur on an annual cycle such as the blooming of certain flowers or the emergence of certain insect species. These cycles can be influenced by factors such as temperature, precipitation and photoperiod (the duration of day light lenth).

3.3.9. Turnover:

The turnover refers to the rate at which species or individuals are replaced in a given ecosystem over time. Here are some examples of turnover in ecology are succession, invasion, climate Change, disturbances etc. The understanding turnover in ecology is important for understanding the dynamics of an ecosystems over time and for predicting how ecosystems may respond to environmental change or disturbances.

3.3.10. Interdependence k:

Independent K is a theoretical concept in ecology that refers to the carrying capacity of a population within an ecosystem, assuming that the carrying capacity is not influenced by the population density of any other species in the ecosystem. Independent K is a useful concept in ecology for understanding the factors that limit population growth and the carrying capacity of ecosystems, but it is important to recognize that in most cases, interactions between species and external factors will influence the carrying capacity of populations and ecosystems. The examples of independent K in ecology are

- **Island Populations:** In some cases, isolated populations on islands or other habitats may experience independent K, as their carrying capacity is not influenced by other species in the surrounding ecosystem. For example, a population of birds on a small island may reach a carrying capacity determined by the resources available on the island, rather than being limited by interactions with other species on the mainland.

- **Lab Populations**: In laboratory experiments, researchers may artificially create conditions of independent K by controlling the resources available to a population of organisms. For example, a population of bacteria grown in a petri dish may reach a carrying capacity determined by the amount of nutrients available in the dish rather than being influenced by other species or external factors.
- **Invasive Species**: Invasive species that are introduced to a new ecosystem may initially experience independent K, as they are not limited by the density of other species in the ecosystem. However, as they become established and interact with other species, their carrying capacity may be influenced by these interactions.
- **Single-Species Ecosystems:** In some cases, ecosystems may be dominated by a single species, such as a field of grass or a forest of trees. In these cases, the carrying capacity of the ecosystem may be largely determined by the resources available to that species, rather than being influenced by the density of other species.

3.3.11. Tropic level:

A trophic level refers to the position of a species within a food chain or food web, based on its feeding relationships with other species. The understanding trophic levels is important for understanding the flow of energy and nutrients within an ecosystems, and how changes in one part of the food chain can impact other parts of the ecosystem. The examples of trophic levels in an ecosystem are primary producers, primary consumers, secondary consumers, tertiary consumers and decomposers etc.

3.3.12. Succession sequence:

Ecological succession is the process by which a community of organisms gradually changes over time following a disturbance or the colonization of a new habitat. Here are some examples of succession sequences in ecology.

3.4. Ecological succession

Ecological succession or ecosystem development involves the changes in the structure and function of a particular community over time. Succession may also be described as the gradual change which occurs in vegetation of a given area of the earth's surface on which one population succeed the other over a period of time. It can also be defined as a continuous, unidirectional and sequential changes in the species composition of the natural community.

Seasonal changes are not usually included in the definition of succession e.g. variation in the grassland vegetation with season. Ecological succession is a normal natural process. Long term changes of thousands or millions of years which include climate change or evolutionary change are usually not included in the definition of succession. It is a fundamental concept in ecology and refers to orderly and predictable changes in the community structure and function with time. The process of change continues until a stable community is reached which not only establishes itself in the given area, but also keeps on increasing in number by reproduction. All these changes are very orderly and predictable with time, the overall process is named as ecological succession. Thus, Ecological Succession may be defined as "the orderly changes in community structure and function in an ecosystem with time mediated through the modifications in physical environment ultimately leading to a stable community over that area." Cowles (1899), Clements (1905, 1916) and many other early twentieth century botanists made significant contributions to establish the concept of succession.

Clements (1916) while studying plant communities defined succession as "the natural process by which the same locality becomes successively colonized by different groups or communities of plants."

3.4.1. Causes of Succession:

A succession always starts on a bare area which may be sand, clay-gravel, rock and water. The causes like physiographic processes, climatic factors and biotic agents are responsible for plant succession.

A number of causes induce together the process of succession which are as follows:

1. Physiographic processes:

It mostly occurs in primary bare areas as-

(a) Erosion- by water, wind, gravity or glaciers.

(b) Deposition- by water, wind, gravity, glaciers, volcanoes.

(c) Ecesis- The soil condition is also changing by the process of invasion, migration, competition and reaction of the population.

2. Climatic factors: It includes temperature, rainfall, light intensity, gaseous composition, wind etc. The climatic factors mostly produce secondry bare are:

(a) Wind- It eliminates the previous vegetation.

(b) Drought- It results in drying and killing of weaker species.

(c) Snow- It kills the previous vegetation.

(d) Lightning- It causes fire in the forest.

3. **Biotic agents:** Producing mostly secondary bare areas :

(a) **Man -** Destroying natural vegetation.

(b) **Animals-** By overgrazing.

(c) **Bacteria, Fungi, Insects-** Eliminates species by disease or grazing.

4. **Stabilizing Causes:** Succession is taking place in order to attain the climax stage. Wind, water, glacier etc. brought soil erosion resulting in open bare land where plant succession can take place.

High velocity winds uproot trees and sometimes destroy even climax vegetation. This causes a fresh succession of plant communities. Similarly drought, snow and fire results in open bare land for plant succession.

In a community, there is competition amongst different members for their existence. In such a process, some of the members are not found suitable and thus are gradually replaced by new one.

3.4.2. Process of Succession:

The succession involves successive colonization of a bare area by different plant communities in course of time. The process of succession is completed through the following sequential steps:

1. Nudation
2. Invasion
3. Competition and Coactions.
4. Reaction
5. Stabilization (Climax)

1 **Nudation -** This is the development of bare area without any life form. Volcanic eruption, landslide, flooding, erosion, fire, disease etc. destroy the present life completely and make the area bare. The succession starts in the bare area.

2 **Invasion-** It is arrival of propagules of various organisms and their establishment in the new area. Invasion includes the following three steps.

i. **Migration-** Seeds, propagules and spores of the different species are brought to new area by the agency of air, water and animals. This is called migration.

ii. **Ecesis (Establishment) -** The successful establishment of species in the new area is known as Ecesis. After migration the seed or propagules germinate, grow into seedlings and adults and start to reproduce.

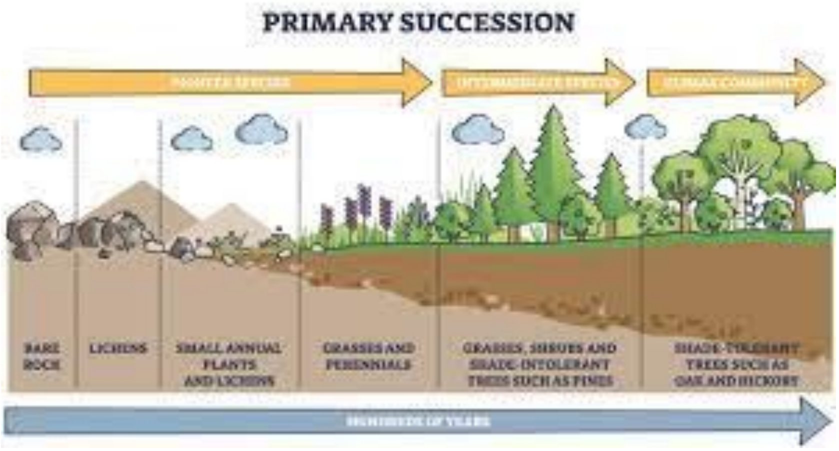
iii. **Aggregation-** It includes multiplication and aggregation of organism in a large population in the area.

3. **Competition and Co-action-** The aggregation of individuals in an area leads to interspecific and intraspecific competition. The competition is for water, nutrients, heat, light, CO_2, O_2 and space. The intraspecific competition is more acute than interspecific competition because the needs of the individuals of the same species are very much similar. Individuals of a species affect each other's life in various ways and this is called co-action.
4. **Reaction-** The interaction and reaction among plant species as well as between habitat changes the soil, water, temperature, light, etc. of the environment. As a result the environment is modified and less suited for the existing community which sooner or later is replaced by another community (Seral community). The whole sequence of communities that replaces on another in the given area is called a **Sere** and different communities constituting the sere are called seral communities.
5. **Stabilization (Climax)-** At last a final or terminal community is established. These are stabilized for a longer period of time and maintain equilibrium with the environment of that particular area. This final community is not replaced and is known as climax community and the stage as climax stage.

3.4.3. Types of Succession

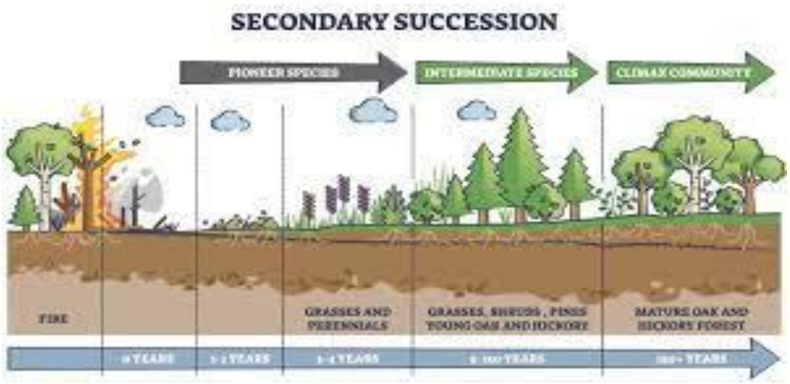
Some basic types of succession are as follows:-

1. **Primary Succession: -** This types of succession being in a sterile area or barren land or in an inorganic environment when a bare or nude area is colonized by organisms for the first time and subsequently the communities are changed in a succession form. The process is known as primary succession.



2. **Secondary Succession-** The community development on area previously occupied by another well developed living community amidst the interruption due to adverse

conditions like natural calamities, biotic intervention, etc, is designated as secondary succession. The natural calamities include forest fire, disease, flood, grazing, etc.



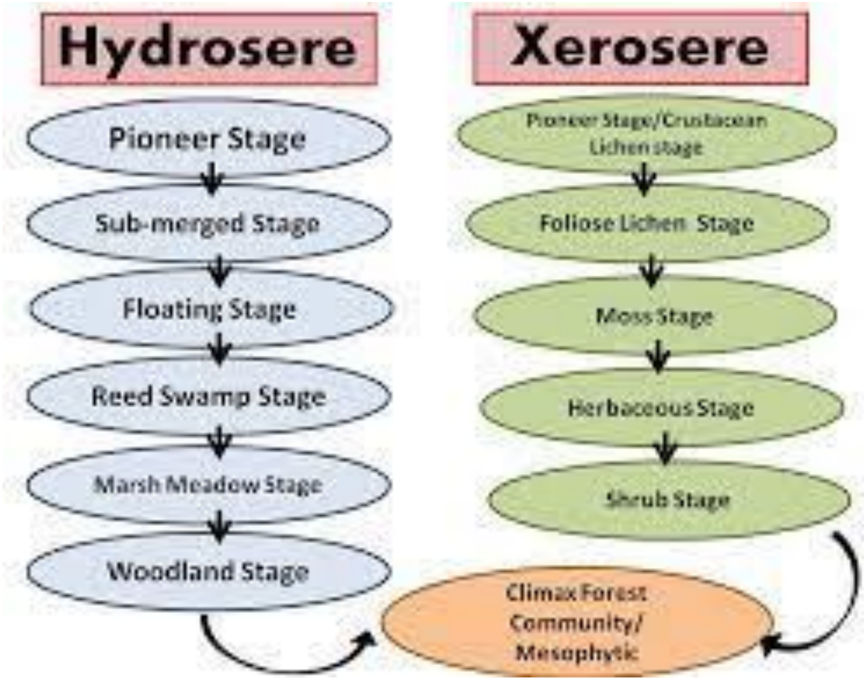
3. **Autotrophic Succession-** When the population of autotrophs (green plants) dominates the population of heterotrophs, the succession caused is known as autotrophic succession.
4. **Heterotrophic Succession -** It is characterized by early dominance of heterotrophs like bacteria, fungi and some animals in an organic environment. Since the environment is dominated by heterotrophs, the succession is called heterotrophic succession.
5. **Autogenic Succession-** Due to continuous interaction of community with environment, there happens a modification of environment causes the replacement of an old community by a new one, which is knows as autogenic succession.
6. **Allogenic Succession-** When the replacement of a community is caused by any other external condition and not by the existing organisms, the course of succession is known as allogenic succession.
7. **Habitat Succession-** Succession is also named differently, on the basis of types of habitat from which the phasic replacement starts.

a) **Hydrosere-** The succession starting from aquatic habitat is known as "Hydrach" and the series of changes occuring in the vegetation of hydrarch are called Hydrosere.

b) **Mesarch-** The succession starting from a habitat where adequate moisture condition are present.

c) **Halosere-** The succession occuring at saline water or soil is known as holosere.

d) **Xerosere-** Succession taking place in xeric habitat like sand or rocks where moisture is present at minimal amount is known as xerosere.



3.4.3.1.Hydrosere- Succession in water

Hydrosere may be studied in a freshly built deep reservoir or any other new water body which has very little or no nutrient in the substratum below the water and water itself does not contain any nutrients. Algal spores are brought by wind along with the soil particles and deposited on the water. Thus Unicellular and colonial phytoplankton invades first in the hydrosere. There are about six stages in this sere.

a. **Phytoplankton stage-** In the initial stage, blue green algae, green algae (*Spirogyra, Oedogonium*) are the pioneer colonizers. If traces of phosphorous is present blooms of blue green algae appears. These are consumed by zooplankton (*Amoeba, Euglena, Paramecium* etc) and fish (sun fish, blue gillfish etc). Gradually these organism dies and increases the content of dead organic matter in the pond.

b. **Rooted submerged stage -** The above algae added large quantities of organic matter and nutrient in the pond. Thus the pond becomes lined with soft mud which is a suitable substratum for the growth of rooted submerged plants. The plants like *Hydrilla, Utricularia, Vallisneria* etc. appear there. The seeds of these plants are brought by birds and animals which frequently visit the water bodies. When these plants die they decomposed partly due to lack of oxygen. Their remains are, therefore, deposited at the bottom. The eroded soil particles brought by streams etc. are deposited within this dead mass of vegetation. All this results in building up of the substratum and shallowing of the water. Now the pond becomes unfavourable for the growth and development of these submerged species. The reduced depth of water and rich substratum favours colonisation of floating plants.

c. **Floating stage (Rooted and free-floating)-** When the water depth is about 2-8 feet, the rooted floating plants such as *Nymphaea, Ranunclulus, Trapa* etc. grow there. In a year or two, they increase in number and gradually spread over wide areas. Many free floating species like *Pistia, Azolla, Lemna, Wolffia, Eicchornia* etc also grow there. These plants cover the whole surface of water body due to which light does not reach to the submerged plants present deep in water. As a result submerged plant die. These plants accelerate the loss of water through transpiration. Due to all above, the water becomes shallow and rich in organic nutrients. In a few years, the rapid soil building process reduces the water depth to such an extent that it becomes too shallow for the survival of the floating species. The floating species migrate inwards, giving way to the swamp plants.

d. **Reed swamp stage (Amphibious stage)-** In shallow water (upto 2 feet depth), the plants like *Typha, Pontederia, Sagittaria, Carex, Mariscus*, etc. grow. These plants are slightly submerged and rooted by large much branched rhizomes. The vegetation is very dense therefore, it helps in accumulating sedimentary materials and plant remains. The water depth is further decreased due to which habitat becomes unfavourable for the growth of most of these species.

e. **Sedge-meadow stage (Marginal mats)-** The filling process finally results in a marshy soil which may be too dry for the plants of preexisting community. The plants of the sedge-meadow stage, therefore, gradually disappear and make way for a mesophytic vegetation depending upon the nature of the climate. In dry climates. The next stage may be grassland or some other xeric climax, but in moister climate it is woodland.

f. **Woodland stage-** Species of shrubs eg. *Slaix, Cephalanthus, Cornus* etc. and woody plants eg. *Alnus, Populus* etc grow in this stage. These plants can tolerate waterlogged conditions. Large amount of humus, bacteria, fungi and organism accumulate in the soil which favours entry of many other trees in the vegetation leading to the climax stage.

g. **Climax forests -** The nature of the climax depends upon the climate of the region. In tropical region dense rain forest develops due to high rainfall. Whereas, in the temperate region, mixed forest develops and in the region of moderate rainfall, deciduous forest develops as climax. (Fig. 3.2)

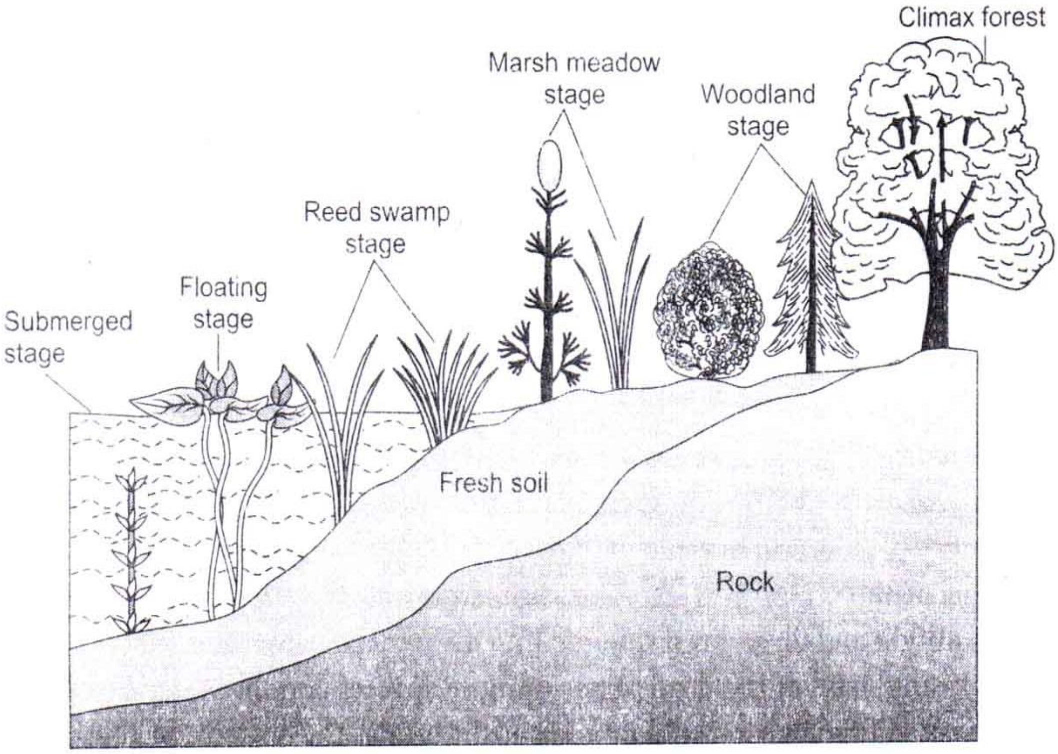


Fig. 3.2 Stage in Hydrosere

3.4.3.2. Xerosere- Succession on Land

The succession occur in dry condition is called xerosere (xerarch). A typical xerosere starts on rocks which are dry and hard. The soil is absent in the extremes of temperature, crustose lichens are supposed to be the pioneer plants, to initiate succession on the bare rocks. The xerosere undergoes following stages.

1 **Crustose Lichen stage-** The rocks have most adverse conditions for the growth of plants. In this, hopless situation crustose lichens (*Rhizocarpon, Lecidia, Rhinodina, Lecanora*) appear as pioneer species. These lichens can live in such extreme conditions. The carbonic acid produced by the metabolic activities of lichen, help to corrode and decompose the rock, supplementing the other forces of weathering. The dead remains of the lichens get mixed up with the rock particles. This soil formation facilitates support the growth of other types of vegetation.

2 **Foliose Lichen-** Now this habitat is suitable for foliose lichens. The foliose lichens are leaf like and remain attached to the rocks by rhizome (fungal filaments without vascular capabilities like plant roots). Their examples are *Parmelia* and *Dermaticarpo*. These lichens have large leaf like thalli, which overlap the crustose lichens. As a results, the

growth of crustose lichen is reduced or decreased. Acids are recreated by living and decaying plants. The weathering of rocks and addition of humus to it, results in the formation of thin layer of soil above the surface of rocks. Thus the habitat becomes changed.

3 **Moss Stage-** The accumulation of soil in the rock crevices favours the growth of xerophytic mosses, e.g. *Polytrichum, Tortula* etc. The mosses compete with lichens for water. They penetrate much deeper in the soil as compared to the lichens. The lichens become dead. Thus more humus is added to the soil. Minerals combine with this humus. Now this environment is suitable for herbaceous plants.

4 **Herbaceous Stage-** Now the soil has large amount of humus and litter with increased water holding capacity. Therefore, herbaceous plants like *Poa, Adiantum, Tridex,* etc. established there. These plants increase the process of weathering. Evaporation or transpiration takes place. It reduces the temperature. The bacteria, fungi and other organisms increase in the soil. This changed habitat do not favour the survival of mosses, therefore, they die and disappear.

5 **Shrub stage-** Now the soil conditions are favourable for shrubs therefore, they start growing. The shrubs become dense and cast shadow on the herbs, so there herbs die. The roots of shrubs penetrate into soil and process of soil formation continues.

6 **Climax stage-** The much improved soil allows the growth and establishment of woody plants which are densely rooted. These plants inhibit the growth of most of plants and dominate. It is a stable stage in succession. Thus the woody forest is the climax stage in a xerosere. (Fig. 3.3)

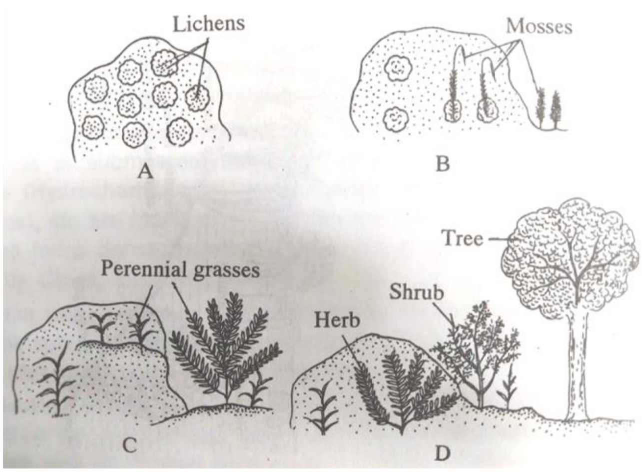


Fig. 3.3 Stages in xerosere

3.5. Monoclimax Theory

This theory explains that similar type of community is present at climax stage in the given land area. In other words, succession begins in diverse areas like pond, rock and river will finally converge into a same single climax community decided by their regional climate. The stable climate leads to a stable climax community which remains stable indefinitely. But, this theory was not accepted by all ecologists. Cowles explained that the succession process cannot reach the equilibrium state. In fact, it is a variable approach rather than a constant approach. However, Cooper considered climax as minimum changing state rather than finally changed state of succession. The climax community in the same climate may differ as it depends upon primary stage along with its habitat characteristic. It may be possible that in same climatic condition, a lithosere and hydrosere may have different pioneer community and after several intermediate. Seral stages finally reach to same climax community. It may also be possible that similar pioneer and seral communities would lead to different climax communities. In various conditions under uniform climate, different climax community can be formed. It occurs due to different soil, topography and other factors. So, climate is not solely responsible for determining the fate of climax. The monoclimax theory of ecological succession suggests that there is a predictable sequence of steps or stages that a given ecosystem goes through as it progresses towards a stable climax community.

Pioneer stage: The first stage of succession is the pioneer stage, which begins with the colonization on bare or disturbed ground by a few hardy plant species. These plants are typically well-adapted to harsh conditions such as drought, high temperatures and poor soil quality. Examples of pioneer species include lichens, mosses and grasses.

Intermediate stage: As the pioneer species begin to establish themselves and grow, they change the environment in ways that make it more favorable for other plant species. Over time, a wider variety of plant species will begin to colonize the area, leading to an intermediate stage of succession. This stage is characterized by increasing biodiversity and the emergence of a more complex community of plant and animal species.

Climax stage: The climax stage is the final stage of succession, in which the community of plant and animal species reaches a stable, self-sustaining state. The climax community is typically dominated by one or a few species of plants, which are well-adapted to the local climate and soil conditions. In the monoclimax theory, the climax community is seen as the end point of succession, with little or no further change expected to occur.

Human-induced disturbance: While not part of the original monoclimax theory, it is now widely recognized that human-induced disturbances such as logging, agricultural practice, industrialization, or urban development can disrupt or reverse the natural succession process. Human activities can create conditions that favor different plant species, prevent the establishment of climax communities and even cause ecosystems to shift to entirely new states that may not have existed before. It's important to note that while the monoclimax theory has been a useful framework for understanding ecological succession, it is now recognized that the process of succession is much more complex and dynamic than previously through.

3.6. Polyclimax theory

According to Tansley (1939), climax is not controlled by a single factor but by several other factors. Various climax communities can be expected in the area which is under the control of different abiotic component such as moisture, soil, temperature and activities of different biotic factors. He also recognized that the existence of a number of climax communities, forming a mosaic correspond to the mosaic of habitat. Climate is only one factor of the several other factors, any of which can control the structure and the stability of climax. Tansley recognized following types of climax.

1. **Climatic climax:** It occurs under normal climatic conditions, soil and topography.
2. **Edaphic climax:** Self-perpetuating vegetation which differs from climatic climax of the area.
3. **Topographic climax:** Variation in topography of the area cause variation in microclimates and each variation causes self-perpetuating vegetation.
4. **Fire climax:** Frequent burning of vegetation causes elimination of those species which are fire sensitive and there is development of self perpetuating vegetation.
5. **Zootic climax**: it is a self perpetuating community which develops due to various zoological factors such as grazing by herbivores.

Polyclimax theory is a hypothesis that suggests that a given ecosystem can exist in multiple states of equilibrium, each with its own dominant plant community or climax stable community. This is in contrast to the traditional concept of a single climax community for each ecosystem. The polyclimax theory of ecological succession suggests that there are multiple possible end points or climax communities that a given ecosystem can reach, depending on a range of biotic and abiotic factors. Unlike the monoclimax theory, the polyclimax theory recognizes that there is no single, predetermined endpoint for ecological succession. The steps involved in the polyclimax theory are:

Initial colonization: The first step of succession is the colonization on bare or disturbed ground by a few hardy plant species. These pioneer species are typically well-adapted to harsh conditions and are able to establish themselves in such environment.

Multiple climax stages: As the community of plant species becomes more diverse and complex, multiple stable endpoints or climax communities may emerge. Each climax community may be dominated by a different set of plant species that are well-adapted to the local environmental conditions. For example, in a forest ecosystem, one climax community may be dominated by coniferous trees, while in another, may be dominated by deciduous trees.

Disturbance and change: The stability of each climax community is not fixed and may be disrupted by disturbances, such as, fire, flooding, or human activities. These disturbances can create opportunities for new species to establish themselves and may lead to shifts in the dominant plant community. As a result, the ecosystem may transition to a new intermediate stage or a different climax community.

Overall, the polyclimax theory emphasizes the complexity and dynamic nature of ecological succession. It recognizes that ecosystems are constantly changing and adapting to new conditions, and that multiple stable endpoints or climax community may exist in given.

3.7. Ecological Niche

An ecological niche refers to the specific role or position that an organism occupies within an ecosystem, including its interactions with both biotic and abiotic factors. It is defined as the role or function of species it plays in its ecosystem. George Evelyn Hutchinson developed seminal concepts about ecological niches and their relation with areas of distribution of a species. Niche concepts of Hutchinson and Grinnell focus on the response of organism to biotic and biotic factors. This niche is defined by sets of zero-growth isoclines in resource space together with impact vectors and resource supply points. The examples of ecological niche are such as a predator is an organism that preys upon other organisms for food. Examples include lions, eagles, and sharks. An herbivore is an organism that eats plants. Examples include cows, rabbits, and deer. A decomposer is an organism that breaks down dead organic matter and recycles it back into the ecosystem. Examples include bacteria and fungi. A parasite is an organism that lives on or inside another living organism and feeds upon it. Examples include ticks, fleas, and tapeworms. A nectar feeder is an organism that feeds on the nectar produced by flowers. Examples include bees, hummingbirds and butterflies. A scavenger is an organism that feeds on dead animals. Examples include vultures, hyenas, and raccoons. An omnivore is an organism that eats both plants and animals. Examples include humans, bears, and raccoons, etc.

3.8. Habitat

A habitat is the natural environment where a particular plant or animal species lives and grows. A habitat can be defined as a place where an organism can find all the resources it needs to survive, including food, water, shelter, and suitable conditions for reproduction. Habitats can be very diverse, ranging from aquatic environments such as oceans, rivers, and ponds, to terrestrial environments such as forests, grasslands, and deserts, such as, African Sahara desert, Asia's Gobi desert, Sonoran desert and Victoria desert etc. They can also be artificially created, such as agricultural fields or urban areas. Habitats can be classified into different types based on their characteristics, such as aquatic habitats (e.g., oceans, rivers, lakes), terrestrial habitats (e.g., forests, grasslands, deserts) and even artificial habitats (e.g., urban areas, agricultural fields, human-made structures). Each habitat has unique features that support specific living organisms and influence their behavior and interactions with other species. For example, a coral reef provides shelter and food for a variety of marine animals, while a forest provides trees for nesting, nuts and fruits for food, and shade for protection from the sun. Understanding the characteristics of different habitats, is important for conservation efforts, as changes in habitats can affect the survival and well-being of the species living within them.

3.9. Competitive exclusion principle

The competitive exclusion principle is a theory in ecology that states that two species competing for the same resources cannot coexist indefinitely in the same habitat if other factors remain constant. This principle is also known as Gause's law of competitive exclusion, named after the Russian biologist Georgy Gause who first formulated it in the 1930s. According to the competitive exclusion principle, if two species have similar ecological requirements and compete for the same resources, one species will eventually outcompete the other, leading to the extinction or local extinction of the weaker competitor. The stronger competitor will continue to occupy the habitat and utilize the resources until a new competitor arrives or environmental factors change, altering the competitive landscape. The competitive exclusion principle is not always applicable in nature, as other factors such as predation; mutualism and habitat heterogeneity can also influence the coexistence of species in a habitat. Two species of bird, the barnacle goose and the brent goose, feed on eelgrass in coastal wetlands. However, the barnacle goose feeds more efficiently on the eelgrass, leading to a competitive advantage over the brent goose. As a result, the brent goose has been excluded from many eelgrass habitats. In the Caribbean, several species of anole lizards live on the same trees and compete for insects as a food source. An experiment showed that when one species was introduced to a tree where another species was already present, the second species was excluded from the tree within a few weeks.

3.10. Ecological hierarchy

Ecological hierarchy refers to the levels of organization in ecology, ranging from individual organisms to the biosphere. Each level is characterized by different scales of size, complexity and interactions among organisms and their environment.

Individual: This is the lowest level of ecological hierarchy, referring to an individual organism of a particular species.

Population: A population is a group of individuals of the same species that live in the same area and can interbreed.

Community: A community refers to all the populations of different species that live and interact in the same area.

Ecosystem: An ecosystem is a community of living organisms and their physical environment

Biome: A biome is a large geographic area characterized by its climate, vegetation, and animal life.

Biosphere: The biosphere is the highest level of ecological hierarchy, referring to the sum of all the planet's ecosystems, including the atmosphere, hydrosphere, and lithosphere.

Each level of ecological hierarchy is interconnected and influences the others. For example, changes in the individual behavior of a predator can impact the population size of its prey, which in turn affects the community and ecosystem levels. Understanding the different levels of ecological hierarchy is crucial for understanding the complex relationships, and interactions between organisms and their environment.

3.11. Summary

Community ecology is the study of the interactions between different species in a given area or ecosystem. It examines how species coexist, compete and interact with each other, and how they respond to changes in their environment. There are several important concepts in community ecology, including species diversity, trophic levels and ecological succession. Species diversity refers to the number and variety of species in a given community, and can have important implications for ecosystem function and stability. Trophic levels refer to the position of a species in a food chain or food web, based on its feeding relationships with other species. Ecological succession is the process by which a community of organisms gradually changes over time following a disturbance or colonization of a new habitat. Other important concepts in community ecology, include niche differentiation, competition, predation and mutualism. Niche differentiation refers to the process by which species evolve different traits and behaviors to avoid competition for resources. Competition occurs when two or more species require the same resources and must compete for them. Predation is the process by which one species kills and eats another, while mutualism is a form of interaction in which both species benefited.

3.12. Terminal Questions

Q.1: Describe the concept and characteristic of community

Answer:---

Q.2: Process of ecological succession and its types.

Answer:---

Q.3: Discuss the Causes and process of Succession

Answer:---

Q.4: Describe succession on land succession.

Answer:---

Q.5: Explain monoclimax and polyclimax theory of climax.

Answer:---

3.13. Further suggested readings

1. Environmental Science, Subhas Chandra Santra, new central book agency, 3rd Edition, 2011
2. A text Book of Environment Studies, Asthana, D. K. and Asthana, M. 2006, S. Chand & Co
3. Atmosphere, Weather and Climate, Barry, R. G. 2003, Routledge Press, UK.
4. Ecology: Theories and Applications (4th Edition) by Peter Stiling; Prentice Hall.
5. Biodiversity: a beginner's guide, john I. spicer, one world Publications.

Block-2

PGEVS-101N

Rajarshi Tandon Open University, Prayagraj

Ecosystem And Biodiversity Conservation

Block- 2

Fundaments of Biodiversity

UNIT -4

Introduction to Biodiversity

UNIT-5

Extinction of Species

UNIT-6

Values of Biodiversity

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Ecosystem And Biodiversity Conservation

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Introduction

This second block of ecology and biodiversity conservation, this consists of following three units:

Unit-4: this unit covers the concept of biodiversity, types of biodiversity, measuring biodiversity, biodiversity hotspots,

hotspots in India, loss of biodiversity, factors affecting biodiversity; key stone species and species richness etc.

Unit-5: This unit describes the concept of extinction, types of extinctions, processes responsible for species extinction, current and future extinction rates, IUCN categories of threatened species, red book data, list of threatened flora and fauna in India, endangered and endemic species of India.

Unit-6: This unit covers the different types of value of biodiversity, in addition the anthropocentrism, biocentrism, egocentrism and religions, intellectual value also discussed

Unit-4: Introduction to Biodiversity

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4.1. Introduction

Biodiversity or biological diversity is the variety and variability of life on the earth. Biodiversity is a measure of variation at the genetics (genetic variability), species (species diversity), and ecosystem (ecosystem diversity) level. It is not distributed evenly on earth; it is usually greater in the tropics as a result of the warm climate and high primary productivity in the region near the equator. Tropical forest ecosystems cover less than 10% of earth's surface and contain about 90% of the world's species. Marine biodiversity is usually higher along coasts in the Western Pacific, where sea surface temperature is the highest, and in the mid-latitudinal band in all oceans. There are latitudinal gradients in species diversity. Biodiversity generally tends to cluster in hotspots, and has been increasing through time, but will be likely to slow in the future as a primary result of deforestation. It encompasses the evolutionary, ecological, and cultural processes that sustain life.

Objectives

- To introduce the concept of biodiversity.
- To discuss the different types of biodiversity
- To discuss various biodiversity hotspots and its significance
- To know about various importance of biodiversity.

4.2. Concept of Biodiversity

Biodiversity is all different kinds of life we will find in one area—the variety of animals, plants, fungi, and even microorganisms like bacteria that make up our natural world. Each of these species and organisms work together in ecosystems, like an intricate web, to maintain balance and they will support life. Biodiversity supports everything in nature that we need to survive: food, clean water, medicine, and shelter. But as humans put increasing pressure on the planet, using and consuming more resources than ever before, we risk upsetting the balance of ecosystems and losing biodiversity. Living Planet Report found an average 69% decline in global populations of mammals, fish, birds, reptiles, and amphibians since 1970.

Three-quarters of the land-based environment and roughly 66% of the ocean environment have been significantly altered. More than a third of the world's land surface and nearly 75% of freshwater resources are now devoted to crop or livestock production. Climate change worsens the impact of other stressors on nature and our well-being. Humans have overfished the oceans, cleared forests, polluted our water sources, and created a climate crisis. These actions are impacting biodiversity around the world, from the most remote locales to our own backyards. Biodiversity plays a critical role in sustaining human populations across the globe. Ecosystem degradation threatens our most basic necessity – a healthy environment to live and thrive in. This is especially true of biodiversity hotspots, which house some of the largest diversity of species in the world and provide important life-support services to the people who live in and around them.

In addition, biodiversity is embedded in human cultures and is fundamental for our understanding of the world. Biodiversity enriches our lives – it has economic, cultural, recreational, religious and aesthetic importance across the world. We have celebrated it in art, music and literature throughout history. More than 190 countries acknowledge its importance to human populations through a show of support for the Convention on Biological Society.

It is essential to increase the resilience of communities and reduce their vulnerability in the face of shocks such as climate change and natural disasters. Biodiversity loss destabilizes ecosystems that can regulate the climate and mitigation of floods. This leads to weakening of community resilience, and their ability to adapt and protect the health and safety of their children and animals, ancient soils and rocks. This field of study is important for anyone interested in past organisms because it provides the context for understanding the origin, extinction and adaptation of any particular organism.

Rapid environmental changes typically cause mass extinctions. The ongoing global biodiversity crisis not only involves biological extinctions, but also the loss of experience and the gradual fading of cultural knowledge and collective memory of species.[3] More than 99.9% of all species that ever lived on earth, amounting to over five billion species, are estimated to be extinct. Estimates on the number of earth's current species range from 10 million to 14 million, of which about 1.2 million have been documented and over 86% have not yet been described. The total amount of related DNA base pairs on Earth is estimated at 5.0 x 10^{37} and weighs 50 billion tone. In comparison, the total mass of the biosphere has been estimated to be as much as four trillion tons of carbon. In July 2016, scientists reported identifying a set of 355 genes from the last universal common ancestor (LUCA) of all organisms living on the earth.

Responsible factors which affect biodiversity

Forest biological diversity is a broad term that refers to all life forms found within forested areas and the ecological roles they perform. As such, forest biological diversity encompasses not just trees, but the multitude of plants, animals and microorganisms that inhabit forest areas and their associated genetic diversity. Forest biological diversity can be considered at different levels, including ecosystem, landscape, species, population and genetic. Complex interactions can occur within and between these levels. In biologically diverse forests, this complexity allows organisms to adapt to continually changing environmental conditions and to maintain ecosystem functions.

4.3. Types of biodiversity

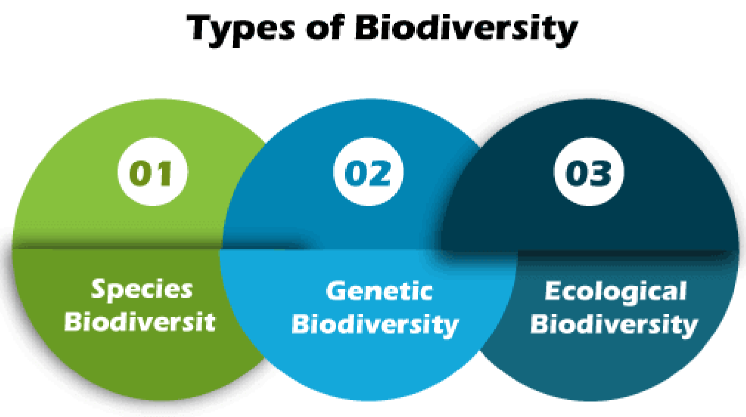
Biodiversity usually makes our planet beautiful, keeps the planet balanced, and helps it to function accordingly. In particular, biodiversity refers to the variability of life on the earth. As there are different types of biodiversity, perhaps the greatest value of biodiversity is yet unknown. Many of the earth's biodiversity is disappearing at an increasingly alarming rate, even before we know what is missing. However, scientists and researchers worldwide are working on finding the actual cause and eliminating or slowing down of the rate. Here, we are discussing the different types of biodiversity and their details.

Biodiversity, also called biological diversity, is one of the most complex and essential features of our planet (earth). It describes the richness and diversity of life on earth. It refers to the variability between plants, animals, and microorganism species. Life cannot exist without biodiversity. The biodiversity typically includes all terrestrial (land-dwelling), marine (aquatic), and many other ecosystems and ecological complexes. The term biodiversity was initially introduced in 1985. By definition, biodiversity refers to the variation among living organisms from distinct sources, including terrestrial, marine, and desert ecosystems and their ecological complexes. In other words, biodiversity can be defined as the total number of species of various animals, plants, fungi, and microbes living on earth or in different habitats.

Fig.1.1. Composition biodiversity

There are three essential types of biodiversity, which are listed below:

- ✓ Species Biodiversity
- ✓ Genetic Biodiversity
- ✓ Ecological Biodiversity



4.3.1. Species Diversity

The species' diversity refers to a group of similar organisms that typically mate to produce offspring. They commonly share the same lineage. The term "biodiversity" includes a wide range of living organisms found in all habitats, including terrestrial, marine, and other aquatic ecosystems as well as the ecological communities to which they belong. A common way to measure biodiversity is the number of species present in a specific area, be it a single tree, an ecosystem, a landscape or region, or the entire globe. However, the two primary components that can be used to measure biodiversity are species richness and species evenness. R.H Whittaker (1969) was the first person to measure biodiversity. Species diversity is the most basic classification unit and includes all species ranging from plants to various microorganisms. Additionally, two different individuals from the same species group are also not exactly similar; they have diversity. For instance, two other human beings are not the same. Apart from this, people situated in entirely different regions have a significant level of diversity.

As species diversity is seen in natural and agricultural ecosystems, the total numbers of different species of plants and animals located in an area form this type of diversity. It is believed that there are about 5-10 million species in the world, however, only 1.75 million of those species have been named scientifically so far on earth. Some areas have more species than others. Areas with more species diversity are generally referred to as 'hotspots' of diversity. The more species found within the area, the more biodiverse the area is called, making the more biodiverse ecosystem.

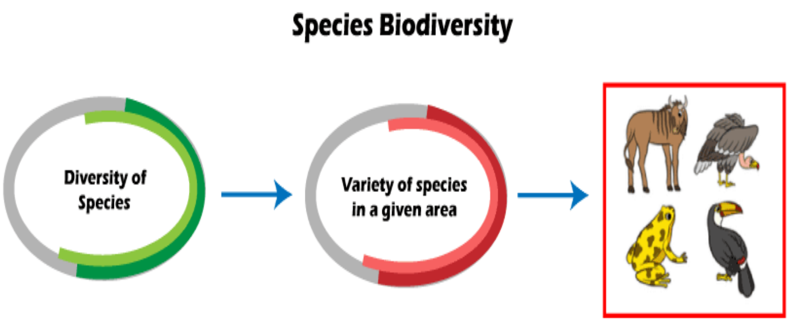


Fig.1.2: Species diversity

4.3.2. Genetic Diversity

It refers to differences between the genetic resources of organisms. Each individual of a particular species differs from the other in its genetic constitution. That is why every human is different from another. Similarly, the species of rice, wheat, maize, barley, etc., have different varieties. Each member of any animal or plant species differs widely from other individuals in its genetic makeup because many combinations of genes are possible that give specific characteristics to each individual. This genetic variability is essential for the healthy reproduction of a species.

Today, the diversity of nature is being exploited more by using wild relatives of crop plants to create new varieties of more productive crops and breed better domestic animals. Modern biotechnology manipulates genes to develop better types of drugs and a variety of industrial products. Although all species have come from a single or common ancestor, species diverge and produce new unique characteristics over time, thus contributing to biodiversity.

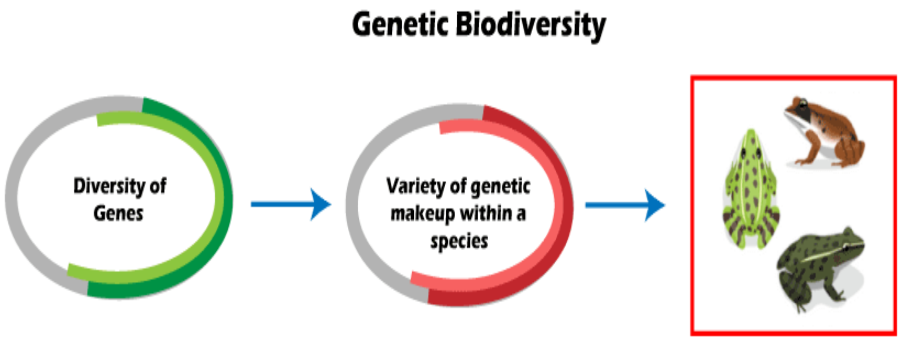


Fig.1.3: Genetic diversity

4.3.3. Ecological Diversity

Ecological diversity is the complex network of different species present in local ecosystems and the dynamic interactions. An ecosystem consists of organisms of many several species living in a region and their connections through the flow of energy, nutrients, and matter. Those relationships occur as organisms of different species interact with each other. The primary source of energy in almost every ecosystem is the Sun. The radiant energy of the Sun is converted into chemical energy by plants. This energy flows from those systems when animals eat plants and are then consumed by other animals in return. Fungi get energy by decomposing organisms, which release nutrients back into the soil.

Thus, an ecosystem comprises living components (microbes, plants, animals, and fungi) and non-living components (climate and chemicals) connected by energy flow and interact with each other. Ecological biodiversity is associated with plant and animal species living together and connected by the food chain and food webs. Diversity in various ecosystems, such as deserts, rainforests, mangroves, etc., also includes ecological diversity. It is generally observed between different ecosystems in a region.

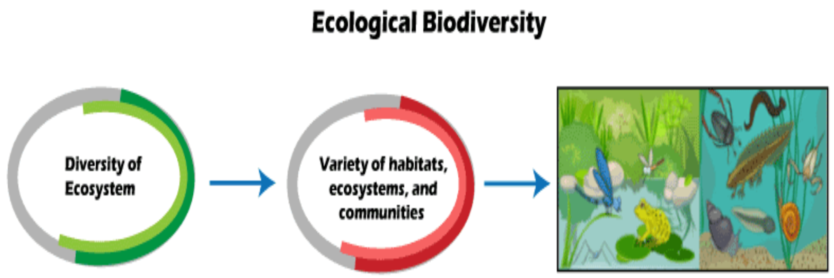


Fig.1.4: Ecological diversity

Ecological diversity has three major perspectives. The diversity of different species in a landscape is typically measured in three distinct scales. They are termed alpha diversity, beta diversity, and gamma diversity.

4.4. Importance of Biodiversity

Biodiversity is a crucial part of any ecosystem and plays a vital role in function of ecosystem and services. Different types of diversities help in maintaining the balance of nature. Therefore, biodiversity and its proper maintenance are so essential to sustain life on the earth. Some fundamental reasons that explain the importance of biodiversity are discussed below:

- **Ecological Stability**

Each species plays an essential role in an ecosystem. They typically capture and store the energy required for biological activities. Additionally, they produce and decompose organic materials in the ecosystem. The ecosystem includes many services necessary for humans to survive. Different species also have a relationship between the services provided by the ecosystem. Therefore, ecological stability results from a diverse, productive ecosystem and helps ecosystems withstand environmental stresses.

- **Economic Importance**

Biodiversity is a storehouse of resources to manufacture food, cosmetic products, pharmacies, and more. Some rich resources of foods include crops, livestock, fishery, and forests. Various wild plants (i.e., Cinchona, foxglove, etc.) are good sources of pharmacies and can be used for medicinal purposes. Additionally, most resources such as wood, fiber, lubricants, resins, resins, poisons, and others also derive from various plant species.

- **Ethical Importance**

Since all species have their roles in the ecosystem, everyone has the right to live. Human beings should not create problems for them and help them to survive. Human beings do not have the right to cause problems for the extinction of any species. Besides, biodiversity maintains the presence of different cultures and spiritual heritage and helps keep the balance between separate species. Thus, it is essential to conserve biodiversity.

4.5. Measures of Biodiversity

Conservation biologists have designed a variety of objective means to measure biodiversity empirically. Each measure of biodiversity relates to a particular use of the data. For practical conservationists, measurements should include a quantification of values that are commonly shared among locally affected organisms, including humans. For others, a more economically defensible definition should allow the ensuring of continued possibilities for both adaptation and future use by humans, assuring environmental sustainability. As a consequence, biologists argue that this measure is likely to be associated with the variety of genes. Since it cannot always be said which genes are more likely to prove beneficial, the best choice for conservation is to assure the persistence of as many genes as possible. For ecologists, this latter approach is sometimes considered too restrictive, as it prohibits ecological succession.

- Richness and evenness across species are two factors that make up the concept of biodiversity.
- Since a high biodiversity level is generally equated with ecological health, measuring biodiversity is extremely crucial.
- Diversity is generally seen to promote a community's stability, productivity, and resistance to invasion and other disturbances.
- As a result, measuring biodiversity is useful for assessing ecological stability.

Several metrics can be used to measure biodiversity, such as:

- the number of species or species richness;
- the extent of uniform/even distribution among species referred to as species evenness;
- the variation in the genetic make-up of organisms within a population or community referred to as genetic diversity;

- the characteristics or phenotypic differences within the community referred to as phenotypic variance;
- The population number is a measurement of the number of specific species within genetically distinct populations.

Species Richness

- The degree of diversity found within a specific ecological system is known as biodiversity.
- The total number of species found on earth is frequently used to quantify the biodiversity of the planet.
- Thus, the species richness of an ecosystem is taken into account as one of the most popular methods for estimating biodiversity.
- Species richness is the measurement of all the species that are present in a given area.
- The ecosystem will be more stable if there are more species since more species mean more species richness.
- Increased species diversity will eventually boost biodiversity, which is a crucial component of preserving biodiversity.

4.5.1. Alpha Diversity

- Alpha diversity is a metric for species diversity within a given ecosystem or geographic region.
- The number of species found in the area of concern is how alpha diversity is expressed.
- As a result, species richness in that particular ecosystem is provided by alpha diversity.
- Compared to beta and gamma diversity, alpha diversity is a small-scale indicator.

4.5.2. Beta Diversity

- When species diversity varies between groups or ecosystems, it is referred to as beta diversity.
- Therefore, beta diversity enables the comparison of ecosystem biodiversity.
- The number of species that are particular to each system is measured in beta diversity.

4.5.3. Gamma Diversity

- Gamma diversity is a measurement for assessing a large area's total biodiversity.

- As a result, it calculates the total diversity of all ecosystems in that area.
- The average species diversity in an ecosystem and the variation in species diversity between those habitats are the two factors that determine total diversity.
- Geographic-scale species diversity is one sort of gamma diversity.

4.6. Biodiversity in India

India is known as one of the most diverse countries worldwide. When it comes to the availability of different plant species, India is in ninth place amongst all countries' list. It is the origin of many important crop species, including cucumber, pigeon pea, sesame, eggplant, and cotton. Apart from this, India is one of the few nations producing a distinct range of domesticated species, including aromatic medicinal crops, legumes, cereals, and vegetables. Two out of twenty-five biodiversity hotspots of the world are also situated in India. India is also known for its equally diverse faunal wealth. The nation has about 91,000 distinct range of animal species. However, there is a steady depletion in diversity, and to control this, various programs on biodiversity conservation are being launched from time to time. It is crucial to conserve nature to obtain necessary resources for sustainable development and derive benefits for present and future generations.

It has been estimated that more than 50 million species of plants, animals and micro-organisms are existing in the world. Out of these, about 1.4 million species have been identified so far. Each species is adapted to live in specific environment, from mountain peaks to the depth of seas, from polar ice caps to tropical rain forests and deserts. All this diversity of life is confined to only about one kilometer thick layer of lithosphere hydrosphere and atmosphere which form biosphere. Though the study of environment and ecology is quite old, the term biodiversity has been introduced by Walter Rosen in 1986. Biological diversity or Biodiversity is defined as the variety and variability among the living organisms and the ecological complexes in which they occur. It refers to the variability's among species of plants, animals and microorganisms; ecosystems; ecosystem including terrestrial, aerial, marine and other aquatic system and ecological complexes of which they are part. In simpler terms, biodiversity is the assemblage of different life forms in given figure. (Fig.4.5).

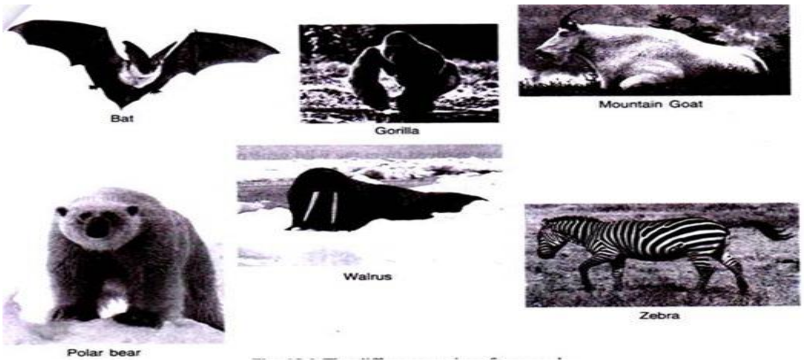


Fig.1.5: Different species

If reflects the number of different organisms and their relative frequencies in an ecological system. It includes the organization of organisms at many levels ranging from complete ecosystems to the chemical components that form the molecular basis of heredity. Thus, biodiversity is sum of all the genes, varieties, species, populations in different ecosystems and their relative abundance.

4.7. Biodiversity hotspots

A biodiversity hotspot is a biogeography region with significant levels of biodiversity that is threatened by human habitation. Norman Myers wrote about the concept in two articles in The Environmentalist in 1988 and 1990, after which the concept was revised following thorough analysis by Myers and others into “Hotspots: Earth’s Biologically Richest and Most Endangered Terrestrial Ecoregions” and a paper published in the journal Nature, both in 2000.

To qualify as a biodiversity hotspot on Myers' 2000 edition of the hotspot map, a region must meet two strict criteria: it must contain at least 1,500 species of vascular plants (more than 0.5% of the world's total) as endemics, and it has to have lost at least 70% of its primary vegetation. Globally, 36 zones qualify under this definition. These sites support nearly 60% of the world's plant, bird, mammal, reptile, and amphibian species, with a high share of those species as endemics. Some of these hotspots support up to 15,000 endemic plant species, and some have lost up to 95% of their natural habitat.

Biodiversity hotspots host their diverse ecosystems on just 2.4% of the planet's surface. Ten hotspots were originally identified by Myer; the current 36 used to cover more than 15.7% of all the land but have lost around 85% of their area. This loss of habitat is why approximately 60% of the world's terrestrial life on only 2.4% of the land surface area. Caribbean Islands like Haiti and Jamaica are facing serious pressures on the populations of endemic plants and vertebrates as a result of rapid deforestation. Other areas include the Tropical Andes, Philippines, Mesoamerica, and Sundaland, which, under the current levels at which deforestation is occurring, will likely lose most of their plant and vertebrate species.

4.8. Hotspot in India

India has always been on the list of the richest countries in the world for its biodiversity which can easily be seen in the demography of its land. Though biodiversity and demographic diversity are two completely different topics, the human population has been dependant on biodiversity forever in numerous ways. Also, as a result of exponential growth in the human population, their survival pressure has increased tremendously on biodiversity.

Rich Biodiversity of India

As it has been already mentioned, India is a country rich in biological diversity. It is situated in the Indomalaya ecozone and comprises of 2 out of the 35 biodiversity hotspots in the world. The third one, that is, Indo Burma lies partially in North-East India.

History India originally belonged to Gondwana from where many of the Indian species (descendants of taxa) originated. Due to the collision of Peninsular India with the Laurasian landmass, there was a mass exchange of species that took place. However, what caused the most turmoil was the eruption of volcanoes and climate change 20 million years ago which led to the extinction of many Indian forms. After this, mammals were seen entering India from Asia through the Himalayas as a result of which out of the Indian species, there were 12.6% mammals and 4.5% birds which were endemic and 45.8% reptiles as well as 55.8% amphibians. According to Conservation International, a region must fulfill the following two criteria to qualify as a hotspot: The region should have at least 1500 species of vascular plants i.e., it should have a high degree of endemism. It must contain 30% (or less) of its original habitat, i.e. it must be threatened.

Four Biodiversity Hotspots in India:

Following the criteria must for an area to be declared as Biodiversity Hotspot, there are major four biodiversity hotspots in India. Some of these biodiversity hotspots are present in India which includes:

- The Himalayas
- Indo-Burma Region

- The Western Ghats
- Sundaland

4.8.1. The Himalayas

Considered the highest in the world, the Himalayas (overall) comprises North-East India, Bhutan, Central and Eastern parts of Nepal. The North Eastern Himalayas holds a record of having 163 endangered species which includes the wild Asian water buffalo, one-horned rhino; and as many as 10,000 plant species, of which 3160 are endemic. This mountain range covers nearly 750,000 km^2.

4.8.2.Indo – Burma Region

the indo-burma region is stretched over a distance of 2,373,000 km^2. in the last 12 years, 6 large mammal species have been discovered in this region: the large-antlered muntjac, the annamite muntjac, the grey-shanked douc, the annamite striped rabbit, the leaf deer, and the saola.

This hotspot is also known for the endemic freshwater turtle species, most of which are threatened with extinction, due to over-harvesting and extensive habitat loss. there are also 1,300 different bird species, including the threatened white-eared night-heron, the grey-crowned crocias, and the orange-necked partridge.

4.8.3.The Western Ghats

The Western Ghats are present along the western edge of peninsular India and covers most of the deciduous forests and rain forests. As per UNESCO, it is home to at least 325 globally threatened flora, fauna, bird, amphibian, reptile and fish species. Originally, the vegetation in this region was spread over 190,000 km^2 but has been now reduced to 43,000 km^2. The region is also known for the globally threatened flora and fauna represented by 229 plant species, 31 mammal species, 15 bird species, 43 amphibian species, 5 reptile species and 1 fish species. unesco mentions that “of the total 325 globally threatened species in the western ghats, 129 are classified as vulnerable, 145 as endangered and 51 as critically endangered.”

Knowing in detail about the Western Ghats will be helpful for the aspirants for the geography preparation.

4.8.4. Sundaland

The Sundaland hotspot lies in South-East Asia and covers Singapore, Thailand, Indonesia, Brunei, and Malaysia. In the year 2013, the Sundaland was declared as a World Biosphere Reserve by the United Nations. This region is famous for its rich terrestrial and marine ecosystem. Sundaland is one of the biologically richest hotspots in the world which comprises 25,000 species of vascular plants, of which 15,000 are found only in this region.

4.9. Loss of Biodiversity

Biodiversity loss includes the worldwide extinction of different species, as well as the local reduction or loss of species in a certain habitat, resulting in a loss of biological diversity. The latter phenomenon can be temporary or permanent, depending on whether the environmental degradation that leads to the loss is reversible through ecological restoration/ecological resilience or effectively permanent (e.g. through land loss). The current global extinction (frequently called the sixth mass extinction or Anthropocene extinction), has resulted in a biodiversity crisis being driven by human activities which push beyond the planetary boundaries and so far has proven irreversible.

Even though permanent global species loss is a more dramatic and tragic phenomenon than regional changes in species composition, even minor changes from a healthy stable state can have dramatic influence on the food web and the food chain insofar as reductions in only one species can adversely affect the entire chain (coextinction), leading to an overall reduction in biodiversity, possible alternative stable states of an ecosystem notwithstanding. Ecological effects of biodiversity are usually counteracted by its loss. Reduced biodiversity in particular leads to reduced ecosystem services and eventually poses an immediate danger for food security, but also can have more lasting public health consequences for humans.

Major Reasons for Loss of Biodiversity in Hotspots

These include:

1. Destruction of habitats
2. Pollution and environmental degradation
3. Poaching
4. Climate Change

It is high time to step up and start taking measures to protect our natural biodiversity before time actually runs out.

Ecotourism

A way forward to stop the loss of biodiversity hotspots can be ecotourism. Ecotourism involves visiting fragile, pristine, and relatively untouched natural areas, with the intention to support conservation efforts. One observes the flora and fauna in their natural environment and cause as little impact as possible. it is often done on a small scale and is a great alternative to mainstream commercial tourism.

Causes of biodiversity loss

Major factors for biotic stress and the ensuing accelerating loss rate are, amongst other threats:

- Habitat loss, fragmentation and degradation
- Land use intensification has been identified to be a significant factor in loss of ecological services due to direct effects as well as biodiversity loss. Habitat fragmentation for commercial and agricultural uses is another factor.
- Excessive nutrient load and other forms of pollution
- Over-exploitation and unsustainable use
- Armed conflict, which disrupts human livelihoods and institutions, contributes to habitat loss, and intensifies over-exploitation of economically valuable species, leading to population declines and local extinctions.
- Invasive alien species that effectively compete for a niche, replacing indigenous species
- Climate change through heat stress and drought stress

According to the IUCN the main direct threats to conservation fall in 11 categories

1. **Residential and commercial development**

- Housing and urban areas (i.e. urban areas, suburbs, villages, vacation homes, shopping areas, offices, schools, hospitals)
- Commercial and industrial areas (i.e. manufacturing plants, shopping centers, office parks, military bases, power plants, train & shipyards, airports)

- Tourism and recreational areas (i.e. skiing, golf courses, sports fields, parks, campgrounds)

2. **Farming activities**

- Agriculture (i.e. crop farms, orchards, vineyards, plantations, ranches)
- Aquaculture (i.e. shrimp or finfish aquaculture, fish ponds on farms, hatchery salmon, seeded shellfish beds, artificial algal beds)

3. **Energy production & mining**

- Renewable energy production: geothermal, solar, wind, & tidal farms), including hydroelectric dams.
- Non-renewable energy production: oil and gas drilling.
- mining: fuel and minerals.

4. **Transportation & service corridors**

- Service corridors: electrical & phone wires, aqueducts, oil & gas pipelines.
- Transport corridors: roads, railroads, shipping lanes, and flight paths.
- Collisions with the vehicles using the corridors
- Associated accidents and catastrophes : oil spills, electrocution, fire.

5. **Biological resource usages**

- Hunting: bushmeat, trophy, fur
- Persecution: predator control and pest control, superstitions.
- Plant destruction or removal: human consumption, free-range livestock foraging, battling timber disease, orchid collection.
- Logging or wood harvesting: selective or clear-cutting, firewood collection, charcoal production.
- Fishing: trawling, whaling, live coral or seaweed or egg collection.

6. **Human intrusions and activities that alter, destroy, disturb habitats and species from exhibiting natural behaviors**

- Recreational activities : off-road vehicles, motorboats, jet-skis, snowmobiles, ultralight planes, dive boats, whale watching, mountain bikes, hikers, birdwatchers, skiers, pets in recreational areas, temporary campsites, caving, rock-climbing.
- War, civil unrest, and military exercises: i.e. armed conflict, minefields, tanks and other military vehicles, training exercises and ranges, defoliation, munitions testing.
- Illegal activities: smuggling, vandalism.
- Newly built housing

7. Natural system modifications

- Fire suppression or creation: controlled burns, inappropriate fire management, escaped agricultural and campfires, arson.
- Water management: dam construction and operation, wetland filling, surface water diversion, groundwater pumping.
- Other modifications: land reclamation projects, shoreline rip-rap, lawn cultivation, beach construction and maintenance, tree-thinning in parks.
- Removing/reducing human maintenance: mowing meadows, reduction in controlled burns, lack of indigenous management of key ecosystems, ceasing supplemental feeding of condors.

8. Invasive and problematic species, pathogens and genes

- Invasive species :feral horses & household pets, zebra mussels, Miconia tree, kudzu, introduction for biocontrol.
- Problematic native species: overabundant native deer or kangaroo, overabundant algae due to loss of native grazing fish, locust-type plagues.
- Introduced genetic material: pesticide-resistant crops, genetically modified insects for biocontrol, genetically modified trees or salmon, escaped hatchery salmon, restoration projects using non-local seed stock.
- pathogens and microbes: plague affecting rodents or rabbits, Dutch elm disease or chestnut blight, Chytrid fungus affecting amphibians outside of Africa.

9. Pollution

- Sewage : untreated sewage, discharges from poorly functioning sewage treatment plants, septic tanks, pit latrines, oil or sediment from roads, fertilizers and pesticides from lawns and golf courses, road salt.
- Industrial and military effluents: toxic chemicals from factories, illegal dumping of chemicals, mine tailings, arsenic from gold mining, leakage from fuel tanks, PCBs in river sediments. Agricultural & forestry effluents (nutrient loading from fertilizer run-off, herbicide run-off, manure from feedlots, nutrients from aquaculture, soil erosion).
- Garbage and solid waste: municipal waste, litter & dumped possessions, flotsam and jetsam from recreational boats, waste that entangles wildlife, construction debris. Air-borne pollutants (acid rain, smog from vehicle emissions, excess nitrogen deposition, radioactive fallout, wind dispersion of pollutants or sediments from farm fields, smoke from forest fires or wood stoves.
- Excess energy : noise from highways or airplanes, sonar from submarines that disturbs whales, heated water from power plants, lamps attracting insects, beach lights disorienting turtles, atmospheric radiation from ozone holes

10. Catastrophic geological events

Earthquakes, tsunamis, avalanches, landslides, & volcanic eruptions and gas emissions

11. Climate changes

Ecosystem encroachment (inundation of shoreline ecosystems & drowning of coral reefs from sea level rise, dune encroachment from desertification, woody encroachment into grasslands)

- Changes in geochemical regimes (ocean acidification, changes in atmospheric CO_2 affecting plant growth, loss of sediment leading to broad-scale subsidence)
- Changes in temperature regimes (heat waves, cold spells, oceanic temperature changes, melting of glaciers/sea ice)
- Changes in precipitation & hydrological regimes (droughts, rain timing, loss of snow cover, increased severity of floods)
- Severe weather events (thunderstorms, tropical storms, hurricanes, cyclones, tornadoes, hailstorms, ice storms or blizzards, dust storms, erosion of beaches during storms)

- Drought can lead to changes in functional composition.

4.10. Factors Affecting Biodiversity

- **Human Impact on Biodiversity**

Throughout our history, humans have had a negative impact on overall biodiversity of the Earth. Hunting, poaching, development of agriculture, development of cities, and pollution of the environment have lead to large scale extinctions of many species resulting in an overall reduction in biodiversity. Farming, in particular, has led to several problems because farmers use several techniques to maximise food production:

- **Deforestation**

Deforestation is the clearing of forests or other habitats such as glaciers to make way for human settlements and farmland. Deforestation for farming has several severe consequences:

- Deforestation ruins habitats. The biggest impact is habitat destruction. Loss of habitat results in loss of shelter, food, water, and other resources that other organisms need to survive.
- Loss of habitat causes extinction. Habitat destruction leads to extinctions and die offs of different species in the ecosystem. This leads to loss of biodiversity which puts the ecosystem in a state of poor biological health.
- Loss of trees leads to soil erosion. Tree roots hold soil in place. Without tree roots, rain and wind can remove the soil from the area. This leads to loss of nutritional value of the soil, which impacts the growth of plants, which in turn impacts the entire ecosystem.

- **Pesticides and Herbicides**

Pesticides and herbicides kill pests and weeds. Pesticides kill undesired animals (pests), and herbicides kill undesired weeds.

Pesticides can kill other animals. Intensive farming often uses pesticides which are toxic to other organisms within the ecosystem. These pesticides can get into the ground and can be carried to nearby river systems by rain water, where they can affect fish and other aquatic animals.

Herbicides can kill other plants. Herbicides can kill other plants aside from weeds, which reduces biodiversity of plants. It also affects any animals that rely on weeds for food.

- **Fertilizers and Eutrophication**

Use of fertilizers can lead to eutrophication. Fertilizers used by farmers. Fertilisers provide nutrients to help farmers promote good crop growth. Fertilisers are carried by rain water. These fertilisers can get mixed in with rain water which carries them to nearby bodies of water. Fertilisers enter lakes and rivers. When the fertilisers get into lakes, rivers, and streams, they lead to a spike in nitrogen, ammonia, and other nutrients in the water. Nitrogen spike kills aquatic animals. This spike in nutrients and nitrogen is beneficial to aquatic plants which causes them to grow very rapidly and densely. However, nitrogen and ammonia are toxic to other aquatic organisms.

- **Overgrowth of plants.**

The over growth of plants removes oxygen from the water. Large loss of aquatic animals. Ultimately, eutrophication leads to large scale die off of aquatic organisms, and eventually the plants themselves.

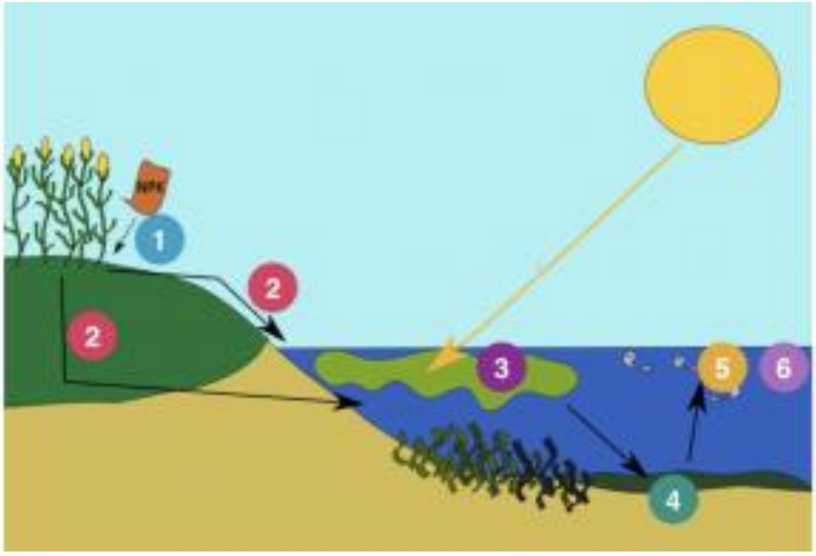


Fig.1.6: Factors affecting biodiversity

- **Selective Breeding**

Selective breeding means choosing plants and animals with the best traits e.g. most food producing and breeding them more. However, this leads to a loss in genetic diversity of farm animals, which leads to a loss in biodiversity.

- **Conservation and Farming**

Modern Farming is Unsustainable

It is important to understand that modern farming is unsustainable.

Loss of genetic diversity increases susceptibility to disease. Loss of genetic diversity in domesticated plants and animals makes them easily susceptible to diseases that can wipe out large numbers of plants and animals, resulting in severe food shortages.

Soil erosion can affect nutritional quality of soil. Soil erosion due to farming leads to poor nutritional quality of soil, which will eventually lead to a shortage of food once the soil is nutritionally wasted.

Conservation is needed: Conservation practices need to be implemented into modern farming in order to sustain it. Here are three strategies:

Conserving wild species – Conservation of wild species of domesticated animals (e.g. dogs) allows for a genetically diverse population of animals that can be used later on.

Preventing deforestation – Preventing deforestation helps improve soil quality, which promotes better farming. Certain areas are protected as SSSIs (sites of special scientific interest).

Preserving habitats – Land and habitat preservation promotes biological diversity which ultimately helps domesticated plants and animals as well.

Methods to Maintain Biodiversity: There are various methods in place to maintain biodiversity. You should be aware of the following:

In-situ conservation – Through establishing protected habitats such as marine conservation zones and wildlife reserves, in-situ conservation hopes to preserve species in their natural habitat.

Ex-situ conservation – Instead of keeping species in their natural habitat, ex situ conservation aims to move a species from its natural habitat into a new, controlled and protected environment. Some examples of ex-situ conservation are zoos, botanic gardens and seed banks.

International Agreements – Countries can work together to improve conservation. This often occurs through the form of agreements, such as CITES (Convention on International Trade in Endangered Species) and CBD (Rio Convention on Biological Diversity). These set out rules such as banning the hunting of endangered species and how resources can be used sustainably.

Local Agreements – Closer to home, the UK has a CSS (Countryside Stewardship Scheme). Through this scheme, the government pays landowners to incorporate conservation methods into their practice. This scheme has helped to increase biodiversity in the British countryside.

4.11. Keystone Species

Every ecosystem has certain species that are critical to the survival of the other species in the system. The keystone species could be a huge predator or an unassuming plant, but without them the ecosystem may not survive. In any arrangement or community, the "keystone" is considered one of the most vital parts. In a marine ecosystem, or any type of ecosystem, a keystone species is an organism that helps hold the system together. Without its keystone species, ecosystems would look very different. Some ecosystems might not be able to adapt to environmental changes if their keystone species disappeared. That could spell the end of the ecosystem, or it could allow an invasive species to take over and dramatically shift the ecosystem in a new direction.

Since a keystone species is not a formal designation, scientists may debate which plants or animals in a particular ecosystem deserve the title. Some wildlife scientists say the concept oversimplifies one animal or plant's role in complex food webs and habitats. On the other hand, calling a particular plant or animal in an ecosystem a keystone species is a way to help the public understand just how important one species can be to the survival of many others. There are three types of keystone species cited by many scientists: predators, ecosystem engineers, and mutualists.

- **Predators**

Predators help control the populations of prey species, which in turn affects the quantity of plants and animals further along the food web. Sharks, for example, often prey upon old or sick fish, leaving healthier animals to flourish. Simply by their presence near sea grass beds, sharks are able to keep smaller animals from overgrazing and wiping out the grass. Scientists in Australia observed that when tiger sharks were not near the grass beds, sea turtles—among tiger sharks' favorite prey—tended to decimate them. But when tiger sharks patrolled the grass beds, the sea turtles were forced to graze across a much wider region.

- **Ecosystem Engineers**

An ecosystem engineer is an organism that creates, changes, or destroys a habitat. There is perhaps no clearer example of a keystone engineer than the beaver. River ecosystems rely on beavers to take down old or dead trees along riverbanks to use for their dams. This allows new, healthier trees to grow in abundance. The dams divert water in rivers, creating wetlands that allow a variety of animals and plants to thrive.

- **Mutualists**

When two or more species in an ecosystem interact for each other's benefit, they are called mutualists. Bees are a primary example of this. As bee take the nectar from flowers, they collect pollen and spread it from one flower to the next, enhancing the odds of fertilization and greater flower growth. Nectar and pollen are also the primary food sources for the bees themselves. Some scientists identify other categories of keystone species. One alternate list includes predators, herbivores, and mutualisms. Another cites predators, mutualists, and competitors for resources. Keystone species can also be plants. Mangrove trees, for instance, serve a keystone role in many coastlines by firming up shorelines and reducing erosion. They also provide a safe haven and feeding area for small fish among their roots, which reach down through the shallow water.

In many cases, the vital role of a keystone species in an ecosystem is not fully appreciated until that species is gone. Ecologist Robert Paine, who coined the term "keystone species" in the 1960s, observed the importance of such species in a study of starfish along the rocky Pacific coastline in Washington State. The starfish fed on mussels, which kept the mussel population in check and allowed many other species to thrive. When the starfish were removed from the area as part of an experiment, the mussel population swelled and crowded out other species. The biodiversity of the ecosystem was drastically reduced. Payne's study showed that identifying and protecting keystone species can help preserve the population of many other species.

4.12. Species richness

Species richness, defined as the number of species per unit area, is the simplest measure of biodiversity. Small-scale species richness generally refers to species richness at the scale of a single community, habitat or microhabitat. Understanding the factors that affect and are affected by small-scale species richness is fundamental to understanding how ecological communities are assembled and function and how biodiversity is maintained. Several factors affect small-scale species richness, including geographic factors such as the regional species pool, dispersal distance and ease of dispersal, biological factors such as competition, facilitation, and predation as well as environmental factors such as resource availability, environmental heterogeneity and disturbance frequency and intensity. The importance of these factors varies with scale of observation. Further, small-scale richness can impact aspects of ecosystem function including productivity, stability, and invisibility.

4.13. Summary

- Small-scale species richness is the number of species per unit area at the scale of a single community, habitat or microhabitat.
- Species richness is similar to alpha (α) diversity, or the number of species occurring at the local scale in a relatively homogeneous area.
- Many factors affect small-scale species richness, including geographic e.g. species pool, dispersal, biotic (e.g. competition, predation, facilitation) and abiotic e.g. resource availability, environmental heterogeneity, disturbance frequency and intensity.
- The species pool is the set of species adapted to a site that are regionally available to colonies that site, and, in conjunction with dispersal processes, define the universe from which the ecological community is assembled.
- Immigration is affected by the distance between suitable habitat sites and the ability of propagates to become established at the local site, and can significantly increase species richness.
- Competition tends to decrease small-scale richness, and its impact is shaped by resource availability, the specific resources being competed for and ecological disturbances that reduce competition.
- Interactions among predators and prey, or pathogens and parasites and their hosts, can maintain or alter small-scale diversity, the impact being largely dependent on the level of dominance of the species directly impacted.
- While there is some evidence of a positive relationship between small-scale richness and productivity, other factors such as the number and identity of functional groups may be the direct cause of the relationship.
- Small-scale richness has complex effects on the stability and invisibility of local sites.

4.14. Further suggested readings

1. Text book of Botany – Singh -Pande-Jain.
2. The elements of Botany- James Hewetson Wilson
3. Textbook of Biotechnology –H. K. Das
4. Biochemistry and molecular biology- Wilson Walker
5. Environmental Science, Subhas Chandra Santra, new central book agency, 3rd Edition, 2011
6. A text Book of Environment Studies, Asthana, D. K. and Asthana, M. 2006, S. Chand & Co
7. Ecology: Theories and Applications (4th Edition) by Peter Stiling; Prentice Hall.

Unit-5: Extinction of Species

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5.1. Introduction

Extinction is the termination of a kind of organism or of a group of kinds (taxon), usually a species. The moment of extinction is generally considered to be the death of the last individual of the species, although the capacity to breed and recover may have been lost before this point. Because a species' potential range may be very large, determining this moment is difficult, and is usually done retrospectively. This difficulty leads to phenomena such as Lazarus taxa, where a species presumed extinct abruptly "reappears" (typically in the fossil record) after a period of apparent absence. More than 99% of all species that ever lived on Earth, amounting to over five billion species, are estimated. It is estimated that there are currently around 8.7 million species of eukaryote globally and possibly many times more if microorganisms, like bacteria, are included. Notable extinct animal species include non-avian dinosaurs, saber-toothed cats, dodos, mammoths, ground sloths, thylacines, trilobites, and golden toads.

Objectives

This is the fifth unit on extinction of species. Under this unit, we have following objectives. These are as under:

- Introduction to extinction of species.
- To know the concepts of extinction of species and its types.
- To know about IUCN categories of species and red data book
- To discuss endangered and endemic species of India

5.2. Concept of extinction

Species extinction is a natural process that occurs without the intervention of humans since, over geological time, all species have a finite span of existence. Extinctions caused directly or indirectly by humans are occurring at a rate that far exceeds any reasonable estimates of background extinction rates, and to the extent that these extinctions are correlated with habitat perturbation, they must be increasing.

Quantifying rates of species extinction is difficult and predicting future rates with precision is impossible. The documentation of definite species extinctions is only realistic under a relatively limited set of circumstances, for example, where a described species is readily visible and has a well-defined range that can be surveyed repeatedly. Unsurprisingly, most documented extinctions are of species that are easy to record and that inhabit sites that can be relatively easily inventoried. The large number of extinct species on oceanic islands is not solely an artifact of recording, because island species are generally more prone to extinction as a result of human actions.

Most global extinction rates are derived from extrapolations of measured and predicted rates of habitat loss, and estimates of species richness in different habitats. These two estimates are interpreted in the light of a principle derived from island biogeography, which states that the size of an area and of its species complement tend to have a predictable relationship. Fewer species are able to persist in a number of small habitat fragments than in the original unfragmented habitat, and this can result in the extinction of species. These estimates involve large degrees of uncertainty, and predictions of current and future extinction rates should be interpreted with considerable caution. The pursuit of increased accuracy in the estimation of global extinction rates is not crucial. It is more important to recognize in general terms the extent to which populations and species that are not monitored are likely to be subject to fragmentation and extinction.

Loss of biodiversity in the form of domesticated animal breeds and plant varieties is of little significance in terms of overall global diversity, but genetic erosion in these populations is of particular human concern in so far as it has implications for food supply and the sustainability of locally adapted agricultural practices. For domesticated populations, the loss of wild relatives of crop or timber plants is of special concern for the same reason. These genetic resources may not only underlie the productivity of local agricultural systems but may also, when incorporated into breeding programs, provide the foundation of traits such as disease resistance, nutritional value, hardiness, etc., that are of global importance in intensive systems and that will assume even greater importance in the context of future climate change. Erosion of diversity in crop gene pools is difficult to demonstrate quantitatively, but can be indirectly assessed in terms of the increasing proportion of world cropland planted to high-yielding, but genetically uniform, varieties. Genetic modification of organisms, varieties, or cultivars for food production, pharmaceuticals, and other products, which has caused concern in some countries but not others, may also contribute to the loss of biodiversity.

When a species becomes extinct, its entire genetic heritage is lost. The species evolve into new species in order to adapt to the environmental changes or changes in the genetic heritage. Over 99% of all the species that once lived on the earth, amounting to over five billion species, are estimated to be extinct. As per the estimations on the number of current species, a range from 10 -14 million, of which more than 1.2 million have been studied and more than 86% have not yet been discovered. This could happen naturally due to a change in the climate or because of human activities like overhunting or the destruction of habitat.

Despite the uncertainties, extinction has three major elements.

1. For species collectively, extinction is a probability if the killing stress is so rare beyond their experience and therefore outside the reach of natural selection.
2. The mass extinctions would pave the way for the major restructuring of the biosphere where a few successful groups are eliminated, allowing minor groups to expand.
3. In a few cases, there is evidence that extinction is selectively argued by Darwin. It has been made impossible to predict which species are going to be the next victim of an extinction event.

Humans exterminate species either directly by hunting, collection, and persecution or indirectly through habitat destruction and modification. Overhunting is perhaps the most obvious direct cause of extinction in animals, but it is undoubtedly far less important than the indirect causes of habitat modification in terms of overall loss of biodiversity. Hunting selectively affects the targeted species, as well as plant and animal species whose populations are subsequently affected either negatively or positively, and so it has important implications for the management of natural resources. Genetic diversity in a hunted population is liable to decrease as a result of the same factors. The genetic diversity represented by populations of crop plants or livestock is also likely to decline as a result of mass production, for the desired economics of scale demand high levels of uniformity.

Sustained human activity will affect the relative abundance of species and in extreme cases may lead to extinction. This may result from the habitat being made unsuitable for the species i.e. clear-felling of forests or severe pollution of rivers or through the habitat becoming fragmented. Fragmentation divides previously contiguous populations of species into small subpopulations. If these are sufficiently small, then chance processes lead to higher probabilities of extinction within a relatively short time. Major changes in natural environments are likely to occur within the next century as a result of changes in global climate and weather patterns. These will cause greatly elevated extinction rates.

5.3. Types of extinction

There are two main types of extinction:

(1) Background extinction and

(2) Mass extinction.

Background extinction refers to extinction that is normal and ongoing occurring at a relatively stable rate throughout geologic time. This type of extinction occurs from environmental or ecological factors including changes in climate, disease, competition with other animals, or loss of their habitat.

Mass extinctions are events with substantial losses of life. There have been five documented mass extinctions in the rock record, some being more severe than others. It has been suggested that we are currently in the midst of another mass extinction with Anthropogenic Climate Change as the driving mechanism. When scientists talk about extinction, are referring to birth and death rates. During times of mass extinction we have increased death, or extinction, rates. It is also, however, possible to have suppressed speciation (birth) rates.

Some of these events are called extinctions while others are just called crises. This is very intentional and the details here are important. We can calculate various statistics by understanding the amount of organisms such as abundance of the same organism or the amount of different organisms in an ecosystem and how they increase or decrease over time. Extinction occurs when animals are dying more quickly than they are able to reproduce, meaning the death rate outpaces the birth rate. If there are large ecosystem restructuring events (e.g., changing sea level, migration, or extinction causing large open space available) the birth rate can be modified to accommodate those severe changes.

The Big Five

The “big five” extinction events were first interpreted from Sepkoski’s family level curve. The identification of these events has remained stable as the data precision has increased. The generic level curves look very similar with more peaks but the big five always stand apart from the rest. Each of these events are outlined below:

End Ordovician Crisis

Considered to be the second largest ‘extinction’ event, after the Permian extinction. This event occurred approximately 450-440 million years ago. This event, as with the Devonian crisis interval appears to not be a time of increased extinction but rather decreased speciation (or origination). Because there are fewer new species appearing, it leaves a record in the rock that implies loss or devastation. Another factor that has hindered the understanding of this event is the lack of rock in the Upper Ordovician and Early Silurian. The rock record is very sparse, and when there is little or limited data it becomes difficult to address and answer these questions.

End Devonian Crisis

This crisis was restricted to the marine realm and was not one, but several pulses of extinction over quite a long interval of time rather than one single event. The reef-builders i.e. corals and stromatoporoids, were greatly affected by this event. Ammonites, trilobites, and jawed vertebrates (including our tetrapod ancestors) were also hit hard during this event. The Devonian is a very important time in earth’s history of as this time marks the large migration from water to land. The earliest forests are found in rocks from the Devonian.

End Permian Mass Extinction

This event happened approximately 251 million years ago and is generally called “The Great Dying”. This event marked the end of the Paleozoic Era and the beginning of the Mesozoic. It was Earth’s most severe extinction event, and the only extinction event to drastically affect insects. Because the loss was so great, the rebound of life took significantly longer than the other events. It is estimate that as much as 96% of all marine species went extinct, but remembers: attempting to quantify this based on available data that are sparse. But it is agreed upon that this extinction event was incredibly severe and set the stage for the Mesozoic communities.

End Cretaceous Mass Extinction

This is most well known for the extinction of the non-avian dinosaurs at approximately 65.5 million years ago. This marks the transition between the Mesozoic (‘middle life’) to the Cenozoic. In addition to the loss of non-avian dinosaurs the marine realm was greatly affected. Many groups of mollusks e.g., clams, snails, octopods, suffered heavy losses. The group known as Cephalopoda (‘head-foot’) lost many major groups – these are extinct relatives of squids, octopods, and cuttlefish.

End Triassic Mass Extinction

Although this extinction is generally considered one of the Big Five, it has received less attention than the others, primarily due to the limited fossil bearing rocks – both in marine and terrestrial realms. Many of the large marine groups, such as brachiopods, corals, and cephalopods, suffered large losses but did not go extinct as a result of this event. This extinction event is often considered the time that dinosaurs were able to rise as the dominant predators in ecosystems. Prior to this extinction synapsids were the top predator and after this event the mammals were much smaller in size, resulting in an open role to be filled: apex predator.

5.4. Causes of Extinction

The extinction of species refers to the complete disappearance of a particular species from the planet. Extinction can occur naturally over geological time or be accelerated by human activities. Here is a summary of the main factors and consequences related to the extinction of species:

- **Asteroid Strikes**

A meteor strike on the Yucatan peninsula in Mexico led to the disappearance of dinosaurs millions of years ago. Most of the mass extinctions, such as KT extinction or Permian-Triassic extinction, were caused due to such events. Astronomers constantly keep an eye on comets or meteors that could lead to the end of human civilization.

- **Climate Change**

Climate change is yet another factor that could destroy terrestrial organisms. During the end of the last ice age, most of the megafauna were unable to adapt to the changing warm temperatures. They died due to a lack of food and hunting by early humans. Even modern civilization is stepping towards the threat of extinction due to global warming.

- **Disease**

Various epidemics had been the cause of the epidemic of a large population of humans and animals on earth. The black death wiped out one-third of the European population in the middle Ages.

- **Loss of habitat**

Every animal has its own comfort zone where it can breed and raise its young ones. For e.g., a bird is comfortable only on the branch of a tree. Due to the expansion of human civilization and industrialization, the forests have been destroyed, which are an abode to most animals. Due to lack of space and eventually food, the populations of many organisms have been minimized.

- **Lack of Genetic Diversity**

Once the number of species starts decreasing, the gene pool of that species grows smaller. Eventually, there is a lack of genetic diversity. For eg., due to habitat loss, the African cheetahs have a considerably low genetic diversity.

- **Better Adapted Competition**

The better-adapted populations win over the ones that lag behind. For eg., the pre-historic mammals were better adapted than the dinosaurs. The ones which are well-adapted survive, while the others become extinct.

- **Pollution**

The pollution from industries and vehicles has led to a drastic change in the oxygen levels in the atmosphere as well as water. This has led to the extinction of most of the aquatic as well as terrestrial species.

- **Invasive Species:**

Invasive species, introduced by human activities, can outcompete native species for resources, prey upon them, or introduce diseases. This can result in the decline or elimination of native species, particularly on islands or in isolated ecosystems with limited natural defenses against invaders.

- **Overexploitation:**

Unsustainable hunting, fishing, and poaching can drive species to extinction. Overharvesting, especially when coupled with illegal trade, affects species like elephants, rhinos, tigers, and marine animals targeted for their valuable parts, such as ivory, horns, or fins.

- **Consequences of Extinction:**

The loss of species has far-reaching ecological, economic, and cultural consequences. Ecologically, species extinction disrupts ecosystems, affecting interactions among organisms and altering nutrient cycles.

Examples of Extinct Animals

Following are the important examples of extinct animals:

- Passenger Pigeon
- Dodo
- Tasmanian Tiger
- Baiji White Dolphin
- Pyrenean Ibex
- Stellers Sea Cow
- Great Auk
- Mammoth
- Sabre-toothed Cat

5.5. Factors Responsible for Extinction

The core threat to biodiversity on the planet, and therefore a threat to human welfare, is the combination of human population growth and resource exploitation. The human population requires resources to survive and grow, and those resources are being removed unsustainably from the environment. The three greatest proximate threats to biodiversity are habitat loss, overharvesting, and introduction of exotic species. The first two of these are a direct result of human population growth and resource use. The third results from increased mobility and trade. A fourth major cause of extinction, anthropogenic climate change, has not yet had a large impact, but it is predicted to become significant during this century. Global climate change is also a consequence of human population needs for energy and the use of fossil fuels to meet those needs. Environmental issues, such as toxic pollution, have specific targeted effects on species, but they are not generally seen as threats at the magnitude of the others.

Humans rely on technology to modify their environment and replace certain functions that were once performed by the natural ecosystem. Other species cannot do this. Elimination of their ecosystem—whether it is a forest, a desert, grassland, a freshwater estuarine, or a marine environment—will kill the individuals in the species. Remove the entire habitat within the range of a species and, unless they are one of the few species that do well in human-built environments, the species will become extinct. Human destruction of habitats accelerated in the latter half of the twentieth century. Consider the exceptional biodiversity of Sumatra: it is home to one species of orangutan, a species of critically endangered elephant, and the Sumatran tiger, but half of Sumatra's forest is now gone. The neighboring island of Borneo, home to the other species of orangutan, has lost a similar area of forest. Forest loss continues in protected areas of Borneo. The orangutan in Borneo is listed as endangered by the International Union for Conservation of Nature (IUCN), but it is simply the most visible of thousands of species that will not survive the disappearance of the forests of Borneo.

The core threats to biodiversity are human population growth and unsustainable resource use. To date, the most significant causes of extinctions are habitat loss, introduction of exotic species, and overharvesting. Climate change is predicted to be a significant cause of extinctions in the coming century. Habitat loss occurs through deforestation, damming of rivers, and other activities. Overharvesting is a threat particularly to aquatic species, while the taking of bush meat in the humid tropics threatens many species in Asia, Africa, and the Americas. Exotic species have been the cause of a number of extinctions and are especially damaging to islands and lakes. Exotic species' introductions are increasing because of the increased mobility of human populations and growing global trade and transportation. Climate change is forcing range changes that may lead to extinction. It is also affecting adaptations to the timing of resource availability that negatively affects species in seasonal environments. The impacts of climate change are greatest in the arctic. Global warming will also raise sea levels, eliminating some islands and reducing the area of all others.

Extinction rate

Extinction, in biology is the dying out or extermination of a species. Extinction occurs when species are diminished because of environmental forces i.e. habitat fragmentation, global change, natural disaster, overexploitation of species for human use or because of evolutionary changes in their members i.e. genetic inbreeding, poor reproduction, decline in population numbers. Rates of extinction vary widely. For example, during the last 100,000 years of the Pleistocene Epoch (about 2.6 million to 11,700 years ago), some 40 percent of the existing genera of large mammals in Africa and more than 70 percent in North America, South America, and Australia went extinct. Ecologists estimate that the present-day extinction rate is 1,000 to 10,000 times the background extinction rate (between one and five species per year) because of deforestation, habitat loss, overhunting, pollution, climate change, and other human activities—the sum total of which will likely result in the loss of between 30 and 50 percent of extant species by the middle of the 21st century.

Although extinction is an ongoing feature of earth's flora and fauna (the vast majority of species ever to have lived are extinct), the fossil record reveals five unusually large extinctions, called mass extinction events, each involving the demise of vast numbers of species. These conspicuous declines in diversity are referred to as mass extinctions; they are distinguished from the majority of extinctions, which occur continually and are referred to as background extinction. Ranked in descending order of severity, they are:

1. Permian extinction (about 265.1 million to about 251.9 million years ago), the most dramatic die-off, eliminating about half of all families and about 90 percent of all species, which included some 95 percent of marine species (nearly wiping out brachiopods and corals) and about 70 percent of land species (including plants, insects, and vertebrates).
2. Ordovician-Silurian extinction (about 443.8 million years ago), which included about 25 percent of marine families and 85 percent of marine species.
3. Cretaceous-Tertiary (K-T), or Cretaceous-Paleogene (K-Pg), extinction (about 66.0 million years ago), involving about 80 percent of all animal species, including the dinosaurs and many species of plants. Although many scientists contend that this event was caused by one or more large comets or asteroids striking Earth, others maintain that it was caused by climatic changes associated with the substantial volcanic activity of the time.
4. End-Triassic extinction (about 201.3 million years ago), possibly caused by rapid climate change or by an asteroid striking Earth. This mass extinction event caused about 20 percent of marine families and some 76 percent of all extant species to die out, possibly within a span of about 10,000 years, thus opening up numerous ecological niches into which the dinosaurs evolved.
5. Devonian extinctions (407.6 million to about 358.9 million years ago), which included 15–20 percent of marine families and 70–80 percent of all animal species. Roughly 86 percent of marine brachiopod species perished, along with many corals, conodonts, and trilobites.

In essence, mass extinctions are unusual because of the large numbers of taxa that die out, the concentrated time frame, the widespread geographic area affected, and the many different kinds of animals and plants eliminated. In addition, the mechanisms of mass extinction are different from those of background extinctions.

The International Union for Conservation of Nature (IUCN) Red List of Threatened Species, also known as the IUCN Red List or Red Data Book, founded in 1964, is the world's most comprehensive inventory of the global conservation status of biological species.[1] It uses a set of precise criteria to evaluate the extinction risk of thousands of species and subspecies. These criteria are relevant to all species and all regions of the world. With its strong scientific base, the IUCN Red List is recognized as the most authoritative guide to the status of biological diversity. A series of Regional Red Lists are produced by countries or organizations, which assess the risk of extinction to species within a political management unit.

The aim of the IUCN Red List is to convey the urgency of conservation issues to the public and policy makers, as well as help the international community to reduce species extinction. According to IUCN the formally stated goals of the Red List are to provide scientifically based information on the status of species and subspecies at a global level, to draw attention to the magnitude and importance of threatened biodiversity, to influence national and international policy and decision-making, and to provide information to guide actions to conserve biological diversity.

Major species assessors include Bird Life International, the Institute of Zoology (the research division of the Zoological Society of London), the World Conservation Monitoring Centre, and many Specialist Groups within the IUCN Species Survival Commission (SSC). Collectively, assessments by these organizations and groups account for nearly half the species on the Red List.

5.6.IUCN Categories for Threatened Spices

The IUCN aims to have the category of every species re-evaluated at least every ten years, or every five years if possible. This is done in a peer reviewed manner through IUCN Species Survival Commission Specialist Groups, which are Red List Authorities responsible for a species, group of species or specific geographic area, or in the case of BirdLife International, an entire class (Aves). The number of species which have been assessed for the Red List has been increasing over time. As of 2019, of 105,000 species surveyed, 28,338 are considered at risk of extinction because of human activity, in particular overfishing, hunting, and land development.

Categories

Species are classified by the IUCN Red List into nine groups, specified through criteria such as rate of decline, population size, area of geographic distribution, and degree of population and distribution fragmentation. There is an emphasis on the acceptability of applying any criteria in the absence of high quality data including suspicion and potential future threats, "so long as these can reasonably be supported".

- Extinct (EX) – beyond reasonable doubt that the species is no longer extant.
- Extinct in the wild (EW) – survives only in captivity, cultivation and/or outside native range, as presumed after exhaustive surveys.
- Critically endangered (CR) – in a particularly and extremely critical state.
- Endangered (EN) – very high risk of extinction in the wild, meets any of criteria A to E for endangered.
- Vulnerable (VU) – meets one of the 5 Red List criteria and thus considered to be at high risk of unnatural (human-caused) extinction without further human intervention.
- Near threatened (NT) – close to being endangered in the near future.
- Least concern (LC) – unlikely to become endangered or extinct in the near future.
- Data deficient (DD)
- Not evaluated (NE)

In the IUCN Red List, "threatened" embraces the categories of critically endangered, endangered, and vulnerable.

1994 categories and 2001 framework

The older 1994 list has only a single "Lower Risk" category which contained three subcategories:

- Conservation Dependent (LR/cd)
- Near Threatened (LR/nt)
- Least Concern (LR/lc)

In the 2001 framework, *near threatened* and *least concern* became their own categories, while *Conservation Dependent* was removed and its contents merged into *near threatened*.

Possibly extinct

The tag of "possibly extinct" (PE) is used by Birdlife International, the Red List Authority for birds for the IUCN Red List. BirdLife International has recommended PE become an official tag for critically endangered species, and this has now been adopted, along with a "Possibly Extinct in the wild" tag for species with populations surviving in captivity but likely to be extinct in the wild.

Criticism

In 1997, the IUCN Red List received criticism on the grounds of secrecy (or at least poor documentation) surrounding the sources of its data. These allegations have led to efforts by the IUCN to improve its documentation and data quality, and to include peer reviews of taxa on the Red List. The list is also open to petitions against its classifications, on the basis of documentation or criteria. In the November 2002 issue of trends in ecology & evolution, an article suggested that the IUCN Red List and similar works are prone to misuse by governments and other groups that draw possibly inappropriate conclusions on the state of the environment or to affect exploitation of natural resources.

In the November 2016 issue of *Science Advances*, a research article claims there are serious inconsistencies in the way species are classified by the IUCN. The researchers contend that the IUCN's process of categorization is "out-dated, and leaves room for improvement", and further emphasize the importance of readily available and easy-to-include geospatial data, such as satellite and aerial imaging. Their conclusion questioned not only the IUCN's method but also the validity of where certain species fall on the List. They believe that combining geographical data can significantly increase the number of species that need to be reclassified to a higher risk category.

5.7. Red Data Book

The Red Data Book is a public document that is created for recording endangered and rare species of plants, animals, fungi as well as some local subspecies that are present in a particular region. The Red Data Book helps us in providing complete information for research, studies and also for monitoring the programs on rare and endangered species and their habitats. This book is mainly created to identify and protect those species which are on the verge of extinction.

Brief History of the Red Data Book

The name of this book has its origins in Russia; it was originally known as the Red Data Book of the Russian Federation or the RDBRF. The book was based on research conducted between 1961 and 1964 by biologists in Russia. Hence, it is also called the Russian Red Data Book. Currently, the International Union for Conservation of Nature maintains the Red Data Book. IUCN is the world's most detailed inventory centre of the global conservation status of biological species. The International Union for Conservation of Nature (IUCN) was founded in 1948 with an aim to maintain a complete record of every species that ever lived. The Red Data Book contains the complete list of threatened species. The main aim behind this documentation is to provide complete information for research and analysis of different species. The Red Data Book contains colour-coded information sheets, which are arranged according to the extinction risk of many species and subspecies.

- Black represents species that are confirmed to be extinct.
- Red represents species that are endangered
- Amber for those species whose status is considered to be vulnerable
- White is assigned for species that are rare
- Green for species that were formerly endangered, but their numbers have started to recover
- Grey coloured for the species that are classified as vulnerable, endangered, or rare but sufficient information is not available to be properly classified.

In a nutshell, the Red Data Book indexes species as:

- Threatened
- Not threatened
- Unknown

Furthermore, The Red Data Book also has information as to why a species has become extinct along with the population trends and the extent of its range (distribution).

Advantages of the Red Data Book

- It helps in identifying all animals, birds and other species about their conservation status.
- It is used to evaluate the population of a particular species.
- The data available in this book can be used to evaluate the taxa at the global level.
- With the help of this book, we can estimate the risk of taxa becoming globally extinct.

- Provides a framework or guidelines for implementing protective measures for endangered species.

5.8.Disadvantages of the Red Data Book

- The information available in the Red Data Book is incomplete. Many species, both extinct and extant are not updated in this book.
- The source of the book's data has been speculated and has been mired in controversy.
- This book maintains the complete record of all animals, plants, other species but it has no information about the microbes.

Red Data Book of India

Red Data Book of India includes the conservation status of animals and plants which are endemic to the Indian subcontinent. The data for this book is provided through surveys which are conducted by the Zoological Survey of India and the Botanical Survey of India under the guidance of the Ministry of Environment, Forest and Climate Change. Critically endangered mammals as per the Red Data List of India include:

- Kondana Rat
- Malabar Civet
- Kashmir Stag
- River Dolphins

Critically endangered arthropods include:

- Rameshwaram Parachute spider
- Peacock Tarantula

Critically endangered fish include:

- Pookode Lake barb
- Ganges River shark
- Pondicherry shark

Critically endangered amphibians and reptiles include:

- Gharial
- White-spotted bush frog
- Toad-skinned frog

Questions Related to Red Data Book

Q. 1 What is a red data book?

Red data book is the document established by IUCN for documenting the rare and endangered species of plants, animals, fungi and also a few local species that exist within a state or country.

Q. 2 How is the red data book important?

Red data book is beneficial for providing detailed information for studies and researches. It also helps in monitoring programs on rare and endangered species. It thus helps in protecting the species that are on the verge of extinction.

Q. 3 The red data book is maintained by which organization?

The red data book is maintained by the International Union for Conservation of Nature. This organization was founded in 1948 and works in the field of conservation of nature and sustainable use of natural resources.

Q. 4 How is the Red List different from the Red Data Book?

The red list contains only the names of the endangered species; however, the Red Data Book contains information about the species that are on the verge of extinction.

Q. 5 What is a green data book?

The green data book is a small pocket-sized book containing environmental data of more than 200 economies. It is based on world development indicators. Agriculture, forestry, biodiversity, pollution, and sanitation are the key indicators.

Q. 6 Which are the critically endangered species of India as per the Red Data List?

The critically endangered species of India are:

- Kashmir stag
- River dolphins
- Kondana rat
- Malabar civet

Q. 7 What are vulnerable species?

Vulnerable species are those that are likely to become endangered in the near future. Vulnerability is mainly caused due to loss of habitat.

5.9.List of threatened flora

Endangered plants are any living species of plants vulnerable to extinction shortly, either globally or in specific geographic locations. Out of the 1.9 million living species of flora and fauna, about 0.7 million are plants. According to The Guardian newspaper, around 40% of existing plants await extinction. The loss of endangered plant species annually will threaten the supply of food, fuel, medicines, etc. As of September 2016, the International Union for Conservation of Nature (IUCN) lists 1851 near threatened plant species. 8.5% of all evaluated plant species are listed as near threatened. The IUCN also lists 51 subspecies and 73 varieties as near threatened. No subpopulations of plants have been evaluated by the IUCN. This is a complete list of near threatened plant species, subspecies and varieties evaluated by the IUCN. Living plant species become endangered when;

1. Its population shrinks significantly in recent years
2. The decline is continuous without a check
3. Its geographic range also sharply shrinks

Bryophytes

There are two bryophyte species assessed as near threatened.

Mosses

- *Archidium elatum*

Liverworts

- *Scapania sphaerifera*

Pteridophytes

There are 25 pteridophyte species assessed as near threatened.

Leptosporangiate ferns

- *Asplenium cardiophyllum*
- *Asplenium ecuadorense*
- *Asplenium jahandiezii, Verdon spleenwort*

Isoetopsida

- *Isoetes acadiensis*
- *Isoetes prototypus*, Prototype quillwort
- *Isoetes setacea,* Iberian quillwort

Lycopodiopsida

Clubmosses and firmosses

- *Huperzia holstii*
- *Huperzia polydactyla*

Gymnosperms

There are 168 species, two subspecies, and 29 varieties of gymnosperms assessed as near threatened.

Cycads

Species

- *Cycas apoa*
- *Cycas arenicola*
- *Cycas badensis*

5.10. List of threatened fauna

WWF (World Wildlife found) conserve species in India started in the early seventies when it supported the launch of Government of India's Project Tiger. In 1997, WWF-India's Tiger Conservation Programme (TCP) began and was aimed at providing support to tiger bearing Protected Areas (PAs). In 2000, a landscape conservation approach was adopted with the focus growing beyond specific PAs. Currently, WWF-India is addressing species conservation through field-level activities in different landscapes as well as through direct interventions aimed at conserving a particular species. These programmes focus on threats to wildlife and the issues surrounding these threats. Prominent among these are poaching, human-wildlife conflict, trade in wildlife parts, habitat destruction and legal support. The project activities are carried out at field as well as policy levels. They are mainly related to scientific information gathering, working with the local communities, NGOs and government agencies including the state forest departments.

Apart from the mega-species– Royal Bengal tiger, Asian elephant and Indian rhino, WWF-India also has Threatened Species Conservation Programme since 2008 and include species, viz., Nilgiri tahr, Asiatic lion, snow leopard, black-necked crane, smooth coated otter, Himalayan quail, great Indian bustard, leopard, gharial, brow-antlered deer, golden mahseer, Indian pangolin, sarus crane, house sparrow and Ganges river dolphin. WWF-India sees some of the above and a few other species as critical to India's wildlife conservation for reasons that include the rarity of the species e.g. Himalayan quail as well as the cultural importance they have for the people e.g. house sparrow. In addition to these species, WWF India also encourages conservation-oriented action/research on species through its Small Grants Programme that began in 2011.

WWF-India's Threatened Species Conservation Programme includes the following species:

- Sarus crane
- Common leopard
- Great Indian bustard
- Himalayan quail
- House sparrow
- Nilgiri tahr
- Gharial
- Asiatic lion
- Ganges river dolphin
- Black-necked crane
- Smooth-coated otter
- Golden mahseer
- Indian pangolin
- Brow-antlered deer

5.11. Endangered species

Endangered species are those that are at risk of becoming extinct in the near future if conservation measures are not implemented. The primary factors contributing to the endangerment of species include habitat loss, poaching, pollution, climate change, and invasive species. Here is a summary of the current state of endangered species: An endangered species is a type of organism that is threatened by extinction. Species become endangered for two main reasons: loss of habitat and loss of genetic variation. A loss of habitat can happen naturally. Dinosaurs, for instance, lost their habitat about 65 million years ago. The hot, dry climate of the Cretaceous period changed very quickly, most likely because of an asteroid striking the earth. The impact of the asteroid forced debris into the atmosphere, reducing the amount of heat and light that reached Earth’s surface. The dinosaurs were unable to adapt to this new, cooler habitat. Dinosaurs became endangered, then extinct. Human activity can also contribute to a loss of habitat. Development for housing, industry, and agriculture reduces the habitat of native organisms. This can happen in a number of different ways. Development can eliminate habitat and native species directly.

In the Amazon rain forest of South America, developers have cleared hundreds of thousands of acres. To “clear” a piece of land is to remove all trees and vegetation from it. The Amazon rain forest is cleared for cattle ranches, logging, and urban use. Development can also endanger species indirectly. Some species, such as fig trees of the rain forest, may provide habitat for other species. As trees are destroyed, species that depend on that tree habitat may also become endangered. Tree crowns provide habitat in the canopy, or top layer, of a rainforest. Plants such as vines, fungi such as mushrooms, and insects such as butterflies live in the rain forest canopy. So do hundreds of species of tropical birds and mammals such as monkeys. As trees are cut down, this habitat is lost. Species have less room to live and reproduce.

Loss of habitat may happen as development takes place in a species range. Many animals have a range of hundreds of square kilometers. The mountain lion of North America, for instance, has a range of up to 1,000 square kilometers (386 square miles). To successfully live and reproduce, a single mountain lion patrols this much territory. Urban areas, such as Los Angeles, California, and Vancouver, British Columbia, Canada, grew rapidly during the 20th century. As these areas expanded into the wilderness, the mountain lion’s habitat became smaller. That means the habitat can support fewer mountain lions. Because enormous parts of the Sierra Nevada, Rocky, and Cascade mountain ranges remain undeveloped, however, mountain lions are not endangered.

Loss of habitat can also lead to increased encounters between wild species and people. As development brings people deeper into a species range, they may have more exposure to wild species. Poisonous plants and fungi may grow closer to homes and schools. Wild animals are also spotted more frequently. These animals are simply patrolling their range, but interaction with people can be deadly. Polar bears, mountain lions, and alligators are all predators brought into close contact with people as they lose their habitat to homes, farms, and businesses. As people kill these wild animals, through pesticides, accidents such as collisions with cars, or hunting, native species may become endangered. The current states of endangered species are followings:

- **Amur Leopard:** The Amur leopard is critically endangered, with only around 100 individuals remaining in the wild.
- **Sumatran Orangutan:** Found in Indonesia, the Sumatran orangutan is critically endangered due to deforestation for palm oil plantations.
- **Black Rhino:** Black rhinos are critically endangered due to poaching for their horns, which are highly valued in traditional medicine markets.
- **Vaquita:** The vaquita is a small porpoise found in the Gulf of California. It is the most endangered marine mammal, with less than 10 individuals remaining.
- **Mountain Gorilla:** Mountain gorillas are critically endangered due to habitat loss, poaching, and civil unrest in their range countries.
- **Hawksbill Turtle:** Hawksbill turtles are critically endangered primarily due to the demand for their shells in the illegal trade.
- **South China Tiger:** The South China tiger is considered functionally extinct in the wild, with no confirmed sightings for many years. It has fallen victim to habitat loss and poaching.
- **Sumatran Tiger**: The Sumatran tiger is critically endangered, with fewer than 400 individuals remaining.
- **Giant Panda:** Although no longer critically endangered, the giant panda is still classified as endangered.
- **African Elephant:** African elephants are classified as vulnerable due to poaching for ivory and habitat fragmentation.

5.12. Endemism and Endemic Species

Before focusing on endemic species, let's look at the definition of endemism. Endemism is a term used in biology to talk about the distribution of a taxon limited to a small geographic area and which can therefore be found naturally in this place. In consequence, endemic species are those that live in a limited area, such as a mountain range, lake or island, among others. Therefore, the ecological aspect of the place and the biological characteristics of the living beings influence this condition. Endemic species are crucial to the health of our planet because of the enormous variety of living beings they contribute to the environment. In fact, it is no coincidence that megadiverse countries, those that are home to at least 70 % of the planet's terrestrial biological diversity account for only around 10 % of the surface but are home to a massive number of endemic species.

Endemic species are the most vulnerable of all and, therefore, those in the greatest danger of extinction, which can be due to natural causes or human activity. As well as the consequences of climate change, there are other threats, such as poaching, changing habitats and the introduction of invasive species. What's more, environmental conservation has become a major standard-bearer for protecting these species.

Examples of endemic species

There are numerous endemic species in the world, but here is a small sample of some endemic animals and plants:

Endemic animals

- I**berian lynx (*Lynx pardinus*):** This carnivorous mammal is endemic to the Iberian Peninsula and is also the world's most seriously threatened feline species.
- **Polar bear (*Ursus maritimus*):** this carnivorous mammal lives in the polar region and in the frozen areas of the Northern Hemisphere. It is the only surviving super-predator in the Arctic.
- **Lemur (Lemuroidea):** This Strepsirrhini primate is native to the island of Madagascar in the Indian Ocean. It has shiny eyes and makes strange noises.
- **Panda (*Ailuropoda melanoleuca*):** This mammal is typical of Asia, although it has become a symbol of China the country that has done most to save it from extinction.

5.13. Summary

The extinction of species refers to the complete disappearance of a particular species from the planet. Extinction can occur naturally over geological time or be accelerated by human activities. The destruction and fragmentation of natural habitats due to activities like deforestation, urbanization, and conversion of land for agriculture are major drivers of species extinction. Rapid changes in climate patterns, primarily caused by human-induced greenhouse gas emissions, pose a significant threat to many species. Invasive species, introduced by human activities, can outcompete native species for resources, prey upon them, or introduce diseases. Unsustainable hunting, fishing, and poaching can drive species to extinction. Overharvesting, especially when coupled with illegal trade, affects species like elephants, rhinos, tigers, and marine animals targeted for their valuable parts, such as ivory, horns, or fins. However, the pollution, including chemicals, pesticides, heavy metals, and plastics are the other causes of habitat degradation. The causes of species extinction require concerted efforts in habitat conservation, sustainable resource management, combating climate change, reducing pollution, and regulating trade. Conservation initiatives, protected areas, captive breeding programs, and public awareness are vital tools in preventing further extinctions and preserving biodiversity of the planet's.

5.14. Terminal Questions

Q.1. What is the concept of extinction of species? Discuss the types and cause of extinction of species.

Answer:---

-

Q.2. Write the factor responsible for extinction of species.

Answer:---

-

Q.3. Discuss the IUCN Categories for threatened spices.

Answer:---

-

Q.4. What do you know about Red Data Book? Write the disadvantages of the Red Data Book.

Answer:---

-

Q.5. Write the name of Indian threatened flora and fauna.

Answer:---

-

Q.6. Discuss about endemism and endemic species.

Answer:---

-

5.15. Further readings

8. Text book of Botany – Singh -Pande-Jain.

9. The elements of Botany- James Hewetson Wilson

10. Textbook of Biotechnology –H. K. Das

11. Biochemistry and molecular biology- Wilson Walker

12. Environmental Science, Subhas Chandra Santra, new central book agency, 3rd Edition, 2011

13. A text Book of Environment Studies, Asthana, D. K. and Asthana, M. 2006, S. Chand & Co

14. Ecology: Theories and Applications (4th Edition) by Peter Stiling; Prentice Hall.

Unit-6: Values of biodiversity

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6.1. Introduction

Biodiversity may be defined as the variety and richness in which life presents on the earth. It refers to the diversity in all species such as plants, animals and microorganisms. Since all species in an ecosystem are interrelated and inter dependent, biodiversity has enormous value in the lives of all organisms, particularly for human beings. It would be difficult for life to continue and, sustain without biodiversity. Biodiversity serves a dual purpose in providing ecological functions. Biodiversity helps living beings procure food, fuel, fibre and other extractable commodities. Biodiversity is vital for the ecosystem because it provides regulatory, cultural, and sustaining functions. Biodiversity refers to the variety of living species on the earth, including plants, animals, bacteria and fungi. While earth's biodiversity is so rich that many species have yet to be discovered, many species are being threatened with extinction due to human activities, putting the earth's magnificent biodiversity at risk.

Objectives

This is the sixth unit on values of biodiversity. Under this unit, we have following objectives. These are as under:

- Introduction to values of biodiversity
- To know the concepts of direct/indirect value of biodiversity
- To discuss the concept of intrinsic value, ethical value and aesthetic value
- To know about anthropocentrism, biocentrism and eco-centrism

6.2. Biodiversity overview

Biodiversity is a term used to describe the enormous variety of life on the earth. It can be used more specifically to refer to all of the species in one region or ecosystem. Biodiversity refers to every living thing, including plants, animals, and human beings. Scientists have estimated that there are around 8.7 million species of plants and animals in existence. However, only around 1.2 million species have been identified and described so far, most of which are insects. This means that millions of other organisms remain a complete mystery. Over generations, all of the species that are currently alive today have evolved unique traits that make them distinct from other species. These differences are what scientists use to tell one species from another. Organisms that have evolved to be so different from one another that they can no longer reproduce with each other are considered different species. All organisms that can reproduce with each other fall into one species.

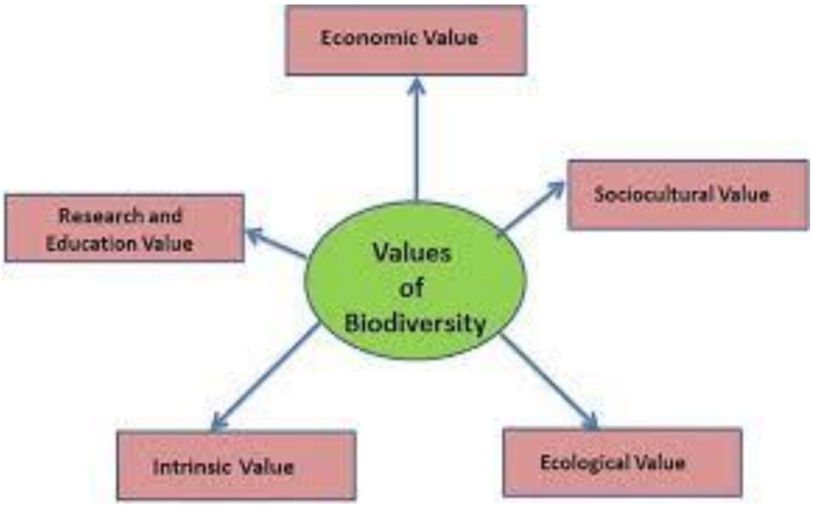
Scientists are interested in how much biodiversity there is on a global scale, given that there is still so much biodiversity to discover. They also study how many species exist in single ecosystems, such as a forest, grassland, tundra, or lake. A single grassland can contain a wide range of species, from beetles to snakes to antelopes. Ecosystems that host the most biodiversity tend to have ideal environmental conditions for plant growth, like the warm and wet climate of tropical regions. Ecosystems can also contain species too small to see with the naked eye. Looking at samples of soil or water through a microscope reveals a whole world of bacteria and other tiny organisms.

Some areas in the world, such as areas of Mexico, South Africa, Brazil, the southwestern United States, and Madagascar, have more biodiversity than others. Areas with extremely high levels of biodiversity are called hotspots. Endemic species are only found in one particular location and also present in hotspots. All the species on the earth’s work together to survive and maintain their ecosystems. For example, the grass in pastures feeds cattle. Cattle then produce manure that returns nutrients to the soil, which help grow more grass. This manure can also be used to fertilize cropland. Many species provide important benefits to humans, including food, clothing, and medicine.

Much of the biodiversity on the earth, however, is in jeopardy due to human consumption and other activities that disturb and even destroy ecosystems. Pollution, climate change, and population growth are threats to biodiversity. These threats have caused an unprecedented rise in the rate of species extinction. Some scientists estimate that half of all species on the earth will be wiped out within the next century. Conservation efforts are necessary to preserve biodiversity and protect endangered species and their habitats.

6.3 Values of Biodiversity

Humans place a high value on biodiversity because they rely on it for social, economic, and environmental wellbeing. Biodiversity also help shape our culture and identity. Different character traits are regularly integrated into cultural practices. Other elements of human wellbeing, such as wellness and economic and political security, depend on biodiversity. Encompassing prospective sources of multiple foods, medications, and energy can help economic activity and make the population healthier. When adjusted for use in wellbeing, agrarian, or industrial applications, biodiversity has proven to be extremely valuable. Biodiversity is commonly defined in terms of species or groups of independent living organisms that can produce offsprings. Marine mammals, fair-skinned deer, pine forests, fresh flowers, and micron-sized bacteria that cannot be seen with the naked eye are some of the examples of species that inhabit the earth.



The individual components of biodiversity like genes, species, and ecosystems are providing society with a wide array of goods and services. Genes, species, and ecosystems of direct, indirect, or potential use to humanity are often referred to as "biological resources". Examples that we use directly include the genes that plant breeders use to develop new crop varieties; the species that we use for various foods, medicines, and industrial products; and the ecosystems that provide services, such as water purification and flood control. The components of biodiversity are interconnected. For example, genetic diversity provides the basis of continuing adaptation to changing conditions, and continued crop productivity rests on the diversity in crop species and on the variety of soil invertebrates and microorganisms that maintain soil fertility. Similarly, a change in the composition and abundance of the species that make up an ecosystem can alter the services that can be obtained from the system. In this chapter, we review the types of goods and services that mankind obtains directly and indirectly from biodiversity and its components.

Biodiversity contributes to our knowledge in ways that are both informative and transformative. Knowledge about the components of biodiversity is valuable in stimulating technological innovation and in learning about human biology and ecology. Experiencing and increasing our knowledge about biodiversity transform our values and beliefs. There is a fairly large literature characterizing nonextractive ecosystem services with direct benefit to society, such as water pollution and purification, flood control, pollination, and pest control. In addition, such services in biophysical and economic terms characterize the institutional mechanisms needed to generate incentives for their preservation.

Biodiversity has fundamental values, which can be categorized into:

- Environmental values
- Social values
- Ecosystem services
- Economic values
- Value of consumptive use
- Value of productive use
- Moral and ethical values
- Aesthetic values

Ecosystem values:

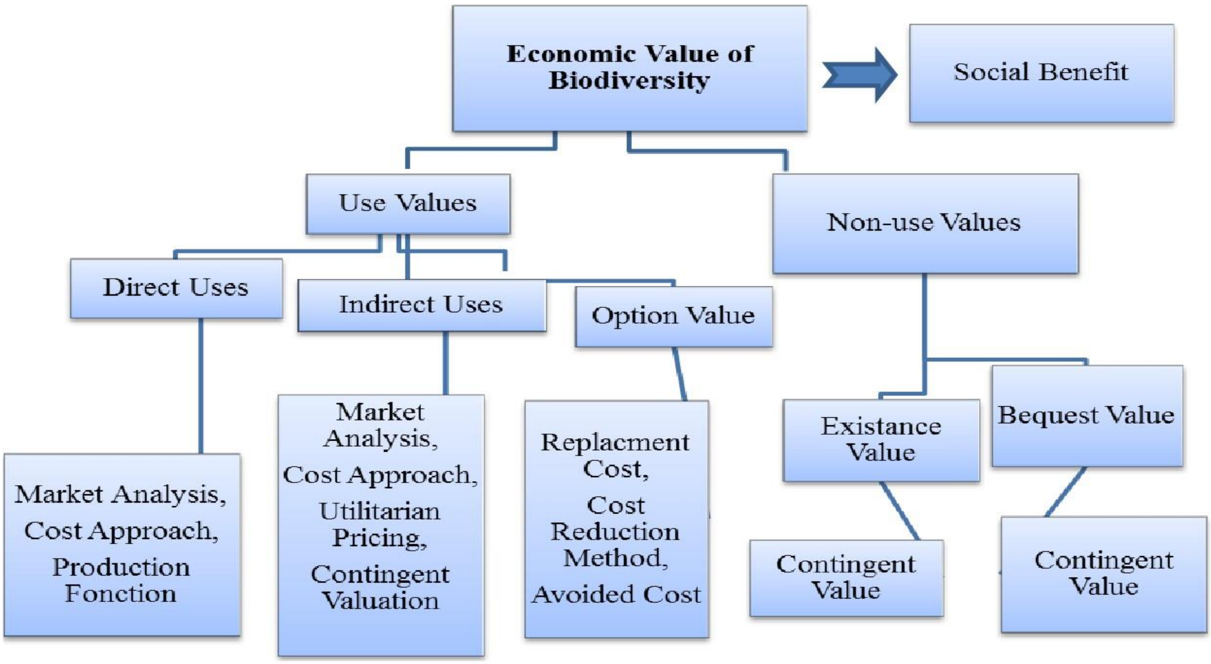
The environmental values of biodiversity can be evaluated by analyzing the functions of the ecosystem. Ecosystem services, such as intensive agricultural production ecosystems, help in maintaining human needs and activities. These include the establishment and maintenance of fertile soil, retention of fresh groundwater resources through vegetation and the output of oxygen by ground plants and microalgae.

1. **Resilience and Stability**: Ecosystems with high biodiversity tend to be more resilient and stable in the face of environmental changes, including disturbances like natural disasters. Different species may have unique roles, and if one species is affected, others can compensate, maintaining ecosystem functions.
2. **Ecosystem Services:** Biodiversity ecosystems provide a wide range of ecosystem services that benefit humans, including:
    a. Pollination: Many food crops depend on diverse pollinator species.
    b. -Water Purification: Wetlands and forests filter and purify water.
    c. Climate Regulation: Forests and oceans store carbon, helping regulate climate.
    d. Nutrient Cycling: Biodiversity supports the recycling of nutrients in ecosystems.
3. **Productivity:** Biodiversity ecosystems often exhibit higher productivity, meaning they can produce more biomass, which can support more life and contribute to human food and resource needs.
4. **Resistance to Pests and Diseases**: In agriculture, diverse cropping systems are less prone to pest and disease outbreaks because they can provide natural controls.
5. **Adaptation to Change:** Biodiversity can offer options for adaptation to environmental changes, such as climate change. Different species may have varying tolerances to different conditions.
6. **Genetic Resources:** Biodiversity provides a vast genetic pool, essential for breeding and improving crops, livestock, and even medicines. Many important drugs and medical treatments come from natural compounds found in diverse ecosystems.
7. **Scientific and Educational Value:** Biodiversity is a source of scientific knowledge and understanding of the natural world. It provides opportunities for ecological and biological research.
8. **Cultural and Aesthetic Values**: Biodiversity contributes to cultural and recreational aspects of human life. People are often drawn to diverse landscapes and wildlife for their aesthetic and spiritual value.

The loss of biodiversity can lead to a decrease in these ecosystem values, making it important to protect and conserve diverse ecosystems to ensure the continued well-being of both nature and human society.

Economic Value:

Biodiversity has a tremendous economic perspective on food, livestock feed, meditative, ethical, and social ideals. Biodiversity is an important resource for many industry sectors that regulate the world economy. Consumptive use value refers to natural products that are used for food, such as livestock feed, wood products, fuel wood, and other purposes. Humans consume 40,000 flora and fauna species daily. Determining the value or worth of biodiversity is complex. Economists typically subdivide utilitarian or use values of biodiversity into direct use value for those goods that are consumed directly, such as food or timber, and indirect use value for those services that support the items that are consumed, including ecosystem functions like nutrient cycling. There are several less tangible values that are sometimes called non-use or passive values, for things that we don't use but would consider as a loss if they were to disappear; these include existence value, the value of knowing something exists even if you will never use it or see it, and bequest value, the value of knowing something will be there for future generations (Moran and Pearce 1994).



Many people remain dependent on wildlife for the majority of their necessities, such as nutrition, temporary housing, and clothing. Productive use value implies products that are sourced and commercially marketed. Almost all of the crops grown today have evolved from wild varieties. Biotechnologists are continuously experimenting with wild plant species to create new, more productive disease-resistant variants. Biodiversity holds significant economic value, contributing to various industries and economic activities in several ways:

1. **Agricultu**re: Biodiversity is essential for crop and livestock production. Diverse genetic resources in crops and livestock can lead to improved yields, resilience to pests and diseases, and adaptation to changing environmental conditions. Loss of biodiversity in agriculture can lead to reduced food security and increased vulnerability to crop failures.
2. **Fisheries and Aquaculture:** Marine and freshwater biodiversity supports the fishing industry and aquaculture. Overfishing and the loss of marine biodiversity can lead to fishery collapses, impacting livelihoods and economies.
3. **Pharmaceuticals**: Many pharmaceuticals and medicines are derived from plants, animals, and microorganisms found in diverse ecosystems. Biodiversity provides a vast source of potential drugs, with many species yet to be explored for their medicinal properties.
4. Tourism: Biodiversity ecosystems and wildlife attract tourists, contributing to the tourism industry. Iconic natural sites, such as coral reefs, rainforests, and wildlife reserves, generate revenue and employment opportunities.
5. Forestry: Diverse forests provide various wood and non-wood products, from timber to nuts and fruits. Sustainable forestry practices that preserve biodiversity can maintain long-term economic benefits.
6. **Biotechnology:** Biodiversity supports biotechnological advancements, including genetic engineering and the development of new agricultural, medical, and industrial products.
7. **Ecosystem Services:** Biodiversity contributes to ecosystem services that have economic value, such as pollination for agricultural crops, water purification, carbon sequestration, and natural hazard mitigation, reducing the economic costs associated with disasters.
8. **Livelihoods and Employment:** Many communities rely on biodiversity for their livelihoods. Activities like fishing, hunting, and gathering, as well as ecotourism and eco-friendly crafts, provide employment and income.
9. **Waste Decomposition and Nutrient Recycling:** Biodiversity plays a role in breaking down organic matter, recycling nutrients, and decomposing waste, which can reduce the costs of waste management and enhance soil fertility.
10. **Insurance against Uncertainty:** Diverse ecosystems provide insurance against unforeseen environmental changes and fluctuations in resource availability.

The economic value of biodiversity is closely tied to its contribution to human well-being and sustainable development. Recognizing and preserving this value is essential for both environmental and economic sustainability. The loss of biodiversity can have adverse economic consequences, making the conservation of biodiversity an economic imperative.

Ethical and Moral Value:

Biodiversity has enormous economic potential in terms of food, livestock feed, medications, etc. Biodiversity is vital for many areas of the economy. The beauty of our planet is due to biodiversity. Otherwise, it would have looked like any other deserted planet, which is scattered throughout the universe. Biological diversity enhances the quality of life and contributes significantly to the most beautiful aspects of nature. Biodiversity makes a significant contribution to the gorgeousness of the landscape. The ethical and moral values of biodiversity are rooted in the recognition that all species and ecosystems have intrinsic worth and deserve respect and consideration. Here are some key ethical and moral aspects of biodiversity:

1. **Intrinsic Value:** Biodiversity is valued for its own sake, independent of its utility to humans. Many people believe that all species have a right to exist and thrive, regardless of their usefulness to humans.
2. **Stewardship:** Many ethical frameworks emphasize humanity's responsibility to act as stewards of the Earth, protecting and preserving biodiversity for future generations and the well-being of the planet.
3. **Respect for Life:** Biodiversity highlights the importance of respecting and valuing all forms of life, from the smallest microorganisms to the largest mammals.
4. **Interconnectedness:** Recognizing the interdependence of all species in ecosystems fosters a sense of ethical responsibility to maintain these intricate relationships and avoid causing harm to any part of the web of life.
5. **Conservation Ethic:** Ethical principles often call for the conservation of biodiversity; emphasizing those human activities should not drive species to extinction or harm ecosystems.
6. **Cultural and Indigenous Values:** Many indigenous cultures have deep, spiritual connections to their natural environments, considering various species and ecosystems as integral to their identities and moral values.
7. **Environmental Justice:** Ethical considerations include ensuring that the benefits and burdens of biodiversity conservation are equitably distributed, and that marginalized communities do not bear the brunt of environmental degradation.

8. **Intergenerational Equity**: Moral considerations encompass the well-being of future generations, calling for responsible stewardship of biodiversity to ensure that they inherit a planet rich in life.
9. **Biophilia:** The concept of biophilia suggests that humans have an innate connection to and affinity for other living beings. Recognizing and nurturing this connection is seen as a moral value.
10. **Sustainable Practices**: Ethical values encourage the adoption of sustainable and responsible practices that minimize harm to the environment and biodiversity.
11. **Ethical Obligations to Non-Human Species:** Some ethical frameworks argue that humans have a moral obligation to protect and care for non-human species, similar to our obligations to other human beings.

Recognizing and promoting these ethical and moral values of biodiversity can lead to more responsible environmental stewardship and conservation efforts, ultimately benefiting the planet and all its inhabitants.

Biodiversity in the Pharmaceutical and Biotechnology Industry

Wild species of plants and animals have long been the source of important pharmaceutical products. Natural products play a central role in traditional healthcare systems. The World Health Organization (WHO) estimates that some 80% of people in developing countries obtain their primary health care in the form of traditional medicines. Systems of ayurvedic medicine in India and the traditional systems of Chinese herbal medicine, for example, reach hundreds of millions of people. Total sales of herbal medicines in Europe, Asia, and North America were estimated at $8.4 billion in 1993. That total is not large on a global scale, but sales of herbal medicines can often be an important source of income for local communities and business. Natural products also continue to play a central role in the pharmacopeia of industrialized nations. Of the highest-selling 150 prescription drugs sold in the United States in 1993, 18% of the 150 consisted of essentially unaltered natural products, and natural products provided essential information used to synthesize an additional 39%. In total, 57% owed their existence either directly or indirectly to natural products.

As the new technologies became available in the 1980s, many companies established natural-products research divisions. Of 27 companies interviewed in 1991, two-thirds had established their natural-products programs within the preceding 6 years. In most large pharmaceutical companies, natural-products research accounts for 10% or less of overall research. But some smaller companies now focus exclusively on natural products. For example, Shaman Pharmaceuticals bases all its drug-discovery research on natural products used in traditional healing systems, and it currently has two drugs in clinical trials.

Biodiversity and Bioremediation

It has become clear in recent years that the fundamental role of microorganisms in global processes can be exploited in maintaining and restoring environmental productivity and quality. Indeed, microorganisms are already playing important roles, both in the prevention of pollution, for example, through waste processing and environmental monitoring and in environmental restoration, for example, through bioremediation of spilled oil.

A variety of probes and diagnostics for monitoring food and environmental quality have been developed, and there is much discussion of the development of genetically engineered organisms for speeding the cleanup of wastes, spills, and contaminated sediments. Furthermore, marine biotechnology is being pursued avidly and on a larger scale in Japan, where one major goal is to find ways to lower global atmospheric CO_2 concentrations. Without doubt, the prediction of climate change will be much improved by a better understanding of global cycles, and the tools of marine biotechnology will be heavily involved in this endeavor.

6.4. Direct and Indirect Values of Biodiversity

The direct use value of biodiversity is self-evident there are many unknown compounds and processes that are inherently valuable to humanity that is provided by nature and its variance. Indirect use value is ever more lucrative and towering. Earth will become the jewel in our shared crown, the center of our human exploits for years to come. The value of a day on terra on a pristine beach is incalculable when intrepid women, men, and those in between venture forward into space-faring enterprises. Biodiversity is the diversity of living things from a variety of sources, including terrestrial, marine, and desert ecosystems as well as the ecological complexes to which they belong. This is the most complex and important feature of our planet. Life cannot be sustained without biodiversity. The term “biodiversity” was coined by Walter G. Rosen in 1985. It is important for both natural and man-made ecosystems. It represents diversity among plant, animal, and microbial species. Biodiversity includes the number and relative abundance of various organisms in an ecosystem. It also reflects the organization of the organism at different levels. Biodiversity is ecologically and economically important. It provides us with food, shelter, fuel, clothing, and other resources. They also earn money from tourism. Therefore, having the right knowledge of biodiversity is very important to ensure sustainable livelihoods.

A. Direct Use of Biodiversity

Direct use values are for those goods that are ensured directly e.g. food and timber. Maintaining a wide range of components of biological diversity can be of direct use, especially in the fields of agriculture, medicine, and industry. Direct use can involve the use of forests, wetlands or other ecosystems for timber extraction, collection of non-timber products, fishing, etc. Direct use values could be due to extractive use where resources are extracted and consumed or due to non-extractive use when there is no extraction or removal of the resource that is used (e.g. bird watching, scientific research in an ecosystem, etc.). However, the difference between extractive and non-extractive use is sometimes fine and hard to define.

Direct value is the benefit derived from the goods provided by biodiversity. For examples food, wood, firewood, medicines, linen, and wool. These commodities can be used by people for their own consumption needs as well as generate income through trade and research. Direct value is the benefit derived from the goods provided by biodiversity. These commodities can be used by people for their own consumption needs as well as generate income through trade and research.

Consumptive Use Value

Many natural foods are consumed locally by people. However, we do not sell or buy these products. These products do not directly contribute to the national economy. The cost of these products is called the value in use of biodiversity. This is the direct use value of being able to directly collect and consume biodiversity products. For examples, food, medicine, textile, etc.

- **Food:** A large number of wild plants are consumed by humans for food. About 80,000 species of edible plants are reported to be found in the wild. About 90% of modern food crops have been domesticated from wild tropical plants.
- **Drugs and medicines:** About 75% population relies on plant or herbal extracts to make medicine. The miracle drug penicillin used as an antibiotic is derived from the fungus Penicillium. Similarly, we get tetracycline from bacteria. Quinine, an antimalarial drug, is extracted from the bark of the cinchona tree, and digitalin is derived from digitalis (digitalis), which is effective against heart disease. Recently, two anticancer drugs, vinblastine, and vincristine were obtained from periwinkle (catarrin) plants, which contain

anticancer alkaloids. It is hypothesized that a large number of marine animals have anticancer properties that have not yet been systematically investigated.

- **Fuel:** Our forests have been used as firewood since ancient times. Fossil fuels such as coal, oil, and natural gas are also products of fossil biodiversity. Privately harvested firewood is generally not sold and is consumed directly by tribes and locals, so it is worth using.

Productive use Value

This is the commercially viable value to which the product is sold and marketed. This can include a variety of wild genetic resources that scientists can sell to confer desirable traits on crops and livestock. These may include animal products such as elephant tusks, musk deer musk, silkworm silk, wool, many animal furs, lacquer insects, etc., all of which are sold in the market. Many industries depend on the value of productive use of biodiversity. Paper industry, plywood industry, railway sleeper industry, silk industry, textile industry, ivory industry, leather industry, pearl industry, etc.

B. Indirect Use of Biodiversity

Indirect value is a benefit that is consistent with services derived from biodiversity and of great value to society as a whole, not individuals or businesses. Examples of indirect value include services such as pollination by bees, maintenance of water and oxygen circulation by plants, decomposition of dead matter by bacteria and fungi, worship of various flora and fauna, sacred forests, and the aesthetic beauty of flora and fauna. Indirect value is a benefit that is consistent with services derived from biodiversity and of great value to society as a whole, not individuals or businesses.

In view of the fact that multiple plants and animals are seen as holy and sacred and are cherished and respected in some rigid nations, cultural and traditional beliefs are an aberrant incentive for biodiversity. Indirect values would include ethical or moral value, existence value, ecological value, aesthetic value, cultural or spiritual value, option value, and scientific or educational value. Social values. The social value of biodiversity lies in the more and more use of resources by affluent societies.

Social Value

Social value of biodiversity prospecting motivated habitat conservation in some areas, as traditional societies valued it as a resource. Ecosystem people value biodiversity as a part of their livelihood as well as through cultural and religious sentiments. A great variety of crops have been cultivated in traditional agricultural systems and permitted a wide range of products to be grown and marketed throughout the year and acted as insurance against the failure of one crop. In recent years, farmers have begun to receive economic incentives to grow cash crops for national or international markets, rather than to supply local needs. This has resulted in local food shortages, unemployment, landlessness, and increased vulnerability to drought and floods. These are values related to social life, customs, religion, and psycho-spiritual aspects of people's. In our country, many plants are considered sacred and sacred, such as Tulasi (holy basil), papal, mango and lotus etc. The leaves, fruits, or flowers of these plants are used for worship. Thus, social life, singing, dancing, and customs are closely linked with wildlife. Many animals such as cows, snakes, bulls, peacocks, owls, and more are worshipped. It is also particularly important because it occupies an important place in our psycho-spiritual realm. Therefore, biodiversity has special social values associated with other societies.

Ethical Value

This is due to ethical issues such as "all living things must be preserved". It is based on the concept of "Live and let live". All biodiversity must be protected because biodiversity is precious for our human beings to survive. Ethical values mean that we may or may not use a species, but the very fact that species exists in nature gives us pleasure. When we learn that 'passenger pigeons' or 'dodos' are no longer on this earth, we all feel sad. We do not directly derive from kangaroos, zebras, or giraffes, but we firmly believe that these species should exist in nature. This means that every species has an inherent ethical or existential value.

Aesthetic and moral Value

Biodiversity has great aesthetic value. None of us would like to visit a vast wasteland that is devoid of any sign of life. People all over the world invest a lot of time and money to visit wildlife where they can enjoy the aesthetic value of biodiversity, and this type of tourism is now known as ecotourism. Such ecotourism's "willing to pay" concept even provides a monetary value for the aesthetic value of biodiversity. Ecotourism is estimated to generate revenues of $12 billion annually, roughly equivalent to the aesthetic value of biodiversity.

Biodiversity is a direct source of pleasure and aesthetic satisfaction – its contribution to the quality of life, outdoor recreation, and scenic enjoyment. They provide opportunities for recreational activities such as hiking, canoeing, bird watching, river rafting, rock climbing, trekking, parasailing, bird watching, and nature photography. The designing of thousands of new horticultural species, wildlife conservation, landscape luxury, national parks, zoological and botanical gardens, snake, crocodile, butterfly parks, and biotechnologically manipulated novel curios species added to the existing aesthetics.

Ecosystem Service Value

Recently, the unused value associated with the self-maintenance of the ecosystem and various important ecosystem services has been recognized. This refers to the services provided by ecosystems such as preventing soil erosion, preventing flooding, maintaining soil fertility, nutrient cycling, nitrogen fixation, water cycle, serving as a carbon sink, absorbing pollutants, and reducing the threat of global warming.

6.5. Monetizing the Value of Biodiversity

Ecosystems of all sorts provide services that benefit both the natural environment and the human-built environment. For example, a forest can provide wind-breaking services to protect from heavy gusts. Forest can provide flood control by intercepting rain and absorption from the soil as well as carbon sequestration by taking in carbon dioxide from the atmosphere and releasing oxygen. Wetlands deliver excellent water filtration and flood control too.

Nature provides valuable services to humans and our infrastructure in cities. Numerous scientific studies demonstrate the importance of restoring ecosystem services in urban environments so that nature can provide amenities that otherwise we would have to build ourselves. A wetland is cheaper than installing wastewater filtration systems, forests are more affordable and more efficient than inventing carbon sequestration devices. Ecosystem monetization is giving a value to the ecosystem services in a dollar amount based on the cost of providing the same service from human-built infrastructure.

Nature has significant capital. The oceans freely sequester carbon, provide food, provide recreation, and provide a cooling effect in the summer. Glaciers provide drinking water and reduce the Earth's albedo without a fee as well. Some scholars estimate that about US$16–54 trillion of services are provided yearly worldwide by ecosystems. That is a lot we take for granted! Especially considering anthropogenic activities like industrial agriculture and resource extraction destroy countless ecosystems annually and contribute to climate change worldwide.

As a result, there has been a growing debate about monetizing ecosystems so that a dollar value can be given to their services. Many municipalities are already considering monetizing their natural assets i.e. ecosystem services to account for vital services that are provided from the environment rather than from engineered infrastructure. This monetization will allow for comparisons with new infrastructure development proposals or other business affairs. The purpose of monetizing ecosystem services is to incentivize environmental behaviour in municipalities and for corporations.

Deforestation in the region has shown effects on erosion, water quality, loss of habitats for wildlife, degradation of aquatic habitats and loss of fishery, an increase in number of disease vectors i.e. mosquitoes and a surge of malaria cases in humans, as well as many environmental disruptions. Poor people are the first to suffer the effects of biodiversity degradation. Vegetation cover is an essential part of biodiversity; it is important for the maintenance of water and humidity levels and crucial for the maintenance of the oxygen/carbon dioxide balance in the atmosphere. The role of biodiversity in natural systems is intrinsically complex, and environmental degradation can affect many other components of the ecosystem, including the loss of species harvested for food by human beings. Biodiversity loss and degradation of natural habitats have led to disruption of ecosystem services, and consequently to economic costs and social losses.

Even though ecological processes and services are important, there are, in addition, moral, philosophical and political arguments that emphasize the value of biodiversity. Thus, biodiversity has an **intrinsic value** because it is part of the natural world, and the conservation of species, genetic resources and ecosystems is important for the maintenance of natural ecological processes. In addition, biodiversity performs a number of **ecological services** for us, which implies economic, aesthetic and recreational values, representing arguments of human interest or anthropocentric arguments.

Intrinsic value

Emphasizes the integrity of ecological communities, nature working as it is, as in representative portions of natural ecosystems preserved in protected areas, national parks, biological reserves and other categories of conservation units. These protected areas managed by man, an important part of nature emphasize the need to facilitate continued evolution of life forms in their natural habitats. There is an altruistic or non-humanistic value to support the intrinsic value of biodiversity: life forms should be conserved simply because they exist: they are the product of a long history of continuing evolution by means of ecological processes, and so they have the right to a continued existence. This ethical argument, stating that the protection of biological integrity is morally good, is based on the fact that most biodiversity loss nowadays is caused by human activities and disturbances, including, as a consequence, the recent extinction of species.

Anthropocentric values

Or economic or utilitarian values of biodiversity rely upon the dependence of man on biodiversity; products that nature can provide: wood, food, fibers to make paper, resins, chemical organic products, genes as well as knowledge. These economic benefits can be direct or indirect. Some benefits of biodiversity are represented in forms of goods that can be directly valued by the market. Extractive goods, such as the Brazil nut or ornamental fish, can be harvested in the forest and sold. Biodiversity is widely valued as a genetic storehouse for biotechnology, including medicine and cosmetic sub-products.

Anthropocentrism is the prevalent ideology in most societies around the world, and also permeates academia and domestic and international governance. Four examples of this are: ‘ecosystem services’; ‘strong sustainability’; ‘education for sustainable development’; and the so-called ‘new conservation’ approach. Anthropocentrism continues to be dominant, even in venues where ecological sustainability is a stated goal. We contend, however, that a fully sustainable future is highly unlikely without an ecocentric value shift that recognizes the intrinsic value of nature and a corresponding Earth jurisprudence. *Hence the need for academics to speak out in support of ecocentrism.*

Other biodiversity benefits are classified as indirect benefits, difficult to quantify in terms of market values, encompassing ecosystem services, such as climate regulation, reproductive and feeding habitats for commercial fish, and so on. Some organisms can create soil fertility through complex cycles and interactions, such as earthworms, termites and bacteria, in addition to fungi responsible for cycling nutrients like nitrogen, phosphorus and sulfur and making them available to plant absorption. Thus, **ecosystem services** are the benefits that people indirectly receive from natural ecosystems functions air quality maintenance, regional climate, water quality, nutrient cycling, reproductive habitats of commercial fish, etc. with their related economic values.

Aesthetic value

This is expressed by humans seeking contact with nature, since natural and wild landscapes are aesthetically pleasing and provide opportunities to escape from large cities dominated by pollution and man-made landscapes. Ecotourism is an increasingly lucrative industry, be it bird watching in the pantanal or floating among fish in Bonito. In addition to protection of water resources, other ecosystem services are: soil formation and protection, nutrient storage and cycling, pollution breakdown and absorption, contribution to climate stability, maintenance of ecosystems and recovery from unpredictable events like severe floods and droughts.

6.6. Biocentrism

Biocentrism is ethical perspective holding that all life deserves equal moral consideration or has equal moral standing.

Although elements of biocentrism can be found in several religious traditions, it was not until the late decades of the 20th century that philosophical ethics in the western tradition addressed the topic in a systematic manner.

Historical roots

Much of the history of environmental ethics can be understood in terms of an expanding range of moral standing. Traditional western ethics has always been anthropocentric, meaning that only presently living human beings deserve moral consideration. As environmental issues such as nuclear waste disposal, human population growth, and resource depletion came to the fore, many ethicists argued that moral standing should be extended to include future generations of human beings. The animal welfare and animal rights movement argued for an extension of moral standing to at least some animals, and arguments followed to extend moral standing to plants and then to such ecological wholes as ecosystems, wilderness areas, species, and populations.

The philosophical challenge throughout that process was to articulate and defend a nonarbitrary criterion by which the question of moral standing could be decided. On what grounds does one decide that objects deserve to be considered in moral deliberation? Supporters of extending moral standing to future generations argued that temporal location, like geographical location, was an arbitrary ground for denying equal moral status to humans not yet living. Defenders of animal rights cited characteristics such as having interests, sentience, being conscious, and being the subject of a life as the most appropriate criteria for moral standing. Biocentric ethics argues that the only nonarbitrary ground for assigning moral standing is life itself and thus extends the boundary of moral standing about as far as it can go. All living beings, simply by virtue of being alive, have moral standing and deserve moral consideration.

Roots of biocentric ethics can be found in a number of traditions and historical figures. The first of the five basic precepts of Buddhist ethics is to avoid killing or harming any living thing. The Christian saint Francis of Assisi preached to animals and proclaimed a biocentric theology that explicitly included animals and plants. Some native of American traditions also hold that all living things are sacred. The Romantic movement of the 18th and 19th centuries defended the intrinsic value of the natural world against the tendency of the technological age to treat all nature as having mere instrumental value.

In the 20th century, preservationists such as John Muir held that the intrinsic value of natural areas, particularly wilderness areas, creates responsibilities for humanity. Preservationists argued that the intrinsic value of nature imposes duties to respect and preserve natural objects. However, the preservationist ethic can go beyond biocentrism in that it is not life itself that always carries moral value. Wilderness areas and ecosystems, after all, are not alive. Similarly, scholar Christopher D. Stone's argument that trees should have legal standing would not strictly be biocentric in that stone also advocated legal standing for mountains and rivers. This observation suggests that biocentrism is essentially an individualistic ethic. Life would seem an attribute of individual living things. Many environmentalists argue that holistic entities such as ecosystems, wilderness areas, and species all deserve moral consideration. To the extent that such entities are not alive, strictly speaking, environmental holism differs from biocentrism.

6.7. Ecocentrism

Ecocentrism finds inherent (intrinsic) value in all of nature. It takes a much wider view of the world than does anthropocentrism, which sees individual humans and the human species as more valuable than all other organisms. Ecocentrism is the broadest of worldviews, but there are related worldviews. Ecocentrism goes beyond *bio*centrism (ethics that sees inherent value to all *living* things by including environmental systems as wholes, and their abiotic aspects. It also goes beyond *zoo*centrism (seeing value in animals) on account of explicitly including flora and the ecological contexts for organisms. Ecocentrism is thus the umbrella that includes biocentrism and zoocentrism, because all three of these worldviews value the nonhuman, with ecocentrism having the widest vision. Given that life relies on geological processes and geomorphology to sustain it, and that 'geodiversity' also has intrinsic value, the broader term 'ecocentrism' seems most appropriate.

Historical Roots of Ecocentrism

Ecocentrism as a worldview has been with humanity since we evolved. Many indigenous cultures around the world speak of lore and (in Australia) 'law' that reflects an ecocentric view of the world. Ecologist Aldo Leopold in *Sand County Almanac* wrote the classic evocation of ecocentrism in 'The Land Ethic', which expanded the 'community' to include animals, plants and the land itself. Philosopher Arne Naess in 1973 coined the term 'deep ecology' for similar sentiments, later articulating the notion in Principle 1 of the *Deep Ecology Platform*: The well-being of non-human life on the earth has value in itself. This value is independent of any instrumental usefulness for limited human purposes. In terms of ecocentrism helping to solve the environmental crisis, ecologist John Stanley Rowe has argued:

It seems to me that the only promising universal belief-system is ecocentrism, defined as a value-shift from Homo sapiens to planet earth. A scientific rationale backs the value-shift. All organisms are evolved from earth, sustained by earth. Thus earth, not organism, is the metaphor for life. Earth not humanity is the life-center, the creativity-center. Earth is the whole of which we are subservient parts. Such a fundamental philosophy gives ecological awareness and sensitivity an enfolding, material focus.

The intrinsic value of nature has had a mixed history in terms of international recognition. The 1972 Stockholm Declaration was anthropocentric, as was the World Conservation Strategy in 1980. In contrast, the World Charter for Nature in 1982 was underpinned by strong ecocentric principles, stipulating that humanity and culture are part of nature. In 1987, the Report of the World Commission on Environment and Development: Our Common Future argued that development: “must not endanger the natural systems that support life on Earth: the atmosphere, the waters, soils, and living beings.” It also (in a little-noticed passage) expressed the view that nature has intrinsic value. However, the Tokyo declaration that accompanied this was anthropocentric, as was the later Rio Declaration in 1992.

Why Ecocentrism is an Essential Solution

We believe that ecocentrism, through its recognition of duties of humanity towards the nature, is central to solving our unprecedented environmental crisis. Its importance is for multiple reasons: In ethical terms: ecocentrism expands the moral community (and ethics) from being just about ourselves. It means we are not concerned *only* with humanity; we extend respect and care to all life, and indeed to terrestrial and aquatic ecosystems themselves. In evolutionary terms: ecocentrism reflects the fact *Homo sapiens* evolved out of the rich web of life on Earth – a legacy stretching back an almost unimaginable 3.5 billion years. Other species literally are our cousins and relatives (close and distant), recognition of a *biological kinship* that many have recognized confers moral responsibilities toward all species.

In spiritual terms: many people and some societies have developed ecocentric moral sentiments. There is increasing evidence that ecocentric values are being fused into nature-based, ecocentric spiritualities, many of which are innovative and new. With such spiritualities, even people who are entirely naturalistic in their worldviews often speak of the earth and its ecosystems as ‘sacred’ and thus worthy of reverent care and defense. In ecological terms, ecocentrism reminds us that all life is interdependent and that *both* humans and nonhumans are absolutely dependent on the ecosystem processes that nature provides. An anthropocentric conservation ethic alone is wholly inadequate for conserving biodiversity. Ecocentrism is rooted in an evolutionary understanding that reminds us that we are latecomers to what Leopold evocatively called “the Odyssey of Evolution”. This logically leads both to empathy for our fellow inhabitants; and also to *humility*, because in this process we are no different from other species. Ecology teaches humility in another way, as we do not know everything about the world’s ecosystems.

6.8. Intellectual values

The **intellectual values of the human being** are those that improve man in terms of reason, intellect and memory. For example science, knowledge, wisdom. The intellectual person is dedicated to reflect and criticize about reality. His ideas are intended to influence it. In addition, it intervenes, as creator or mediator, in politics, in the production of ideologies, of cultural currents and in the defense of one or other values. Values are principles that guide the behavior of human beings. But there is no absolute, dominant or arbitrary definition of values, since the notion includes different contents and meanings addressed from various theories and concepts.

An integral view might refer to a quality of"excellence"or"perfection." A value is telling the truth, a value is to work instead of stealing.

Characteristics of Intellectual Values

Intellectual values move around truth, knowledge, research and rationality. In other words we could think that the intellectual values, studied from the logic, have:

- As an objective aim, the truth
- As a subjective end, the wisdom

His main activities are abstraction and construction

- With preference to reason
- With the need to satisfy self-realization, which ultimately results in a whole person.

- Importance to knowledge

6.9. Classification and Types of Values

Neither is there a fair or unique order of values. Valuation hierarchies change easily according to context. The most common classification discriminates logical, ethical and aesthetic values, where intellectual values are found. Most of the classifications imposed are divided into"ethical values"and"moral values", but they have also been categorized as, according to Scheler

- Values of the pleasant and the unpleasant
- Vital values
- Vpiritual values: the beautiful and the ugly, the just and the unjust
- Values of pure knowledge of truth
- Religious values: the holy and the profane.

On the other hand, Marín, differentiates six groups:

- Technical, economic and utilitarian values
- Vital values: physical education and health education
- Aesthetic values: literary, musical and pictorial
- Intellectual values: humanistic, scientific and technical
- Moral values :individual and social
- Transcendental values: worldview, philosophy and religion

On the other hand, Francisco Leocata (1991) realizes a scale of values with the synthesis of Hartman, Scheler and Lavelle (2000) between which also it emphasizes to the intellectual values:

- Economic values: they have to do with the physical needs, the usefulness and the productivity of the human beings
- Sensitive-affective values or values of vitality: linked to the expression of the person with his way of feeling good and the sensitivity of pleasure
- **Aesthetic values**: mold the passage from the natural to the cultural

- **Intellectual values:** gather to demonstrate truth, knowledge, research and rationality
- **Moral values**: intersubjectivity, awareness and behavior in relation to other people
- Religious values: where beliefs and faith play an important role.

Finally, Ervilla (1998) does a classification between values and intellectual antivalores and relates them with the"rational nature of the human being". Intellectual values are defined as the essential virtues for the cognitive development of people: literacy, creativity, reflection. In opposition, the anti-values are: illiteracy, ignorance, dogmatism.

6.10. Anthropocentrism

Anthropocentrism of biodiversity refers to the human-centric perspective and approach towards biodiversity and its conservation. It reflects a viewpoint that primarily values biodiversity based on its benefits and usefulness to human beings, often overlooking the intrinsic value and rights of non-human species. In anthropocentric thinking, biodiversity is primarily seen through the lens of its instrumental value to humans. It is valued for the ecosystem services it provides, such as food production, clean water, climate regulation, and medicinal resources. Biodiversity is also recognized for its economic value, as it forms the basis for industries like agriculture, forestry, fisheries, and pharmaceuticals. Consequently, the conservation and preservation of biodiversity are often justified based on the tangible benefits and contributions it offers to human well-being, including economic prosperity and improved quality of life. While anthropocentrism recognizes the importance of biodiversity, it tends to prioritize human interests and needs above the intrinsic value of other species and ecosystems. This perspective may lead to the exploitation and overutilization of biodiversity resources, habitat destruction, pollution, and the introduction of invasive species. It may also result in the neglect or under appreciation of less visible or less immediately useful components of biodiversity.

Critics of anthropocentrism argue that it fails to acknowledge the inherent worth and rights of non-human species and ecosystems. They emphasize that biodiversity has value and rights independent of its usefulness to humans. This perspective, known as biocentrism or ecocentrism, highlights the importance of valuing and respecting all forms of life and ecosystems for their own sake, beyond their instrumental or economic significance.

Recognizing the limitations of anthropocentrism, conservation efforts are increasingly embracing more holistic approaches. Conservation strategies now strive to incorporate ecological, social, and ethical dimensions into decision-making processes. This includes the consideration of indigenous and local knowledge systems, community engagement, and the recognition of the intrinsic value and rights of biodiversity. Efforts are being made to adopt more inclusive and participatory approaches that incorporate diverse perspectives and cultural values in biodiversity conservation. Shifting away from the anthropocentrism of biodiversity involves recognizing the intrinsic value of non-human species, respecting their rights, and adopting more ecologically conscious and sustainable practices. It requires a shift towards a more balanced and inclusive approach that considers the well-being of all species and the long-term health and integrity of ecosystems. By embracing a more holistic perspective, we can better appreciate the richness and diversity of life on the earth and work towards the conservation and preservation of biodiversity for its own sake and for the benefit of future generations.

6.11. Studies on Intellectual Values

According to subjectivism, one of the main axiological theories, it is the subject who gives value and significance to things. In other words, things are not valued by themselves; it is the human being who gives them their valuation. The subjectivist visions are born of a psychologist theory. According to Muñoz,"to the extent that they presuppose that value depends and is based on the subject that values: thus from these theoretical positions, value has been identified with some psychological fact or state."

Subjectivism fits values within what is not real and what is not worth on its own, but the human group is who catalogue, categorizes and gives meaning to a specific value. The same assessment establishes that the values will depend on the approval of a group accepted in the company. The good and the bad will be delimited according to the judgment or valuation granted by the majority social group. From the point of view of axiological objectivism that is obviously opposed to subjectivism, the added value of things is not linked to individual experience.

According to Frondizi, this current is born as a"reaction against the implicit relativism in the subjectivist interpretation and the necessity to make foot in a stable moral order". This school posits that the values are ideal and objective that have a value independent of the estimates of the people and that they are real. In this way, although we are all unfair because we consider it a value, to say an example, justice still has value.

6.12. Summary

The value of biodiversity cannot be overstated, as it plays a vital role in sustaining life on our planet. This article explores the importance of biodiversity, highlighting its ecological, economic, and intrinsic value. Biodiversity is crucial for maintaining the balance of ecosystems. Recognizing the value of biodiversity, conservation efforts are crucial to mitigate its loss. Conservation strategies include the establishment of protected areas, habitat restoration, sustainable resource management, and the promotion of responsible consumption. International agreements and collaborations, such as the Convention on Biological Diversity (1992), aim to conserve and sustainably use biodiversity. Public awareness and education also play a vital role in fostering a sense of responsibility and encouraging individual actions to protect biodiversity. Biodiversity is a priceless asset that sustains of our planet's ecosystems, which provides economic benefits, supports vital ecosystem services, and holds cultural and intrinsic value. Protecting and conserving biodiversity is not only essential for the survival and well-being of human beings but also a moral imperative. By recognizing and valuing the importance of biodiversity, we can work towards a sustainable future where the wonders of nature thrive, and all life forms can coexist harmoniously.

6.13. Terminal questions

Q.1. What is the biodiversity? Discuss it Important.

Answer: --

Q.2. What is the value of biodiversity?

Answer: --

Q.3. Discuss the direct and indirect values of biodiversity.

Answer: --

Q.4. Discuss the monetizing the value of biodiversity.

Answer: ---

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Q.5. What is the Biocentrism? Discuss the **intellectual values of biodiversity.**

Answer: ---

--

Q.6. Discuss the classification and studies on intellectual values.

Answer: ---

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6.14. Further readings

15. Text book of Botany – Singh -Pande-Jain.

16. The elements of Botany- James Hewetson Wilson

17. Textbook of Biotechnology –H. K. Das

18. Biochemistry and molecular biology- Wilson Walker

19. Environmental Science, Subhas Chandra Santra, new central book agency, 3rd Edition, 2011

20. A text Book of Environment Studies, Asthana, D. K. and Asthana, M. 2006, S. Chand & Co

21. Ecology: Theories and Applications (4th Edition) by Peter Stiling; Prentice Hall.

Block-3 **PGEVS-101N**

Rajarshi Tandon Open University, Prayagraj

Ecosystem And Biodiversity Conservation

Block- 3

Conservation of biodiversity

UNIT -7

Concept and Strategies

UNIT-8

Biodiversity Conservation

UNIT-9

Threats to Biodiversity

Rajarshi Tandon Open University, Prayagraj

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Introduction

This third block of ecology and biodiversity conservation, this consists of following three units:

Unit-7: this unit covers national and international framework for biodiversity conservation. In addition, the conservation and treaties for conservation, habitat conservation plan and CBD convention also discussed in this unit.

Unit-8: This unit describes the In-situ, ex-situ conservation through sanctuaries, national parks, tiger reserves, biosphere reserves, zoos, zoological parks, and captive breeding. The role of government and non-governmental organizations in biodiversity conservation also discussed in this unit.

.**Unit-9:** This unit covers the threats to Biodiversity. The cause of biodiversity loss by habitat destruction, fragmentation, transformation, degradation and overexploitation are mentioned here. The impacts of pesticide, herbicide, air water and noise pollution on biodiversity depletion are also discussed in this unit.

Unit: 7: Concept and Strategies

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7.1. Introduction

Biodiversity conservation refers to the protection, upliftment, and management of biodiversity in order to derive sustainable benefits for present and future generations." Protection, restoration, and management of biodiversity in order to derive sustainable benefits for present and future generations. It can also be defined as, "the totality of genes, species, and ecosystems in a defined area. The variability of life on the earth is called biodiversity. Biodiversity takes into account all the living organisms present on Earth. Healthy and good biodiversity indicate a healthy and good ecosystem. Hence, biodiversity is very important. A healthy ecosystem also includes the availability of pure water, pure air, healthy land, a good climate, and the availability of nutrients on the earth. Therefore, biodiversity conservation plays an important role in the quality of life of all living organisms. The protection and management of biodiversity in obtaining sustainable development of resources is called biodiversity conservation.

Objectives

After reading this martial the students will be

- Able to preservation of the diversity of species.
- Sustainability of species and ecosystem.
- Maintaining life-supporting and essential ecological processes.

7.2. Biodiversity Conservation Overviews

Biodiversity conservation is the protection and management of biodiversity to obtain resources for sustainable development. Biodiversity conservation refers to the protection, preservation, and management of ecosystems and natural habitats and ensuring that they are healthy and functional. Biodiversity conservation has three main objectives:

- To preserve the diversity of species.
- Sustainable utilization of species and ecosystem.
- To maintain life-supporting systems and essential ecological processes.

Biodiversity refers to the various life forms that exist on the earth, including animals, plants, microorganisms, and the entire ecosystem they live in. Biodiversity is in the forms of biological resources, including genes, species, organisms, and ecosystems. Thus, the four main levels of biodiversity are species, genetic, ecosystem, and global biodiversity. Because of these characteristics, biodiversity plays a fundamental role in maintaining the aesthetic value of the environment, the integrity of the natural environment, and promotes the overall well-being of all plants and animals life. This calls for the need for biodiversity conservation for the survival of all living things and their natural habitats.

Hence, biodiversity conservation is all about protecting all organisms and species within their natural habitats with the aim of ensuring intergenerational equity. Activities such as habitat fragmentation, human disturbance, and habitat loss have to be adequately curtailed to enrich biodiversity conservation measures. Herein are the types, importance, and methods of biodiversity conservation.

7.3. Methods of Biodiversity Conservation

Biodiversity refers to the variability of life on the earth. It can be conserved in the following ways:

- *In-situ* Conservation
- *Ex-situ* Conservation

In-situ Conservation

In-situ conservation of biodiversity is the conservation of species within their natural habitat. In this method, the natural ecosystem is maintained and protected.

The in-situ conservation has several advantages. Following are the important advantages of in-situ conservation:

- It is a cost-effective and convenient method of conserving biodiversity.

- A large number of living organisms can be conserved simultaneously.
- Since the organisms are in a natural ecosystem, they can evolve better and can easily adjust to different environmental conditions.

Certain protected areas where in-situ conservation takes place include national parks, wildlife sanctuaries and biosphere reserves.

National Parks

These are limited reserves maintained by the government for the conservation of wildlife as well as the environment. Human activities are prohibited in national parks and they are solely dedicated to the protection of natural fauna of the area. They mostly occupy an area of 100-500 square km. currently there are a total of 104 national parks in India. The national parks may even be within a biosphere reserve. These are small reserves that are protected and maintained by the government. Its boundaries are well protected, where human activities such as grazing, forestry, habitat, and cultivation are restricted. **Example**- Kanha National Park, Gir National Park, Kaziranga National Park etc.

Wildlife Sanctuaries

Wildlife sanctuaries are protected areas meant only for the conservation of wild animals. A few human activities such as cultivation, wood collection, and other forest product collection are allowed here, but they must not interfere with the conservation of the animals. Tourist visits are also allowed in these areas. There are a total of 551 wildlife sanctuaries in India. These are the places where only wild animals can be found. Certain human activities like timber harvesting, cultivation, collection of woods, and other forest products are permitted unless they interfere with the conservation project. Recreation tourism is also permitted. **Example**- Ghana Bird Sanctuary, Abohar Wildlife Sanctuary, Mudumalai Wildlife Sanctuary, etc.

Biosphere Reserves

These are national governments nominated sites, large areas often up to 5000 square km of an ecosystem where the traditional lifestyle and natural habitat of the inhabitants of that ecosystem are protected. They are mostly open to tourists and researchers. **Example-** Sundarban, Nanda Devi, Nokrek, and Manas in India.

Ex-situ Conservation

Ex-situ conservation of biodiversity involves the breeding and maintenance of endangered species in artificial ecosystems such as zoos, nurseries, botanical gardens, gene banks, etc. There is less competition for food, water and space among the organisms. Ex-situ conservation has the following advantages:

- The animals are provided with a longer time and breeding activity.
- The species bred in captivity can be reintroduced in the wild.
- Genetic techniques can be used for the preservation of endangered species.

7.4. Strategies for Biodiversity Conservation

Following are the important strategies for biodiversity conservation:

- **Conservation of Ecosystems-** The intent of the conservation of biodiversity is to provide long term viability to the ecosystems. It is to make sure that ecological integrity is intact. The landscapes of the region which have undergone historical or evolutionary deterioration can be reinstated. The threats can be removed and the ecosystems should be able to continue with ecological processes.
- **Reverse the decline of species-** According to this strategy, the aim of conservation is to restore the population of declined species in a particular ecosystem.
- **Conservation of all biological aspects-** This strategy aims at giving cover and conserving food, livestock, microbial population, agricultural stock including plants and animals.
- All the varieties of food, timber plants, livestock, microbes and agricultural animals should be conserved.
- All the economically important organisms should be identified and conserved.
- Unique ecosystems should be preserved first.
- The resources should be utilized efficiently.
- Poaching and hunting of wild animals should be prevented.
- The reserves and protected areas should be developed carefully.
- The levels of pollutants should be reduced in the environment.

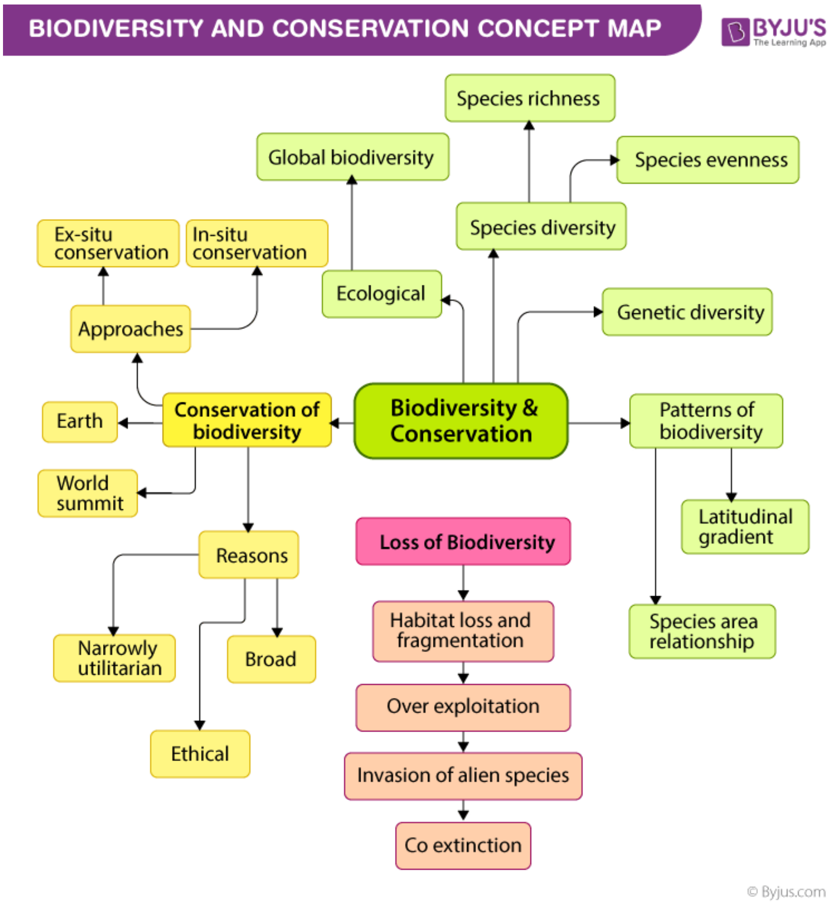
- Deforestation should be strictly prohibited.
- Environmental laws should be followed strictly.
- The useful and endangered species of plants and animals should be conserved in their nature as well as artificial habitats.
- Public awareness should be created regarding biodiversity conservation and its importance.

Why should we conserve Biodiversity?

It is believed that an area with higher species abundance has a more stable environment compared to an area with lower species abundance. We can further claim the necessity of biodiversity by considering our degree of dependency on the environment. We depend directly on various species of plants for our various needs. Similarly, we depend on various species of animals and microbes for different reasons. Biodiversity is being lost due to the loss of habitat, over-exploitation of resources, climatic changes, pollution, invasive exotic species, diseases, hunting, etc. Since it provides us with several economic and ethical benefits and adds aesthetic value, it is very important to conserve biodiversity.

7.5. Loss of Biodiversity

A number of factors like pollution, erosion, evolution, urbanization, industrialization, population, and depletion lead to the loss of biodiversity. Loss of biodiversity is very harmful to the ecosystem as it indicates either loss of species, or reduction of species in a natural habitat, or both of them on a global level. Loss of biodiversity has a poor impact on the ecosystem. Loss of biodiversity directly impacts the ecosystem and food chains in it. It affects agriculture and weakens the resistance to natural disasters like floods, drought, etc.



7.6. National Framework on Biodiversity

The Indian constitution encompasses the protection of environment and this sentiment is enshrined in article 48a and 51a (g) which states that "the state shall endeavor to protect and improve the environment and to safeguard the forests and wild life of the country and that it shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wild life, and to have compassion for living creatures."

In efforts to realize the constitutional mandate of environmental protection, India has planned and executed multiple policies, programs and laws and one of the important laws in relation to biological conservation and bringing into effect the convention on biological diversity (CBD) is the Biological Diversity Act 2002. There are multiple acts and rules related to biodiversity in India such as the Indian forests act, 1927, the air (prevention and control of pollution) act 1981, protection of plant varieties and farmer's rights (PPVFR) act, (2001) etc.

India was one of the first few countries to bring about a comprehensive legislation on biodiversity conservation. the biological diversity act, 2002 and the biological diversity rules notified in 2004 give effect to the objectives of the CBD which is to conserve biodiversity, to have sustainable use of its components and to have fair and equitable sharing of the benefits arising from genetic resources and is the primary legislation through which the access and benefit sharing mechanism enshrined in the Nagoya protocol is implemented in India.

Domestic Laws relating to Biological Diversity

- Biological Diversity Act, 2002
- Biological Diversity Rules, 2004
- Protection of Plant Varieties and Farmers' Rights (PPVFR) Act, 2001
- Wildlife (Protection) Act, 1972
- The Patents Act, 1970
- Environment (Protection) Act, 1986
- Water (Prevention and Control of Pollution) Act, 1974
- Water (Prevention and Control of Pollution) Cess Act, 1977
- Air (Prevention and Control of Pollution) Act, 1981
- Forest (Conservation) Act, 1980
- The Indian Forest Act, 1927

7.7. International framework on Biodiversity

The concept of conservation of wildlife, flora and fauna in the early 20th century international legal regime can be found in many International Legal instruments such as the international convention for the protection of birds of 1950, convention on international plant protection (1951) agreed measures for the conservation of Antarctic fauna and flora (1964) etc. this phase marked the beginning of a growing awareness of environmental concerns. With the end of World War II and the unprecedented progress of science and technology, a parallel issue that drew the concern of the international community was that of the exploitation of the nature and its resources that seemed to be accompanying the technological progress.

The first International legal instruments to have noted the importance of environmental conservation and which are still widely regarded as the beginning of the international environmental jurisprudence were the United Nations Conference on Human Environment held in 1972 and the Ramsar Convention on Wetlands adopted in 1971. Some of the subsequent major international instruments are the following:

- Convention on Biodiversity act, 1963
- The Cartagena protocol on Biodiversity
- Convention on wetlands, 1971
- UN convention on law of SEA, 1982
- International treaty on plant genetic resources for food and agriculture (ITPGRFA)
- Nagoya protocol on access and benefit sharing
- Convention on the conservations of migratory species of wild animals, 1979

The framework's theory of change assumes that transformative actions are taken to deploy solutions to reduce threats to biodiversity. Actions should ensure that biodiversity is used sustainably in order to meet the needs of peopl. It aims to ensure progress is monitored in a transparent and accountable manner with adequate stocktaking exercises to ensure that, by 2030, the world is on a path to reach the 2050 Vision for Biodiversity.

The theory of change is complementary to and supportive of the 2030 agenda for sustainable development. It also takes into account the long-term strategies and targets of other multilateral environment agreements, including the biodiversity-related Rio conventions, to ensure synergistic delivery of benefits from all the agreements for the planet and people.

Partnerships and Implementation

The framework is built upon the recognition that its implementation will be done in partnership with many organizations at the global, national and local levels to leverage ways to build a momentum for success. Its implementation will take a rights-based approach, recognizing the principle of intergenerational equity. Further, the framework's theory of change acknowledges that its implementation will require the engagement of actors beyond governments to include are following.

- Non-governmental organizations,

- Indigenous peoples and local communities,
- Women's groups,
- Youth groups
- Business and finance community.

7.8. International Conventions

International conventions are treaties signed between two or more nations that act as an international agreement. A treaty is a binding agreement between nation-states that forms the basis for international law. Authority for the enforcement of these treaties is provided by each signing party's adherence to the treaties. Conventions generally have built in mechanisms to ensure compliance, such as procedures for inspections. These treaties also include methods to enforce noncompliance, such as economic sanctions. Outside of internal mechanisms, states could resort to external enforcement methods through other escalations including the threat of military action.

The word "treaty" is used as a generic term embracing all kinds of international agreements which are known by motley of different names such as conventions, pacts, general acts, charters, statutes, declarations, covenants, protocol as well as the name 'agreements' itself. A treaty may be defined as an international agreement concluded between states in written form and governed by international law. A treaty is the agreement between two or more parties to solve an issue that affects the parties signing the treaty. A convention is the set of rules for the parties agreeing to the convention to solve an issue that affects larger part of the world. The Vienna convention on the law of treaties is an international agreement treaty between states.

The "Treaty on treaties", delineates the role of international treaties and conventions as a source of international law. As per Article 2 of the convention, 'treaty' means an international agreement concluded between states in written form and governed by international law, whether embodied in a single instrument or in two or more related instruments and whatever its particular designation.
In broad terms, treaties are of two kinds:

1. **Law Making Treaties:**

These are multilateral treaties and mainly intend to have universal or general relevance.

2. Treaty Contracts

These treaties apply only between two or small number of states. They are mainly bilateral treaties. It is only the first kind, the law-making treaties or the so-called general treaties, which are intended to have a universal and general application and thus they constitute a primary source of international law. Some of the examples of this kind of treaty are: the convention relating to the status of refugees, the United Nations convention on the law of the sea, the Geneva conventions, and the rome statute of the international criminal court. The treaty contracts or the so-called particular treaties are not directly a source of international law since their application is confined only to the contracting parties which are two or a small number of states, and they deal with limited affairs. This kind of treaty does not create new rules of public international law; rather it develops new rules of particular or regional application.

However, when a significant number of states accept and acknowledge such new rules formulated in this kind of treaty, as obligatory, these rules will become part of the public international law. Examples of such treaties are bilateral treaties on commercial and friendship relations, etc. the law-making treaties constitute a primary source of international law. Since the mid-nineteenth century, there has been an astonishing development of law making treaties. The rapid development of this kind of treaty has been due to the inadequacy of customs in meeting the pressing demands arising from the changes which have been transforming the whole structure of international life. Law-making treaties have been concluded to regulate almost every aspect concerning the international community. Treaties act as a direct source of rights and obligations for the states and they codify the existing customary source of law. These conventions are subject to certain rules that determine their application and authority. They are consent-based in the sense that states voluntarily agree to be bound by the terms of a certain treaty; that is, they consent to a treaty. The signing of the treaty by the representative of a state is either a means of expressing the final consent of the state to be bound by the treaty, or an expression of provisional consent subject to ratification, acceptance or approval.

A state is only governed by a treaty if it has ratified it. the means of expressing consent is dealt with in article 11 of the Vienna convention on the law of treaties, which states that 'the consent of a state to be bound by a treaty may be expressed by signature, exchange of instruments constituting a treaty, ratification, acceptance, approval or accession, or by any other means if so agreed'. The purpose of a treaty is to encourage countries/states to be signatories to it and increase its universality of application so as to hold them to the same standard of justice. Some examples of important treaties are: the charter of the United Nations, the four Geneva conventions of 1949, the Vienna convention on diplomatic relations of 1961, the international covenant on civil and political rights of 1966 and the convention on the law of the sea of 1982.

3. Treaties as Law

Treaties and conventions are significant sources of international law. They are considered "hard law". Treaties play the role of contracts between two or more parties, such as an extradition treaty or a defense pact. They can also act as legislation in order to regulate a particular aspect of international relations or form the constitutions of international organizations. Article 38 (1) (a) of the ICJ Statute, which uses the term "international conventions", concentrates upon treaties as a source of contractual obligation but at the same time, it also acknowledges the possibility of a state expressly accepting the obligations of a treaty to which it is not formally a party. For a treaty-based rule to be a source of law, rather than simply a source of obligation, it must either be capable of affecting non-parties or have consequences for parties more extensive than those specifically imposed by the treaty itself. A series or a recurrence of treaties laying down a similar rule may produce a principle of customary international law.

4. Treaties As Customs

Some treaties are the outcome of codifying existing customary law, such as laws governing the global commons i.e. those parts of the planet that fall outside national jurisdiction and to which all nations have access like atmosphere, deep sea bed. While the intent of a treaty is to establish a code of a general application, its efficacy depends upon the number of states that ratify or accede to the particular convention. Relatively few such instruments have a sufficient number of parties to be regarded as international law in their own right. The most evident example is the (1949) Geneva conventions for the protection of war victims which has been ratified by around 196 countries.

5. Enforcement of Treaties

Enforcement of treaties is done through various resolution mechanisms/ judicial organs like international court of justice, the international tribunal for the law of the sea, the permanent court of arbitration and the dispute settlement bodies of the world trade organization, among others.

6. **Efficacy of Treaties**

Treaties are generally binding only on states which become parties to them because there is a rule of customary international law, which requires all states to honour their treaties. If any state is coerced by another state to become a signatory to a particular treaty or if any state threatens any other state for the same, then such a treaty is void as per the Vienna convention on the law of treaties 1969. Article 52 of the Vienna convention on the law of treaties 1969 states that, a treaty is void if its conclusion has been procured by the threat or use of force in violation of the principles of international law embodied in the charter of the United Nations. Article 53 of the Vienna convention on the law of treaties 1969 deals with treaties conflicting with a peremptory norm of general international law. It states that, "a treaty is void if, at the time of its conclusion, it conflicts with a peremptory norm of general international law. For the purposes of the present convention, a peremptory norm of general international law is a norm accepted and recognized by the international community of states as a whole as a norm from which no derogation is permitted and which can be modified only by a subsequent norm of general international law having the same character.

7. **Termination of Treaties**

Article 59-64 of the Vienna Convention on the Law of Treaties 1969 deal with termination of treaties under various circumstances such as:

- mutual consent of parties
- fulfillment of purpose or object
- expiry of specified period for which a treaty was concluded
- withdrawal
- war between party states
- unforeseen change, or circumstances an obligation provided for in the treaty (rebus sic stantibus)
- material breach

7.9. Habitat Conservation Plans

The importance of preserving rare species was legally recognized in 1973 when the Endangered Species Act (ESA) was signed into federal law. The purpose of the ESA is not only to protect species that have been listed as threatened or endangered, but also to conserve the ecosystems upon which those species depend. In aiming to protect species in danger of becoming extinct, the ESA prohibits actions that have the potential to result in a "taking" of any listed species. The term "take" under the ESA refers to any attempt or action involving the harassment, harm, pursuit, hunting, shooting, wounding, killing, trapping, capturing, or collecting of any listed species. Under this definition, the alteration of habitat that results in injury to, or death of, any listed species by preventing essential behaviour such as breeding, feeding or sheltering, considered unlawful "harm". The United States Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) are the lead agencies tasked with the implementation of the ESA and are therefore responsible for regulating prohibited and allowable activities. While the primary objective of the ESA is the protection of endangered species, and the take of such species is considered unlawful, the ESA is not absolute.

In 1982, amendments were made to the 1973 ESA which authorize the secretary of the interior and the secretary of commerce to allow the take of federally endangered species act. Section 10 of the ESA requires that parties wishing to obtain an Incidental Take Permit must submit a conservation plan, hereafter referred to as a "Habitat Conservation Plan" or "HCP," with their application.

Since two-thirds of federally listed species have at least some habitat on private land, and some species have most of their remaining habitat on private land, the U.S. fish and wildlife service has developed an array of tools and incentives to protect the interests of private landowners while encouraging management activities that benefit listed and other at-risk species. Congress recognized the need for a process to reduce conflicts between listed species and economic development, so it amended the endangered species Act (ESA) in 1982 to add an exemption for incidental take of listed species that would result from non-federal activities. Non-federal entities must develop a conservation plan that meets specific requirements as identified in the ESA, apply for an incidental take permit, and, once issued, implement the project as specified in their permit. The habitat conservation plan program creates creative partnerships that allow public and private sectors to work with the service to address listed and at-risk species in an ecosystem context generate long-term commitments to conserve such species, and deliver regulatory assurances to project proponents.

What is a Habitat Conservation Plan?

A Habitat Conservation Plan (HCP) is a planning document designed to accommodate economic development to the extent possible by authorizing the limited and unintentional take of listed species when it occurs incidental to otherwise lawful activities. The plan is designed not only to help landowners and communities but also to provide long-term benefits to species and their habitats. HCPS describe the anticipated effects of the proposed taking, how those impacts will be minimized or mitigated, and how the conservation measures included in the plan will be funded. If the service finds an HCP meets the specified criteria, it issues an incidental take permit. This allows the permit holder to proceed with an activity that could otherwise result in the unlawful take of a listed species.

Who can participate?

Any non-federal entity (such as private companies, local or state governments, etc.) may pursue an incidental take permit for their otherwise lawful activity.

What is the applicant's role?

Working with the service, the potential applicant develops an HCP that assesses the likely impacts on target species from the proposed project, the steps that will be taken to minimize and mitigate those impacts, and how the steps will be funded. The plan also identifies any alternatives that could avoid the incidental take and the reasons why those alternatives are not being chosen. The applicant then applies to the service for an incidental take permit. An HCP that individual landowners can join may already exist in a given area. Such plans are known as programmatic HCPS and are often county- or even region-wide. HCPS can also include conservation measures for vulnerable plant and animal species that are not listed federally as endangered or threatened.

What are the benefits?

For the non-Federal permitted:

After receiving an incidental take permit for activities that would otherwise result in the unlawful take of listed species, they can move forward with their project having the assurance that such take will not be in violation of the ESA.

For the species:

HCPs can provide permanent protection and management of habitat for the species covered by the HCP. Incidental take permits make the elements of the HCP legally binding. While incidental take permits have expiration dates, the identified mitigation measures may extend into perpetuity. Violating the terms of an incidental take permit may constitute unlawful take under the ESA.

7.10. Convention on Biological Diversity (CBD)

The convention on biological diversity (CBD), known informally as the biodiversity convention, is a multilateral treaty. The convention has three main goals: the conservation of biological diversity; the sustainable use of its components; and the fair and equitable sharing of benefits arising from genetic resources. Its objective is to develop national strategies for the conservation and sustainable use of biological diversity, and it is often seen as the key document regarding sustainable development.

The convention was opened for signature at the earth Summit in Rio de Janeiro on 5 June 1992 and entered into force on 29 December 1993. The United States is the only UN member state which has not ratified the Convention. It has two supplementary agreements, the Cartagena Protocol and Nagoya Protocol.

The Cartagena Protocol on Biosafety to the Convention on Biological Diversity is an international treaty governing the movements of living modified organisms (LMOs) resulting from modern biotechnology from one country to another. It was adopted on 29 January 2000 as a supplementary agreement to the CBD and entered into force on 11 September 2003.

The Nagoya protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization (ABS) to the convention on biological diversity is another supplementary agreement to the CBD. It provides a transparent legal framework for the effective implementation of one of the three objectives of the CBD: the fair and equitable sharing of benefits arising out of the utilization of genetic resources. The Nagoya Protocol was adopted on 29 October 2010 in Nagoya, Japan, and entered into force on 12 October 2014.

2010 was also the international year of biodiversity, and the secretariat of the CBD was its focal point. Following a recommendation of CBD signatories at Nagoya, the UN declared 2011 to 2020 as the United Nations decade on biodiversity in December 2010. The convention's *strategic plan for biodiversity 2011-2020*, created in 2010, includes the Aichi biodiversity targets. The meetings of the parties to the convention are known as conferences of the parties (cop), with the first one (cop 1) held in Nassau, Bahamas, in 1994 and the most recent one (cop 15) in 2021/2022 in Kunming, China and Montreal, Canada.

In the area of marine and coastal biodiversity CBD'S focus at present is to identify ecologically or biologically significant marine areas (EBSAS) in specific ocean locations based on scientific criteria. The aim is to create an international legally binding instrument

(ILBI) involving area-based planning and decision-making under (UNCLOS) to support the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction (BBNJ).

Origin and scope

The notion of an international convention on biodiversity was conceived at a United Nations environment programme (UNEP) Ad Hoc working group of experts on biological diversity in November 1988. The subsequent year, the ad hoc working group of technical and legal experts was established for the drafting of a legal text which addressed the conservation and sustainable use of biological diversity, as well as the sharing of benefits arising from their utilization with sovereign states and local communities. In 1991, an intergovernmental negotiating committee was established, tasked with finalizing the convention's text.

A conference for the adoption of the agreed text of the convention on biological diversity was held in Nairobi, Kenya, in 1992, and its conclusions were distilled in the Nairobi final act. The convention's text was opened for signature on 5 June 1992 at the United Nations conference on environment and development (the Rio "earth summit"). By its closing date, 4 June 1993, the convention had received 168 signatures. It entered into force on 29 December 1993.

The convention recognized for the first time in international law that the conservation of biodiversity is "a common concern of humankind" and is an integral part of the development process. The agreement covers all ecosystems, species, and genetic resources. It links traditional conservation efforts to the economic goal of using biological resources sustainably. It sets principles for the fair and equitable sharing of the benefits arising from the use of genetic resources, notably those destined for commercial use. It also covers the rapidly expanding field of biotechnology through its cartagena protocol on biosafety, addressing technology development and transfer, benefit-sharing and biosafety issues. Importantly, the convention is legally binding; countries that join it are obliged to implement its provisions.

The convention reminds decision-makers that natural resources are not infinite and sets out a philosophy of sustainable use. While past conservation efforts were aimed at protecting particular species and habitats, the convention recognizes that ecosystems, species and genes must be used for the benefit of humans. However, this should be done in a way and at a rate that does not lead to the long-term decline of biological diversity.

The convention also offers decision-makers guidance based on the precautionary principle which demands that where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat. The convention acknowledges that substantial investments are required to conserve biological diversity. It argues, however, that conservation will bring us significant environmental, economic and social benefits in return.

Issues

Some of the many issues dealt with under the convention include:

- Measures the incentives for the conservation and sustainable use of biological diversity.
- Regulated access to genetic resources and traditional knowledge, including prior informed consent of the party providing resources.
- Sharing, in a fair and equitable way, the results of research and development and the benefits arising from the commercial and other utilization of genetic resources with the contracting party providing such resources (governments and/or local communities that provided the traditional knowledge or biodiversity resources utilized).
- Access to and transfer of technology, including biotechnology, to the governments and/or local communities that provided traditional knowledge and/or biodiversity resources.
- Technical and scientific cooperation.
- Coordination of a global directory of taxonomic expertise (global taxonomy initiative).
- Impact assessment.
- Education and public awareness.
- Provision of financial resources.
- National reporting on efforts to implement treaty commitments.

7.11. International Bodies Established

Conference of the Parties (COP)

The convention's governing body is the conference of the parties (COP), consisting of all governments (and regional economic integration organizations) that have ratified the treaty. This ultimate authority reviews progress under the convention, identifies new priorities, and sets work plans for members. The cop can also make amendments to the convention, create expert advisory bodies, review progress reports by member nations, and collaborate with other international organizations and agreements. The conference of the parties uses expertise and support from several other bodies that are established by the convention. In addition to committees or mechanisms established on an ad hoc basis, the main organs are:

CBD Secretariat

The CBD Secretariat, based in Montreal, Quebec, Canada, operates under (UNEP), the United Nations Environment Programme. Its main functions are to organize meetings, draft documents, assist member governments in the implementation of the programme of work, coordinate with other international organizations, and collect and disseminate information.

Subsidiary Body for Scientific, Technical and Technological Advice (SBSTTA)

The SBSTTA is a committee composed of experts from member governments competent in relevant fields. It plays a key role in making recommendations to the cop on scientific and technical issues. It provides assessments of the status of biological diversity and of various measures taken in accordance with convention, and also gives recommendations to the conference of the parties, which may be endorsed in whole, in part or in modified form by the COPs. As of 2020 SBSTTA had met 23 times, with a 24th meeting taking place in Geneva, Switzerland in 2022.

Protocols and plans developed by CBD

Cartagena Protocol (2000) the Cartagena protocol on biosafety, also known as the biosafety protocol, was adopted in January 2000, after a CBD open-ended adhoc working group on biosafety had met six times between July 1996 and February 1999. The working group submitted a draft text of the protocol for consideration by conference of the parties at its first extraordinary meeting, which was convened for the express purpose of adopting a protocol on biosafety to the convention on biological diversity. After a few delays, the Cartagena protocol was eventually adopted on 29 January 2000. The biosafety protocol seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology.

The Biosafety Protocol makes clear that products from new technologies must be based on the precautionary principle and allow developing nations to balance public health against economic benefits. It will, for example, let countries ban imports of a genetically modified organism if they feel there is not enough scientific evidence the product is safe and requires exporters to label shipments containing genetically modified commodities such as corn or cotton. The required number of 50 instruments of ratification/accession/approval/acceptance by countries was reached in May 2003. In accordance with the provisions of its Article 37, the Protocol entered into force on 11 September 2003.

Global Strategy for Plant Conservation (2002) In April 2002, the parties of the UN CBD adopted the recommendations of the gram canaria declaration calling for a global plant conservation strategy, and adopted a 16-point plan aiming to slow the rate of plant extinctions around the world by 2010.

Nagoya Protocol (2010) the Nagoya protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization to the convention on biological diversity was adopted on 29 October 2010 in Nagoya, Aichi prefecture, Japan, at the tenth meeting of the conference of the parties, and entered into force on 12 October 2014. The protocol is a supplementary agreement to the convention on biological diversity, and provides a transparent legal framework for the effective implementation of one of the three objectives of the CBD: the fair and equitable sharing of benefits arising out of the utilization of genetic resources. It thereby contributes to the conservation and sustainable use of biodiversity.

7.12. Summary

Biodiversity conservation refers to the protection and preservation of the variety of life forms on earth, including plants, animals, and microorganisms, as well as their habitats and ecosystems. It is a crucial aspect of environmental sustainability and involves the maintenance of the intricate web of interactions among species, which ultimately supports the well-being of ecosystems and human societies. The concept and strategy for biodiversity conservation revolve around the preservation of ecosystems, species, and genetic diversity, while promoting sustainable practices and raising awareness about the importance of biodiversity. by implementing these strategies at local, regional, and global scales, we can strive towards a more sustainable and biodiversity future. Conservation efforts focus on identifying and safeguarding endangered species, especially those that play key ecological roles or have high cultural or economic value. Strategies include habitat protection, captive breeding and reintroduction programs, and regulation of trade in endangered species. Effective conservation requires collaboration among governments, non-governmental organizations (NGOS), local communities, scientists, and other stakeholders. International agreements and policies, such as the convention on biological diversity (CBD), provide a framework for coordination and implementation of conservation efforts. Public awareness and education play a vital role in biodiversity conservation. By fostering an understanding of the importance of biodiversity and the threats it faces, individuals and communities can be inspired to take action and make informed decisions to protect and conserve ecosystems.

7.13. Terminal questions

Q.1: What do you understand by biodiversity?

Answer: --

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Q.2: What is meant by biodiversity conservation?

Answer: --

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Q.3: How can we conserve biodiversity?

Answer: --

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Q.4: Why is it important to conserve biodiversity?

Answer: --

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Q.5: What are the different methods of conserving biodiversity?

Answer: --

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Q.6: What is CBD convention? Discuss the national and international treaty for biodiversity conservation.

Answer: --

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Q.7: Discuss the international bodies established for biodiversity conservation.

Answer: --

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7.14. Further readings

1. Text book of Botany – Singh -Pande-Jain.
2. The elements of Botany- James Hewetson Wilson
3. Biochemistry and molecular biology- Wilson Walker
4. Environmental Science, Subhas Chandra Santra, new central book agency, 3rd Edition, 2011
5. A text Book of Environment Studies, Asthana, D. K. and Asthana, M. 2006, S. Chand & Co
6. Biodiversity: a beginner's guide, john I. spicer, One world Publications.

Unit-8: Biodiversity conservation

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8.1. Introduction

The conservation of biodiversity is the practice of protecting the natural environment and, its various plant and animal species. This is done through various methods such as the protection of natural areas, the promotion of sustainable practices, and the restoration of degraded ecosystems. The conservation of biodiversity is important because it helps to maintain the natural balance of the environment and it also provides a variety of economic and social benefits. Biodiversity is the variety of life on the Earth, and is one of the planet's most important resources. The conservation of biodiversity is the practice of protecting the natural environment and its many species. This can be done through the establishment of protected areas, such as national parks and natural reserves, and by encouraging responsible land-use practices. The conservation of biodiversity important for a number of reasons. First, it is necessary to maintain the ecosystems that provide us with essential services, such as clean air and water. Second, many of the world's medicinal plants come from biodiversity hotspots, and so it is important to protect these regions in order to ensure that we continue to have access to new drugs. Biodiversity is important for tourism, and many people visit parks and reserves to see the amazing array of plants and animals that exist there. Finally, it is simply morally wrong to destroy species just for the sake of it, when we have no need to do so. There are a number of ways that we can help to conserve biodiversity. First, we can reduce our consumption, especially of resources that are derived from endangered species. Second, we can support the establishment of protected areas and the funding of conservation projects. Third, we can vote for politicians who are committed to conservation, and we can speak out about the importance of biodiversity. Finally, we can educate ourselves and our children about the importance of conserving the planet's biodiversity.

Objectives

- to discuss the biodiversity conservation and its types
- To know the concepts of sanctuaries, national parks and tiger reserves
- To discuss biosphere reserves, zoological parks and captive breeding
- To know about role of governmental and non-government organization in its conservation

8.2. Biodiversity Conservation

Conservation of biodiversity is considered as key component for administration of natural assets. Biodiversity is an all-encompassing concept that describes the magnitude of ecological diversity. Biodiversity is the wide range of life associated with different types of framework for biodiversity. The warnings to biodiversity involve: habitat fragmentation, stressing the already squeezed natural resources, deforestation; annexation of invasive species and climate alternation. Because environmentalists and the public have become increasingly aware of these threats, preventive ecosystem protection has become an essential component of Natural resource management (NRM). Decision making relies on facts leading to strong quality of evidence, the restriction of specific activities and knowledge and control criteria. Numerical evidence is required before making the policy of safety measure. Such activities should be banned if the imminent threat of operations is deemed a serious and permanent risk. Conservation of biodiversity in natural heritage sites including sacred groves, protected areas and other biodiversity 'hotspots' is crucial for maintaining the resilience of ecosystems. The lagoons of Lakshadweep are a very unique ecosystem harboring wide diversity of marine flora and fauna, which needs to be conserved on top priority. Specific actions are included in the following existing programme for biodiversity conservation, which has climate change effect inbuilt, study of the status of corals and lagoons and mangroves by the concerned government department.

- *In-situ and ex-situ* conservation of genetic resources, especially of threatened flora and fauna
- Creation of biodiversity registers at national, district and local levels for documenting genetic diversity and the associated traditional knowledge.
- Management of non-biodegradable wastes, which is very crucial to check pollution

8.3. Methods of Biodiversity Conservation

The process of conservation of biodiversity involves sustainable development. It also involves in *situ* conservation where conserving and protecting the ecosystem will protect the entire biodiversity. At the same time, it includes *ex-situ* conservation, which involves conservation measures when an organism is endangered. Therefore, this means that the conservation methods of biodiversity aim at preservation, maintenance, conservation, recovery, and enhancement as discussed below:

1. Protection against degradation and destruction of natural ecosystems

Biodiversity conservation involves promoting a balance between the environment, society, and development in line with the sustainable development goals. The present society should develop conservation strategies that meet their need without compromising that of the future generation. Having a balance between the development of the environment and society results in ensuring the achievement of biodiversity conservation. Through properly enforced policies, sustainable development can be achieved. Environmental institutions can enforce these conventions.

2. Maintain, restore, and increase ecological systems while promoting the implementation of better conservation practices

It involves the in-situ and ex-situ methods. In situ conservation involves the conservation of the whole ecosystem and the natural habitats. It also includes the maintenance and recovery of a variety of species and degraded ecological systems such as damaged forest areas and heavily polluted lakes, rivers, and lands, among other natural environments. The ex-situ conservation involves the strategic protection of biodiversity hotspots for endangered species and habitats. *In-situ* conservation refers to the conversation within natural habitat or original location while *ex-situ* conservation refers to conversation out of target area.

3. Identification and protection of endangered species

Ex-situ biodiversity conservation aims to reduce the ongoing extinction up to 30% or higher by mainly focusing on two things. First is the focus on conservation of biodiversity in their natural habitats in places like museums, arboretums, zoos, and gene bank etc. High biodiversity areas should be covered in the form of natural parks, sanctuary, biosphere reserves etc. The second strategy focuses on captive conservation methods that involve the protection of endangered species. This type of conservation is a collective responsibility of all nations. An example is the Earth Summit, which was held in Rio de Janeiro, asking nations to take appropriate measures towards the protection of vulnerable habitats and species.

4. Establishing buffer zones to prevent any alteration in the balance of natural ecosystems

Biodiversity conservation prioritizes on establishing control measures that maintain the balance of natural ecosystems such as water balance, soil ecology, and genetic as well as species balance. It involves inter-generational and intra-generational equity that allows equitable sharing of resources and the benefits derived from natural habitats to ensure social and ecological stability. Some of the conservation efforts that have been advanced under this category include the World Conservation Union, International Board for Plant Genetic Resources, and UNESCO program on Man and Biosphere.

5. Science, Technology and Research-Tools for conserving biodiversity

As our society develops, it leads to improved science and technology. Science, and specifically ecology, helps scientists to understand the web of interactions in our biomes and pinpoint the key species in ecosystems. This information is used to guide conservation efforts. The same is also used to understand pollution and its cascading effects within an ecosystem as Bio-magnification of toxins in a food chain can cause huge problems for top predators. Technology is becoming vital in conservation biology. Sustainable technologies, like renewable energies, biodegradable packaging, and recycling, help reduce human impact on the environment. There are also technologies like cloning that give scientists the ability to bring back species that are already considered extinct.

8.4. Biodiversity conservation strategies

There are two basic conservation strategies, each composed of various techniques. The conservationist can adopt to conserve genetic diversity once it has been located. The two strategies are *ex situ* and *in situ* conservation. Article 2 of the Convention on Biological Diversity (CBD, 1992) provides the following definition of these categories: *Ex situ* conservation means the conservation of components of biological diversity outside their natural habitats. *In situ* conservation means the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties.

8.5. *In situ* biodiversity conservation

In-situ biodiversity conservation refers to the conservation of biological diversity within its natural habitat or original location. It involves protecting and managing ecosystems, species, and genetic resources in their native environment. There is an obvious fundamental difference between these two strategies: *ex situ* conservation involves the sampling, transfer, and storage of target taxa from the target area, whereas *in situ* conservation involves the designation, management, and monitoring of target taxa where they are encountered. Because of this fundamental difference, there is little overlap between the two strategies.

8.5.1. Wildlife Sanctuaries

Wildlife sanctuary can be defined as the area in which the birds and animals are protected and are kept safely in their natural habitats protecting them from the illegal activities like poaching and trafficking. Other terms for wildlife sanctuary are natural reserve, biosphere reserve or a conservation area. They are important for studies and research purposes. These are directly controlled by the government and are also owned privately by charities and research institutes. In these areas, there are strict prohibitions against killing, poaching or capturing of the birds and animals present there. These are mainly established for the protection of species that are endangered. Furthermore, human activities are not allowed here and no disturbances are allowed in these areas. The surroundings of the wildlife habitats are also protected and no disturbances are allowed in these areas too. India has about 543 wildlife sanctuaries that cover an area of 118,918 square kilometers in total. The wildlife sanctuaries aim to protect the natural habitats and the animals dwelling on it. The country has many beautiful sanctuaries which are covered with large rivers, forests and beautiful mountains too.

Wildlife Sanctuaries in India

In India, there are about 543 wildlife sanctuaries which cover a total of 118,918 square kilometers. Tourism is not permitted in a wildlife sanctuary. People are not allowed unescorted there. The main objective of establishing a wildlife sanctuary is to educate humans as to how to treat the animals. The animals are taken care of and allowed to live peacefully in their natural habitats. Some of the prominent ones are:

Table.8.1: Wildlife Sanctuaries in India

S. No.	Name of Wildlife Sanctuaries	State
1.	Bharatpur Bird Sanctuary	Rajasthan
2.	Chilika Lake Bird Sanctuary	Odisha
3.	Chinnar Wildlife Sanctuary	Kerala
4.	Gir National Park and Wildlife Sanctuary	Gujarat
5.	Govind Wildlife Sanctuary	Uttarakhand
6.	Madumalai Sanctuary	Tamil Nadu
7.	Periyar Wildlife Sanctuary	Kerala

Bhadra Wildlife Sanctuary, Karnataka:

A protected area as well as a tiger reserve is located 23 kilometres south of Bhadravathi and 38 kilometres Northwest of Chikmagalur in Karnataka. It was first declared a Wildlife Sanctuary in 1951 by the Government of Mysore. It was then declared as a Project Tiger Reserve in 1998. It is a hotspot of biological diversity consisting of about 120 plant species and a number of wild animals including wild boar, elephants, black leopard, sambar, jackals and many birds.

Gir National Park and Wildlife Sanctuary:

It is a forest and wildlife sanctuary near Gujarat in an area known as Talala Gir. The sanctuary is also known as Sasan Gir. It was established in the year 1965 and consists of a total area of 1,412 square kilometres. More than 400 species of plants have been recorded here along with a count of 2,375 distinct species of animals and birds. This wildlife sanctuary mainly aims at the preservation and increase in population of the Asian Lion which is an endangered species.

Chinnar Wildlife Sanctuary, Kerala:

This Sanctuary is located 18 kilometres north of Marayoor, in the Devikulam taluk of the Idukki district of Kerala. It is one among the twelve wildlife sanctuaries in the protected areas of the state. It is the only rehabilitation centre in India for the Indian Star Tortoise. There are about 600 species of animals and birds along with about 963 species of flowering plants.

Senchal Wildlife Sanctuary:

It was set up in the year 1915 in Darjeeling in the state of West Bengal and covers an area of 38.6 square kilometres. It is a habitat for animals like a jungle cats, Assam macaque, Rhesus monkeys, Himalayan flying squirrel, Indian leopards and is also rich in birdlife.

Pani Dihing Wildlife Sanctuary:

This wildlife sanctuary is located in the Sivasagar district of Assam and occupies about 33.93 square kilometres. It was mainly established as a Bird Sanctuary in the year 1999. The Brahmaputra river and the Disang river border it in the northwest and south respectively. Birds from about 267 different species can be found here. About 70 species of migratory birds have also been seen and identified here. Some of the commonly seen birds are a bar-headed goose, spot-billed ducks, ferruginous duck, white-necked stork and red-crested pochard. Rare birds like the white-rumped vultures and griffins have been seen at the sanctuary. This sanctuary is a paradise for bird watchers and a lot of people have been seen visiting this sanctuary.Other Wildlife Sanctuaries worth mentioning are the Chilika Bird Sanctuary, Govind Wildlife Sanctuary, Dandeli Wildlife Sanctuary and Periyar Wildlife Sanctuary.

Importance of Wildlife Sanctuaries

There are a number of reasons for establishing wildlife sanctuaries. Some of the reasons are listed below:

- The wildlife sanctuaries are established to protect the endangered species.
- It is quite difficult to always relocate the animals from their natural habitat, therefore, protecting them in their natural environment is advantageous.
- The endangered species are specially monitored in the wildlife sanctuaries. If they reproduce and grow in number while under protection, few specimens can be kept for breeding in the conservation parks for their survival.
- Biologist activities and researches are permitted in the wildlife sanctuaries so that they can learn about the animals living there.
- A few sanctuaries take in injured and abandoned animals and rehabilitate them to health before releasing them in the forest.
- Wildlife sanctuaries preserve the endangered species and protect them from humans and predators.

Protection of Endangered Species

Many species of plants and animals are on the verge of extinction. Such creatures are conserved in the wildlife sanctuaries. Various sanctuaries have been established such as the

Fleurieu peninsula sanctuary is maintained to protect sheoak habitat for glossy black cockatoos.

Conservation of Biodiversity

The landowners of a wildlife sanctuary are involved in:

- Production and distribution of electricity.
- Horticulture, grazing and farming enterprises
- Wine production
- Organic horticulture

Ecotourism

Many sanctuaries are involved in ecotourism. They offer accommodation, tour guides, nature walks, etc.

Education and Public use

The sanctuaries that are created on public land are involved in public use along with the conservation of biodiversity. For example-golf courses, picnic areas, lakes for boating and swimming.Thus we know that a wildlife sanctuary is one of the finest ways of preserving the endangered species.

8.5.2. National Parks

National parks are areas that aim to protect the natural environment. They are also involved in public recreation and enjoyment activities. In a national park, the landscapes and its flora and fauna are present in their natural state. India is rich in biodiversity. It comprises about 7.6% mammals, 6.2% reptiles, 12.6% birds, and 6.0% flowering plant species under the Indomalayan ecozone. Many eco-regions of our country like Shola forests exhibit high rates of endemism.

The forests cover over the ranges from the tropical rainforest, the Western Ghats, and Northeast India to the coniferous forests in the Himalayan region. The significant terrestrial ecosystem coming along the Indomalayan ecozone consists of temperate, polar, wet, dry regions for different kind of species to live. The species include elephant, tiger, cobra, crocodile, apes, sambar deer, spotted deer, rhinoceros, goats, lions along with different types of flora and fauna. Indian wildlife has around 99 world-recognized national parks in different parts of the country. All these national parks and the wildlife reserves have been recognized by the IUCN or the International Union for the Conservation of Nature under the second category of protected areas.

List of National Parks in India

National parks provide a haven for wildlife away from civilization. India has currently over 100 national parks distributed across the country, stretching across various biomes.The Hailey National Park is the first national park in India. It is one of the finest examples of ecological conservation. The other national parks in India include:

1. Bandipur National Park in Karnataka
2. Bandhavgarh National Park in Madhya Pradesh
3. Bhadra Wildlife Sanctuary in Karnataka
4. Chinnar Wildlife Sanctuary in Kerala
5. Corbett National Park in Uttarakhand
6. Dandeli Wildlife Sanctuary in Karnataka
7. Dudhwa National Park in Uttar Pradesh
8. Gir National Park and Sasan Gir Sanctuary in Gujarat
9. Hemis National Park in Jammu and Kashmir
10. Kanha National Park in Madhya Pradesh
11. Kaziranga National Park in Assam
12. Keoladeo Ghana National Park in Bharatpur, Rajasthan
13. Manas National Park in Assam
14. Nagarhole National Park in Karnataka
15. Panna National Park in Madhya Pradesh
16. Periyar National Park in Kerala.
17. Pench National Park in Madhya Pradesh
18. Ranthambore National Park in Rajasthan
19. Sariska National Park in Rajasthan
20. Tadoba Andhari Tiger Reserve in Maharashtra
21. The Great Himalayan National Park in Himachal Pradesh

All these national parks are an abode to a large number of wild animals because of the optimum environmental conditions with proper upbringing and breeding facilities.

8.5.3. Biosphere Reserve

Biosphere reserves are the protected areas meant for the conservation of plants and animals. It also restores the traditional life of the trials living in that vicinity. They conserve the biodiversity of that area. There are 18 Biosphere Reserves in India established by the government that protect large areas of natural habitats. These areas are provided with the buffer zones that are open for some economic uses. Not only the flora and fauna but also the humans inhabiting these areas are protected. The biosphere reserves are identified by the Man and Biosphere Reserve Program to promote sustainable development. This program was initiated by UNESCO in 1971.This program recognizes areas which are:

- The world's most typical terrestrial and coastal ecosystems.
- That exhibit approaches to live and works in harmony with nature.
- That demonstrates the achievement of a sustainable balance between conserving natural ecosystems and biodiversity.

Zones of Biosphere Reserve

There are three biosphere reserve zones:

- Core
- Buffer
- Manipulation

Core Zone

This is a legally protected area where human intervention is strictly prohibited. It is the innermost undisturbed ecosystem. The information from these areas helps to assess the sustainability of activities, or maintenance of environmental quality in the surrounding areas.

Buffer Zone

The area surrounding the core zone is the buffer zone. Here only the research and education activities are permitted to humans. These activities should not obstruct the conservation objectives of the core area. This area also includes activities that help to manage natural vegetation, agricultural land, fisheries, or forests to enhance the quality of production. This zone might also include recreation and tourism facilities. Human activities are less intensive in this zone as compared to the transition zone.

Manipulation Zone

It is the peripheral area of a biosphere reserve where human activities like cropping, recreation, forestry, and settlements are permitted with the cooperation of reserve management and local people. Through these activities, the degraded area is resumed to its natural form. The local communities, scientists, conservation agencies, cultural groups, and other stakeholders work in this zone to use the area in a sustainable way for the welfare of humans living there.

Biosphere Reserves in India

Biosphere Reserves in India are as under:

Table: list of Biosphere Reserves in India

Name of Biosphere Reserves	States
Nilgiri Biosphere Reserve (2000)	Tamil Nadu, Kerala, Karnataka
Sundarbans Biosphere Reserve (2001)	West Bengal
Gulf of Mannar Biosphere Reserve (2001)	Tamil Nadu
Nanda Devi Biosphere Reserve (2004)	Uttarakhand
Simlipal Biosphere Reserve (2009)	Odisha
Pachmarhi Biosphere Reserve (2009)	Madhya Pradesh
Nokrek Biosphere Reserve (2009)	Meghalaya
Achanakmar-Amarkantak Biosphere Reserve (2012)	Chhattisgarh, Madhya Pradesh
Great Nicobar Biosphere Reserve (2013)	Great Nicobar
Agasthyamalai Biosphere Reserve (2016)	Kerala and Tamil Nadu
Khangchendzonga National Park (2018)	Sikkim

Importance of Biosphere Reserves

The importance of biosphere reserves is mentioned below:

Conservation

Biosphere reserves conserve the species, ecosystems, genetic diversities, and landscapes without affecting the inhabitants.

Development

It ensures sustainable developments including economic, cultural, social and economic developments.

Restoration

The biosphere reserves restore any damage caused to the ecosystems and habitats.

Education and Research

These areas provide a lot of information on how to restore, conserve, and develop the ecosystem. The researches provide ways to recreate landscapes that have been affected by human activities.

Land Use Planning

All the landowners, public institutions, farmers, scientists, industry, and conservation groups found in these areas can work together to look for comprehensive land management.

Healthy Ecosystems

They help in maintaining healthy ecosystems by preventing soil erosion, protecting water springs, and maintaining the decomposers to maintain the soil quality. Thus, we know that biosphere reserves are a great source for biodiversity conservation.

8.5.4. Tiger Reserves

The Bengal tiger was declared a National animal of India in April 1973 under the initiative of project tiger. Prior to this, the lion was considered the National animal of India. In order to conserve tigers as they were considered an endangered species according to the IUCN Red Data book, The Tiger Reserve of India was established in 1973. Presently, there are 53 tiger reserves in India, which are governed by project tiger and are administered by the National Tiger **Conservation Authority (NTCA).** India is home to 80% of the tiger's world population. The Latest added tiger reserve is Guru Ghasidas National Park of Chhattisgarh is the 53rd Tiger Reserve in India as of 2022). According to the **Tiger census Report 2018** (held once every four years), the total count of tigers has risen to 2,967 in 2018 from 2,226 in 2014. So here is the list of 53 tiger reserves with their total area.

List of 53 Tiger Reserves in India

Below is the list of the 53 tiger reserves In India. Recently, in 2022, 53rd tiger reserve in India has been approved by National Tiger Conservation Authority (NTCA), that is, Guru Ghasidas National Park Of Chhattisgarh which is also the 4th Tiger Reserve of Chhattisgarh.

S. No.	**State/UT**	Name Of Tiger Reserve	Total area (sq. Kms.)
1	Andhra Pradesh	Nagarjunsagar Srisailam	3296.31
4	Arunachal Pradesh	Pakke	1198.45
9	Bihar	Valmiki	899.38
11	Chattisgarh	Achanakmar	914.01
13	Jharkhand	Palamau	1129.93
14	Karnataka	Bandipur	1456.3
19	Kerala	Periyar	925

20	Kerala	Parambikulam	643.66
21	Madhya Pradesh	Kanha	2051.79
27	Maharashtra	Melghat	2768.52
33	Mizoram	Dampa	988
35	Odisha	Satkosia	963.87
38	Rajasthan	Mukandra Hills	759.99
39	Tamil Nadu	Kalakad-Mundanthurai	1601.54
44	Telangana	Amrabad	2611.39
45	Uttar Pradesh	Dudhwa	2201.77
50	West Bengal	Buxa	757.90
51	Tamil Nadu	Srivilliputhur Megamalai	1016.57
52.	Rajasthan	Ramgarh Vishdhari Wildlife Sanctuary	252
53.	Chhattisgarh	Guru Ghasidas National Park(Sanjay National Park)	466.67

Top 10 Largest Tiger Reserves in India

1. Nagarjunsagar Srisailam (3296.31 sq.km.)

This tiger reserve is one of the largest tiger reserves in India. Nagarjunsagar Tiger reserve is spread over 5 districts in Andhra Pradesh and Telangana. The area consists mostly of the Nallamala Hills. The multipurpose reservoirs- Srisailam and Nagarjunasagar are located in the reserve. This is home to a variety of wild animals such as the Bengal tiger, leopard, pangolin, Indian rock python, etc.

2. Manas National Park (3150.92 sq.km.)

Manas National Park is located in the Himalayan foothills in Assam. The park is known for its rare and endangered endemic wildlife. Manas National Park is more than a National Park, it has been listed as a UNESCO World Heritage Site, Tiger Reserve, Elephant Reserve, Biosphere Reserve, and National Park. It is home to a variety of species of fauna such as One-horned Rhinoceros, Asiatic Elephants, Indian Tigers, Clouded leopards, Hoolock Gibbons, and Barking Deer, etc.

3. Similipal National Park (2750 sq.km.)

Simlipal National Park is a national park and a tiger reserve in the Mayurbhanj district in the Indian state of Odisha. The area of Simlipal reserve is gifted with great bio-diversity and ultimate varieties of faunas in the ranges with the ambience of cool breeze emerging out of the dense forests. There are many small waterfalls that add character to the Royal Bengal Tiger in the reserve.

4. Sunderbans Tiger Reserve (2584.89 sq.km.)

Sundarban the world’s largest delta is located in India and Bangladesh. Sundarbans National Park is located in the southern part of West Bengal. Sundari trees can be found in abundance in this forest. The Royal Bengal tigers are well-known in Sundarban.This national park is designated by UNESCO as World Heritage Site. It is well known for the conservation of tiger under project tiger.

5. Dudhwa Tiger Reserve (2201.7748 sq.km.)

The Dudhwa Tiger Reserve is a protected area in Uttar Pradesh located on the India-Nepal border. It stretches mainly across the Lakhimpur Kheri and Bahraich districts. The Dudhwa national park has a number of species of birds, reptiles, wild elephants, aquatic animals, one-horned rhinos, and wild elephants besides its enriched flora and fauna. Its undisturbed natural forest cover, vast spans of grasslands, and wetlands. It is the only place in U.P. where both tigers and rhinos can be spotted together.

6. Satpura Tiger Reserve(2133.30 sq.km.)

Satpura Tiger reserve is located in the south of River Narmada in the district of Madhya Pradesh. Satpura National Park is rich in biodiversity. The animals here include leopard, sambar, chital, Indian muntjac, nilgai, four-horned antelope, Chinkara, wild boar, bear, black buck, fox, porcupine, flying squirrel, mouse deer, and Indian giant squirrel.

7. Namdapha Tiger Reserve (2052.82 sq.km.)

Namdapha Tiger Reserve is located in the Changlang district in Andhra Pradesh. It is the only park in the World to have the four Feline species of big cat namely the Tiger, Leopard, Snow Leopard, Clouded Leopard, and the number of Lesser cats.

8. Kanha Tiger Reserve (2051.79 sq.km.)

Kanha National Park was created on 1 June 1955 and in 1973 was made the Kanha Tiger Reserve. It stretches over an area spread in the two districts Mandla and Balaghat. The park has a significant population of the Royal Bengal tiger, Indian leopards, the sloth bear, barasingha, and Indian wild dog.

8.6. *Ex situ* conservation

Ex situ conservation literally means, off-site conservation. It is the process of protecting an endangered species, variety or breed, of plant or animal outside its natural habitat. ForExample, is removing the part of the population from a threatened habitat and placing it in a new location, an artificial environment which is similar to the natural habitat of the respective animal and within the care of human's i.e. zoological parks and wildlife sanctuaries. In *ex-situ* conservation involves the removal of species from their native environment and their preservation and management in controlled settings such as zoos, botanical gardens, seed banks, and captive breeding programs. The degree to which humans control or modify the natural dynamics of the managed population varies widely, and this may include alteration of living environments, reproductive patterns, access to resources, and protection from predation and mortality. *Ex-situ* management can occur within or outside a species' natural geographic range. Individual's maintained *ex-situ* exist outside an ecological niche. This means that they are not under the same selection pressures as wild populations, and they may undergo artificial selection if maintained *ex situ* for multiple generations. Agricultural biodiversity is also conserved in *ex-situ* collections. This is primarily in the form of gene banks where samples are stored in order to conserve the genetic resources of major crop plants and their wild relatives. Some examples of ex situ biodiversity conservation are

8.6.1. Aquariums

Aquariums play a vital role in *ex-situ* conservation by housing and breeding endangered species. They provide suitable habitats, veterinary care, and breeding programs to ensure the survival of endangered animals and raise awareness about their conservation.

8.6.2. Botanical Gardens

Botanical gardens provide *ex-situ* conservation by maintaining living plant collections outside their natural habitats. This approach safeguards plant species from extinction risks associated with habitat loss, climate change, or other threats. By preserving diverse plant species, botanical gardens act as a reservoir of genetic diversity that can be used for research, education, and future restoration efforts. Botanical gardens serve as living museums that house diverse collections of plants, including rare, endangered, and threatened species. Botanical garden conservation involves several activities aimed at preserving plant diversity and promoting sustainable practices. Some key aspects of botanical garden conservation are such as:

- **Collection and Documentation:** Botanical gardens collect and maintain living plant specimens from various regions, including native and exotic species. These collections often include plants of scientific, ecological, or cultural significance. Each plant is carefully documented, with detailed information on its taxonomy, distribution, habitat, and conservation status. This documentation helps in cataloging and preserving plant diversity for future reference.

- **Plant Propagation and Research:** Botanical gardens engage in plant propagation through various methods, including seed germination, vegetative propagation, and tissue culture. This process allows for the cultivation and multiplication of plant species, including those that are rare or endangered. Additionally, botanist and taxonomist cam conduct research in botanical garden on plant biology, ecology, and conservation techniques, contributing to the scientific knowledge and understanding of plant species.
- **Seed Banks and Cryopreservation**: Many botanical gardens operate seed banks that store seeds from a wide range of plant species. These seed banks help preserve plant genetic materials for long-term conservation. Some botanical gardens also employ cryopreservation techniques, which involve freezing plant tissues, seeds, or embryos at ultra-low temperatures. Cryopreservation ensures the long-term viability of plant material and serves as an insurance policy against catastrophic events or loss of genetic diversity.
- **Education and Outreach:** Botanical gardens play a crucial role in raising awareness about plant conservation. They offer educational programs, workshops, guided tours, and exhibitions to inform visitors about the importance of plant biodiversity and conservation efforts. Botanical gardens also collaborate with local communities, schools, and conservation organizations to promote sustainable practices and conservation initiatives.
- **Rare and Endangered Species Recovery**: Botanical gardens often participate in rare and endangered species recovery programs. They collaborate with conservation agencies, government bodies, and other stakeholders to propagate and reintroduce threatened plant species back into their natural habitats. Botanical gardens provide a safe and controlled environment for the cultivation, study, and propagation of endangered plants before their reintroduction.

8.6.3. Seed Banks:

Seed banks are repositories that store and preserve seeds from a wide range of plant species. They play a crucial role in conserving plant genetic diversity. Seeds are collected, dried, and stored under controlled conditions to maintain their viability for long periods. The

Svalbard Global Seed Vault in Norway is a famous example, where millions of seeds from various plant species are stored as a backup to protect against the loss of plant genetic resources. Some key points about seed bank conservation are such as:

- **Seed Collection:** Seed banks collect seeds from diverse plant species, including those that are rare, endangered, or have cultural, economic, or ecological importance. Expeditions are often conducted to gather seeds from various regions, focusing on both wild and cultivated plant populations. Collectors carefully document the seed sources, noting information about the species, location, habitat, and any other relevant details.
- **Seed Processing and Storage:** Once collected, the seeds undergo processing to remove any unwanted materials such as debris or non-seed plant parts. The cleaned seeds are then carefully dried to a specific moisture content to ensure their long-term viability. Proper drying is critical to prevent fungal or microbial growth that could damage the seeds during storage. After drying, the seeds are placed in airtight containers, such as sealed envelopes or glass jars, and stored in cool and dry conditions.
- **Long-Term Storage:** Seed banks utilize controlled environments to preserve the seeds for extended periods. The optimal storage conditions typically involve low temperatures and low humidity to maintain seed viability. Some seed banks employ cryopreservation techniques, where seeds are frozen at ultra-low temperatures typically below -20°C or even colder to greatly extend their storage life. Cryopreservation is particularly useful for long-term conservation of recalcitrant seeds that cannot be stored under regular conditions.
- **Viability Testing:** Seed banks regularly assess the viability of stored seeds to ensure their quality and determine whether new collections are needed. Viability testing involves germinating a sample of the stored seeds under controlled conditions to check for germination rates and overall seed quality. By monitoring seed viability, seed banks can identify batches of seeds that may require regeneration or replacement.
- **Genetic Resource Conservation:** Seed banks serve as repositories for plant genetic resources. They aim to preserve the genetic diversity within and between plant species, safeguarding valuable traits that may be important for future breeding programs, ecological restoration, or adaptation to changing environmental conditions. Seed banks often collaborate with researchers, plant breeders, and conservationists to facilitate access to the genetic material for various purposes while adhering to ethical and legal guidelines.

Seed bank conservation is an important strategy to preserve plant diversity and protect genetic resources. It offers a secure and cost-effective approach for long-term storage of seeds, ensuring the availability of plant material for future generations and contributing to the overall conservation and sustainable use of plant species.

8.6.4. Zoos and Zoological Parks

Every year, millions of tourists and locals visit zoos to see and admire wild animals enjoying a leisurely stroll in an artificially created 'natural habitat'. The trend to create natural habitats and give more space to the animals is on the rise. Originally meant to educate and entertain the public, zoos are now strictly regulated and inspected by the Governments. India is peppered with some of the largest zoos in the world. Sprawled across hundreds of acres of land, these places help in rehabilitating and displaying animals safely and securely. With many vulnerable animals on the verge of extinction, the need of the hour is to have excellent conservation strategies.

It is important to protect wildlife. If you wish to see these animals at close quarters without visiting national park or sanctuaries, visit a zoo. Here, we have curated a list of zoological parks in India. Take your kids along with you, who are sure to feel curious to know more about animals they have so far seen only in their picture books. It is going to be an entertaining and educational experience for them.

Top 11 Largest Zoos in India

- Arignar Anna Zoological Park (Vandalur Zoo), Chennai
- Nandankanan Zoological Park, Bhubaneswar
- Indira Gandhi Zoological Park, Visakhapatnam
- Assam State Zoo cum Botanical Garden, Guwahati
- Nehru Zoological Park, Hyderabad
- Mysore Zoo (Sri Chamarajendra Zoological Garden)
- Allen Forest Zoo, Kanpur
- National Zoological Park, New Delhi
- Sanjay Gandhi Jaivik Udyan, Patna
- Rajiv Gandhi Zoological Park, Pune
- Sajjangarh Biological Park, Udaipur

India is rich in wildlife and natural resources. These are some of India's best zoos that allow you to observe wildlife and admire natural beauty all around. If you are a die-hard animal-lover, witness the greatness of nature in these zoos and enjoy an ultimate fun experience. Go straight to the list of the biggest zoos in India.

1. Arignar Anna Zoological Park (Vandalur Zoo)

Arignar anna zoological park was the first and the largest zoon in India. Gigantic in size, it is located approximately 15 km away from Chennai International Airport. You will be amazed to see a diverse range of wildlife species housed in the zoo. Approximately 1500 types of animals, winged creatures alongside flightless feathered creatures and creepy insects, reside here.

- **Location:** Chennai, Tamil Nadu
- **Started** in 1855
- **Area:** 6.03 km2 or 1,490 sections of land

2. Nandankanan Zoological Park

Nandankanan zoo is the second largest zoo in India. This zoo is also referred to as the "Garden of Heaven". It is located in Bhubaneswar, Odisha. It is also famous for white tiger safari. Bird's lovers can join Nandankanan Bird Walk and spot some of the rarest species of birds.

- **Location:** Bhubaneswar, Odisha
- **Started** in 1960
- **Area:** 4.006 km2 or 1080 sections of land

3. Indira Gandhi Zoological Park

This zoo is named after the late PM of India, Indira Gandhi. Nestled in the lap of Kambalakonda Forest Reserve, this park is spread across 625 acres of land. More than 80 species of wildlife indigenous to this area reside in the park.

- **Location:** Visakhapatnam, Andhra Pradesh
- **Started** in 1977
- **Area:** 2.52 km2 or 625 sections of land

4. Assam State Zoo cum Botanical Garden

Another zoological garden situated within Hengrabari Reserved Forest, the State Zoo of Assam, also attracts a lot of visitors. This fenced-in area is home to more than 113 types of animals from different parts of the world.

- **Location:** Guwahati, Assam
- **Started** in 1958
- **Area:** 1.74 km2 432.4 sections of land

5. Nehru Zoological Park

Located 16 km away from Hyderabad, the Nehru Zoological Park is a famous tourist attraction. In 1963, the zoo was opened to the public. Spread across 380 acres of land, the zoo is home to 1500 species of reptiles, birds, and mammals. Here, the animals are kept in open enclosures, resembling natural habitats.

- **Location:** Hyderabad, Telangana
- **Started** in 1963
- **Area:** 1.53 km2 or 380 sections of land

6. Mysore Zoo (Sri Chamarajendra Zoological Garden)

Originally, this zoo was set up in approximately 10 acres area, but later more area was added to it, and ape enclosures were built. This zoo is home to around 168 types of animals found near the famous Mysore Palace. It was founded by a German exterior decorator and horticulturist, G.H. Krumbiegel, in the royal residence of the lord of Mysore Maharaja Sri Chamaraja Wodeyar.

- **Location:** Mysore, Karnataka
- **Started** in 1892
- **Area:** 0.99 km2 or 244 sections of land

7. Allen Forest Zoo

One of the oldest zoological parks in India, Allen Forest Zoo or the Kanpur Zoo, was opened to the public in 1974. It is beautifully set up in a man-made forest and is spread across 76.56 hectares of land. The park's undulating landscape gives it a look of a high forest.

- **Location:** Kanpur, **Uttar Pradesh**
- **Started** in 1971
- **Area:** 0.77 km2 or 190.2 sections of land

8. National Zoological Park

Home to numerous birds, animals, reptiles and mammal species, residing in a natural-looking environment is one of the biggest attractions in Delhi. This **National Zoological**

Park in India is a lovely zoological park that has more than 126 types of animals, a lovely green island, and a citadel that goes back to the sixteenth century. The specialty and an incredible attraction at the zoo are the white tiger.

- **Location:** New Delhi, Delhi
- **Started** in 1959
- **Area:** 0.71 km2 or 175.4 sections of land

9. Sanjay Gandhi Jaivik Udyan

Also referred to as the Sanjay Gandhi Botanical Park is home to more than 300 distinct species of plants. It is also known for housing more than 400 types of creatures, birds, trees, and fish.

- **Location: Patna, Bihar**
- **Started** in 1973
- **Area:** 0.62 km. or 153.2 sections of land

10. Rajiv Gandhi Zoological Park

This zoo is special by the distinctive sections created as per different species of animals residing in them. The first is the animal halfway house, a separate snake park, and a zoo. This zoo is notable for housing the most poisonous creatures.

- **Location: Pune, Maharashtra**
- **Started** in 1999
- **Area:** 0.53 km. or 130.9 sections of land

11. Sajjangarh Biological Park

This zoological park is located in the foothills of the famous Sajjangarh Palace or the Monsoon Palace. Sprawled across 36 acres of area, it is home to a unique variety of species. The park also encloses a zoo hospital where sick animals are treated.

- **Location: Udaipur, Rajasthan**
- **Started** in 2015
- **Area:** 0.36 km2 or 89 sections of land

Enjoy a close encounter with wildlife at some of the best zoological parks in India and enjoy watching animals, birds, reptiles, and vegetation of diverse species. Plan a visit to any of these zoos and get a glimpse of the wildlife treasures of our country. Adotrip provides end-to-end travel assistance, exciting flight deals, amazing tour packages, and hassle-free hotel bookings so that you can have an unforgettable vacation.

Central Zoo Authority (CZA) of India

The Central Zoo Authority (CZA) is the body of the Government of India responsible for oversight of zoos.It is an affiliate member of the World Association of Zoos and Aquariums (WAZA).

The CZA was formed to bring Indian zoos up to international standards. Before the CZA was formed, many zoos were poorly managed, with unsuitable animal enclosures and little or no breeding records of animals, which caused inbreeding and hybridization. The example of genetic pollution, as in one case where an Asiatic lion cross-bred with an African lion.

The Central Zoo Authority has been constituted under the section 38A of Wild Life protection act 1972. The authority consists of a chairman, ten members and a Member Secretary. The main objective of the authority is to complement the national effort in conservation of wild life. Standards and norms for housing, upkeep, health care and overall management of animals in zoos has been laid down under the recognition of zoo rules, 1992. Every zoo in the country is required to obtain recognition from the Authority for its operation. The authority evaluates the zoos with reference to the parameters prescribed under the rules and grants recognition accordingly. Zoos which have no potential to come up to the prescribed standards and norms may be refused recognition and asked to close down.

Since its inception in 1992, the authority has evaluated 347 zoos, out of which 164 have been recognized and 183 refused recognition. Out of 183 zoos refused recognition, 92 have been closed down and their animals relocated suitably. Cases of the remaining 91 non-recognized zoos are currently under review. The authority’s role is more of a facilitator than a regulator. It, therefore, provides technical and financial assistance to such zoos which have the potential to attain the desired standard in animal management. Only such captive facilities which have neither the managerial skills nor the requisite resources are asked to close down.

Apart from the primary function of grant of recognition and release of financial assistance, the central zoo authority also regulates the exchange of animals of endangered category Listed under Schedule-I and II of the wildlife protection act among zoos. Exchange of animals between Indian and foreign zoos is also approved by the Authority before the requisite clearances under EXIM Policy and the CITES permits are issued by the competent authority.

Key Points

- The CZA is a statutory body under the Ministry of Environment, Forest and Climate Change. It was constituted in 1992 under the Wildlife (Protection) Act, 1972.
- **Members:** It is chaired by the Environment Minister and has 10 members and a member-secretary.
- **Objective:** The main objective of the authority is to complement and strengthen the national effort in conservation of rich biodiversity.
- **Functioning:** The authority provides recognition to zoos and is also tasked with regulating the zoos across the country.
    - It lays down guidelines and prescribes rules under which animals may be transferred among zoos nationally and internationally.
    - It coordinates and implements programmes on capacity building of zoo personnel, planned breeding programmes and *ex-situ* research.

8.6.5. Captive Breeding

Captive breeding, also known as captive propagation, is the process of keeping plants or animals in controlled environments, such as wildlife reserves, zoos, botanic gardens, and other conservation facilities. It is sometimes employed to help species that are being threatened by the effects of human activities such as climate change, habitat loss, fragmentation, overhunting or fishing, pollution, predation, disease, and parasitism.

For many species, relatively little is known about the conditions needed for successful breeding. Information about a species' reproductive biology may be critical to the success of a captive breeding program. In some cases a captive breeding program can save a species from extinction, but for success, breeders must consider many factors—including genetic, ecological, behavioural, and ethical issues. Most successful attempts involve the cooperation and coordination of many institutions.

The breeding of species of conservation concern is coordinated by cooperative breeding programs containing international studbooks and coordinators, who evaluate the roles of individual animals and institutions from a global or regional perspective. These studbooks contain information on birth date, gender, location, and lineage (if known), which helps determine survival and reproduction rates, number of founders of the population, and inbreeding coefficients. A species coordinator reviews the information in studbooks and determines a breeding strategy that would produce most advantageous off-springs.

If two compatible animals are found at different zoos, the animals may be transported for mating, but this is stressful, which could in turn make mating less likely. However, this is still a popular breeding method among European zoological organizations. Artificial fertilization by shipping semen is another option, but male animals can experience stress during semen collection, and the same goes for females during the artificial insemination procedure. Furthermore, this approach yields lower-quality semen, because shipping requires extending the life of the sperm for the transit time. There are regional programmes for the conservation of endangered species:

- **Americas**: Species Survival Plan (SSP) (Association of Zoos and Aquariums AZA, Canadian Association of Zoos and Aquariums CAZA)
- **Europe**: European Endangered Species Programme EEP (European Association of Zoos and Aquaria EAZA)
- **Australasia**: Australasian Species Management Program (ASMP) (Zoo and Aquarium Association ZAA)
- **Africa**: African Preservation Program (APP) (African Association of Zoological Gardens and Aquaria PAAZAB)
- **Japan**: Conservation activities of Japanese Association of Zoos and Aquariums (JAZA)
- **South Asia**: Conservation activities of South Asian Zoo Association for Regional Cooperation (SAZARC)
- **South East Asia**: Conservation activities of South East Asian Zoos Association (SEAZA)

8.6.6. Protected Areas:

One of the primary approaches to in-situ conservation is the establishment and management of protected areas. These areas include national parks, wildlife sanctuaries, nature reserves, and other designated areas where natural ecosystems and their biodiversity are safeguarded. Protected areas help maintain ecological processes, protect endangered species, and preserve critical habitats.

- **Habitat Restoration**: In-situ conservation efforts often focus on restoring degraded habitats to their natural state. This involves rehabilitating ecosystems that have been impacted by human activities such as deforestation, mining, or pollution. Habitat restoration aims to create suitable conditions for the recovery and survival of species, as well as the overall functioning of ecosystems.
- **Species Conservation**: *In-situ* conservation involves targeted efforts to protect and manage individual species. This may include monitoring populations, implementing conservation breeding programs, mitigating threats, and controlling invasive species. By preserving species within their natural habitats, in-situ conservation helps maintain the ecological interactions and evolutionary processes that are essential for biodiversity.
- **Community-Based Conservation**: Engaging local communities and indigenous peoples in conservation efforts is crucial for effective *in-situ* biodiversity conservation. Recognizing and respecting their traditional knowledge, practices, and rights can lead to more sustainable and successful conservation outcomes. Community involvement can also enhance the protection of ecosystems by promoting sustainable resource management and reducing human-wildlife conflicts.
- **Genetic Resource Conservation**: *In-situ* conservation also encompasses the conservation of genetic resources, including plant varieties, crop wild relatives, and animal breeds. Preserving the genetic diversity within species is essential for their long-term adaptability and resilience to changing environmental conditions. Genetic resource conservation may involve the establishment of seed banks, gene banks, or botanical gardens to safeguard valuable genetic material.
- **Connectivity and Corridors**: *In-situ* conservation efforts recognize the importance of maintaining ecological connectivity and establishing wildlife corridors. These corridors allow for the movement of species between fragmented habitats, ensuring gene flow, and reducing the risk of population isolation and genetic bottlenecks. Connectivity of conservation enhances the long-term viability of species and promotes ecosystem resilience.
- **Integrated Approaches**: *In-situ* conservation is most effective when integrated with other sectors and approaches. This includes incorporating biodiversity considerations into land-use planning, agricultural practices, forestry management, and infrastructure development. Integrating conservation goals with sustainable development can help strike a balance between human needs and biodiversity conservation.

In-situ biodiversity conservation plays a vital role in preserving the richness and integrity of ecosystems and the species they support. By protecting natural habitats and promoting sustainable practices, *in-situ* conservation contributes to the maintenance of ecological processes, the preservation of species, and the overall well-being of the planet.

8.6.7. In vitro Conservation:

In vitro conservation is a method of preserving plant or animal species outside their natural habitat. It involves the cultivation and maintenance of living organisms under controlled laboratory conditions. This conservation approach is particularly useful for species that are endangered, rare, or facing the risk of extinction in their natural environments. In the case of plant species, in vitro conservation typically involves the collection of plant tissues, such as seeds, embryos, or explants i.e. small sections of plant tissue, and their subsequent growth in artificial nutrient media. The plant tissues are placed in sterile containers, such as test tubes or Petri dishes, and provided with the necessary nutrients, hormones, and environmental conditions to promote growth and development. This technique is commonly referred to as tissue culture or micro propagation. During *in-vitro* conservation, the plants are carefully monitored and regularly subculture to ensure their continued growth and viability. The conservation process may involve cryopreservation, where plant tissues are stored at extremely low temperatures to maintain their long-term viability. Cryopreservation allows for the storage of genetic material over extended periods, protecting against genetic erosion and potential loss of biodiversity. In vitro conservation offers several advantages. It provides a controlled environment that minimizes the risk of disease, predation, and environmental fluctuations that could threaten species survival. It also allows for the rapid propagation of endangered species, facilitating the production of large numbers of individuals for future reintroduction efforts. Additionally, in vitro conservation can preserve genetic diversity, as multiple individuals can be maintained and propagated simultaneously. However, there are also challenges associated with *in-vitro* conservation. It requires specialized laboratory facilities, skilled personnel, and significant resources to maintain the cultures and ensure their long-term survival. Contamination with pathogens or genetic mutations can also occur during tissue culture, affecting the genetic integrity of the conserved species. Therefore, proper protocols and quality control measures must be in place to minimize such risks. *In -vitro* conservation is an important tool in biodiversity conservation efforts, complementing other conservation strategies such as *in-situ* (on-site) conservation, where species are protected in their natural habitats. By preserving species in controlled laboratory conditions, in vitro conservation helps safeguard biodiversity, prevent species extinction, and provide a potential source for future reintroduction or ecological restoration programs.

8.7. Role of Governmental Organization in Biodiversity Conservation

Government is protecting environment through different departments by some acts and rules like The Wildlife Protection Act, 1972; The Biological Diversity Act, 2002; The Environment (Protection) Act and Rules, 1986, The Environment (Protection) Second Amendment Rules, 2004; Forest (Conservation) Act, 1980, amended 1988; Forest (Conservation) Rules, 2003. In our country all our natural resources are assessed and protected by various departments such as Department of Forest, Geological Survey of India, Zoological Survey of India, Botanical Survey of India, State Biodiversity Board, Pollution Control Board. All these departments and working bodies in combination acts for the cause of conservation and environmental protection.

8.8. Role of Non-Governmental Organization (NGO) in Biodiversity Conservation

As our natural resources are spread over entire geographical boundary, within human habitation, in remote inaccessible places. Hence only for the governmental departments it is impossible to maintain or look after those resources in the best possible manner. NGOs come into the picture at this point. NGOs are the organization run by a group of focused people to attain certain objectives. They works on aspects like understanding the internal relationship of various natural resources, assessment of resource requirement and planning of resource management. They also help the government to obtain relevant information for promoting and facilitate the implementation of major environmental programmes. Today, the necessity of environmental awareness and enforcement is more demanding and urgent than ever before. The importance of public awareness and NGOs involvement in environmental protection is acknowledged worldwide. Areas of intervention of these NGOs are environmental protection are awareness generation, resource development and documentation, introduction of alternative livelihood, coordination and assistance with various governmental departments, habitat monitoring management and restoration etc. Many NGOs are working at the international, national and regional levels for the said cause.

8.9. Importance of Biodiversity Conservation

1. Biodiversity conservation is important for economic growth and poverty reduction

This argument is based on the numerous direct economic benefits that humans derive from natural environments such as food, construction material, firewood, industrial products, and medicines approximately 25,000 plant species are used by native people to extract traditional medicine. More than 25% of drugs sold worldwide are derived from plants. According to the UN, the majority of the world's poor lives in rural areas depend upon wetlands, forests, pastures, and water for their livelihoods. Billions of people worldwide also depend on timber products for income and subsistence. The national parks and sanctuaries are a source of tourism that amazes people as a source of natural beauty.

2. Supports the Continuity of Various Ecosystems Globally

Biodiversity plays an essential role in ecosystem rejuvenation and protection. The Amazon forest, for example, can produce approximately 20% of the total oxygen on earth through photosynthesis. There are also thousands of pollinators such as insects and birds, and other numerous biological activities that take place in the forest. If the biodiversity of the forest is conserved, it means the entire ecosystem that relies on the Amazon forest is equally protected and allowed to rejuvenate. Other ecosystems like the coral reefs, tundra, rivers and streams, and grasslands can as well be supported and protected through biodiversity conservation.

3. Aesthetic value

The natural environment provides great pleasure to human beings with its shape, structure, senses, and color, which enriches people's culture. Activities such as visits to animal parks, bird watching, natural art, and cultural heritage as ways of enjoying and appreciating nature are only made possible through biodiversity conservation.

4. Ecological Balance

The integrity of the ecology, the harmonious coexistence of organisms and their environment is preserved by biodiversity. Some of the main aspects can be explained through:

- Carbon dioxide and oxygen balance which helps in addressing the effects of climate change. The sequential balance between atmospheric carbon dioxide and oxygen are maintained through biodiversity. Failure to conserve biodiversity leads to the accumulation of carbon dioxide resulting in a greenhouse effect and the gradual depletion of ozone. The results are global warming and natural calamities.
- Biochemical cycles. An example is a hydrological cycle. The availability of biological resources such as forests and wetlands are vital for biochemical cycles. Lack of these

resources would lead to incomplete cycles and increased incidences of natural calamities like desertification and species extinction.

- Decomposition. Biodiversity conservation protects decomposers – organisms that aid in the breakdown of waste organic matter. Decomposition is thus an essential part of the food chain as it transforms the waste of dead organic matter, which is then converted into minerals (mineralization) that are utilized by primary producers.
- Climate. The maintenance of the micro, local or regional climate is determined and regulated by biodiversity. Biodiversity achieves this by influencing the air turbulence, temperature, and precipitation.

5. Ethical value for every form of life in the environment

Ecosystem's right of an organism states that every form of life in any ecosystem is unique and deserves respect from human beings. The right suggests that every organism the earth, whether it is valuable to humans or not, has an inherent right to exist. Besides, the present generation has a social responsibility towards future generations, and this includes the protection of all living organisms in the world. Through biodiversity conservation, therefore, the ethics on environmental sustainability and conservation can be encouraged.

6. Ecosystem services worth billions of dollars

Ecosystem services means processes by biodiversity provide to support human life. For example, pollination, decomposition of waste, water purification, renewal of soil fertility and moderation of floods. Ecosystem services can be separated into three categories.

Provisioning services include anything related to the production of renewable resources, like farming or energy production.

Regulating services mean anything that lessens environmental change. Cultural services are anything that provides direct value or enjoyment from natural resources and beauty.

Ecosystem processes are not generally valued as part of the economy until they cease to function. When the economic value is assigned to these services, they are worth billions of dollars. For example, insect pollinators help in the production of many commercially important fruits such as almonds, melons, blueberries, and apples. The global economic value of pollination services performed by insects has been valued at $217 billion per year.

8.10. Benefits of Biodiversity Conservation

- Conservation of biological diversity leads to conservation of essential ecological diversity to preserve the continuity of food chains.
- The genetic diversity of plants and animals is preserved.
- It ensures the sustainable utilization of life support systems the earth.
- It provides a vast knowledge of potential use to the community.
- A reservoir of wild animals and plants is preserved, thus enabling them to be introduced, if need be, in the surrounding areas.
- Biodiversity conservation assures sustainable utilization of potential resources.

When we conserve and protect the whole ecosystem, its biodiversity at all levels is protected. e.g. we save the entire forest to save the tiger. This approach is called in **in-situ (on site)** conservation. However, when there are situations where an animal or plant is endangered or threatened and needs urgent measures to save it from extinction, **ex-situ (off-site)** conservation is the desirable approach.

8.11. Summary

Biodiversity conservation refers to the efforts aimed at protecting and preserving the variety of life the Earth, including the diversity of species, ecosystems, and genetic resources. It is a critical component of environmental sustainability and plays a crucial role in maintaining the overall health and functioning of the planet. Biodiversity is essential for maintaining ecosystem stability, providing ecosystem services, and supporting human well-being. It contributes to processes like nutrient cycling, pollination, and pest control, and offers potential for scientific and medical discoveries. Biodiversity faces numerous threats, primarily caused by human activities. These include habitat destruction, deforestation, pollution, climate change, invasive species, overexploitation of resources, and unsustainable agricultural practices. These threats result in species extinctions and habitat degradation, leading to a loss of biodiversity. Observation efforts employ various strategies to protect biodiversity. These include the establishment and management of protected areas, such as national parks and nature reserves, to safeguard ecosystems and endangered species. Conservation also involves habitat restoration, sustainable resource management, captive breeding programs, and the promotion of sustainable practices in agriculture, forestry, and fisheries. Biodiversity conservation is vital for the well-being of both ecosystems and humanity. It requires a comprehensive approach involving protected areas, sustainable practices, community engagement, and international cooperation to ensure the preservation and sustainable use of biodiversity.

8.12. Terminal questions

Q.1: What do mean about biodiversity conservation?

Answer: ---

Q.2: Discuss the methods of biodiversity conservation.

Answer: ---

Q.3: How many types of biodiversity conservation are used in practices?

Answer: ---

Q.4: What is the ex-situ biodiversity conservation? Discuss the role of National Parks in biodiversity conservation.

Answer: ---

Q.5: Discuss the role of biosphere reserve in biodiversity conservation.

Answer: ---

Q.6: Discuss the role of zoos and zoological parks in biodiversity conservation.

Answer: ---

8.13. Further readings

7. Text book of Botany – Singh -Pande-Jain.
8. The elements of Botany- James Hewetson Wilson
9. Biochemistry and molecular biology- Wilson Walker
10. Environmental Science, Subhas Chandra Santra, new central book agency, 3rd Edition, 2011
11. A text Book of Environment Studies, Asthana, D. K. and Asthana, M. 2006, S. Chand & Co.

Unit-9: Threats to Biodiversity

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9.9. Further suggested readings

9.1. Introduction

Biodiversity, the intricate web of life on Earth, is a fundamental component of our planet's health and resilience. It encompasses the variety of species, genetic diversity within those species, and the different ecosystems that collectively form the tapestry of life. However, this intricate web is under siege from a multitude of threats that jeopardize the stability and vitality of ecosystems, as well as the future of countless species. Since the industrial revolution, human activities have increasingly destroyed and degraded forests, grasslands, wetlands and other important ecosystems, threatening human well-being. Many scientists are now calling this loss of biodiversity and nature the "sixth mass extinction", one that is driven by human activity and other without human activities, such a level of loss would have taken thousands of years. Wild animals now account for just 4% of all mammals worldwide – the remaining 96% are humans and agricultural livestock. Even here biodiversity is diminishing due to the impact of globalised market forces, as local varieties and breeds of domesticated plants and animals are disappearing. Before the industrial revolution, ecology was characterized by stability. Within each habitat, ecosystems had been assembled by long-term evolutionary processes where predators and prey, collaborators and competitors, from microbes to mammals co-existed within complex, inter-connected webs. Change in biodiversity, the mix of plants, animals, fungi and microscopic organisms living within each habitat, occurred but was largely driven by long-term processes happening over centuries to millennia. Human activity, such as burning fossil fuels and industrialized farming, has combined to dramatically impact the planet's biomes and ecosystems. Climate change, deforestation, and pollution have destroyed or damaged habitats, changed where species live and eliminated species at a speed and scale comparable to major extinction events of the past. The threats to biodiversity are diverse and often interconnected, and they stem from human activities as well as natural processes. Human-driven factors, such as habitat destruction, pollution, and overexploitation of natural resources, have escalated over the past century, exacerbating the challenges faced by countless species. Climate change, another major threat, is intensifying at an alarming rate and influencing all other threats to biodiversity. In this context, it is essential to delve into the various threats to biodiversity to understand their causes, consequences, and potential solutions. From the loss of critical habitats to the spread of invasive species, from the consequences of pollution to the escalating impacts of climate change, addressing these threats is of paramount importance if we are to preserve the rich tapestry of life on Earth and sustain a healthy and balanced environment for future generations. This overview will explore the primary threats to biodiversity and the urgent need for conservation efforts to mitigate these challenges and protect the diverse life forms that share our planet.

Objectives

This is the ninth unit on threats to biodiversity. Under this unit, we have following objectives. These are as under:

- Introduction to threats of biodiversity
- To know the concepts of fragmentation, degradation and overexploitation
- To discuss pesticides, its types and its impacts
- To discuss water and air pollution, and their effect on biodiversity

9.2. Threats to biodiversity

Threats to biodiversity include the burning of fossil fuels and clearing forests and other wild lands for industrialized agriculture. More direct human interventions, such as poaching and hunting can also have a serious effect. Within each ecosystem, the interconnected nature of species interactions means even the elimination of a single species, whether an apex predator, a pollinating insect or a plant can have cascading effects, causing ripple effects which reconfigure the entire ecosystem in ways that are unpredictable and with unexpected consequences.

A famous example is the impact that removal and reintroduction of wolves had in Yellowstone in the US. The US government sought to exterminate wolves in the late 19th and early 20th century, seeing them as a dangerous threat to people and livestock. But with the wolves gone, deer populations exploded, grazing out the vegetation in Yellowstone and rapidly diminishing tree growth. The lack of trees in turn reduced beaver populations, meaning less dam were built, affecting the flooding patterns of Yellowstone's rivers. The ecological crisis and related loss of biodiversity is a deep tragedy with potentially very severe implications for humanity, as we are not separate from nature. Human societies are living systems that are intertwined and interdependent with healthy ecosystems that provide our basic needs, food security and resilience, clean water, fresh air, health and wellbeing. Degradation has systemic impacts, as shown by the connection of the COVID-19 pandemic to deforestation and the illegal wildlife trade. Deforestation further amplifies climate breakdown and the water crisis. Weakening of ocean ecosystems through overfishing, pollution and climate change threatens the collapse of food webs and the ability of many human communities to feed them. The loss and degradation of topsoil worldwide is both, accelerating climate change and hampering our ability to feed a growing population. We have to act now, within this decade, to reverse this destruction and embark on a massive drive of ecological restoration.

Supporting evidence:

- According to the Living Planet Report, 75% of the Earth's ice-free land surface has already been significantly altered, most of the oceans are polluted, and more than 85% of the area of wetlands has been lost.
- The most important direct driver of biodiversity loss in terrestrial systems in the last several decades has been land-use change, primarily the conversion of pristine native habitats into agricultural systems, while much of the oceans have been overfished. Globally, climate change has not yet been the most important driver of the loss of biodiversity. However, it is projected to become as important or more than the other drivers.
- Fewer and fewer varieties and breeds of plants and animals are being cultivated, raised, traded and maintained around the world, despite many local efforts, which include those by indigenous peoples and local communities.

9.3. Causes of biodiversity degradation

Biodiversity has declined at an alarming rate in recent years, largely as a result of human activity. Climate change impacts biodiversity at various levels: species distribution, population dynamics, community structure and the functioning of the ecosystem. When we talk about pollution, we may think of car exhaust fumes billowing and the atmosphere, but biodiversity is not only affected by this type, it is also affected by noise pollution and light pollution. Soil pollution and changes in its uses due to activities such as deforestation have a negative impact on ecosystems and the species that make them up. Invasive alien species are the second biggest cause of loss of biodiversity in the world, according to the United Nations Development Programme (UNDP). They act as predators, compete for food, hybridize with native species, introduce parasites and diseases, etc. The loss of biodiversity is caused by a combination of natural and human-induced factors. The key causes of biodiversity degradation are:

- Climate Change
- Habitat Destruction

- Fragmentation
- Transformation
- Pollution
- Overexploitation and Illegal Wildlife Trade
- Invasive Species
- Agricultural Intensification
- Population Growth and Human Activities

9.3.1. Climate change

Climate change is altering what parts of the planet can accommodate each species as where each species lives is determined by climate either directly – through their ability to cope with heat or cold, dry or wet conditions or indirectly through change in the availability of food. As the world's climate changes, the 'envelope' of suitable climate for each species tends to move towards the planet's poles. But species respond differently to this change as some can track it quickly and move as the climate changes, but others with limited dispersal ability may not track the climate envelope in real time.

As certain species depart ecosystems, seeking cooler climates or spreading into newly warmed areas, animals and plants they interact with changes, meaning the climate change fundamentally 'rewires' historical ecosystems. Animals and plants, pests and diseases may 'escape' from their own natural enemies so climate change can lead to outbreaks of new, invasive species or pests such as locusts or contribute to diseases jumping to new hosts, including from animals to humans. A warming world is causing ice and snow to melt and raising sea levels, leading to increased flooding and erosion of vital coastal ecosystems. Increasing global temperatures also raises the probability of fires and drought that destroy natural habitats, such as forests and rivers, threatening the survival of more species and driving more climate change.

Wild areas, such as forests and peat lands are vital carbon sinks, absorbing carbon dioxide from the atmosphere but, as warming increases and more wild areas are destroyed, more carbon dioxide enters the atmosphere and warming accelerates even more, threatening more destruction of biodiversity. This creates a vicious circle of heating leading to destruction leading to more heating and more destruction.

9.3.2.Habitat destruction

Industrialized farming methods have seen the cultivation of single crops, known as ‘monoculture’, and the rearing of livestock on a massive scale. This has been, and still is, justified as essential to feeding the expanding human population, and delivering more affordable and safer food supplies. But industrialized agriculture has enormous impact on biodiversity and human health. Instead of wild animals, a small number of farmed animal species, mainly cows and pigs, now dominate. Together they account for 60 per cent of all mammal species by mass, compared to four per cent for wild mammals and 36 per cent for humans. Farmed chickens now account for 57 per cent of all bird species by mass, whereas wild birds make up 29 per cent of the total.

Wild areas of the planet are being continually cleared to accommodate expanding demand for land to host livestock and for the crops to feed them. This is highly destructive to global biodiversity, reducing wild areas, carving up the territories of large predators, ecologically re-wiring ecosystems and creating cascading effects. Pesticides are used on a vast scale to protect crops, wiping out insect populations. When it rains, fertilizers run off the ground and contaminate rivers, impacting the ecology in multiple ways. Nutrient-rich rivers become dominated by fast-growing bacteria and algae, crowding out other wildlife and reducing the oxygen available in the water and creating ‘dead zones’.

Bee populations of all kinds have been declining worldwide due to the use of pesticides in intensive farming and climate change, but they are vital to delivering successful yields of crops, especially nutrient-rich fruit and vegetables. Even clearing hedgerows has a serious impact as hedges and grassy margins accommodate species of small wasp which provide free natural pest control. Without them more pesticide must be used and insect populations of all kinds continue to decline.

Mass livestock cultivation and the clearing of wild areas to support it also increases the likelihood of humans becoming exposed to new and dangerous pathogens, which can leap from to new host species, and then via livestock and ‘bushmeat’ to people. One theory for the origin of COVID-19 is that it spread from bats via pangolins to people via a ‘wet’ market in China. Antibiotics, used in farming to accelerate the growth of livestock, are also increasing the resistance of microbes, threatening a future where antibiotics are no longer remain effective for animals or people and minor injuries and infections kills them.

Loss of total habitat area

The destruction of habitat leaves species with less space to find everything they need to survive. For example, ancient woodland now covers just 2% of the UK. This means the many species that rely on this irreplaceable habitat have limited space in which to live.

Reduction in habitat quality

Fragmented habitats are often lowers are quality. This is known as the ‘edge effect’. As a habitat is broken into smaller sections, the proportion of edge - where one habitat meets another - increases. While some species can thrive along habitat edges, others struggle to survive. For instance, species that have evolved to live in the interior of a wood are less suited to its edge, where conditions are quite different. Examples of wildlife affected in this way are varied, ranging from birds like the tree creeper to lichens and mosses.

Increased extinction risk

Fragmentation limits wildlife mobility. Individuals struggle to move between habitat patches, which can lead to inbreeding and a loss of genetic diversity. This reduces the long-term health of a population, making it more vulnerable to disease, and at greater risk of extinction.

Habitat fragmentation in action

The dormouse (*Muscardinus avellanarius*) is a perfect example of a UK species, affected by fragmentation. These tiny rodents spend most of their life among trees and can only travel small distances across open ground. As a result, the continued loss and damage of our native woods, and the hedgerows that once connected them has been disastrous. Unable to move between the fragmented pockets of habitat that remain, dormice are confined to isolated areas. Cut off, populations are at risk from inbreeding and loss of genetic diversity. This has contributed to dormice numbers falling by more than 50% since 1995.

Biodiversity loss refers to the decline or disappearance of biological diversity, understood as the variety of living things that inhabit the planet, its different levels of biological organization and their respective genetic variability, as well as the natural patterns present in ecosystems. On biodiversity warning that out of a total of eight million, one million species are in danger of extinction. Some researchers even dared to talk about the sixth mass extinction in the history of the planet.

9.3.3. Fragmentation

Fragmentation happens when parts of a habitat are destroyed, leaving behind smaller unconnected areas. This can occur naturally, as a result of fire or volcanic eruptions, but is normally due to human activity. A simple example is the construction of a road through woodland. For much of the wildlife that lives in the wood, the road is an obstacle that can only be crossed with difficulty or not at all. A barrier has been created that effectively divides the wood. Habitat fragmentation can negatively impact wildlife in several ways.

9.3.4. Transformation

Biodiversity transformation refers to the changes that occur in biodiversity patterns and composition over time, often as a result of various natural and human-induced factors. It encompasses shifts in species abundance, distribution and interactions within ecosystems. Biodiversity transformation involves the loss of species from ecosystems. Extinctions can occur due to natural processes, such as competition or changes in environmental conditions, but human activities have significantly accelerated the extinction rate. Invasive species can outcompete native species, alter ecosystem dynamics, and negatively impact local biodiversity. Biodiversity transformation often includes changes in the abundance of different species within ecosystems. Some species may decline in numbers due to factors such as habitat loss, pollution, or overexploitation. Changes in predator-prey relationships, mutualistic interactions and other ecological connections can have cascading effects on ecosystem structure and function. Biodiversity transformation can also occur at the genetic level. Environmental changes, such as pollution or habitat fragmentation, can influence the genetic diversity of species and populations. Genetic diversity is crucial for species' ability to adapt and respond to changing conditions. Reduced genetic diversity can make species more vulnerable to disease, climate change and other stressors. Biodiversity transformation can impact ecosystem functioning and the services they provide to humans. Ecosystems with higher biodiversity tend to be more resilient, stable and productive. Changes in biodiversity can alter processes such as nutrient cycling, primary productivity and water purification. Consequently, the provision of ecosystem services, such as clean water, carbon sequestration and pest regulation, may be affected.

9.3.5. Overexploitation

Overexploitation, also called overharvesting, refers to harvesting a renewable resource to the point of diminishing returns. Continued overexploitation can lead to the destruction of the resource, as it will be unable to replenish. The term applies to natural resources, such as water aquifers, grazing pastures and forests, wild medicinal plants, fish stocks and other wildlife.

In ecology, overexploitation describes one of the five main activities threatening global biodiversity. Ecologists use the term to describe populations that are harvested at an unsustainable rate, given their natural rates of mortality and capacities for reproduction. This can result in extinction at the population level and even extinction of whole species. In conservation biology, the term is usually used in the context of human economic activity that involves the taking of biological resources or organisms, in larger numbers than their populations can withstand. The term is also used and defined somewhat differently in fisheries, hydrology and natural resource management.

Overexploitation can lead to resource destruction, including extinctions. However, it is also possible for overexploitation to be sustainable, as discussed below in the section on fisheries. In the context of fishing, the term overfishing can be used instead of overexploitation, as can overgrazing in stock management, over logging in forest management, over drafting in aquifer management, and endangered species in species monitoring. Overexploitation is not an activity limited to humans. Introduced predators and herbivores, for example, can overexploit native flora and fauna. Unsustainable fishing practices, for example, can lead to the collapse of fish populations and disrupt marine ecosystems. The illegal wildlife trade, driven by demand for products such as ivory, rhino horns and exotic pets, contributes to the decline of numerous species.

The overexploitation of natural resources, that is, their consumption at a speed greater than that of their natural regeneration, has an obvious impact on the planet's flora and fauna. Nature loss has far-reaching consequences. Damaged ecosystems exacerbate climate change; undermine food security, and put people and communities at risk.

- Around 3.2 billion people, or 40 percent of the global population, are adversely affected by land degradation.
- Up to $577 billion in annual global crop production is at risk from pollinator loss.
- 25 percent of global greenhouse gas emissions are generated by land clearing, crop production and fertilization.
- Development is putting animals and humans in closer contact, increasing the risk of diseases like COVID-19 to spread. About 60 percent of human infections are estimated to have an animal origin.
- 100-300 million people are at increased risk of floods and hurricanes because of coastal habitat loss.

- Declines in nature and biodiversity at current trajectories will undermine progress toward 35 out of 44 of the targets of SDGs (Sustainable development Goals) related to poverty, hunger, health, water cities, climate, oceans and land.

9.3.6. Invasive Species

Non-native species introduced to new environments, can have detrimental effects on native biodiversity. Invasive species often lack natural predators or competitors in their new habitats, allowing them to rapidly reproduce and outcompete native species for resources. This competition can lead to the displacement or extinction of native species, disrupting ecosystem dynamics. Some examples of invasive species found in India

- Water hyacinth (*Eichhornia crassipes*)
- Lantana (*Lantana camara*)
- Parthenium weed (*Parthenium hysterophorus*)
- Mimosa or sensitive plant (*Mimosa pudica*)
- American bullfrog (*Lithobates catesbeianus*)
- Common myna (*Acridotheres tristis*)
- Indian house crow (*Corvus splendens*)
- Red-whiskered bulbul (*Pycnonotus jocosus*)
- Apple snail (*Pomacea canaliculata*)
- Giant African snail (*Achatina fulica*)
- Common carp (*Cyprinus carpio*)
- Mozambique tilapia (*Oreochromis mossambicus*)
- Australian swamp stonecrop (*Crassula helmsii*)
- Yellow crazy ant (*Anoplolepis gracilipes*)

9.3.7. Agricultural Intensification

The expansion of agriculture, particularly through intensive farming practices, has significant impacts on biodiversity. Large-scale monoculture farming, heavy use of pesticides and fertilizers, and land conversion for agricultural purposes can result in the loss of natural habitats, soil degradation and pollution of water bodies, leading to declines in plant and animal species.

9.3.8. Population Growth and Human Activities

The increasing global population and associated human activities place additional pressure on biodiversity. As result more land is converted for human settlements, infrastructure, and resource extraction, natural habitats are diminished, leading to habitat loss and fragmentation. Human activities, such as recreational pursuits, tourism and urban development, can also directly impact local biodiversity such as

1. **Habitat Loss:** As human populations expand, the demand for land increases for agriculture, urban development, and infrastructure. This leads to the clearing of forests, wetlands, and other natural habitats, resulting in the loss of critical environments for many species.
2. **Deforestation**: Population growth often drives deforestation, primarily for agriculture. Forests are home to a vast array of species, and their destruction can have catastrophic effects on biodiversity.
3. **Urbanization:** Expanding cities consume natural areas, disrupting ecosystems and displacing wildlife. Urban development can lead to fragmentation of habitats, making it challenging for species to find suitable living spaces.
4. **Overexploitation**: As the human population grows, so does the demand for resources such as food, water, and energy. Overharvesting of resources, overfishing, and the exploitation of wildlife can lead to the decline or extinction of many species.
5. **Pollution:** Increasing human populations produce more pollution, including air and water pollution. Pollution can harm ecosystems and wildlife, affecting their health and survival.
6. **Invasive Species:** Globalization and increased travel due to higher populations facilitate the spread of invasive species, which can outcompete or prey on native species, leading to their decline.
7. **Climate Change:** Population growth contributes to increased greenhouse gas emissions. Climate change disrupts ecosystems, shifts the ranges of species, and leads to altered breeding and migration patterns, affecting biodiversity.
8. **Infrastructure Development:** The need for transportation and energy infrastructure often results in the construction of roads, railways, and pipelines through natural habitats, further fragmenting ecosystems.
9. **Agriculture Expansion:** Feeding a growing population requires the expansion of agricultural land, often at the expense of natural habitats. This expansion can result in the destruction of ecosystems and the use

9.4. Impacts of Pesticides on biodiversity

The term pesticide covers a wide range of compounds including insecticides, fungicides, herbicides, rodenticides, molluscicides, nematicides, plant growth regulators and others. Among these, organochlorine (OC) insecticides, used successfully in controlling a number of diseases, such as malaria and typhus, were banned or restricted after the 1960s in most of the technologically advanced countries. The introduction of other synthetic insecticides, organophosphate (OP) insecticides in the 1960s, carbonates in 1970s, and pyrethroids in 1980s, and the introduction of herbicides and fungicides in the 1970s-1980s contributed greatly to pest control and agricultural output. Ideally a pesticide must be lethal to the targeted pests, but not to non-target species, including man. Unfortunately, this is not the case, so the controversy of use and abuse of pesticides has surfaced. The rampant (Uncontrolled) use of these chemicals, under the adage, “if little is good, a lot more will be better” has played havoc with human and other life forms.

Direct impact on humans

If the credits of pesticides include enhanced economic potential in terms of increased production of food and fibre, and amelioration of vector-borne diseases, then their debits have resulted in serious health implications to man and his environment. There is now overwhelming evidence that some of these chemicals do pose a potential risk to humans and other life forms, and unwanted side effects to the environment. No segment of the population is completely protected against exposure to pesticides and the potentially serious health effects, though a disproportionate burden is shouldered by the people of developing countries and by high risk groups in each country. The world-wide deaths and chronic diseases, due to pesticide poisoning number about 1 million per year.

The high risk groups exposed to pesticides include production workers, formulators, sprayers, mixers, loaders and agricultural farm workers. During manufacture and formulation, the possibility of hazards may be higher, because the processes involved are not risk free. In industrial settings, workers are at increased risk, since they handle various toxic chemicals including pesticides, raw materials, toxic solvents and inert carriers.

Impact through food commodities

For determining the extent of pesticide contamination in the food stuffs, programs entitled ‘Monitoring of Pesticide Residues in Products of Plant Origin in the European Union’ started to be established in the European Union since 1996. In 1996, seven pesticides (acephate, chlopyriphos, chlopyriphos-methyl, methamidophos, iprodione, procymidone and chlorothalonil) and two groups of pesticides (benomyl group and maneb group, i.e. dithiocarbamates) were analyzed in apples, tomatoes, lettuce, strawberries and grapes.

An average of about 9700 samples has been analyzed for each pesticide or pesticide group. For each pesticide or pesticide group, 5.2% of the samples were found to contain residues and 0.31% had residues higher than the respective MRL (Maximum Residue Level) for that specific pesticide. Lettuce was the crop with the highest number of positive results, with residue levels exceeding the MRLs more frequently than in any of the other crops investigated. The highest value found in 1996 was for a compound of the maneb group in lettuce which corresponded to a mancozeb residue of 118 mg/kg.

In 1997, 13 pesticides (acephate, carbendazin, chlorothalonil, chlopyriphos, DDT, diazinon, endosulfan, methamidophos, iprodione, metalaxyl, methidathion, thiabendazole, triazophos) were assessed in five commodities (mandarins, pears, bananas,beans and potatoes). Some of 6000 samples were analysed. Residues of chlorpyriphos exceeded MRLs most often (0.24%), followed by methamidophos (0.18%) and iprodione (0.13%). With regard to the commodities investigated, around 34% contained pesticide residues at or below the MRL, and 1% contained residues at levels above the MRL. In mandarins, pesticide residues were most frequently found at levels at or below the MRL (69%), followed by bananas (51%), pears (28%), beans (21%) and potatoes (9%). MRLs were exceeded most often in beans (1.9%), followed by mandarins (1.8%), pears (1.3%), and bananas and potatoes (0.5%).

Impact on environment

Pesticides can contaminate soil, water, turf and other vegetation. In addition to killing insects or weeds, pesticides can be toxic to a host of other organisms including birds, fish, beneficial insects and non-target plants. Insecticides are generally the most acutely toxic class of pesticides, but herbicides can also pose risks to non-target organisms.

Surface water contamination

Pesticides can reach surface water through runoff from treated plants and soil. Contamination of water by pesticides is widespread. The results of a comprehensive set of studies done by the U.S. Geological Survey (USGS) on major river basins across the country in the early to mid- 90s yielded startling results. More than 90 percent of water and fish samples from all streams contained one or more often several pesticides. Pesticides were found in all samples from major rivers with mixed agricultural and urban land use influences and 99 percent of samples of urban streams. The USGS also found that concentrations of insecticides in urban streams commonly exceeded guidelines for protection of aquatic life.

Twenty-three pesticides were detected in waterways in the Puget Sound Basin, (a strip of water that extends into north-western Washington, U.S., from the Pacific Ocean) including 17 herbicides. According to USGS, more pesticides were detected in urban streams than in agricultural streams. The herbicides 2,4-D, diuron and prometon, and the insecticides chlorpyrifos and diazinon, all commonly used by urban homeowners and school districts, were among the 21 pesticides detected most often in surface and ground water across the nation. Trifluralin and 2,4-D were found in water samples collected in 19 out of the 20 river basins studied. The USGS also found that concentrations of insecticides in urban streams commonly exceeded guidelines for protection of aquatic life. According to USGS, “in general more pesticides were detected in urban streams than in agricultural streams. The herbicide 2,4-D was the most commonly found pesticide, detected in 12 out of 13 streams. The insecticide diazinon, and the weed-killers dichlobenil, diuron, triclopyr, and glyphosate were also detected in Puget Sound basin streams. Both, diazinon and diuron were found at levels exceeding in concentrations recommended by the National Academy of Sciences for the protection of aquatic life.

Ground water contamination

Groundwater pollution take place due to pesticides is a worldwide problem. According to the USGS, at least 143 different pesticides and 21 transformation products have been found in ground water, including pesticides from every major chemical class. Over the past two decades, detections have been found in the ground water of more than 43 states. During one survey in India, 58% of drinking water samples drawn from various hand pumps and wells around Bhopal, were contaminated with Organo Chlorine pesticides above the EPA (Environmental Protection Agency), standards. Once ground water is polluted with toxic chemicals, it may take many years for the contamination to dissipate or to be cleaned up.

Soil contamination

A large number of transformation products (TPs), from a wide range of pesticides, have been documented. Not many of all possible pesticide TPs have been monitored in soil, showing that there is a pressing need for more studies in this field. Persistency and movement of these pesticides and their TPs are determined by some parameters, such as water solubility, soil-sorption constant (K_{oc}), the octanol/water partition coefficient (K_{ow}), and half-life in soil (DT_{50}). Pesticides and TPs could be grouped into: (a) Hydrophobic, persistent and bioaccumulable pesticides that are strongly bound to soil. Pesticides that exhibit such behavior include the organ chlorine DDT (Dichlorodiphenyltrichloroethane), endosulfan, endrin, heptachlor, lindane and their TPs. Most of them are now banned in agriculture but their residues are still present in soil and water bodies’ \. (b) Polar pesticides are represented mainly by herbicides but they also include carbamates, fungicides and some organ phosphorus insecticide and TPs.

Effect on soil fertility (beneficial soil microorganisms)

Heavy treatment of soil with pesticides can cause decrease in populations of beneficial soil microorganisms. According to the soil scientist, Dr. Elaine Ingham, “If we lose both, bacteria and fungi, then the soil degrades”. Overuse of chemical fertilizers and pesticides have effects on the soil organisms that are similar to human overuse of antibiotics. Indiscriminate use of chemicals might work for a few years, but after awhile, there aren't enough beneficial soil organisms to hold onto the nutrients. For example, plants depend on a variety of soil microorganisms to transform atmospheric nitrogen into nitrates is known as biological nitrogen fixation, which increase soil fertility and plants can use it for growth and development.

Common landscape herbicides disrupt this process: triclopyr inhibits soil bacteria that transform ammonia into nitrite glyphosate reduces the growth and activity of free-living nitrogen-fixing bacteria in soil and 2, 4-D (2, 4- Dichlorophenoxyacetic acid) reduces nitrogen fixation by the bacteria that live on the roots of bean plants, reduces the growth and activity of nitrogen-fixing blue-green algae, and inhibits the transformation of ammonia into nitrates by soil bacteria. Mycorrhizal fungi grow with the roots of many plants and aid in nutrient uptake. These fungi can also be damaged by herbicides in the soil.

Contamination of air, soil, and non-target vegetation

Pesticide sprays can directly hit non-target vegetation or can drift or volatilize from the treated area and contaminate air, soil and non-target plants. Some pesticide drift occurs during every application, even from ground equipment. Drift can account for a loss of 2 to 25% of the chemical being applied, which can spread over a distance of a few yards to several hundred miles. As much as 80–90% of an applied pesticide can be volatilized within a few days of application.

According to the USGS, pesticides have been detected in the atmosphere in all sampled areas of the USA. Nearly, every pesticide investigated has been detected in rain, air, fog, or snow across the nation at different times of the year. Many pesticides have been detected in air at more than half the sites sampled nationwide. Herbicides are designed to kill plants, so it is not surprising that they can injure or kill desirable species, if they are applied directly to such plants or if they drift or volatilize onto them. Many ester-formulation herbicides have been shown to volatilise off treated plants with vapors sufficient to cause severe damage to other plants. In addition to killing non-target plants outright, pesticide exposure can cause sublethal effects on plants.

9.5. Impacts of Water pollution on Biodiversity

For aquatic environments, pollution poses a serious issue as it can cause variations in the environmental conditions to which aquatic organisms are sensitive. Aquatic organisms respond to drastic changes in their environment by migrating to any other suitable habitat or in extreme cases they just die off. In less extreme cases only the reproductive capacity and metabolism of the aquatic organisms are affected negatively. However, this can have a negative consequence on their population in the long run.

Every species present in various trophic levels are important for freshwater ecosystems. Zooplanktons and macrobenthic organisms modulate the aquatic productivity of aquatic ecosystems by occupying the intermediate level in the food chain. The aforementioned aquatic organisms are also capable of indicating changes in the aquatic environment. Recent studies have demonstrated that some species of zooplankton and macrobenthic organisms can be used as an indicator of deteriorating water quality resulting from eutrophication and pollution.

The intricate relationships between species in a food web are important. Fish numbers may start to dip as a result of food chain disruption and diversity loss or degradation take place. The relationship between biodiversity decline and food chain disruption was demonstrated; when data from two separate studies about the Egyptian Nile waters conducted several years apart were compared side by side. In 1907, the first study reported that there are a total of 85 fish species in the Egyptian Nile waters. However, the second study, which was conducted in 1997, reported that there are a total of 71 fish species. This significant reduction in fish species has been attributed to several pollution sources, generated by industrial activities, agricultural sources and sewage drains. These findings showed evidence that pollution can reduce species diversity and affect the fish population.

Studies have also shown that pollution can make rivers more susceptible to drastic changes. In one study, researchers investigated the effects of rising water temperature and low oxygen levels brought about by pollution in water bodies by use of common mayfly species. Mayfly species are considered cool water insects and they are used as bioindicators that help to determine ecologically important features of freshwater ecosystems. During warmer seasons, they have trouble thriving in polluted waters, due to elevated temperatures and reduced dissolved oxygen conditions that the mayfly species are not accustomed to.

In a controlled laboratory setting, mayfly species such as the green drake and blue-winged olive, or *Ephemera danica* and *Serratella ignita* respectively, are capable of tolerating higher temperatures where dissolved oxygen levels are sufficient. Lowered oxygen levels, near depletion, can lower the mayflies' ability to tolerate temperature extremes. These laboratory findings were substantiated by field study data. Analysis of data collected by the Environment Agency and Natural Resources Wales demonstrated that mayflies populations dropped when the freshwater oxygen concentration decreased and temperature increased.

So with all the findings of the studies combined, there is strong evidence that water pollution can reduce dissolved oxygen in freshwater environments and increase the temperature. Moreover, reductions in dissolved oxygen compromised the mayflies' ability to survive temperature extremes. Their ability to increase in numbers was also severely restricted even at temperatures below the lethal limits.

Improving dissolved oxygen levels in freshwater environments is one method of improving their resilience against rising temperatures. By reducing the amount of pollution, especially those of agricultural origins, the freshwater environment can absorb oxygen better. This is supported by a review published in Global Change Biology, which mentioned that there is growing evidence that freshwater ecosystems that contain minimal pollution are resilient against changes brought about by climate change. Pollution reduction may also help to improve biodiversity in the freshwater ecosystem. From contaminating our environment to damaging our health, poor air quality is a major global challenge. No one is immune to the negative effects of air pollution, but many think this shared burden doesn't affect their lives.

Clean air is everyone's business and air pollution is preventable. The solutions to this pressing issue are also key to tackling the climate crisis, fostering inclusive societies and improving childhood development. By working together, we have a golden opportunity to transform our approach to one of the great hidden killers. Here are five reasons that clean air is everyone's business from our latest report as well as recommendations for funders and campaigners. This are-

a) Polluted air is creating a health emergency.
b) Children are most at risk.
c) Pollution and poverty go hand in hand.
d) The cheaper the fuels, the high the cost.
e) The right to clean air is a human right.

9.6. Impacts of Air Pollution on biodiversity

Air pollution has a significant impact on biodiversity, affecting various organisms and ecosystems. Here are some key effects of air pollution on biodiversity:

1. Impact on human health

Even though you can't see it, the air you are breathing is probably polluted. Worldwide, 9 out of 10 of us breathe air that is damaging our health. Invisible particles penetrate every cell and organ in our bodies, causing acute and chronic diseases, including asthma, strokes, heart attacks and dementia. Outdoor air pollution causes around 4.2 million early deaths every year. Our children, and all future generations, deserve to breathe air that is free from toxic pollution. 93% of children under 15 are denied their right to grow up in a clean and healthy environment. Many babies breathe polluted air from their first breath, a critical period when the foundations of growth and cognitive development are being established. Air pollution negatively impacts a child's physical health, their right to an education and to play. These factors are detrimental to brain development, and contribute to mental health and behavioural issues.

2. The most marginalized are hit the hardest

The worst effects of air pollution are often felt by those least responsible. The poorest and most marginalized communities are most likely to live in congested neighborhoods or they work where they are exposed to toxic levels of pollution. The impact on their health prevents them from attending school or work, which further exacerbates poverty and inequity.

3. Our cities should be liveable and sustainable

Throughout the world, many cities priorities the movement of cars over people. By 2050, 68% of the world's population is projected to live in urban areas. However, only half of the world's urban population has convenient access to public transport. How our cities are designed and consequently, how we travel, determine the quality of air we breathe, as well as our health, safety and wellbeing as city dwellers.

4. Duties of funders and campaigners

Action on air pollution can address some of our biggest problems at the same time and will pay for itself many times over. Clean air is a critical but unacknowledged secret weapon to achieving the Sustainable Development Goals and building a fairer, greener future. Here are six ways funders and campaigners can contribute to this effort:

- Develop internal knowledge and strengthen your team's understanding of the benefits of clean air.

- Build and diversify demand for clean air by discussing how clean air benefits your work in your communications, advocacy and lobbying.
- Support the delivery of clean air by applying your issue-specific expertise to the problem.
- Use data and evidence on air pollution to understand the impact of air pollution on your work and vice-versa.
- Engage with the communities you serve to build alliances with the groups that are most affected.
- Help make the case for more efficient funding and projects that address several development goals together.

5. Habitat Destruction:

Air pollution can lead to the destruction of habitats essential for many species. Acid rain, caused by pollutants like sulfur dioxide and nitrogen oxides, can harm forests, agricultural crop, freshwater ecosystems, and soil quality. This damages or destroys the natural habitats of plants and animals, reducing their populations and biodiversity.

6. Decline in Species Population:

Air pollution can directly harm organisms by damaging their respiratory systems, impairing their reproduction and weakening their immune systems. Pollutants like particulate matter, ozone, and toxic gases can affect the health and survival of animals, including insects, birds and mammals. As a result, species populations can decline, leading to a loss of biodiversity.

7. Disruption of Ecosystems:

Air pollution can disrupt the balance of ecosystems by affecting the interactions between species. For example, pollutants can reduce the population of pollinators, such as bees and butterflies, leading to a decline in plant reproduction and impacting the entire food chain. Similarly, air pollutants can harm aquatic ecosystems, affecting fish populations and disrupting the food web.

8. Changes in Plant Communities:

Air pollution can alter the composition and distribution of plant communities. Some plants are more sensitive to pollutants than others, and their decline can disrupt the habitats and food sources of many animal species. This can lead to a loss of plant diversity and further impact on the overall biodiversity of this particular area.

9. Genetic and Evolutionary Effects:

Air pollution can have genetic and evolutionary consequences for organisms. Some pollutants can cause mutations in DNA, leading to heritable changes in species over time. These changes may affect the ability of species to adapt to their environment, potentially reducing their survival and reproductive success.

10. Indirect Effects:

Air pollution can have indirect effects on biodiversity by interacting with other stressors, such as climate change. Pollutants can exacerbate the impacts of climate change, making species more vulnerable to temperature changes, altering precipitation patterns and affecting the availability of nutrients. These combined effects can further impact on biodiversity and disrupt ecological systems.

9.7. Summary

Biodiversity faces numerous threats that put ecosystems and species at risk of decline and extinction. The Habitat Loss and Fragmentation, Climate Change, Overexploitation, Invasive Species and Pollution, including air pollution, water pollution and soil contamination, negatively impacts on biodiversity are mainly responsible for biodiversity losses. Unsustainable practices related to agriculture, forestry, water management and infrastructure development can degrade habitats, deplete water resources, and introduce pollutants. These threats to biodiversity require a comprehensive approach that includes conservation efforts, sustainable land and resource management practices, reduction in pollution, climate change mitigation and international cooperation. Protecting and restoring ecosystems, implementing sustainable development practices, and raising awareness about the importance of biodiversity are essential steps toward preserving Earth's rich and interconnected web of life.

9.8. Terminal questions

Q.1. What is the Threats to biodiversity, discuss the causes of biodiversity threats.

Answer--

Q.2. Discuss the effect of Climate change on biodiversity loss.

Answer--

Q.3. Discuss the effect of Habitat destruction on biodiversity loss.

Answer--

Q.4. Discuss the role of overexploitation on biodiversity loss.

Answer---

Q.5. What are Invasive Species? Discuss its role in biodiversity loss.

Answer---

Q.6. Discuss the effects of Pesticides on biodiversity loss.

Answer---

Q.7. Discuss the impacts water and air pollution on Biodiversity.

Answer---

9.9. Further readings

12. Text book of Botany – Singh -Pande-Jain.

13. The elements of Botany- James Hewetson Wilson

14. Biochemistry and molecular biology- Wilson Walker

15. Environmental Science, Subhas Chandra Santra, new central book agency, 3rd Edition, 2011

16. A text Book of Environment Studies, Asthana, D. K. and Asthana, M. 2006, S. Chand & Co

17. Biodiversity: a beginner's guide, john I. spicer, One world Publications.

Block-4 **PGEVS-101N**

Rajarshi Tandon Open University, Prayagraj

Ecosystem And Biodiversity Conservation

Block- 4

Wildlife Protection and Ecotourism

UNIT -10

Introduction to Wildlife

UNIT-11

Wildlife Management of India

UNIT-12

Ecotourism

Rajarshi Tandon Open University, Prayagraj

Ecosystem And Biodiversity Conservation

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Introduction

This fourth block of ecology and biodiversity conservation, this consists of following three units:

Unit-10: this unit covers the man and wildlife conflict, causes of wildlife depletion, economic importance of wildlife, need for wildlife conservation, endangered flora and fauna of India. This unit also discussed the special project on tiger, GIR lion tiger reserve, elephant, crocodile.

Unit-11: This unit describes the constitution of state board for wild life, Indian wildlife board, the wild life (protection) act 1972, hunting of wild animals to be permitted in certain cases, protected areas of wildlife, illegal hunting and trade.

Unit-12: This unit covers ecotourism and the environment, importance of ecotourism, ecotourism resources, understanding ecotourism resource categories, ecotourism and education. The ecotourism and protected areas, ecolabeling and greenbelt, impact of ecotourism in society is also discussed.

Unit-10: Introduction to wildlife

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10.6.1. Needs and benefits for Gir Lions Project
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10.1. Introduction

Wildlife refers to all living organisms that are not domesticated and live in their natural habitats. It includes a diverse range of species, from tiny microorganisms to large mammals, reptiles, birds, and fish. Wildlife is an essential component of ecosystems of our planet and they play a crucial role in maintaining the balance of the natural world. There are millions of species of wildlife on earth, and each of them has unique characteristics and adaptations that allow them to survive in their environments. Some species are endangered or threatened due to habitat loss, climate change, poaching, or other human activities. Protecting wildlife and their habitats is essential for maintaining biodiversity, as well as preserving the health and well-being of our planet and its inhabitants. Wildlife conservation is a critical issue that requires collaboration between governments, conservation organizations, and individuals. Many conservation efforts focus on protecting threatened and endangered species, managing habitats, and reducing human impact on ecosystems. By preserving and protecting wildlife, we can help ensure a sustainable future for the ourselves and plants.

Objectives

- To understand the wildlife and it importance for human beings
- To discuss the conflict of man and wildlife
- To discuss the economic and social effects of wildlife
- To discuss the endangered flora and fauna of India

- To discuss the special project for endangered species

10.2. Man and Wildlife Conflict

The conflict between humans and wildlife is an ongoing issue that arises due to the competition for resources between the two. As human populations continue to grow, their activities increasingly encroach upon wildlife habitats, leading to various forms of conflict. One of the primary causes of human-wildlife conflict is habitat loss, which occurs when natural habitats are destroyed or converted for human use, such as agriculture, urbanization, or infrastructure development. This displacement forces wildlife to move into new areas in search of food and shelter, often bringing them into conflict with humans. The competition for resources is one of the primary causes of human-wildlife conflict. As human populations continue to grow, they require more natural resources, such as food, water, and land, which often leads to the depletion of these resources. This competition forces wildlife to search for alternative sources of food and water, which can bring them into contact with humans and their property, leading to conflict. Another cause of human-wildlife conflict is the competition for resources, such as food and water. As human populations grow, their demand for resources also increases, leading to overexploitation and depletion of natural resources. This, in turn, forces wildlife to search for alternative sources of food and water, often bringing them into conflict with humans. The conflict between humans and wildlife can take many forms, such as crop damage, livestock predation, property damage, and even attacks on humans. These conflicts often lead to negative attitudes towards wildlife and can result in retaliatory killing and persecution of wildlife. To address human-wildlife conflict, conservationists and governments have developed various strategies, such as habitat restoration, conflict mitigation measures, and education and awareness programs. These strategies aim to reduce the negative impacts of human activities on wildlife, promote coexistence between humans and wildlife, and ensure the long-term survival of wildlife populations. For example, deforestation for agricultural land, timber, and fuel wood in tropical forests has led to the loss of critical habitats for many wildlife species, such as orangutans, tigers, and elephants. This loss of habitat forces these species to move into human-dominated landscapes, leading to conflict. Moreover, the fragmentation of habitats into smaller, isolated patches further exacerbates the conflict. Fragmented habitats can disrupt animal movement and migration patterns, reduce genetic diversity, and increase the risk of disease transmission, leading to population declines and local extinctions. Human activities that affect wildlife behavior and distribution can also lead to conflict. For example, hunting and poaching can deplete wildlife populations and disrupt their social structures, leading to changes in their behavior and distribution. Similarly, human disturbance such as noise pollution, traffic, and recreational activities can affect wildlife behavior, causing stress and reducing their habitat use. Human-wildlife conflict can take many forms, such as crop damage, livestock predation, property damage, and even attacks on humans. These conflicts can lead to negative attitudes towards wildlife and result in retaliatory killing and persecution of wildlife. For instance, farmers often respond to crop damage by poisoning, trapping, or shooting wildlife, which can have severe consequences for wildlife populations and ecosystems. Similarly, in urban areas, the conflict between humans and wildlife, such as bears, coyotes, and deer, can lead to calls for culling or relocation of these species, which can be expensive and often ineffective in the long term. To address human-wildlife conflict, conservationists and governments have developed various strategies, such as habitat restoration, conflict mitigation measures, and education and awareness programs. Habitat restoration aims to restore degraded or fragmented habitats, creating larger and more connected landscapes that can support viable wildlife populations. For instance, corridors of habitat can be created to connect fragmented habitats, allowing wildlife to move between them safely. Similarly, reforestation projects can restore degraded landscapes, providing critical habitats for wildlife and reducing conflict with humans. Conflict mitigation measures aim to reduce the negative impacts of human activities on wildlife, promote coexistence between humans and wildlife, and ensure the long-term survival of wildlife populations. For example, electric fencing, guard dogs, and scare devices can be used to protect crops and livestock from wildlife damage. Similarly, garbage management programs and restrictions on feeding wildlife in urban areas can reduce conflicts between humans and wildlife.

10.2.1. Causes of human-wildlife conflict

There are several causes of human-wildlife conflict, including habitat loss and fragmentation, competition for resources, and human activities that affect wildlife behavior and distribution. Habitat loss and fragmentation occur when natural habitats are destroyed or converted for human use, such as agriculture, urbanization, or infrastructure development. This displacement forces wildlife to move into new areas in search of food and shelter, often bringing them into conflict with humans. The loss of critical habitats also disrupts animal movement and migration patterns, reduces genetic diversity, and increases the risk of disease transmission, leading to population declines and local extinctions. Competition for resources is another significant cause of human-wildlife conflict. As human populations continue to grow, they require more natural resources, such as food, water, and land, which often lead to the depletion of these resources. This competition forces wildlife to search for alternative sources of food and water, which can bring them into contact with humans and their property, leading to conflict. Human activities that affect wildlife behavior and distribution can also lead to conflict. For example, hunting and poaching can deplete wildlife populations and disrupt their social structures, leading to changes in their behavior and distribution. Similarly, human disturbance such as noise pollution, traffic, and recreational activities can affect wildlife behavior, causing stress and reducing their habitat use. Another cause of human-wildlife conflict is the encroachment of human settlements into wildlife habitats. As human populations expand, they often build homes and infrastructure in areas that were previously wildlife habitats, leading to conflict with wildlife. This conflict can take many forms, such as crop damage, livestock predation, property damage, and even attacks on humans. Climate change is also a significant factor contributing to human-wildlife conflict. The changing climate is altering the timing and location of food and water resources, affecting wildlife behavior and distribution. Moreover, extreme weather events such as floods and droughts can also affect wildlife populations and their habitats, leading to conflict with humans.

Lastly, inadequate conservation policies and enforcement can also lead to human-wildlife conflict. Weak laws and regulations, insufficient enforcement, and corruption can exacerbate the conflict by allowing illegal wildlife trade and poaching to continue, leading to the depletion of wildlife populations and increasing the risk of conflict.

10.2.2. Identifying the causes and types of human-wildlife

Identifying the causes and types of human-wildlife conflict is essential for developing effective solutions to reduce conflict and promote coexistence between humans and wildlife. By understanding the impacts of human activities on wildlife, conservationists and policymakers can develop strategies to minimize harm to wildlife while ensuring the well-being of humans and their livelihoods.

- **Conservation**: Understanding the causes and types of human-wildlife conflict is essential for conservation efforts to protect wildlife populations. By identifying the sources of conflict, conservationists can develop targeted strategies to minimize the impact of human activities on wildlife and their habitats.

- **Human safety:** Human-wildlife conflict can result in injuries or fatalities to humans. Identifying conflict hotspots and types of conflict can help authorities and local communities develop measures to reduce the risk of attacks and improve public safety.
- **Livelihoods:** Many communities rely on natural resources for their livelihoods, including agriculture and livestock rearing. Identifying conflicts that affect these resources can help communities develop strategies to protect their livelihoods while minimizing harm to wildlife.
- **Public perception:** Human-wildlife conflict can lead to negative attitudes towards wildlife, which can impact conservation efforts. By identifying the causes and types of conflict, conservationists can educate communities on the importance of coexistence with wildlife and promote positive attitudes towards conservation.
- **Policy development:** Identifying human-wildlife conflict can help policymakers develop effective policies and regulations to manage conflict and promote coexistence between humans and wildlife.

10.2.3. Types of man and wildlife conflict

The conflicts can take many forms, ranging from minor incidents such as wildlife feeding in residential gardens to more severe events such as attacks on humans and livestock. India is home to a diverse range of wildlife, including tigers, elephants, bears, monkeys, and crocodiles. As a result, human-wildlife conflict is a significant issue in many parts of the country. Here are some of the most common types of human-wildlife conflict:

- **Crop damage:** Wildlife such as elephants, monkeys, and wild boars often raid crops, causing significant damage to agricultural fields. This can result in financial losses for farmers and create a negative perception of wildlife among the local communities.
- **Livestock predation**: Carnivorous wildlife such as lions, tigers, wolves, and coyotes may attack and kill livestock, leading to financial losses for livestock owners. This can also result in retaliatory killings of wildlife by farmers.
- **Property damage**: Wildlife may cause damage to property, such as breaking into buildings or vehicles, which can be costly to repair.
- **Road accidents**: Wildlife can cause road accidents when they cross roads or highways, leading to injury or death of both humans and animals.

- **Human-wildlife conflict in urban areas**: As urbanization expands, wildlife is increasingly found in urban areas, leading to conflict with humans. This includes incidents such as bears or cougars entering residential areas or causing damage to property.
- **Wildlife feeding:** Feeding wildlife can alter their natural behavior and lead to aggressive behavior towards humans. It can also cause animals to become reliant on humans for food, which can lead to overpopulation and other negative impacts.
- **Attacks on humans:** In rare cases, wildlife such as lions, tigers, and crocodiles may attack and kill humans, leading to fear and negative attitudes towards wildlife.
- **Poaching:** Poaching of wildlife for meat, trophies, or traditional medicines is a significant cause of human-wildlife conflict. This not only depletes wildlife populations but can also lead to confrontations between poachers and park rangers.
- **Wildlife trade**: The illegal trade of wildlife, including live animals and animal parts, can lead to the depletion of populations and create conflicts between traders and authorities.
- **Conservation conflicts:** Conflicts can arise between conservationists and local communities over the use and management of natural resources, including wildlife.

10.2.4. How to reduce man and wildlife conflict

Reducing human-wildlife conflict requires a multifaceted approach that addresses the underlying causes of conflict and promotes coexistence between humans and wildlife. Here are some strategies that can help to reduce human-wildlife conflict:

- **By Habitat conservation**: Habitat loss and fragmentation are significant drivers of human-wildlife conflict. Protecting and restoring habitat can help to reduce conflicts by providing sufficient space and resources for wildlife.
- **By Land-use planning:** Land-use planning that takes into account the needs of wildlife can help to reduce conflicts by minimizing human activities in areas important for wildlife, such as migration corridors or breeding grounds.
- **By Crop protection:** Developing and implementing effective crop protection measures can help reduce crop damage by wildlife. These include physical barriers, such as fences or trenches, or non-lethal methods such as scaring devices or predator deterrents.

- **By Livestock management:** Livestock management practices, such as fencing, night enclosures, and guard animals, can help reduce livestock predation by carnivorous wildlife
- **By Education and outreach:** Educating communities about the importance of coexisting with wildlife and promoting positive attitudes towards conservation can help reduce conflicts. This can include training on how to prevent conflicts, such as secure waste disposal, and how to respond to conflicts when they occur.
- **By Wildlife monitoring and research:** Regular monitoring of wildlife populations and their behavior can help to identify conflict hotspots and develop effective solutions to mitigate conflicts.
- **By Law enforcement:** Enforcing laws and regulations that protect wildlife and punish those who engage in illegal activities such as poaching or wildlife trafficking can help reduce conflicts
- **By Compensation and insurance schemes:** Providing compensation or insurance to communities affected by wildlife conflicts can help reduce economic losses and reduce the need for retaliatory killings of wildlife.
- **By Collaboration and partnerships:** Collaboration between conservation organizations, local communities, government agencies, and other stakeholders is essential for developing effective solutions to reduce human-wildlife conflict.

10.2.5. Causes of wildlife depletion

Wildlife depletion refers to the decline in the population or extinction of animal species due to various factors, including human activities. Wildlife depletion is a significant environmental issue that affects the balance of ecosystems, disrupts food chains, and leads to the loss of biodiversity. In this article, we will discuss some of the leading causes of wildlife depletion. Many wild animals became extinct due to various human and natural activities:

1. Absence of cover or shelter to wild animals.
2. Due to deforestation for cultivation, road-building, railways routes, dam construction or for urbanization, occurs reduction in the area for free movement of wild animals which retard reproductive capacity of certain wild animals such as deer, bison, rhino, tiger, etc.
3. Destruction of wild plants of forests for timber, charcoal and fire wood etc.

4. Noise pollution by different transporting media (trucks, buses, rails, aeroplanes, etc.) and polluting river water have adversely affected wild animals.
5. Various natural calamities such as floods, droughts, fires, epidemics, etc. have also caused great destruction of wild life.
6. Hunting methods of all kinds and for any purpose (i.e. for food, recreating, hide, fur, plumage, musk, tusk, horn, etc.) have caused destruction of wild life.

Destruction of natural habits of wild animals as follows:

1. **Habitat Loss and Fragmentation**

Habitat loss and fragmentation are among the most significant causes of wildlife depletion globally. Human activities such as deforestation, mining, urbanization, and agriculture have resulted in the destruction of natural habitats, forcing many animal species to migrate, adapt, or perish. Habitat fragmentation refers to the breaking up of natural habitats into smaller, isolated pieces, which can reduce the availability of food, water, and shelter for wildlife. Habitat loss and fragmentation lead to a decline in wildlife populations and biodiversity loss.

2. **Overexploitation and Unsustainable Use**

Overexploitation and unsustainable use of wildlife resources are significant contributors to wildlife depletion. Overexploitation refers to the unsustainable harvest of wildlife resources for food, medicine, clothing, and other purposes. Hunting and poaching of wildlife for their meat, ivory, horns, fur, and other parts have led to the decline or extinction of many animal species. Unsustainable fishing practices, such as overfishing, have also led to a decline in marine wildlife populations, including fish, sharks, and sea turtles. Unsustainable use of wildlife resources also includes habitat destruction for resource extraction, such as logging and mining.

3. **Climate Change**

Climate change is a significant contributor to wildlife depletion, as it affects natural habitats and ecosystems. Climate change leads to rising temperatures, changing rainfall patterns, and extreme weather events such as floods, droughts, and wildfires, which can alter or destroy natural habitats. Climate change also affects the timing of natural events such as breeding, migration, and hibernation, which can disrupt food chains and affect the survival of animal species. Climate change has led to the loss of coral reefs, the melting of Arctic sea ice, and the decline in polar bear populations, among other impacts.

4. **Pollution**

Pollution is another significant cause of wildlife depletion, as it affects the quality of natural habitats and ecosystems. Pollution can come from various sources, including industrial activities, agriculture, transportation, and waste disposal. Polluted air, water, and soil can harm wildlife by affecting their health, reproduction, and behavior. Pollution can also lead to the bioaccumulation of toxic substances in wildlife, which can affect their survival and the health of humans who consume them.

5. **Invasive Species**

Invasive species are non-native species that have been introduced to natural habitats, where they can compete with native species for resources, alter ecosystems, and spread diseases. Invasive species can outcompete native species for food, water, and shelter, and may have no natural predators or parasites to keep their populations in check. Invasive species can also disrupt natural ecosystems by altering food chains, affecting soil quality, and reducing the availability of resources for native species. Invasive species are a significant cause of wildlife depletion, as they can lead to the decline or extinction of native species. the invasive specis are parthenium hysterophorus, Lantana camara and eichhornia crassipes.

6. **Disease**

Disease is another significant cause of wildlife depletion, as it can spread rapidly through animal populations, leading to a decline or extinction of species. Disease can be caused by viruses, bacteria, fungi, or parasites and can be spread through direct contact or through vectors such as mosquitoes, ticks, or fleas. Disease can affect animal behavior, reproduction, and survival, and can lead to the collapse of entire ecosystems. Diseases such as white-nose syndrome have led to the decline of bat populations, while chronic wasting disease has affected deer and elk populations.

7. **Human-Wildlife Conflict**

Human-wildlife conflict is also a significant cause of wildlife depletion. Killing of wild animals for food for protection of man and domestic animals, and for fun and glory, has assumed dangerous proportions. During the last century, big game hunting became the chief sport of the British officers and Indian Princes. This resulted into large-scale killing of tigers and other wild animals for fun, pleasure and glory.

8. **Hunting: Human greed for wild animal products:**

Poaching, i.e., illegal killing of wild animals for various products like hides, fur, leather, meat, aphrodisiac and other drugs, perfumes, cosmetics, decoration, souvenirs, museum specimens, etc. took the place of legal hunting after independence, and so, killing of wild animals continued. For instance, there has been an indiscriminate killing of elephants for ivory, rhinocerous for its horn which is used in preparation of aphrodisiac drugs, musk deers for musk (a highly odoriferous fluid found in a cyst near and navel of male deers), whales for fat, meat and hide, foxes, tigers, gharials, crocodiles, sambhar, etc. for skins and so on. Similarly, millions of snakes have been killed for skin. All this killing has brought many wild animals species to the brink of extinction.

9. **Forest fires:**

   Geological evidences indicate that use of 'fire by man" is about one and a half million years old. It was **Java Ape Man** who discovered fire and used it for hunting, protection and cooking. Since then, forest fires, caused due to human negligence, have brought about large-scale destruction of forest.

10. **Highway conveyance and transportation:**

    Construction of roads and lying of railway lines and transportation play a significant role in fragmentation and shrinkage of natural habitats.

11. **Ecological disturbances:**

    Natural habitats of wildlife get environmentally degraded and ecologically disturbed owing to a number of factors like air and water pollution, immigration of certain wild animals from one to the other habitats, deliberate or chance introduction of exotic species from one to the other habitats by man, and so on.

12. **Human greed for forest products:**

    Human greed for forest products and products of natural pasturelands, like commercial timber, valuable herbs and exotic flowers, etc. has increased so much in the modern materialistic human living that it is now playing a significant role in destruction of natural habitats at a fast rate. So many areas have been deforested and turned into dry, infertile lands during the past decades by native people to their own doom.

10.2.6. Measures of Wildlife conservation

The conservation of wild life is required for the following benefits:

1. The wild life helps us in maintaining the ‘balance of nature’. The destruction of carnivores or insectivores often leads to the increase in herbivores which in turn affects the forest vegetation or crops.
2. The wild life can be used commercially to earn more and more money. It can increase our earning of foreign exchange, if linked with tourism.
3. The preservation of wild life helps many naturalists and behavior biologists to study morphology, anatomy, physiology, ecology, behavior biology of the wild animals under their natural surroundings.

The wildlife of India is our cultural asset and has deep-rooted effect of Indian art, sculpture, literature and religion

10.2.7. Economic importance of wildlife

Wildlife has significant economic importance, as it provides various goods and services that contribute to human well-being and economic growth.

Ecotourism

Wildlife is a significant attraction for tourists, who are willing to pay to see and experience wildlife in its natural habitat. Ecotourism, which involves responsible travel to natural areas, can provide economic benefits to local communities, including employment, income, and investment opportunities. In many developing countries, wildlife-based tourism is a significant contributor to GDP and job creation. For example, in Kenya, tourism accounts for over 10% of GDP, with wildlife-based tourism being a significant contributor. The Maasai Mara National Reserve, which is home to the annual wildebeest migration, attracts over 150,000 tourists annually, generating over $100 million in revenue.

Hunting and Fishing

Hunting and fishing are traditional economic activities that provide food, income, and recreation opportunities. In many countries, hunting and fishing are regulated to ensure sustainability and conservation of wildlife populations. Hunting and fishing can provide economic benefits to local communities through the sale of meat, hides, and other parts of the animals. For example, in Alaska, hunting and fishing generate over $2 billion in annual revenue, with over 20,000 jobs created in the hunting and fishing industry.

Bioprospecting

Bioprospecting involves the search for new medicinal, agricultural, and industrial products from natural resources, including wildlife. Wildlife species, including plants, animals, and microbes, have provided various products, such as medicine, food, and cosmetic products. For example, the Madagascar periwinkle, a plant species found in Madagascar, is the source of two cancer-fighting drugs, vincristine and vinblastine. The bark of the African yohimbe tree is used to make a drug that treats impotence. Bioprospecting can provide significant economic benefits to local communities, who can benefit from the royalties and licensing fees of the products derived from the natural resources.

Wildlife-Based Agriculture

Wildlife-based agriculture involves the cultivation of wildlife species, such as bees, silkworms, and fish, for economic purposes. Wildlife-based agriculture can provide economic benefits to farmers and rural communities, who can generate income from the sale of the products derived from the wildlife species. For example, honey production from bees provides a significant source of income for many rural communities, who sell the honey in local and international markets. In India, the production of honey generates over $200 million in annual revenue, with over 2.5 million households involved in beekeeping.

Research and Education

Wildlife provides various opportunities for research and education, which can lead to new knowledge, innovation, and economic growth. Research on wildlife species can provide insights into their biology, behavior, and ecology, which can be used to develop new technologies, products, and services. Education on wildlife can also provide opportunities for skill development, entrepreneurship, and innovation. For example, research on the physiology of hibernating animals has led to the development of new medical technologies that can be used to treat patients with heart disease and stroke.

Biodiversity:

Wildlife plays a critical role in maintaining biodiversity, which is the variety of living organisms on Earth. This includes everything from the smallest insects to the largest mammals. Biodiversity is essential because it helps ecosystems function properly and provides humans with a wide range of ecological services, such as clean air and water, fertile soil, and pollination of crops.

Ecosystem Services:

Wildlife provides a range of ecosystem services that are vital to human survival. For example, wetlands provide important habitat for fish and wildlife, filter pollutants from water, and protect against floods. Forests provide oxygen, absorb carbon dioxide, and regulate the Earth's climate. Coral reefs are home to millions of species and protect coastlines from storms and erosion.

Cultural Importance:

Wildlife is an important part of many cultures around the world. For example, the bald eagle is a symbol of strength and freedom in the United States, while elephants are considered sacred in many African and Asian cultures. Wildlife also plays a critical role in traditional medicines and cultural practices. Wildlife has significant economic importance, as it provides various goods and services that contribute to human well-being and economic growth. Ecotourism, hunting and fishing, bioprospecting, wildlife-based agriculture, research, and education are some of the examples of how wildlife contributes to the economy. The conservation and sustainable use of wildlife resources are crucial to ensure the continued provision of economic benefits from wildlife.

10.2.8. Needs of Wildlife conservation

Wildlife conservation refers to the practice of protecting, preserving, and managing wild plants and animals, as well as their habitats, for the benefit of future generations. Wildlife conservation is essential to ensure the continued existence of wild species and the functioning of ecosystems. Wildlife faces numerous threats, including habitat loss, poaching, climate change, and disease, and conservation efforts are necessary to address these threats and protect vulnerable species. Wildlife conservation is critical for ensuring the continued existence of wild species and the functioning of ecosystems. Conservation efforts require a range of strategies and interventions, including habitat protection, anti-poaching measures, education and outreach, sustainable use, and research and monitoring. Protecting and conserving wildlife is essential to ensure the continued provision of ecological, cultural, economic, and scientific benefits for generations to come. The needs of wildlife conservation are due to following reason.

- **Biodiversity:** Wildlife conservation is crucial for maintaining biodiversity, which is essential for the functioning of ecosystems. Biodiversity provides numerous benefits, including food, medicine, and clean air and water.
- **Ecosystem Services:** Wildlife provides a wide range of ecosystem services, including pollination, seed dispersal, and soil fertilization, which are essential for the growth and survival of many plants.
- **Habitat Protection**: Habitat protection is critical for the survival of many species. This involves preserving natural areas, restoring degraded habitats, and protecting critical habitats, such as breeding grounds and migration routes.
- **Anti-Poaching Measures**: Poaching is a major threat to wildlife, and anti-poaching measures are necessary to prevent the illegal hunting and trading of wildlife products. This includes increasing penalties for poaching, improving law enforcement efforts, and reducing demand for wildlife products.
- **Cultural Importance:** Many cultures around the world rely on wildlife for food, medicine, and other resources. Wildlife also plays an essential role in cultural practices and traditions.
- **Economic Importance**: Wildlife provides significant economic benefits, including ecotourism, hunting and fishing, and wildlife-based agriculture. These industries support millions of jobs and generate billions of dollars in revenue.
- **Scientific Importance:** Wildlife is essential for scientific research, including studies on animal behavior, genetics, and ecology. This research can help us better understand how ecosystems work, how to protect endangered species, and how to manage natural resources sustainably.
- **Sustainable Use:** Sustainable use of wildlife resources, such as hunting and fishing, can provide economic benefits while also supporting conservation efforts. This requires the establishment of effective management systems to ensure that wildlife populations are not overexploited.
- **Research and Monitoring:** Research and monitoring are critical for understanding the needs of wildlife and assessing the effectiveness of conservation efforts. This includes conducting population surveys, monitoring habitat quality, and studying the impacts of threats such as climate change and disease.

Wildlife conservation is critical for ensuring the continued existence of wild species and the functioning of ecosystems. Conservation efforts require a range of strategies and interventions, including habitat protection, anti-poaching measures, education and outreach, sustainable use, and research and monitoring. Protecting and conserving wildlife is essential to ensure the continued provision of ecological, cultural, economic, and scientific benefits for generations to come.

10.3. Endangered flora and fauna of India

India is a country with rich biodiversity and is home to many endangered species of flora and fauna. A plant, animal or microorganism that is in immediate risk of biological extinction is called “endangered species” or “threatened species”. In other words, these are those species whose life is under risk or threat and which are about to be extinct. These species which was native to a region and their population strength has reduced from 50 per cent to 5 per cent, such species are known as endangered species. The conservation of these species is crucial to maintaining the balance of the ecosystem and preserving the natural heritage of the country.. Here are some examples of endangered species in India and their conservation strategies:

- **Endangered plant species of India**

According to the Red List of Threatened Species compiled by the International Union for Conservation of Nature and Natural Resources (IUCN), there are currently 86 Critically Endangered, 88 Endangered, and 219 Vulnerable animal species in India.

The flora of India is one of the richest in the world due to the country's wide range of climate, topology, and environment. There are over 15,000 species of flowering plants in India which account for 6% of all plant species in the world. Many plant species are being destroyed, however, due to their prevalent removal. Roughly 1/4 of all plant species in the world are at risk of being endangered or going extinct to face on. Some of the endangered plant species in India are:

- **Himalayan Yew:** The Himalayan Yew, Taxus wallichiana is a slow-growing tree that is found in the Himalayan region. It is endangered due to over-harvesting for its bark, which is used to produce the anti-cancer drug, Taxol.

- **Nilgiri Tahr Grass**: The Nilgiri Tahr Grass (Danthonia nilagirica) is a grass species found in the Western Ghats of India. It is endangered due to habitat loss and fragmentation caused by human activities.
- **Lady's Slipper Orchid:** The Lady's Slipper Orchid (Cypripedium cordigerum) is a rare and endangered orchid species found in the Eastern Himalayas. It is threatened due to habitat destruction and collection for horticulture.
- **Red Sanders**: Red Sanders (Pterocarpus santalinus) is a tree species found in the Eastern Ghats of India. It is endangered due to overexploitation for its valuable wood, which is used in furniture making and carving.
- **Foxtail Orchid:** The Foxtail orchid (Rhynchostylis retusa) is an epiphytic orchid species found in the Western Ghats of India. It is endangered due to habitat destruction and collection for horticulture.
- **Indian Ghost Tree:** The Indian ghost Tree (Kalanchoe pinnata) is a tree species found in the Western Ghats of India. It is endangered due to overexploitation for its medicinal properties.
- **Sangai Lily:** The Sangai lily (Lilium mackliniae) is a rare and endangered lily species found in the Manipur hills of India. It is threatened due to habitat loss and collection for horticulture. These are just a few examples of the endangered plant species in India, and there are many more that are facing similar threats. It is important to conserve and protect these plant species to maintain the balance of the ecosystem and the survival of the planet.

- **Endangered Animal species of India**

India, a megadiverse country 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. Being one of the 17 identified mega diverse countries; India has 10 biogeography 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 Sundaland, are represented in India. According to the Red List of Threatened Species compiled by the International Union for Conservation of Nature (IUCN), there are currently 86 critically endangered, 88 endangered, and 219 vulnerable animal species in India.

Some of the critically endangered animal species in India include the Ganges River Dolphin, Himalayan Wolf, Nilgiri Marten, Indian Vulture, and the Pygmy Hog. Endangered species in India include the Indian rhinoceros, asiatic lion, Indian wild ass, and Indian pangolin. vulnerable species include the bengal tiger, snow leopard, Indian elephant, indian giant squirrel, and Indian flying fox. Some of the critically endangered animal species in India include:

- **Ganges River Dolphin:** This freshwater dolphin is only found in the Ganges-Brahmaputra-Meghna and Karnaphuli-Sangu river systems. It is threatened by habitat loss, pollution, and fishing activities.
- **Himalayan Wolf**: This species of wolf is found in the high altitude regions of the Himalayas. It is threatened by habitat loss, poaching, and retaliatory killings.
- **Nilgiri Marten:** This arboreal carnivorous mammal is found in the Western Ghats of India. It is threatened by habitat loss, fragmentation, and hunting.
- **Indian Vulture:** These large scavenger birds were once widespread across India but are now critically endangered due to the use of the veterinary drug diclofenac, which is toxic to them.
- **Pygmy Hog:** This small wild pig is found only in the grasslands of Assam. It is threatened by habitat loss and hunting.

Other endangered animal species in India include:

- **Indian Rhinoceros:** This one-horned rhino is found in the grasslands and forests of North-Eastern India. It is threatened by poaching for its horn and habitat loss.
- **Asiatic Lion:** This subspecies of lion is found only in the Gir Forest of Gujarat. It is threatened by habitat loss, poaching, and human-wildlife conflict.
- **Indian Wild Ass:** This endangered subspecies of wild ass is found in the Little Rann of Kutch in Gujarat. It is threatened by habitat loss and hunting.
- **Indian Pangolin:** This scaly anteater is found in the forests of India. It is threatened by habitat loss and poaching for its meat and scales.
- **Bengal Tiger:** This iconic big cat is found in various habitats across India. It is threatened by habitat loss, poaching, and human-wildlife conflict.
- It is crucial for individuals and governments to work together to protect these species and their habitats, to prevent their extinction and maintain the health of ecosystems.

10.4. Special projects for endangered species

Special projects for endangered species are crucial for their conservation and protection. Here are some examples of special projects for endangered species in India:

- **Project Tiger:** Project tiger is a flagship conservation program of the Government of India launched in 1973 to protect the endangered Bengal tiger. The project aims to ensure the survival and growth of the tiger population by protecting its habitats, preventing poaching and illegal trade of tiger parts, and promoting awareness and participation of local communities in conservation efforts.
- **Project Elephant:** Project elephant is a conservation program launched by the Government of India in 1992 to protect the endangered Asian elephant. The project aims to protect and conserve elephant habitats, prevent poaching and illegal trade of elephant parts, and address human-elephant conflict through scientific management and community participation.
- **Great Indian Bustard Conservation Project:** The Great Indian Bustard Conservation Project is a joint initiative of the Government of India and the Rajasthan government launched in 2018 to protect the critically endangered Great Indian Bustard. The project aims to protect and conserve the bird's habitats, prevent poaching and illegal trade, and address the human-bird conflict through community participation and scientific management.
- **Snow Leopard Conservation Project:** The Snow Leopard Conservation Project is a conservation program launched by the Government of India in 2009 to protect the endangered snow leopard. The project aims to protect and conserve snow leopard habitats, prevent poaching and illegal trade of its parts, and promote awareness and community participation in conservation efforts.
- **Indian Rhino Vision 2020:** Indian Rhino Vision 2020 is a conservation program launched in 2005 to protect the endangered one-horned Indian rhinoceros. The project aims to increase the population of the rhinoceros in the wild by reintroducing the species to its former range and establishing new populations in protected areas. The project also involves habitat management, anti-poaching measures, and community participation in conservation efforts.

Special projects for endangered species are essential for their conservation and protection. These projects involve scientific management, habitat conservation, community participation, and anti-poaching measures to ensure the survival and growth of endangered species in India. The success of these projects depends on the commitment of government. community participation, and awareness programs to promote conservation efforts.

10.5. Project tiger

Project Tiger is one of the most successful conservation initiatives in India that was launched on April 1, 1973, by the government of India to protect and conserve the dwindling population of tigers in the country such as Bengal tiger and its habitat. The project is a collaborative effort between the Government of India and various state governments, with support from national and international conservation organizations. It was launched in response to the alarming decline in the tiger population due to poaching, habitat loss, and other human activities. The project was initiated with the help of renowned tiger expert, Dr. Kailash Sankhala, who emphasized the need for the conservation of tigers and their habitats. The project was implemented by the National Tiger Conservation Authority (NTCA) under the Ministry of Environment, Forest, and Climate Change. The project aimed to conserve the remaining tiger population in the country and to ensure that the habitats essential for their survival were protected and restored. It involved the creation of a network of tiger reserves across the country and the implementation of measures to reduce poaching and habitat loss. The initial phase of the project covered nine tiger reserves in different parts of the country, including Bandhavgarh, Kanha, Sariska, and Palamau. The success of project in these reserves led to its expansion to other parts of the country, with the creation of new tiger reserves. Over the years, the scope of Project Tiger has expanded to include measures to address the threats to tigers and their habitats, such as habitat fragmentation, poaching, and human-tiger conflicts. The project has also emphasized the importance of community participation in conservation efforts and the promotion of ecotourism as a means of generating income for local communities. The Tiger Reserve Project has been successful in increasing the population of tigers in India. The initial estimate of the tiger population in India in 1972 was around 1,800, which had declined to around 1,400 by the early 2000s. However, with the implementation of the Tiger Reserve Project, the tiger population in India has shown a significant increase, with the latest estimate putting the number at around 2,967 tigers in 2018. Today, Project Tiger covers 50 tiger reserves in different parts of the country, covering an area of over 72,749 square kilometers. The project has been instrumental in increasing the tiger population in the country from around 1,411 in 2006 to 2,967 in 2019, making India home to 70% of the world's tigers. However, the government of India has allocated a substantial amount of funds for the project over the years. As per the 2021 budget allocation, the government has allocated around INR 380 crores (approximately USD 50 million) for Project Tiger for the financial year 2021-2022. The funds allocated are used for various purposes, including the development of tiger reserves, the improvement of infrastructure for tourism, the training of staff and forest guards, the conservation of tiger habitats, and the implementation of anti-poaching measures. Additionally, the project also receives funds from international organizations, private donors, and other sources.

Project Tiger has a significant impact on the conservation of tigers and their habitats in India. The success to project has been due to the government's commitment, the efforts of conservationists, and the involvement of local communities in conservation efforts. The project's history and scope highlight the importance of conservation initiatives that involve collaboration and cooperation among various stakeholders to achieve conservation goals. India has the largest population of tigers in the world, and the Tiger Reserve Project has become a model for conservation efforts worldwide. However, there is still a long way to go to ensure the long-term survival of tigers and other wildlife in India, and efforts to conserve and protect these species need to be continued and strengthened. The survey in September 2021 reveals that India has 51 tiger reserves spread across 18 states, covering an area of around 72,749 square kilometers. Some name of tigers reserve project in India are

- Agasthyamalai Biosphere Reserve, Kerala
- Bandhavgarh Tiger Reserve, Madhya Pradesh
- Bandipur Tiger Reserve, Karnataka
- Bori-Satpura Tiger Reserve, Madhya Pradesh
- Buxa Tiger Reserve, West Bengal
- Dampa Tiger Reserve, Mizoram
- Indravati Tiger Reserve, Chhattisgarh
- Kalakad-Mundanthurai Tiger Reserve, Tamil Nadu
- Kanha Tiger Reserve, Madhya Pradesh
- Kali Tiger Reserve, Karnataka
- Kudremukh Tiger Reserve, Karnataka
- Melghat Tiger Reserve, Maharashtra

- Nagarjunsagar-Srisailam Tiger Reserve, Andhra Pradesh and Telangana
- Nagzira Wildlife Sanctuary, Maharashtra
- Namdapha Tiger Reserve, Arunachal Pradesh
- Nameri Tiger Reserve, Assam
- Pakke Tiger Reserve, Arunachal Pradesh
- Palamau Tiger Reserve, Jharkhand
- Pench Tiger Reserve, Maharashtra and Madhya Pradesh
- Periyar Tiger Reserve, Kerala
- Ratapani Tiger Reserve, Madhya Pradesh
- Sathyamangalam Wildlife Sanctuary, Tamil Nadu and Karnataka
- Sariska Tiger Reserve, Rajasthan
- Simlipal Tiger Reserve, Odisha
- Sitanadi-Udanti Wildlife Sanctuary, Chhattisgarh
- Satpura Tiger Reserve, Madhya Pradesh
- Sunderbans Tiger Reserve, West Bengal
- Tadoba-Andhari Tiger Reserve, Maharashtra
- Valmiki National Park, Bihar
- Palpur-Kuno Wildlife Sanctuary, Madhya Pradesh
- Sanjay-Dubri Tiger Reserve, Madhya Pradesh
- Udanti-Sitanadi Tiger Reserve, Chhattisgarh
- Anamalai Tiger Reserve, Tamil Nadu
- Bhadra Wildlife Sanctuary, Karnataka
- Mudumalai National Park and Wildlife Sanctuary, Tamil Nadu and Karnataka
- Periyar Wildlife Sanctuary, Kerala
- Sariska Wildlife Sanctuary, Rajasthan
- Wayanad Wildlife Sanctuary, Kerala
- Kawal Wildlife Sanctuary, Telangana
- Mukundra Hills Tiger Reserve, Rajasthan
- Balaghat Range, Madhya Pradesh
- Bor Wildlife Sanctuary, Maharashtra
- Navegaon-Nagzira Tiger Reserve, Maharashtra
- Umred Karhandla Wildlife Sanctuary, Maharashtra

- Bhagwan Mahavir Wildlife Sanctuary and Mollem National Park, Goa
- Satkosia Tiger Reserve, Odisha
- Rajaji Tiger Reserve, Uttarakhand
- Sathyamangalam Wildlife Sanctuary, Tamil Nadu and Karnataka.

Tiger reserves in Uttar Pradesh:

- **Dudhwa Tiger Reserve:** Located in the Lakhimpur Kheri district, Dudhwa Tiger Reserve covers an area of 1288.3 square kilometers. It was declared a tiger reserve in 1988 and is home to a variety of flora and fauna, including tigers, leopards, elephants, swamp deer, and rhinoceros. The reserve is managed by the Uttar Pradesh Forest Department, with support from the National Tiger Conservation Authority (NTCA) and various conservation organizations.
- **Pilibhit Tiger Reserve:** Located in the Pilibhit district, Pilibhit Tiger Reserve covers an area of 727.68 square kilometers. It was declared a tiger reserve in 2014 and is home to tigers, leopards, elephants, and various species of birds and reptiles.
- **Amangarh Tiger Reserve:** Located in the Bijnor district, Amangarh Tiger Reserve covers an area of 387.22 square kilometers. It was declared a tiger reserve in 2021 and is home to tigers, leopards, elephants, and various species of birds and reptiles.

10.5.1. Needs and benefits of tigers reserve project

The Tiger Reserve Project was initiated in India with the aim of conserving the tiger and its habitat. Here are some of the needs and benefits of the project:

Needs:

- **Protection of Tigers**: The main objective of the project is to protect tigers and their habitat. The tiger is an endangered species and the project aims to protect the remaining population of tigers in India.
- **Habitat conservation**: The project aims to conserve the natural habitats of tigers and other wildlife. It includes the protection of forests, grasslands, wetlands, and other ecosystems that are important for the survival of tigers.

- **Anti-poaching measures**: The project focuses on reducing poaching of tigers by strengthening anti-poaching measures, such as increased patrolling and the deployment of wildlife rangers.
- **Community participation**: The project involves local communities in conservation efforts, creating awareness about the importance of tigers and their habitat and encouraging their participation in conservation activities.
- **Ecotourism:** The project promotes ecotourism as a means to generate revenue and provide employment opportunities for local communities while reducing the pressure on tiger habitats.

Benefits:

- **Conservation of tigers:** The reserves provide a safe haven for tigers, protecting them from poaching and habitat loss. This, in turn, helps to conserve the tiger population in the state.
- **Conservation of endangered species:** The project has contributed significantly to the conservation of endangered species, particularly the tiger, by protecting their natural habitats and reducing human-wildlife conflict.
- **Preservation of biodiversity:** The project aims to preserve biodiversity by protecting the habitats of various wildlife species, which also benefits the ecosystem as a whole.
- **Economic benefits:** The project generates economic benefits through ecotourism, creating employment opportunities for local communities and contributing to the growth of the tourism industry.
- **Improved livelihoods**: The project involves local communities in conservation efforts, which helps to improve their livelihoods by providing alternate livelihood options and reducing their dependency on natural resources.
- **Increased awareness:** The project has helped to increase awareness about the importance of wildlife conservation, leading to a greater understanding of the ecological, economic, and social benefits of conservation.

10.6. GIR Lion Project

The Gir Lion Project, also known as the Asiatic Lion Conservation Project, was launched in 1972 by the Government of India with the objective of conserving the Asiatic lion, which is an endangered species found only in the Gir Forest of Gujarat, India. The Gir Lion Project was initiated in response to the dwindling population of the Asiatic lion, which had fallen to less than 200 individuals in the early 1900s due to habitat loss and hunting. The project was designed to focus on the conservation of the Asiatic lion's habitat, the Gir Forest, and to increase the lion population through captive breeding and reintroduction. Historically, the population of Gir lions had declined to dangerously low levels due to habitat loss, hunting, and human-wildlife conflict. However, with the initiation of the Gir Lion Project in 1972, conservation efforts were intensified to save the species from extinction. The project involved measures such as habitat protection, anti-poaching efforts, and community involvement in conservation activities.

Today, the population of Gir lions has increased significantly from less than 200 individuals in the early 1900s to over 500 individuals in recent years. The success of the Gir Lion Project has also led to the reintroduction of lions into the Kuno Wildlife Sanctuary in Madhya Pradesh, India, to increase the range of the species and reduce the risk of a catastrophic event affecting the entire population. Gir Lion Project has evolved over the years, with a focus on three main areas:

Habitat management: The project aims to protect and restore the Gir Forest and its ecosystem, which is critical to the survival of the Asiatic lion. This includes measures such as reducing human-wildlife conflict, managing invasive species, and improving habitat connectivity.

Population management: The project focuses on increasing the Asiatic lion population through captive breeding and reintroduction programs. The captive breeding program has been successful, with the lion population increasing from less than 200 in the early 1900s to over 500 individuals today. The reintroduction program has also been successful, with lions being reintroduced into the Kuno Wildlife Sanctuary in Madhya Pradesh, India.

Community engagement: The project recognizes the importance of local communities in conservation efforts and works to engage them in the process. This includes providing employment opportunities, promoting sustainable livelihoods, and educating local communities about the importance of conservation.

. The project serves as a model for conservation efforts in India and around the world, highlighting the importance of habitat conservation, captive breeding, reintroduction, and community engagement in wildlife conservation.

10.6.1. Needs for Gir Lions Project

The Gir Lion Project was initiated to address the urgent need to conserve the Asiatic lion and its habitat, and it has been successful in increasing the lion population and ensuring the long-term survival of the species, and it was aimed to address the following needs:

Habitat protection and management: The Gir Forest is a crucial habitat for the Asiatic lion, and its conservation is critical to the survival of the species. The Gir Lion Project was initiated to protect and manage the Gir Forest and its ecosystem to ensure that it can sustain the lion population. This involves measures such as reducing human-wildlife conflict, managing invasive species, and improving habitat connectivity.

Population management: The Asiatic lion population had dwindled to less than 200 individuals in the early 1900s, making it critically endangered. The Gir Lion Project was initiated to increase the lion population through captive breeding and reintroduction programs. The captive breeding program has been successful, with the lion population increasing from less than 200 in the early 1900s to over 500 individuals today. The reintroduction program has also been successful, with lions being reintroduced into the Kuno Wildlife Sanctuary in Madhya Pradesh, India.

Conservation awareness: The Gir Lion Project aims to create awareness among the local communities about the importance of wildlife conservation and the need to protect the Asiatic lion. It involves educating people about the importance of the Gir Forest ecosystem, the threats facing the Asiatic lion, and the steps needed to conserve the species.

Research and monitoring: The Gir Lion Project involves conducting research and monitoring to understand the ecology and behavior of the Asiatic lion and to identify the threats to its survival. This information is used to develop conservation strategies and to inform policy decisions related to the protection of the species.

Benefits

The Gir Forest is not only important for the conservation of Gir lions but also for the protection of a diverse range of flora and fauna. The ecosystem of the Gir Forest is home to several other endangered species, such as the Indian leopard, Indian pangolin, and Bengal fox, among others. The conservation of Gir lions and their habitat is crucial for the preservation of this unique and endangered subspecies of lions. Efforts to conserve the Gir Forest ecosystem and its wildlife need to be continued and strengthened to ensure the long-term survival of these majestic animals.

The Gir Lion Project has been successful in ensuring the long-term survival of the Asiatic lion, conserving its habitat, and generating income for the local communities through ecotourism. It is an excellent example of how conservation efforts can lead to positive outcomes for both wildlife and humans. It has several benefits such as:

Increased population: The population of Asiatic lions had dwindled to less than 200 individuals in the early 1900s, making it critically endangered. Through the Gir Lion Project, the lion population has increased from less than 200 in the early 1900s to over 500 individuals today.

Conservation of habitat: The Gir Forest is a crucial habitat for the Asiatic lion, and its conservation is critical to the survival of the species. The Gir Lion Project has helped protect and manage the Gir Forest and its ecosystem to ensure that it can sustain the lion population. This has involved measures such as reducing human-wildlife conflict, managing invasive species, and improving habitat connectivity.

Successful reintroduction: The Gir Lion Project has also been successful in reintroducing lions into the Kuno Wildlife Sanctuary in Madhya Pradesh, India. This has helped to increase the range of the species and reduce the risk of a catastrophic event, such as a disease outbreak, affecting the entire population.

Conservation awareness: The Gir Lion Project has created awareness among local communities about the importance of wildlife conservation and the need to protect the Asiatic lion. It has involved educating people about the importance of the Gir Forest ecosystem, the threats facing the Asiatic lion, and the steps needed to conserve the species.

Ecotourism: The increase in the lion population and the success of the Gir Lion Project has led to an increase in ecotourism in the region. This has generated income for the local communities, and helped in their economic development.

10.7. Elephant project

The Indian Elephant Project was launched in 1992 to address the conservation needs of the Indian elephant. The Indian Elephant Project was initiated by the Government of India in collaboration with the World Wide Fund for Nature (WWF) and other conservation organizations. The project was launched in response to the declining population of elephants in India and the increasing human-elephant conflicts.

As of 2021, there are 32 elephant reserves in India. These reserves are areas that have been specifically designated for the protection and conservation of elephants and their habitats. Some of the prominent elephant reserves in India include the Periyar Elephant Reserve in Kerala, the Mudumalai Elephant Reserve in Tamil Nadu, the Mahananda Elephant Reserve in West Bengal, and the Mayurbhanj Elephant Reserve, Odisha.

Some Elephant Projects in India

Uttar Pradesh Elephant Conservation Action Plan was launched in 2018 with the aim of protecting elephants and their habitats in the state of Uttar Pradesh.

Kosi-Katarniaghat Elephant Reserve: It is a designated elephant reserve located in the northern part of Uttar Pradesh. The reserve covers an area of 2,748 sq km and is home to around 165 elephants.

Chilla-Motichur Elephant Reserve: This reserve is located in the state of Uttarakhand, but its range extends to Uttar Pradesh. The reserve covers an area of around 2,197 sq km and is home to around 101 elephants.

Periyar Elephant Reserve: Located in the state of Kerala, this reserve is one of the most prominent elephant reserves in India. It covers an area of around 925 sq km and is home to around 900 elephants.

In addition some other projects was launched time to time for conservation and protection of elephants Which are as mentioned below:

Project Elephant: It is a centrally sponsored scheme launched in 1992 by the Ministry of Environment, Forest and Climate Change, Government of India, with the objective of protecting elephants, their habitats, and migration corridors

Human-Elephant Conflict Management - A project launched by the Ministry of Environment, Forest and Climate Change, Government of India, to mitigate human-elephant conflict in elephant habitats.

Project Jumbo - A conservation initiative launched by the Wildlife Trust of India to protect and conserve the Asian elephant and its habitat.

Asian Elephant Conservation Programme - A project initiated by the World Wide Fund for Nature (WWF) to conserve the Asian elephant in India and its neighboring countries.

Elephant Family – Elephant family is UK-based charity that works towards protecting Asian elephants and their habitat in India.

Friends of Elephants - An NGO based in Tamil Nadu that works towards the conservation of elephants in India.

Save The Asian Elephants - A campaign initiated by the UK-based NGO, Elephant Family, to protect the Asian elephant and its habitat in India. These are some of the important elephant projects and initiatives in India.

10.7.1. Aim of Elephant Project

The Indian Elephant Project aims to protect and conserve the Indian elephant and its habitat by implementing various measures: Some of the key components of the project are:

Habitat management: The project focuses on habitat management to ensure the conservation of natural habitats of elephants. This includes the protection and restoration of forests, grasslands, and wetlands, which are crucial for the survival of elephants.

Anti-poaching measures: The project focuses on reducing elephant poaching by strengthening anti-poaching measures, such as increasing patrolling and the deployment of wildlife rangers.

Human-elephant conflict mitigation: The project aims to reduce human-elephant conflict by implementing various measures, such as the construction of barriers and trenches to prevent elephants from entering human settlements.

Ecotourism: The project promotes ecotourism as a means to generate revenue and provide employment opportunities for local communities while reducing the pressure on elephant habitats.

Community participation: The project involves local communities in conservation efforts, creating awareness about the importance of elephants and their habitat, and encouraging their participation in conservation activities.

The Indian Elephant Project has been successful in protecting and conserving the Indian elephant and its habitat. The project has contributed significantly to the increase in the population of elephants in India and has reduced human-elephant conflict in several regions. However, there is still a long way to go in terms of ensuring the long-term conservation of elephants in India.

10.7.2. Needs and benefits of elephant project

The Indian Elephant Project is essential for the conservation of Indian elephants and their habitat. Here are some of the key needs and benefits of the project:

Needs:

Conservation of habitat: The Indian elephant requires vast areas of forest, grassland, and wetland habitats to survive. The project aims to protect and restore these habitats to ensure the survival of the species.

Mitigation of human-elephant conflict: As human populations expand, there is increasing pressure on elephant habitats, resulting in human-elephant conflicts. The project seeks to address this issue by implementing measures to mitigate human-elephant conflict.

Protection against poaching: Elephants are poached for their ivory tusks and other body parts. The project aims to prevent poaching by deploying wildlife rangers and increasing patrolling in elephant habitats.

Ecotourism: Ecotourism provides a means to generate revenue and create employment opportunities for local communities while reducing the pressure on elephant habitats. The project promotes ecotourism as a means of conservation.

Community participation: Local communities are essential stakeholders in elephant conservation. The project involves local communities in conservation efforts, creating awareness about the importance of elephants and their habitat, and encouraging their participation in conservation activities.

Benefits:

Increase in elephant population: The Indian Elephant Project has contributed significantly to the increase in the population of elephants in India. The project has been successful in protecting and conserving elephant habitats, which is critical to the survival of the species.

Reduced human-elephant conflict: The project has helped reduce human-elephant conflict in several regions through the implementation of measures such as construction of barriers and trenches to prevent elephants from entering human settlements.

Improved conservation of natural resources: The project has led to the conservation of natural resources such as forests, grasslands, and wetlands, which not only benefit elephants but also provide ecological services to humans.

Promotion of ecotourism: The project promotes ecotourism, which provides a means of generating revenue and creating employment opportunities for local communities.

Involvement of local communities: The project involves local communities in conservation efforts, creating awareness about the importance of elephants and their habitat, and encouraging their participation in conservation activities. This has resulted in a sense of ownership among local communities, leading to better conservation outcomes.

10.8. Crocodile Project

The Crocodile Breeding and Management Programme, also known as the Crocodile Project, was initiated in India in 1975 with the aim of conserving three species of crocodilians – the Indian crocodile (also known as the marsh crocodile), the mugger crocodile, and the gharial. The project was launched by the Ministry of Environment and Forests, Government of India, with technical assistance from the United Nations Development Programme and the Food and Agriculture Organization. The main objective of the Crocodile Project was to increase the population of these endangered crocodile species through captive breeding and rearing, habitat improvement, and protection from poaching and other human activities. The project was implemented in various crocodile habitats across the country, including national parks and wildlife sanctuaries. Under the Crocodile Project, a network of captive breeding centers and hatcheries were established, where eggs and hatchlings of these crocodile species were collected and raised under controlled conditions. Once they reached a certain size, the young crocodiles were released into the wild, where they could contribute to the population growth of these species. The project also involved habitat improvement measures, such as the restoration of riverine forests and wetlands, which are crucial for the survival of these crocodile species. Additionally, measures were taken to control poaching and illegal trade of crocodile products, which was a major threat to their survival. the Crocodile Project has been successful in increasing the population of these crocodile species in India. According to the latest estimates, the Indian crocodile population has increased from around 200 in the 1970s to over 2,000 today, while the Mugger crocodile population has increased from around 1,200 to over 3,000. The Gharial population, which was once on the brink of extinction, has also shown signs of recovery, with the number of individuals increasing from just over 200 in the 1970s to around 700 today. In addition to the conservation of these crocodile species, the Crocodile Project has also helped to raise awareness about the importance of conserving wildlife and their habitats. The project has become a model for other conservation initiatives in India and has inspired similar efforts to conserve other endangered species in the country. The crocodile is one of the most iconic and endangered species in the world. India is home to several species of crocodiles, including the mugger crocodile, the saltwater crocodile, and the gharial. The crocodile project in India was initiated with the aim of conserving and protecting these species from extinction. The need for the crocodile project arises from the fact that crocodiles are threatened due to habitat loss, hunting, and poaching. The crocodile project is essential to the conservation and management of crocodile populations in India. The project helps maintain the ecological balance of the ecosystem, as crocodiles are apex predators and play a vital role in the food chain. The project also helps promote tourism, as crocodile sanctuaries are popular tourist destinations. Overall, the crocodile project in India has been successful in achieving its objectives of conserving and protecting crocodiles from extinction, maintaining ecological balance, promoting tourism, and improving the socio-economic status of the local communities.

List of crocodile project in India

- Mugger crocodile project in Madhya Pradesh
- Saltwater crocodile conservation project in Odisha
- Gharial conservation project in Chambal
- Crocodile breeding and management project in West Bengal
- Mahanadi crocodile project in Odisha
- Crocodile conservation project in Andhra Pradesh
- Bhagwan Mahavir Wildlife Sanctuary crocodile project in Goa
- Crocodile breeding project in Tamil Nadu
- Crocodile breeding project in Kukrail, Utter Pradesh
- Crocodile conservation project in Gujarat
- Crocodile breeding and reintroduction project in Rajasthan.

10.9. Crocodile Breeding Project

The crocodile breeding project is a conservation initiative aimed at the breeding and rearing of crocodiles in captivity for reintroduction into the wild. The project involves creating artificial nesting sites for crocodiles, collecting and incubating eggs, and raising hatchlings in captivity until they are mature enough to be released into their natural habitat. India has several crocodile breeding projects, including the Gharial Conservation Alliance in Uttar Pradesh, which focuses on the conservation of the critically endangered Gharial crocodile. The Madras Crocodile Bank Trust and Centre for Herpetology in Tamil Nadu is another prominent crocodile breeding center in India, which has successfully bred and released several species of crocodiles into the wild.

The Crocodile breeding project was started in Uttar Pradesh, India, which is located at the Kukrail Reserve Forest in Lucknow. The project was established in the 1970s to conserve and breed the Indian Marsh crocodile, also known as the mugger crocodile, which is found in the rivers and wetlands of India and neighboring countries. The crocodile breeding project at Kukrail involves collecting eggs from the wild, incubating them in captivity, and raising the hatchlings until they are large enough to be released back into the wild. The project has been successful in increasing the population of the mugger crocodile in the area, which was previously under threat due to habitat loss and hunting. The project also serves as an educational center for the public, where visitors can learn about the importance of conserving crocodiles and other wildlife. Additionally, the project provides employment opportunities for local communities, who are involved in the maintenance and management of the crocodile breeding center.

10.10. Summary

Wildlife and wildlife protection projects are essential for the conservation of the Earth's natural resources. India has a diverse range of flora and fauna, making it one of the world's most biologically rich countries. However, habitat destruction, poaching, climate change, and other factors have resulted in the depletion of wildlife populations, endangering several species. In order to address this issue, India has launched several wildlife protection projects, including Project Tiger, Project Elephant, Gir Lion Project, and Crocodile Breeding Project, among others. Wildlife protection projects are essential for the conservation of our natural heritage and the maintenance of ecological balance. It is crucial that these efforts are continued and strengthened to ensure the long-term survival of our planet's wildlife.

10.11. Terminal question

Q.1: What do you understand by wildlife projects? Discuss the characteristics of wildlife.

Answer:--

Q.2: What is endangered species? Discuss the endangered species of flora and fauna of India.

Answer:---

Q.3: Discuss the some special wildlife projects of India.

Answer:---

Q.4: Discuss the history and scope of tiger reserve projects in India.

Answer:---

Q.5: Discuss the history and scope of elephant projects in India.

Answer:---

Q.6: Discuss the crocodile breeding projects in utter Pradesh.

Answer:---

10.12. Further suggested readings

6. Environmental Science, Subhas Chandra Santra, new central book agency, 3rd Edition, 2011
7. A text Book of Environment Studies, Asthana, D. K. and Asthana, M. 2006, S. Chand & Co
8. Atmosphere, Weather and Climate, Barry, R. G. 2003, Routledge Press, UK.
9. Ecology: Theories and Applications (4th Edition) by Peter Stiling; Prentice Hall.

10. Biodiversity: a beginner’s guide, john I. spacer, One world Publications.

Unit-11: Wildlife management

11.1. Introduction

Objectives

11.2. Wildlife management overview

11.3. Constitution of state board for wildlife

11.4. The wildlife protection act 1972

11.5. Protected area of wildlife

11.6. Illegal hunting and trade

11.7. Hunting of wildlife animals to be permitted in certain cases

11.8. Summary

11.9. Terminal questions

11.10. Further suggested readings

11. 1. Introduction

Wildlife management is the practice of managing and conserving wild animal populations, and their habitats in a sustainable and ethical manner. It is a scientific discipline that applies ecological principles to the management of wildlife populations, including monitoring their numbers, habitat use and behaviors as well as controlling their interactions with human activities. The goal of wildlife management is to maintain healthy and diverse populations of wild animals, while, also ensuring that their interactions with humans are sustainable and beneficial for both, wildlife and people. Wildlife management involves a variety of strategies and techniques, including habitat management, population monitoring, hunting and fishing regulations, and predator control. Wildlife management is an interdisciplinary field that involves biologists, ecologists, environmental scientists and other experts who work together to develop and implement effective management plans. These plans take into account the complex interactions between wildlife, their habitats, and human activities, as well as the economic, social and cultural factors that influence wildlife management decisions. Overall, wildlife management plays a critical role in protecting biodiversity and ensuring the long-term survival of wild animal populations. It requires a deep understanding of ecology and the natural world, as well as a commitment to ethical and sustainable practices. The diverse ecosystems of India support a wide range of flora and fauna. The Western and Eastern Ghats are treasure troves of plant diversity, with thousands of species, many of which are found nowhere else on Earth. The mighty Himalayas host a variety of medicinal plants, while the Thar Desert is adapted to arid conditions with unique plant and animal adaptations.

The conservation of India's wildlife and ecosystems is a matter of paramount importance. The country has established an extensive network of national parks and wildlife sanctuaries to protect its natural heritage. These protected areas serve as havens for wildlife and provide opportunities for eco-tourism. The Wildlife Protection Act of 1972 and the Forest Rights Act of 2006 are pivotal legal frameworks that aim to safeguard India's wildlife and forested landscapes.

India's indigenous communities often live in close proximity to these natural habitats, and their traditional knowledge and practices have played a significant role in conservation efforts. The symbiotic relationship between people and nature is a hallmark of India's approach to wildlife conservation.

Despite these efforts, India's wildlife faces numerous challenges. Habitat loss due to urbanization and agricultural expansion, poaching, and human-wildlife conflicts are persistent threats. Conservationists, government agencies, and non-governmental organizations are working tirelessly to mitigate these issues and protect India's invaluable natural heritage.

Objectives

After studying this unit, you will able to known

- To discuss the wildlife management

- To discus wildlife protected area and its management
- To discuss the Constitution of state board for wildlife
- To discuss the wildlife protection act 1972

11.2. Wildlife management overview

Wildlife management in India is a complex and multifaceted issue due to the country's rich biodiversity, growing human population and socio-economic challenges. The Indian government has implemented various policies and programs to manage and conserve wildlife and their habitats. One of the key initiatives in wildlife management in India is the Wildlife Protection Act of 1972, which provides legal protection for endangered species and regulates hunting, poaching and trade in wildlife. The government has also established national parks, wildlife sanctuaries and other protected areas to conserve wildlife and their habitats. The Ministry of Environment, Forest and Climate Change is responsible for implementing wildlife management policies and programs in India. This ministry also provides financial support to state governments for wildlife conservation efforts and works with NGOs and other stakeholders to promote public awareness and education on wildlife conservation. India has several successful wildlife management programs, such as Project Tiger, which was launched in 1973, to protect and conserve the Bengal tiger. The program has been successful, in increasing the tiger population in India and is considered a model for other countries to follow. Other initiatives include the Elephant Task Force, which was established to address the challenges faced by wild elephants in India, and the National Mission for Clean Ganga, which aims to conserve and rejuvenate the Ganges river ecosystem, including its wildlife. Despite these efforts, wildlife management in India faces several challenges, including habitat loss and fragmentation, poaching, human-wildlife conflicts and climate change. Addressing these challenges will require continued efforts from the government, NGOs and other stakeholders to ensure the long-term survival of India's rich and diverse wildlife.

11.3. Constitution of state board for wildlife

India is a land of remarkable biodiversity, boasting a rich tapestry of wildlife that has fascinated naturalists and enthusiasts for centuries. With a diverse range of ecosystems, from dense forests to arid deserts, from soaring mountains to vast wetlands, India provides a habitat for a multitude of species. This nation's wildlife is not only captivating but also of immense ecological and cultural significance. One of the most iconic and majestic creatures found in India is the Bengal Tiger (Panthera tigris). The country is home to approximately 70% of the world's wild tiger population, making it a global stronghold for this endangered species. India's tiger reserves, such as the Sundarbans and Bandipur, are vital for their conservation. Efforts to protect these big cats have led to the establishment of Project Tiger, a pioneering wildlife conservation initiative launched in 1973.

Apart from tigers, India is home to a plethora of other charismatic wildlife species. The Indian elephant (Elephas maximus indicus), the largest land animal in Asia, roams the country's forests and grasslands. These gentle giants play a crucial role in maintaining the health of forest ecosystems. The Indian rhinoceros (Rhinoceros unicornis) is another remarkable species, primarily found in the Kaziranga National Park in Assam. India's unique biodiversity also extends to the elusive snow leopard (Panthera uncia) that inhabits the high-altitude regions of the Himalayas.

In the avian world, India is a birder's paradise. The country is home to over 1,300 species of birds, from the vibrant Indian peafowl to the regal Great Indian Bustard. Keoladeo National Park, a UNESCO World Heritage Site, is a birdwatcher's delight, attracting thousands of migratory birds each year. The Western Ghats, a mountain range, along India's western coast, is a biodiversity hotspot and a refuge for numerous endemic bird species.

India's wildlife is not confined to the mainland, it extends to the Andaman and Nicobar Islands, and the Lakshadweep archipelago. These remote island groups are home to unique species, like the Nicobar megapode and the dugong, a marine mammal often referred to as the "sea cow." India's coastline is also frequented by olive ridley sea turtles, which nest in large numbers on the sandy beaches of Odisha.

The Constitution of State Board for Wildlife in India is governed by the Wildlife Protection Act of 1972. Under this act, each state in India is required to establish a State Board for Wildlife, which is responsible for advising the state government on matters related to wildlife conservation and management. The State Board for Wildlife is headed by the Chief Minister of the state and includes a range of experts such as wildlife biologists, ecologists, environmentalists and representatives from local communities. The board is responsible for advising the state government on issues related to wildlife conservation, including the establishment of protected areas, hunting regulations, and habitat management. One of the key functions of the State Board for Wildlife is to approve proposals for the declaration of new protected areas, such as national parks and wildlife sanctuaries, and to provide recommendations on the management of these areas. The board also plays a key role in regulating hunting and trade in wildlife, and in promoting public awareness and education on wildlife conservation. In addition to the State Board for Wildlife, each state in India is also required to establish a Wildlife Advisory Board, which is responsible for advising the state government on matters related to wildlife conservation and management at the district level. The Wildlife Advisory Board is chaired by the District Collector and includes local stakeholders, such as farmers, hunters and representatives from local NGOs. The establishment of State Boards for Wildlife and Wildlife Advisory Boards is an important step towards ensuring the long-term conservation of India's rich and diverse wildlife. It allows for the participation of a range of stakeholders in decision making processes, related to wildlife conservation, and helps to ensure that these decisions are based on sound scientific principles and ethical considerations.

Role of state wildlife board in wildlife management

The State Wildlife Board plays a critical role in wildlife management in India. Here are some of the key roles and responsibilities of the State Wildlife Board:

1. **Advising the State Government:** The State Wildlife Board is responsible for advising the state government on all matters related to wildlife conservation and management. This includes issues related to the establishment of protected areas, wildlife habitats, hunting regulations and human wildlife conflict management.
2. **Approval of Protected Areas:** One of the primary responsibilities of the State Wildlife Board is to approve proposals for the declaration of new protected areas, such as national parks, wildlife sanctuaries and conservation reserves. The board also provides recommendations on the management of these areas.
3. **Regulating Hunting and Trade**: The State Wildlife Board is responsible for regulating hunting and trade in wildlife in the state. The board sets quotas for hunting and ensures that wildlife trade is legal and sustainable.
4. **Wildlife Rescue and Rehabilitation:** The State Wildlife Board is responsible for overseeing the rescue and rehabilitation of injured or orphaned wildlife in the state. The board works with local NGOs, wildlife rehabilitators and veterinary professionals to ensure that injured wildlife is treated and released back into the wild when possible.
5. **Promoting Public Awareness:** The State Wildlife Board is responsible for promoting public awareness and education on wildlife conservation. The board works to educate

local communities on the importance of wildlife conservation, the role of protected areas and the need to protect endangered species.

Overall, the State Wildlife Board plays a critical role in wildlife management in India. By advising the state government, regulating hunting and trade, overseeing wildlife rescue and rehabilitation, and by promoting public awareness, the board helps to ensure the long-term conservation of India's rich and diverse wildlife.

11.4. The wildlife protection act 1972

The Wildlife Protection Act of 1972 is one of the most important laws related to wildlife conservation in India. The act was passed by the Indian Parliament in August 1972 and came into force in September 1973. The act replaced the earlier Indian Wild Birds and Animals Protection Act of 1912, which was outdated and inadequate for the conservation of India's rich and diverse wildlife.

The Wildlife Protection Act of 1972 was introduced in response to the growing concern over the rapid decline of wildlife populations in India. Many species, including tigers, elephants, rhinos and crocodiles, were on the brink of extinction, due to habitat loss, poaching and hunting. The act was designed to provide legal protection to these species and their habitats, and to regulate hunting, poaching and trade in wildlife.

Key Provisions:

The Wildlife Protection Act of 1972 is a comprehensive legislation that covers a wide range of issues related to wildlife conservation and management. Here are some of the key provisions of the act.

1. **Establishment of Protected Areas:** The act empowers the central and state governments to declare areas as national parks, wildlife sanctuaries and conservation reserves. These areas are managed for the conservation of wildlife and their habitats.
2. **Regulation of Hunting:** The act regulates hunting by imposing restrictions on the use of firearms, hunting seasons and bag limits. It also prohibits the use of certain types of traps, snares, and poisons.
3. **Protection of Forests:** The act provides for the protection and management of forests and other natural habitats of wildlife. It prohibits the diversion of forest land for non-forestry purposes without prior permission of the central government.

4. **Promotion of Wildlife Research and Education:** The act provides for the promotion of wildlife research, education and training. It encourages the establishment of research institutes, wildlife museums and zoological parks.
5. **Impact identification:** The Wildlife Protection Act of 1972 has a significant impact on wildlife conservation. The act has helped to protect many species of endangered wildlife, including tigers, elephants, rhinos and crocodiles, and has contributed to the recovery of their populations in some areas. The act has also led to the establishment of a network of protected areas, which are now home to a diverse range of wildlife, and provide important ecological services, such as water catchment and carbon storage. The act has also helped to reduce the incidence of wildlife crimes, such as poaching and smuggling. The establishment of special courts for wildlife crimes has improved the conviction rates for wildlife crimes, and has sent a strong message that these crimes will not be tolerated. The act has also promoted research and education on wildlife conservation. Many research institutes, wildlife museums and zoological parks have been established under the act, and these institutions have contributed significantly to our understanding of India's rich and diverse wildlife. Thus, we can say that the wildlife protection Act of 1972 is a landmark legislation that has played a crucial role in wildlife conservation.

11.5. Protected area of wildlife

India boasts a vast and diverse array of protected areas for wildlife conservation, spanning from dense forests to arid deserts and from soaring mountains to coastal wetlands. These protected areas are crucial for safeguarding the country's rich biodiversity and are essential for the survival of numerous endangered species. In this comprehensive exploration, we will delve into the various types of protected areas in India, their significance and some of the most prominent ones across the country.

Protected areas are designated regions of land or water that are set aside to protect and conserve wildlife, ecosystems, and cultural resources. These areas play a critical role in preserving biodiversity, protecting endangered species and maintaining ecological processes. In this response, we will discuss protected areas of wildlife and their importance in conservation efforts. Protected areas of wildlife can take many forms, such as national parks, wildlife reserves, and sanctuaries. These areas are established and managed by governments, non-governmental organizations or private entities, and are designed to conserve natural resources, provide recreational opportunities, and promote research and education. One of the main objectives of protected areas is to preserve and maintain biodiversity. Protected areas can serve as a refuge for endangered species and other threatened wildlife, and can also support the conservation of natural habitats and ecosystems. By maintaining healthy ecosystems, protected areas can also support the provision of ecosystem services, such as water filtration, carbon storage and pollination. Protected areas also play an important role in promoting sustainable development. By supporting tourism, sustainable agricultural development and other economic activities that do not harm natural resources, protected areas can provide economic benefits to local communities while promoting conservation. To ensure the effective conservation of wildlife and ecosystems, it is important to manage protected areas effectively. This involves careful planning, monitoring and evaluation to ensure that the needs of both wildlife and human communities are met. Effective management also involves enforcing laws and regulations that protect wildlife, preventing poaching and illegal activities, and promoting sustainable use of resources. Thus the protected areas of wildlife have a crucial tool for conservation efforts. They play a critical role in preserving biodiversity, protecting endangered species, and promoting sustainable development. However, to ensure their effectiveness, it is important to carefully manage and protect these areas, enforce laws and regulations, and promote sustainable use of natural resources. By working together, we can ensure the survival and conservation of wildlife and ecosystems for future generations.

However, the India's protected areas are established to conserve its unique and diverse wildlife, ecosystems and natural heritage. These areas play a vital role in preserving the country's biodiversity, maintaining ecological balance and promoting scientific research and eco-tourism. India's protected area network encompasses national parks, wildlife sanctuaries, conservation reserves, and community reserves each with specific regulations and objectives.

National parks

National parks in India are the highest level of protected areas, primarily established for the conservation of charismatic mega fauna and their habitats. They are known for their strict regulations and often serve as flagship areas for wildlife conservation. National parks offer unparalleled opportunities for scientific research and ecotourism. One of India's most famous national parks is “Jim Corbett National Park” located in the state of Uttarakhand, established in 1936, it was India's first national park and is renowned for its significant tiger population. The park's lush forests and diverse wildlife make it a prime destination for nature enthusiasts and wildlife photographers.

Wildlife Sanctuaries

Wildlife sanctuaries are protected areas primarily focused on conserving specific species and their habitats. Unlike national parks, they allow a limited degree of human activity, such as grazing by local communities. These areas are essential for protecting diverse ecosystems and providing safe havens for a variety of wildlife. One notable example is the “Periyar Wildlife Sanctuary” in Kerala. It is home to diverse flora and fauna, including the Bengal tiger and the Indian elephant. The sanctuary is also famous for its picturesque Periyar Lake, where visitors can go boating while enjoying the serene natural surroundings.

Conservation Reserves

Conservation reserves are relatively new additions to India's protected area system, established to protect wildlife outside national parks and sanctuaries. They are critical for preserving habitats and corridors for wildlife movement. These areas often overlap with human habitation and require sustainable resource management practices. An excellent illustration is the “Nawegaon National Park and Navegaon Wildlife Sanctuary” in Maharashtra. It is a combination of a national park and wildlife sanctuary, and it serves as an essential corridor for wildlife movement between different forest patches in the region.

Community Reserves

Community reserves are areas where local communities actively participate in conservation efforts. They are crucial for engaging and empowering local people in wildlife conservation and ensuring that they directly benefit from protecting their natural heritage. These reserves are often managed jointly by the local community and the government “Kulik Bird Sanctuary” in West Bengal is a fine instance of community involvement in wildlife conservation. The local community is deeply engaged in conserving the avian diversity of the region and the sanctuary is a haven for numerous bird species.

Significance of India's Protected Areas

India's protected areas play a vital role in the conservation of the country's unique biodiversity. They offer a range of benefits:

1. **Biodiversity Conservation:** These areas protect a wide variety of species, including many that are endangered or endemic to India. The conservation of keystone species, such as tigers and elephants, has a cascading effect on the entire ecosystem.
2. **Ecosystem Services:** Protected areas contribute to maintaining ecological balance, providing essential ecosystem services like clean water, pollination and carbon sequestration.
3. **Scientific Research:** These areas are invaluable for scientific research and studies related to ecology, wildlife behavior and climate change.

4. **Eco-Tourism:** Many protected areas promote eco-tourism, which not only generates revenue for local communities but also raises awareness about wildlife conservation.
5. **Cultural and Spiritual Significance:** Many of these areas hold cultural and spiritual significance for indigenous communities, preserving their traditions and heritage.

Protected Area cover in India

According to Ministry of Environment, Forest and Climate Change (MEFCC) report 2023 the protected area coverage in the country has been steadily increasing. The coverage of Protected Areas which was 4.90% of country's geographical area in 2014 has now increased to 5.03%. This includes an increase in Protected Areas in the country from 740 with area of 1, 61,081.62 sq.kms, in 2014 to present 981 with an area of 1, 71,921 sq.kms. Population of several species like Tiger, Asiatic Lion, Greater one Horned Rhinoceros, Asian elephants, etc., increased. Wildlife health is being addressed to aggressively monitor zoonotic diseases. India has taken a leadership role in conservation of migratory birds along the Central Asian Flyway and had organized a two day workshop in October 2021, with Central Asian Flyway (CAF) Range countries on conservation of migratory birds along the Central Asian Flyway. The Ministry has released, guidelines for sustainable ecotourism in forest and wildlife areas-2021 in October 2021. These guidelines emphasize on participation of local community in ecotourism activities. India's vast landscape is dotted with numerous protected areas. Let's explore some of the most prominent ones:

1. **Ranthambhore National Park, Rajasthan:** Ranthambhore is renowned for its thriving tiger population. The park's historic Ranthambhore Fort adds to its charm, making it a must visit for wildlife enthusiasts.
2. **Kaziranga National Park, Assam**: Kaziranga is famous for its population of the Indian one-horned rhinoceros. It's also a UNESCO World Heritage Site and home to tigers, elephants and diverse bird species.
3. **Sundarbans National Park, West Bengal**: Sundarbans is the largest mangrove forest in the world and a UNESCO World Heritage Site. Its home to the elusive Bengal tiger and saltwater crocodiles.

4. **Keoladeo National Park, Rajasthan:** This park is a UNESCO World Heritage Site and a paradise for birdwatchers, with over 350 bird species, including migratory birds from Central Asia.
5. **Kanha National Park, Madhya Pradesh:** Kanha's picturesque landscapes inspired Rudyard Kipling's "The Jungle Book." It's home to the Bengal tiger, leopards and barasingha deer.
6. **Bandipur National Park, Karnataka:** Known for its varied wildlife, including tigers, elephants, and gaurs (Indian bison), Bandipur offers excellent opportunities for wildlife safaris.
7. **Great Himalayan National Park, Himachal Pradesh:** This park is a UNESCO World Heritage Site, with pristine Himalayan landscapes and diverse wildlife, including the elusive snow leopard.
8. **Bhitarkanika Wildlife Sanctuary, Odisha**: Bhitarkanika is famous for its mangrove forests and estuarine crocodiles. It's a unique ecosystem that supports various reptiles and bird species.
9. **Mudumalai National Park, Tamil Nadu**: Mudumalai's varied terrain makes it a haven for wildlife, from tigers and leopards to elephants, and various bird species.
10. **Gir National Park, Gujarat:** Gir is the last abode of the Asiatic lion. This park is a significant success story for conservation efforts, as the lion population has shown remarkable recovery.

Despite their importance, India's protected areas face several challenges, including habitat loss, poaching and human-wildlife conflicts. Climate change and increased anthropogenic activities further threaten these areas. Conservation efforts involve a combination of stricter enforcement of wildlife protection laws, community involvement and sustainable tourism practices.

11.6. Illegal hunting and trade of wildlife

Illegal hunting and trade of wildlife, also known as wildlife poaching and trafficking, is a major global issue that threatens the survival of many species of animals and plants. Illegal hunting of wildlife in India is a pressing issue that poses a significant threat to the country's rich biodiversity. Despite stringent laws and conservation efforts, poaching and illegal hunting continue to jeopardize the survival of many endangered species. In this 600-word essay, we will delve into the causes, consequences and measures to combat illegal hunting of wildlife in India.

Wildlife poaching and trafficking involves the illegal hunting, capturing and transportation of wild animals or plants for trade, either for their body parts, such as ivory, rhino horn, and tiger bones, or for live animals and pets.

Wildlife poaching and trafficking have a significant impact on biodiversity and ecological systems. The illegal trade in wildlife is considered the second-largest illegal activity in the world, after drug trafficking, with an estimated annual value of up to $23 billion. The illegal trade in wildlife is driven by high demand for animal products in many countries, particularly in Asia, where traditional medicines, luxury goods and exotic pets are highly valued. Poaching and trafficking can lead to the decline or even extinction of many species, including elephants, rhinos, tigers, pangolins and sea turtles. The loss of these species can have a cascading effect on ecosystems and biodiversity, leading to further declines in other species, and potentially impacting the overall health of the ecosystem. To address the issue of wildlife poaching and trafficking, many countries have established laws and regulations to prohibit the illegal trade in wildlife, and to protect threatened and endangered species. Additionally, international treaties, such as the Convention on International Trade in Endangered Species (CITES) provide a framework for regulating international trade in wildlife. Efforts to combat poaching and trafficking include increased law enforcement, community-based conservation efforts, and education and awareness raising campaigns.

India's remarkable natural diversity is home to a wide range of wildlife, including majestic tigers, graceful leopards and rare one-horned rhinoceros. However, this biodiversity faces an imminent threat from illegal hunting, primarily driven by the demand for animal products in the illegal wildlife trade. This trade encompasses the trafficking of animal parts, such as tiger skins, ivory, rhino horns and exotic pets. The demand for these products on the black market fuels poaching activities across the country.

Illegal hunting is driven by several interconnected factors. One of the most prominent factors is the economic incentive it offers to impoverished communities. Many individuals, often from marginalized and rural backgrounds, are drawn to poaching as a means of livelihood, as the sale of animal parts can fetch substantial sums. The lure of quick money, in the absence of alternative livelihood options, makes poaching an attractive choice for many peoples.

Inadequate law enforcement and corruption within the system, also contribute to the prevalence of illegal hunting. Poachers often operate with impunity due to weak enforcement of wildlife protection laws. Additionally, corrupt officials may turn a blind eye to illegal activities in exchange for bribes, further perpetuating the problem.

The consequences of illegal hunting are devastating for India's wildlife. Numerous species have been pushed to the brink of extinction due to poaching. The Bengal tiger, for instance, has seen a significant decline in its population, with the demand for its skin and bones driving rampant poaching. Similarly, the Indian rhinoceros and elephants are hunted for their horns and ivory, resulting in severe population declines.

Moreover, the disruption of natural ecosystems due to poaching can have cascading effects. The loss of key species can lead to imbalances in prey-predator relationships and the degradation of ecosystems, ultimately affecting the overall health of the environment. This, in turn, can impact human populations, as many communities depend on these ecosystems for their sustenance and livelihoods.

To combat illegal hunting of wildlife in India, several measures have been put in place. The Wildlife Protection Act of 1972, serves as the cornerstone of wildlife conservation in the country, providing legal protection to endangered species and their habitats. Under this legislation, poaching, hunting, and the trade of wildlife products are strictly prohibited. However, enforcement of these laws remains a significant challenge.

Anti-poaching units, often consisting of forest department personnel and local volunteers, are actively involved in patrolling protected areas to deter poaching activities. Additionally, the use of modern technology, such as camera traps and drones, has been instrumental in monitoring wildlife and identifying potential threats.

Community based conservation initiatives have also gained momentum, aiming to involve local communities in the protection of wildlife and their habitats. These initiatives provide economic incentives and livelihood alternatives to poaching, reducing the reliance on illegal activities.

Furthermore, international collaboration is crucial in tackling the illegal wildlife trade. India cooperates with other nations to combat this transnational problem, with a focus on strengthening the legal framework and increasing the penalties for poachers and traffickers.

11.7. Hunting of wildlife animals to be permitted in certain cases

In many countries, hunting of wildlife animals is legal and may be permitted under certain circumstances, such as for subsistence, scientific research, population control and trophy hunting. However, it is important to note that the regulations and laws surrounding hunting of wildlife animals vary widely from country to country and often within regions of countries. In some cases, hunting of wildlife animals may be necessary to control their populations and prevent damage to crops and property, or to prevent the spread of diseases. For example, in some regions of the United States, hunting of white tailed deer is permitted to control their population and prevent damage to crops and property. However, in many cases, hunting of wildlife animals can have negative impacts on ecosystems, and can lead to the depletion of populations of endangered or threatened species. Poaching or illegal hunting, is also a major problem worldwide, and can result in the extinction of species and significant ecological disruption. In light of these concerns, many countries have implemented strict regulations and laws regarding hunting of wildlife animals, and have established protected areas,where hunting is strictly prohibited. These protected areas serve as important habitats for wildlife animals and help to ensure their survival and conservation. In conclusion, while hunting of wildlife animals may be permitted under certain circumstances, it is important to carefully consider the impacts on ecosystems and to implement strict regulations and laws to ensure the conservation of wildlife populations.

11.8. Summary

Wildlife management is the practice of protecting and conserving wild animals and their habitats to maintain healthy ecosystems and promote sustainable development. This involves the establishment of protected areas, the enforcement of laws and regulations, to prevent poaching and illegal activities, and the promotion of sustainable use of natural resources. Effective wildlife management requires careful planning, monitoring, and evaluation to ensure that the needs of both, wildlife and human communities are met. Wildlife management also involves promoting research and education, supporting community based conservation efforts, and raising awareness about the importance of biodiversity conservation. The Wildlife Protection Act of 1972 in India is an example of a comprehensive legal framework that aims to protect wildlife and their habitats, and establish penalties for poaching and illegal activities. Additionally, state wildlife boards play an important role in wildlife management in India by advising the government on conservation policies and promoting sustainable use of natural resources. However, wildlife management faces many challenges, including habitat loss, climate change, and illegal poaching and trafficking of wildlife. These challenges require a coordinated effort from governments, organizations, and individuals to address and mitigate their impact on wildlife and ecosystems. However, wildlife management faces many challenges, including habitat loss, climate change, and illegal poaching and trafficking of wildlife. These challenges require a coordinated effort from governments, organizations, and individuals to address and mitigate their impact on wildlife and ecosystems. India's protected areas are not just geographic spaces, but repositories of the country's natural and cultural heritage. They offer a glimpse into the remarkable diversity of India's wildlife and ecosystems, while highlighting the challenges and successes of conservation efforts. Preserving these areas is essential for the well-being of the planet and future generations, emphasizing the need for continued vigilance and collective action in the face of ongoing environmental challenges.

11.9. Terminal questions

Q.1: What do you understand by wildlife management?

Answer:---

Q.2: Discuss the provision for the protection of wildlife?

Answer:--

Q.3: Discuss the Constitution of state board for wildlife.

Answer:--

Q.4: What is the wildlife protection acts? Discuss it briefly.

Answer:--

Q.5: What do you understand by Illegal hunting and trade discuss briefly.

Answer:--

Q.6: Discuss the protected area of wildlife.

Answer:--

11.10. Further suggested readings

11. Environmental Science, Subhas Chandra Santra, new central book agency, 3rd Edition, 2011

12. A text Book of Environment Studies, Asthana, D. K. and Asthana, M. 2006, S. Chand & Co

13. Atmosphere, Weather and Climate, Barry, R. G. 2003, Routledge Press, UK.

14. Ecology: Theories and Applications (4th Edition) by Peter Stiling; Prentice Hall.

15. Biodiversity: a beginner’s guide, john I. spicer, One world Publications.

Unit-12: Ecotourism

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12.1. Introduction

Ecotourism is a form of sustainable tourism that involves visiting natural areas in a responsible and environmentally conscious manner. It aims to minimize the negative impact of tourism on the environment while also providing educational and cultural experiences for visitors. Ecotourism promotes conservation, fosters respect for different cultures, and supports local communities by providing economic benefits. Ecotourism involves activities such as hiking, bird watching, wildlife safaris, and other outdoor adventures. The focus is on experiencing natural and cultural environments in a way that preserves their integrity and minimizes negative impacts. Ecotourism is often associated with ecologically sensitive destinations such as rainforests, marine environments, and wildlife reserves. One of the key principles of ecotourism is that it should involve minimal impact on the environment and local communities. This means that ecotourism operators must carefully manage the number of visitors and ensure that their activities do not damage the environment or disrupt local communities. They must also educate visitors about the importance of conservation and responsible travel practices. Ecotourism can provide many benefits to both visitors and local communities. Visitors can gain a deeper appreciation and understanding of the natural world, while also supporting conservation efforts and sustainable development in the areas they visit. Local communities can benefit from the economic opportunities provided by tourism, while also preserving their cultural and natural heritage.

Objectives

- To discuss the concept of ecotourism and its scope
- To discuss the role of ecotourism in society and environment
- To discuss the green belt design and its benefits
- To discuss the ecotourism and environmental education

12.2. Ecotourism over view

Ecotourism is a relatively new concept that emerged in the late 20th century as a response to the growing concerns about the negative impacts of mass tourism on the environment, local communities, and cultural heritage. The history and scope of ecotourism can be traced back to the early efforts of conservationists and environmentalists to promote sustainable travel practices and protect natural resources. Early initiatives to promote sustainable tourism practices can be traced back to the 1970s when environmental groups began to raise concerns about the negative impacts of tourism on the environment. The term ecotourism was first coined in the 1980s by Mexican architect Hector Ceballos-Lascurain, who defined it as "environmentally responsible travel to natural areas, in order to enjoy and appreciate nature (and accompanying cultural features, both past and present) that promote conservation, have a low visitor impact, and provide for beneficially active socio-economic involvement of local peoples." During the 1990s, ecotourism began to gain popularity as a niche market within the tourism industry, with a growing number of operators offering ecotourism experiences in natural areas around the world. The International Ecotourism Society (TIES), which was founded in 1990, played a key role in promoting the principles and practices of ecotourism and providing a forum for the exchange of ideas and best practices. Since then, ecotourism has evolved into a global industry that encompasses a wide range of activities, destinations, and stakeholders. The scope of ecotourism has expanded to include not only nature-based tourism but also cultural tourism, adventure tourism, and sustainable tourism. The United Nations has recognized the importance of ecotourism as a tool for sustainable development, and it has been included as one of the targets of the Sustainable Development Goals (SDGs). The growth of ecotourism has been driven by a variety of factors, including increased awareness of environmental and social issues, changing consumer preferences, and technological advancements that have made it easier to access remote destinations. The increasing demand for ecotourism experiences has led to the development of new destinations and activities, such as wildlife viewing, bird watching, hiking, and cultural tours. One of the key features of ecotourism is its emphasis on responsible travel practices that minimize negative impacts on the environment and local communities. This includes promoting sustainable resource use, reducing waste and pollution, supporting conservation efforts, and involving local communities in tourism planning and development. Ecotourism also emphasizes the importance of providing educational opportunities for visitors to learn about the environment, local cultures, and conservation efforts.

Ecotourism has come a long way since its inception and has emerged as a key player in the tourism industry. Its scope continues to evolve as new destinations, activities, and stakeholders emerge, but its core principles of sustainability, responsible travel practices, and conservation remain at the heart of its philosophy. As the world continues to face environmental and social challenges, ecotourism has the potential to play a critical role in promoting sustainable development and preserving our planet for future generations.

Ecotourism is a form of sustainable tourism that focuses on visiting natural areas and participating in environmentally conscious activities. The purpose of ecotourism is to minimize the negative impact of tourism on the environment while also providing educational and cultural experiences for visitors. The goal is to promote conservation, foster respect for different cultures, and support local communities by providing economic benefits. Ecotourism is a form of sustainable tourism that focuses on visiting natural areas and participating in environmentally conscious activities. The purpose of ecotourism is to minimize the negative impact of tourism on the environment while also providing educational and cultural experiences for visitors. The goal is to promote conservation, foster respect for different cultures, and support local communities by providing economic benefits. One of the key principles of ecotourism is to minimize the impact on the environment and local communities. Ecotourism operators must carefully manage the number of visitors and ensure that their activities do not damage the environment or disrupt local communities. They must also educate visitors about the importance of conservation and responsible travel practices. Ecotourism can provide many benefits to both visitors and local communities. Visitors can gain a deeper appreciation and understanding of the natural world, while also supporting conservation efforts and sustainable development in the areas they visit. Local communities can benefit from the economic opportunities provided by tourism, while also preserving their cultural and natural heritage. Ecotourism is an important form of tourism that promotes sustainability, conservation, and responsible travel practices. It provides opportunities for visitors to connect with nature and culture in a meaningful way, while also supporting local communities and protecting the environment for future generations. The scope of ecotourism continues to evolve as new destinations, activities, and stakeholders emerge once. While ecotourism has the potential to provide significant economic, social, and environmental benefits, it also faces challenges and conflicts, such as overcrowding, resource depletion, and cultural commodification. Addressing these challenges requires a commitment to sustainability and collaboration among stakeholders, including governments, tourism operators, local communities, and conservation organizations. The scope of ecotourism continues to evolve as new destinations, activities, and stakeholders emerge. While ecotourism has the potential to provide significant economic, social, and environmental benefits, it also faces challenges and conflicts, such as overcrowding, resource depletion, and cultural commodification. Addressing these challenges requires a commitment to sustainability and collaboration among stakeholders, including governments, tourism operators, local communities, and conservation organizations.

12.2.1 Principal of ecotourism

The following are some of the key principles of ecotourism:

- Ecotourism aims to minimize the negative impacts of tourism on the environment by conserving natural resources, reducing waste and pollution, and supporting biodiversity conservation efforts. It also involves promoting environmental education and awareness-raising among visitors.

- Ecotourism promotes environmental and cultural education and awareness among visitors to promote responsible travel practices and respect for local cultures and traditions
- Ecotourism aims to provide enjoyable and educational experiences for visitors while also providing economic benefits and positive impacts for local communities.
- Ecotourism supports conservation efforts by contributing to the protection and management of natural and cultural resources.
- Ecotourism promotes respect for local cultures and traditions by providing opportunities for visitors to learn about and interact with local communities.
- Ecotourism involves local communities in tourism planning and development, and provides economic benefits and employment opportunities to support sustainable development.
- Ecotourism aims to be financially sustainable by providing economic benefits for local communities, supporting conservation efforts, and contributing to the protection of natural and cultural resources.

12.2.2. Scope of ecotourism

The scope of ecotourism is broad and encompasses a variety of activities, destinations, and stakeholders. The following are some of the key aspects of the scope of ecotourism:

- Ecotourism activities can include a wide range of outdoor and cultural experiences, such as hiking, bird watching, wildlife safaris, cultural tours, and nature photography. The focus is on activities that are environmentally and culturally responsible and that provide visitors with educational and experiential opportunities.
- Ecotourism destinations can range from remote wilderness areas to urban parks and cultural heritage sites. The key factor is that the destination has a unique natural or cultural heritage that is worth visiting and that can be experienced in a sustainable and responsible manner.
- Ecotourism involves a range of stakeholders, including local communities, governments, tour operators, and visitors. All stakeholders have a role to play in ensuring that ecotourism is sustainable and responsible, and that it provides economic, social, and environmental benefits to all involved.

- The benefits of ecotourism are numerous and can include economic benefits for local communities, conservation of natural and cultural heritage, and education and awareness rising for visitors. Ecotourism can also provide opportunities for research and monitoring of natural and cultural resources, and can contribute to the development of sustainable tourism practices.
- The scope of ecotourism also includes a range of challenges, such as balancing economic development with environmental and cultural conservation, managing visitor impacts on fragile ecosystems and cultures, and ensuring that tourism benefits are shared equitably among stakeholders. Addressing these challenges requires collaboration and commitment from all involved in ecotourism.

Overall, the scope of ecotourism is diverse and complex, and requires a multidisciplinary approach to ensure that it is sustainable, responsible, and provides benefits to all stakeholders involved.

12.3. Ecotourism and environment

Ecotourism and the environment are intimately linked, as ecotourism aims to promote conservation and responsible travel practices that minimize negative impacts on the environment. The following are some of the ways in which ecotourism and the environment are connected:

- **Conservation:** Ecotourism supports conservation efforts by promoting the protection and management of natural resources and wildlife habitats. This involves activities such as environmental monitoring, restoration, and wildlife management.
- **Sustainable resource use:** Ecotourism promotes sustainable resource use by minimizing waste and pollution and reducing the use of non-renewable resources. This includes activities such as energy and water conservation, waste reduction and recycling, and the use of renewable energy sources.
- **Habitat preservation:** Ecotourism supports the preservation of habitats and ecosystems by promoting responsible travel practices that minimize negative impacts on wildlife and their habitats. This includes activities such as wildlife viewing, hiking, and camping, which are conducted in a way that minimizes disturbance to the environment.
- **Environmental education:** Ecotourism provides educational opportunities for visitors to learn about the environment and the importance of conservation. This includes activities such as guided tours, environmental interpretation, and nature-based activities.

- **Environmental advocacy:** Ecotourism supports environmental advocacy efforts by promoting public awareness of environmental issues and encouraging visitors to support conservation efforts. Thus the ecotourism plays a vital role in promoting environmental conservation and responsible travel practices.

By supporting conservation efforts, promoting sustainable resource use, preserving habitats, providing environmental education, and advocating for environmental protection, ecotourism can help to ensure that natural resources are protected for future generations.

12.4. Ecotourism and environment conflict

Although ecotourism aims to promote sustainable and responsible travel practices that minimize negative impacts on the environment. There can be conflicts between ecotourism and environmental conservation. Some of the potential conflicts between ecotourism and the environment include:

- **Overcrowding:** Ecotourism can lead to overcrowding in natural areas, which can result in negative impacts such as habitat degradation, soil erosion, and wildlife disturbance.
- **Resource depletion:** Ecotourism lead to resource depletion in natural areas, such as water resources, firewood, and non-renewable energy sources.
- **Habitat degradation:** Ecotourism activities such as hiking and camping can result in habitat degradation, which can negatively impact wildlife and their habitats.
- **Pollution:** Ecotourism activities contribute to pollution, such as litter, noise pollution, and air pollution.
- **Climate change:** Ecotourism activities contribute to climate change through greenhouse gas emissions from transportation and energy use.

To minimize conflicts between ecotourism and environmental conservation, it is essential to implement sustainable and responsible travel practices. This includes limiting the number of visitors in natural areas, promoting sustainable resource use, minimizing habitat disturbance, reducing pollution, and supporting conservation efforts. It is also important to involve local communities in ecotourism planning and development to ensure that the interests and needs of local communities are taken into account. By implementing these practices, ecotourism can promote environmental conservation while also providing economic benefits and educational opportunities for visitors.

12.5. Understanding ecotourism resources categories

Ecotourism resources can be categorized in various ways, depending on the perspective and purpose of the categorization. In this response, we will discuss four broad categories of ecotourism resources: natural resources, cultural resources, built resources, and human resources.

Natural resources:

Ecotourism is often associated with natural areas and wilderness, which are considered prime attractions for tourists seeking to experience nature and wildlife. Natural resources include diverse ecosystems such as forests, wetlands, deserts, mountains, rivers, and oceans, as well as flora and fauna such as trees, plants, animals, birds, and marine life. These resources are critical for maintaining the biodiversity and ecological integrity of the planet and are essential for the survival of many species. Ecotourism provides a way for people to appreciate and value these natural resources and to support conservation efforts that protect them. The examples of natural resources are

National parks and wildlife reserves, such as Yellowstone National Park in the USA or Serengeti National Park in Tanzania Marine reserves and protected areas, such as the Great Barrier Reef Marine Park in Australia or the Galapagos, marine reserve in Ecuador ecosystems and landscapes, such as rainforests, deserts, mountains, and wetlands. Ecosystems and landscapes, such as rainforests, deserts, mountains, and wetlands natural wonders, such as waterfalls, canyons, glaciers, and geysers

Cultural resources:

Ecotourism is also linked to cultural diversity and heritage, as many destinations combine natural attractions with cultural experiences such as traditional lifestyles, arts and crafts, music, food, and rituals. Cultural resources are important for promoting cultural understanding and respect, preserving cultural identity and heritage, and generating economic benefits for local communities. Ecotourism provides a way for people to engage with local cultures, learn from them, and support their preservation. The examples of cultural resources are- Indigenous communities and their traditions, such as the Maori in New Zealand or the Inuit in Canada, local festivals and events, such as the Holi festival in India or the day of the dead in Mexico etc. Traditional music and dance, such as flamenco in Spain or samba in Brazil etc.

Built resources:

Ecotourism also relies on a range of built resources, such as accommodations, transport, infrastructure, and amenities that support and enhance the visitor experience. These resources can be designed and operated in ways that minimize their environmental impact, conserve natural resources, and promote sustainable practices. Built resources are important for providing comfort and convenience to visitors while minimizing the impact on the natural and cultural resources. Examples of sustainable built resources include eco-lodges, low-impact transport, green buildings, and renewable energy systems. Sustainable accommodations or glamping sites, low-impact transportation, such as bikes, electric vehicles, or horse-drawn carriages, sustainable infrastructure, such as solar panels, composting toilets, or rainwater harvesting systems, etc.

Human resources:

Finally, ecotourism relies on human resources such as local communities, guides, and operators, who are critical for providing the services and experience those visitors, seek. These resources include the knowledge, skills, and expertise of local people who have a deep understanding of the natural and cultural resources of the area. Human resources are important for promoting local participation and empowerment, creating employment and income opportunities, and supporting community development. Ecotourism provides a way for local people to benefit from tourism while preserving and promoting their cultural and natural heritage. The examples of human resources are- local guides and operators, who offer their expertise and knowledge of the area, local artisans and vendors, who provide handmade products and souvenirs, local volunteers and activists, who support conservation and community development efforts, local conservationists and scientists, who work to protect and study the natural resources of the area etc. Ecotourism resources can be categorized into four broad categories: natural resources, cultural resources, built resources, and human resources. Each category plays a critical role in supporting ecotourism as a sustainable form of tourism that promotes conservation, cultural understanding, and community development. By understanding and valuing these resources, ecotourism can provide a way for people to experience and appreciate the beauty and diversity of nature and culture while supporting their preservation and sustainable use.

12.6. Ecotourism and education

Ecotourism and education are closely intertwined, as ecotourism provides a unique opportunity for travelers to learn about and engage with the natural and cultural resources of a destination. In this response, we will explore the relationship between ecotourism and education, including the benefits of ecotourism education, the challenges and limitations of ecotourism education, and some examples of successful ecotourism education initiatives. Ecotourism education can provide a range of benefits for both travelers and local communities. Here are some of the key benefits of ecotourism education:

- **Increased environmental awareness:** Ecotourism education can help travelers better understand the natural world and the impacts of human activities on the environment. By learning about the local flora and fauna, travelers can develop a deeper appreciation for the biodiversity of the area and the need to protect it.
- **Economic benefits**: Ecotourism education can also provide economic benefits for local communities by creating jobs in the tourism industry and generating revenue for local businesses. By valuing the natural and cultural resources of a destination, ecotourism can help promote their conservation and sustainable use.
- **Personal growth:** Ecotourism education can also provide a transformative experience for travelers, allowing them to step outside their comfort zone and challenge their assumptions about the world. By immersing themselves in new environments and cultures, travelers can broaden their horizons and gain a deeper appreciation for the diversity of life on earth.

Needs for ecotourism education

Ecotourism education is crucial for promoting sustainable tourism and creating awareness about the natural and cultural resources of a destination. In this response, we will explore some of the key needs for ecotourism education.

- **Understanding of the natural environment:** Ecotourism education is necessary to develop an understanding of the natural environment and the importance of conserving it. This includes knowledge about the flora and fauna, the ecosystem, and the natural processes that sustain the environment.
- **Awareness of local culture:** Ecotourism education can also help travelers develop an appreciation for the local culture and traditions of a destination. This includes knowledge of the local customs, language, art, and history.
- **Sustainable tourism practices:** Ecotourism education is important for promoting sustainable tourism practices that minimize negative impacts on the environment and

local communities. This includes knowledge of waste management, water conservation, and responsible use of natural resources.

- **Conservation of natural and cultural resources:** Ecotourism education is essential for promoting the conservation of natural and cultural resources of a destination. This includes knowledge of endangered species, protected areas, and cultural heritage sites.
- **Positive impact on local communities:** Ecotourism education is necessary for promoting positive interactions between travelers and local communities. This includes knowledge of the local economy, social norms, and the impact of tourism on local livelihoods.
- **Personal growth and transformation**: Ecotourism education can also provide a transformative experience for travelers, allowing them to challenge their assumptions and broaden their perspectives. This includes the opportunity to learn from different cultures and environments, and to develop a deeper appreciation for the diversity of life on earth.

Thus we can say that ecotourism education is essential for promoting sustainable tourism practices, conserving natural and cultural resources, promoting positive interactions with local communities, and fostering personal growth and transformation. By providing travelers with a deeper understanding of the natural and cultural resources of a destination, ecotourism education can help promote conservation and sustainable use of these resources for future generations.

12.7. Ecotourism and protected area

Ecotourism and protected areas have a close relationship as ecotourism often takes place in or near protected areas. Protected areas, such as national parks, wildlife reserves, and marine sanctuaries, are designated areas that are managed and protected to conserve biodiversity, cultural heritage, and natural resources. Ecotourism can support the goals of protected areas by providing a sustainable economic benefit to local communities while promoting conservation and awareness of the natural and cultural resources within the protected area. Protected areas offer a unique opportunity for ecotourism experiences, as they often provide access to pristine natural areas and rare wildlife species that are not found elsewhere. Visitors to protected areas can participate in activities such as hiking, wildlife viewing, and cultural experiences that are designed to minimize negative impacts on the environment and promote conservation efforts. Additionally, ecotourism in protected areas can provide economic benefits to local communities, which can incentivize them to support conservation efforts and become involved in the management of the protected area. However, it is important to note that ecotourism in protected areas must be carefully managed to avoid negative impacts on the environment and the local communities. Ecotourism activities must be designed to minimize disturbance to wildlife and ecosystems, and the number of visitors must be limited to prevent overcrowding and other negative impacts. Additionally, local communities must be involved in the planning and management of ecotourism activities to ensure that they receive a fair share of the economic benefits and that their cultural heritage is respected. Ecotourism and protected areas have a mutually beneficial relationship, as ecotourism can support conservation efforts and provide economic benefits to local communities while offering visitors unique and sustainable tourism experiences in pristine natural areas. However, it is important to carefully manage ecotourism activities in protected areas to avoid negative impacts on the environment and local communities. India is home to several protected areas that offer ecotourism opportunities for visitors. Here are some examples:

- **Jim Corbett National Park:** Located in the state of Uttarakhand, Jim Corbett National Park is one of the oldest and most popular national parks in India. The park is home to Bengal tigers, Indian elephants, and several species of birds and reptiles. Visitors can participate in activities such as wildlife safaris, nature walks, and bird watching.
- **Kaziranga National Park:** Located in the state of Assam, Kaziranga National Park is a UNESCO World Heritage Site and home to the largest population of one-horned rhinoceros in the world. Visitors can participate in activities such as elephant safaris, jeep safaris, and bird watching.
- **Periyar National Park:** Located in the state of Kerala, Periyar National Park is a protected area that is known for its beautiful scenery and diverse wildlife. Visitors can participate in activities such as jungle treks, bamboo rafting, and boat rides on the Periyar Lake.
- **Sunderbans National Park:** Located in the state of West Bengal, Sunderbans National Park is a UNESCO World Heritage Site and a biosphere reserve that is home to the Royal Bengal tiger and several species of migratory birds. Visitors can participate in activities such as wildlife safaris, bird watching, and cultural experiences with the local communities.
- **Gir Forest National Park**: Located in the state of Gujarat, Gir Forest National Park is the only place in the world where the Asiatic lion can be found in the wild. Visitors can

participate in activities such as wildlife safaris, bird watching, and cultural experiences with the local communities.

These are just a few examples of the many protected areas in India that offer ecotourism opportunities for visitors. Each of these protected areas has unique natural and cultural resources that are worth exploring, and ecotourism can provide a sustainable economic benefit to local communities while promoting conservation and awareness of these resources.

Characteristics of ecotourism protected area

Ecotourism in protected areas is a type of tourism that involves visiting natural areas while preserving the environment and benefiting local communities. Here are some of the key characteristics of ecotourism in protected areas:

- **Conservation:** The primary goal of ecotourism in protected areas is to conserve and protect natural resources. Ecotourism should not negatively impact the environment, and activities should be designed to minimize any potential harm.
- **Sustainable:** Ecotourism in protected areas should be sustainable, which means it should be socially, economically, and environmentally responsible. The tourism activities should not compromise the ability of future generations to enjoy the same natural resources.
- **Local community involvement:** Ecotourism in protected areas should involve and benefit local communities. This can be achieved by providing economic benefits to local communities, involving them in decision-making processes, and preserving their cultural heritage.
- **Education:** Ecotourism in protected areas should promote environmental education and awareness among visitors. This can be achieved by providing educational tours, interpretive displays, and educational materials to visitors.
- **Small-scale and low-impact:** Ecotourism in protected areas should be small-scale and low-impact. This means that visitor numbers should be limited, and activities should be designed to minimize environmental impacts.
- **Authentic:** Ecotourism in protected areas should offer authentic experiences that reflect the natural and cultural resources of the area. Visitors should have the opportunity to interact with local communities and learn about their way of life.

- **Professionalism:** Ecotourism in protected areas should be conducted in a professional and responsible manner. This means that tour operators and guides should be trained and qualified to provide safe and enjoyable experiences for visitors.

12.8. Ecolabelling

Ecolabeling, also known as eco-certification, is a system that identifies products and services that meet specific environmental standards. The history and scope of ecolabeling are closely tied to the evolution of the environmental movement and the growing awareness of the impact of human activities on the natural environment. The origins of ecolabeling can be traced back to the 1970s, when concerns about environmental degradation and pollution were becoming widespread. In 1975, the Nordic Swan eco-label was introduced in Sweden, making it the first official eco-labeling system in the world. This was followed by the Blue Angel in Germany in 1978 and the EU Eco-Label in 1992. Over time, ecolabeling has become an important tool for promoting sustainable consumption and production practices. Today, ecolabels are used in many different sectors, including food and agriculture, textiles, building materials, and energy. The scope of ecolabeling has expanded to include a wide range of environmental criteria, such as energy efficiency, water conservation, waste reduction, sustainable materials, and carbon footprint. Ecolabels also often incorporate social criteria, such as fair labor practices and human rights. The benefits of ecolabeling are numerous. For consumers, ecolabels provide a way to make informed purchasing decisions that align with their values and support environmentally and socially responsible practices. For businesses, ecolabels can be a way to differentiate themselves from competitors and demonstrate their commitment to sustainability. Ecolabels can also help to drive innovation by encouraging companies to develop more sustainable products and processes. There are many different ecolabeling systems in use around the world. Some of the most well-known ecolabels include:

- **The Nordic Swan:** The Nordic Swan is a widely recognized eco-label in Northern Europe that indicates that a product or service has met certain environmental criteria.
- **The EU Eco-Label:** The EU Eco-Label is a symbol that indicates that a product or service has met certain environmental criteria established by the European Union.
- **Energy Star:** The Energy Star symbol is a widely recognized symbol in the United States that indicates that a product is energy-efficient and has met certain energy performance criteria.

- **Fairtrade:** A certification system that promotes fair trade practices and supports farmers and workers in developing countries.
- **Organic:** The organic symbol is a widely recognized symbol that indicates that a product has been produced without the use of synthetic pesticides or fertilizers.
- **Forest Stewardship Council (FSC):** The FSC symbol is a widely recognized symbol that indicates that a product has been produced using responsible forestry practices and sustainable wood and paper products.

Eco-label symbols are an important tool for promoting sustainable consumption and production practices, and for providing consumers with clear and reliable information about the environmental and social impact of the products and services they purchase.

Why do eco labeling?

Eco-labeling is a voluntary program that allows businesses to communicate to consumers their commitment to environmental sustainability. The main purpose of eco-labeling is to provide consumers with information about the environmental impacts of a product or service so they can make informed choices when purchasing goods and services. There are several reasons why companies choose to participate in eco-labeling programs:

a) **Competitive advantage:** Companies can use eco-labeling as a way to differentiate themselves from their competitors and gain a competitive advantage in the market.
b) **Meeting consumer demand**: Consumers are increasingly concerned about the environmental impact of the products they buy and are more likely to choose products that have eco-labels.
c) **Meeting regulatory requirements**: In some cases, eco-labeling may be required by law or regulation, such as in the case of labeling for energy efficiency or emissions standards.
d) **Corporate responsibility:** Many companies see eco-labeling a part of their corporate social responsibility efforts and a way to demonstrate their commitment to environmental sustainability.
e) **Cost savings:** Some eco-labeling programs, such as those for energy efficiency or water conservation, can help companies reduce their operating costs and save money.

In addition to these benefits for companies, eco-labeling also has several benefits for the environment and society as a whole. By providing consumers with information about the environmental impact of products, eco-labeling can encourage more sustainable consumption patterns and promote the adoption of more environmentally friendly practices in production and manufacturing. It can also help to raise awareness about environmental issues and encourage companies to take a more proactive approach to sustainability.

12.8.1. Types of eco labeling:

There are several types of eco-labeling, each with its own set of criteria and objectives. Some of the most common types of eco-labeling include:

- **Type I eco-labels:** Type I eco-labels are awarded to products and services that meet specific environmental criteria. These criteria are typically developed by an independent third-party organization and are based on a life cycle analysis of the product or service. Examples of Type I eco-labels include the European Union's Eco-Label and the U.S. Environmental Protection Agency's Energy Star program.
- **Type II eco-labels:** Type II eco-labels provide information about the environmental impact of a product or service, but do not set specific criteria that must be met. Instead, they provide information about the environmental impact of a product or service based on a standardized set of metrics. Examples of Type II eco-labels include the Carbon Trust's Carbon Reduction Label and the good guide rating system.
- **Type III eco-labels:** Type III eco-labels provide detailed information about the environmental impact of a product or service, including information about its life cycle and the impact on the environment. These labels are based on a standardized set of metrics and are designed to provide consumers with comprehensive information about the environmental impact of a product or service. Examples of Type III eco-labels include the Global Reporting Initiative's Sustainability Reporting Framework and the International Organization for Standardization's Environmental Product Declarations.
- **Government eco-labels:** Some governments have developed their own eco-labeling programs to promote sustainable production and consumption practices. Examples include the U.S. Department of Agriculture's Organic Seal and the Nordic Swan eco-label in Scandinavia.
- **Industry eco-labels:** Some industries have developed their own eco-labeling programs to promote sustainable practices within their sector. Examples include the Forest Stewardship Council's certification for sustainable forestry practices and the Marine Stewardship Council's certification for sustainable fishing practices.

Thus the eco-labeling can play an important role in promoting sustainable production and consumption practices, by providing consumers with information about the environmental impact of the products and services they buy. By choosing products and services with eco-labels, consumers can help to reduce their environmental impact and support companies that are committed to sustainability.

12.8.2. Criteria of eco labeling:

The criteria for eco-labeling may vary depending on the type of product or service being evaluated, as well as the specific eco-labeling program being used. However, some common criteria for eco-labeling may include:

- **Environmental impact:** The product or service should have a minimal environmental impact throughout its life cycle, from production to disposal.
- **Resource conservation:** The product or service should conserve natural resources, such as water, energy, and raw materials.
- **Pollution prevention:** The product or service should minimize pollution, including air and water pollution, and should not use harmful chemicals.
- **Social responsibility:** The product or service should be produced and marketed in a socially responsible manner, including fair labour practices and respect for human rights.
- **Health and safety:** The product or service should be safe for human health and should not pose any risks to workers or consumers.
- **Transparency and verification:** The eco-labeling program should be transparent, and the criteria used to evaluate products and services should be available to public. The program should also have a verification process in place to ensure that products and services meet the criteria for eco-labeling.

These criteria help to ensure that eco-labeling programs promote sustainable production and consumption practices, while providing consumers with accurate and reliable information about the environmental impact of products and services.

12.8.3. Eco labeling in India

Eco-labeling in India is a voluntary program aimed at promoting sustainable production and consumption practices. The Government of India has established several eco-labeling schemes to encourage companies to adopt environmental friendly practices and provide consumers with information about the environmental impact of products. Here are some examples of eco-labeling schemes in India:

- **Bureau of Energy Efficiency (BEE) Star Label**: The BEE Star Label is a voluntary energy efficiency labeling program that rates appliances and equipment on their energy efficiency performance. The label rates appliances on a scale of 1 to 5 stars, with 5 stars being the most energy-efficient. The BEE Star Label is mandatory for certain appliances such as air conditioners, refrigerators, and televisions.
- **India Organic Certification:** The India Organic Certification is a voluntary certification program that verifies that products have been produced using organic farming practices. The certification is issued by the Agricultural and Processed Food Products Export Development Authority (APEDA) and is recognized both nationally and internationally.
- **Green Pro Certification:** The Green Pro certification program is a voluntary certification program that assesses products and services on their environmental impact and sustainability performance. The certification is issued by the Confederation of Indian Industry (CII) and covers a wide range of products and services including buildings, electronics, chemicals, and packaging materials.
- **Forest Stewardship Council (FSC) Certification:** The FSC certification program is a voluntary certification program that verifies that forest products have been produced using responsible forestry practices. The certification is issued by the FSC and is recognized both nationally and internationally.
- **Ecomark Certification:** The Ecomark certification program is a voluntary certification program that verifies that products have been produced using environmental friendly practices. The certification is issued by the Bureau of Indian Standards (BIS) and covers a wide range of products including textiles, paper products, and cleaning products.

These eco-labeling schemes in India have helped to promote sustainable production and consumption practices and provide consumers with information about the environmental impact of products. They have also encouraged companies to adopt environmental friendly practices and promote sustainable development in India.

12.8.4. Eco labeling awareness and society

Eco-labeling awareness is important for society because it helps consumers make informed choices about the environmental impact of the products and services they buy. When consumers are aware of eco-labeling programs and the criteria used to evaluate products and services, they are better equipped to make choices that promote sustainability. Eco-labeling awareness also has several benefits for society as a whole:

- **Promotes sustainable consumption:** Eco-labeling awareness can encourage consumers to choose products and services that have a lower environmental impact, thereby promoting sustainable consumption practices.
- **Reduces environmental impact:** When consumers choose products and services that meet eco-labeling criteria, it can reduce the environmental impact of production and consumption, leading to a more sustainable future.
- **Supports green businesses**: Eco-labeling awareness can support green business that committed to sustainable production and consumption practices, by providing them with a way to differentiate themselves from their competitors.
- **Creates demand for sustainable products:** When consumers demand sustainable products and services, it creates a market for these products, which can incentivize companies to adopt sustainable production practices.
- **Promotes social responsibility:** Eco-labeling awareness can also promote social responsibility among companies, by encouraging them to adopt fair labour practices and respect human rights.

Overall, eco-labeling awareness is an important tool for promoting sustainable development and ensuring that economic growth is achieved in an environmental responsible manner. By promoting eco-labeling awareness, society can encourage sustainable consumption practices and create a more sustainable future for all.

12.9. Green belt design

Green belt design is a concept that has evolved over time, but it is generally defined as a planning strategy that involves the creation of a continuous stretch of green spaces around urban areas. The concept of green belts can be traced back to the early 20th century, when city planners began to recognize the need to preserve open spaces around rapidly growing cities. The first official green belt was established in London in 1938, in response to concerns about urban sprawl and the loss of agricultural land. The green belt was designed to protect open spaces and farmland around the city, and to encourage the development of compact, walkable communities within the urban area. Today, the London green belt covers over 500,000 acres and is considered one of the most successful green belt programs in the world. The concept of green belts has since been adopted by cities and regions around the world, as a way to promote sustainable development and protect natural resources. Green belts can take many forms, from urban parks and nature reserves to agricultural land and forests. They can also be designed to provide a range of environmental, social, and economic benefits, including:

- **Preserving natural habitats:** Green belts can provide a habitat for a wide range of plant and animal species, including those that are threatened or endangered. By preserving natural habitats, green belts can help to maintain biodiversity and support healthy ecosystems.
- **Mitigating climate change:** Green belts can help to mitigate the effects of climate change by sequestering carbon and reducing the urban heat island effect. Trees and vegetation in green belts absorb carbon dioxide from the atmosphere, while providing shade and cooling to urban areas.
- **Promoting recreation and public health**: Green belts can provide opportunities for recreation and outdoor activities, such as hiking, biking, and bird watching. These activities can promote physical health and mental well-being, while also providing educational opportunities for children and adults.
- **Supporting local agriculture:** Green belts can provide land for local agriculture, including small-scale farming and community gardens. This can support local food systems and promote sustainable agriculture practices.
- **Enhancing property values:** Green belts can enhance property values by providing attractive and well-maintained public spaces, and by creating a sense of community pride and identity.

Overall, green belt design is a powerful tool for promoting sustainable development and protecting natural resources. By preserving open spaces and creating green corridors around urban areas, green belts can provide a range of environmental, social, and economic benefits for communities around the world.

12.9.1. Characteristics of green belt

Green belts are typically characterized by the following features:

- **Vegetation:** The presence of trees, shrubs, grasses, and other vegetation is a defining feature of green belts. Vegetation provides a range of environmental benefits, including improved air and water quality, reduced erosion, and enhanced habitat for wildlife.
- **Open space:** Green belts are often characterized by open space, which provides opportunities for recreation, relaxation, and physical activity. Open space can also help to reduce the heat island effect in urban areas by providing shade and evaporative cooling.

- **Connectivity:** Green belts can provide important connectivity between different habitats, such as parks, forests, and wetlands, and can help to maintain or enhance biodiversity.
- **Protection:** Green belts are typically protected from development and other forms of human disturbance to ensure that they continue to provide their environmental and social benefits.
- **Planning and management:** Green belts are often planned and managed to achieve specific environmental and social goals, such as reducing greenhouse gas emissions, improving public health, or enhancing the aesthetic quality of the landscape.
- **Community involvement**: Green belts can provide opportunities for community involvement in their planning and management, and can help to foster a sense of ownership and stewardship among local residents.

Overall, green belts can provide a range of environmental, social, and economic benefits, and can help to create more livable and sustainable communities.

12.9.2. Types of green belt design

There are different types of green belt design depending on their location, size, and purpose. Some common types of green belt designs include:

- **Urban green belts**: These are green spaces located within or around urban areas that provide a range of benefits, including improved air quality, enhanced biodiversity, and opportunities for recreation and relaxation.
- **Agricultural green belts:** These are areas of agricultural land that are protected from urban development to ensure that they continue to provide food and other products.
- **Forest green belts:** These are areas of forest land that are protected for their ecological and recreational values, and can provide important habitat for wildlife.
- **Coastal green belts:** These are areas of coastal land that are protected to preserve important ecosystems, including wetlands, dunes, and beaches.
- **Green corridors:** These are linear green spaces that connect different habitats, such as parks, forests, and wetlands, and provide important migration routes for wildlife.
- **Buffer zones:** These are areas of green space that are designed to buffer or separate different land uses, such as residential and industrial areas, and can help to mitigate the impacts of noise, pollution, and other disturbances. Each type of green belt design has its own unique characteristics and benefits, and can be tailored to meet the specific needs and goals of the community and environment.

12.9.3. Green belt model for House

A green belt model for a house involves incorporating plants and vegetation in the outdoor spaces surrounding the house to create a green and sustainable environment. Here are some steps to create a green belt around your house:

- **Assess the outdoor space:** Take a look at the outdoor space surrounding your house and assess the available area, the quality of the soil, the amount of sunlight, and the climatic conditions in the region. This assessment will help you to identify the best plants and vegetation suitable for your green belt.
- **Choose the right plants:** Based on the assessment, choose the right plants that will thrive in the given conditions. It is essential to choose native plants as they require less maintenance and are more suited to the local environment. Choose plants of varying heights and colors to create a diverse and vibrant landscape.
- **Plan the layout:** Plan the layout of your green belt, keeping in mind the available space and the types of plants you want to include. You can create pathways, seating areas, and even water features to enhance the appeal of the green belt.
- **Implement a water management system:** To maintain a healthy green belt, it is crucial to implement a water management system that utilizes rainwater and other sources of water efficiently. Consider installing rainwater harvesting system, drip irrigation, and other water-saving techniques.
- **Use organic methods:** To create a truly sustainable green belt, it is essential to use organic methods to maintain the plants and vegetation. Avoid using chemical fertilizers, pesticides, and herbicides, and instead use natural methods such as composting, mulching, and companion planting.

A green belt model for a house can bring numerous benefits, including:

- **Improved air quality:** The plants in the green belt help to absorb pollutants and improve the air quality around the house.
- **Reduced energy costs**: A green belt provides natural shade, which can help to reduce the temperature inside the house, reducing the need for air conditioning.
- **Increased biodiversity:** A green belt provides a habitat for a variety of plant and animal species, which can contribute to the overall biodiversity of the region.
- **Enhanced aesthetic appeal:** A well-designed green belt can enhance the aesthetic appeal of the house, making it more attractive to residents and visitors.

- **Improved mental health:** Being surrounded by nature has been shown to have numerous benefits for mental health, including reducing stress and anxiety and improving mood and overall well-being.

12.9.4. Public awareness about green belt design

Public awareness about green belt design is essential for its success. Here are some ways in which awareness can be raised:

- **Community outreach:** Community outreach programs can be conducted to educate the public about the benefits of green belt design. This can include seminars, workshops, and public meetings.
- **Social media:** Social media can be used to share information about green belt design, including its benefits and how to create and maintain green belts.
- **Public signage:** Signs can be placed in public areas to promote awareness about green belt design and its benefits.
- **School programs**: Schools can incorporate green belt design education into their curriculum, teaching students about the importance of green space and how to create and maintain green belts.
- **Volunteer opportunities:** Volunteering opportunities can be provided to encourage public participation in green belt design and maintenance activities. This can help raise awareness about green belts and their benefits.
- **Incentives:** Incentives can be provided to encourage property owners to create and maintain green belts, such as tax breaks or other financial benefits.
- **Collaborative efforts:** Collaboration between government agencies, non-governmental organizations, and community groups can help raise awareness about green belt design and promote its implementation.

Public awareness about green belt design is crucial for its success in promoting sustainable development and improving the quality of life for residents. It can help to create a sense of ownership and responsibility among the public, leading to better participation in green belt design and maintenance activities.

12.9.5. Green belt practice in India

Green belt practices in India vary depending on the specific location and context. Some examples of green belt practices in India include:

- **Afforestation initiatives:** Many parts of India have experienced significant deforestation and degradation of natural habitats. To address this issue, afforestation initiatives have been undertaken to plant trees and restore degraded land. For example, the Indian government launched the National Afforestation Programme in 2002, which aims to increase the country's forest cover to 33% of its total land area.
- **Urban green belts:** Several Indian cities have established urban green belts to provide open space and recreational opportunities for residents. For example, the Chennai Green Belt is a 45 km long stretch of green space that runs around the city, providing opportunities for cycling, walking, and birdwatching.
- **Protected areas**: India has a network of protected areas, including national parks, wildlife sanctuaries, and biosphere reserves, which are designed to conserve important habitats and biodiversity. These protected areas often include green belt zones around their perimeters to provide a buffer between the protected area and surrounding human activities.
- **Agroforestry:** Agroforestry is a practice that involves the integration of trees into agricultural landscapes. This practice can provide multiple benefits, including improved soil health, increased biodiversity, and increased productivity. In India, agroforestry initiatives have been undertaken in several states, including Madhya Pradesh, Maharashtra, and Kerala.
- **Watershed management**: Watershed management involves the protection and restoration of natural areas that provide water resources. In India, watershed management initiatives have been implemented to protect and restore forests, wetlands, and other natural areas that contribute to the country of water supply. Overall, green belt practices in India are aimed at conserving and restoring natural areas, improving the quality of life for residents, and promoting sustainable development.

12.9.6. Benefits of green belt design

Green belt design offers several benefits, which are following:

- **Improving air quality:** Trees and other vegetation in green belts absorb pollutants, including carbon dioxide, sulfur dioxide, and nitrogen oxide, and release oxygen, thereby improving air quality.
- **Mitigating the urban heat island effect:** Green belts help reduce the urban heat island effect, which occurs when urban areas are significantly warmer than surrounding rural areas due to the absorption and retention of heat by buildings and paved surfaces.

- **Enhancing biodiversity:** Green belts can provide important habitats for wildlife, including birds, insects, and mammals. They also serve as corridors for wildlife to move between larger natural areas.
- **Reducing noise pollution**: Trees and other vegetation in green belts help a reduce noise pollution by absorbing sound waves.
- **Improving property values**: Properties located near green belts often have higher values due to the aesthetic and environmental benefits of the green space.

Overall, green belt design offers multiple benefits for the environment, wildlife, and human communities, making it a valuable tool for promoting sustainable development.

10.10. Summary

Ecotourism is a form of sustainable tourism that aims to promote responsible travel to natural areas while preserving the environment and improving the well-being of local communities. It involves activities such as hiking, wildlife viewing, and cultural immersion, and it has become increasingly popular worldwide. Ecotourism provides numerous benefits, including economic growth, conservation of natural resources, and cultural preservation, but it also presents challenges, such as the potential for environmental degradation and cultural disruption. Ecolabeling is a certification system that allows consumers to identify products and services that meet certain environmental standards. It provides information about the environmental impact of a product or service, and it encourages businesses to adopt environmental friendly practices. Ecolabeling has a long history, dating back to the 1970s, and it has become an important tool for promoting sustainable consumption and production. However, there are challenges associated with ecolabeling, including the need for clear standards, reliable verification, and consumer awareness. Green belt design is a concept that involves planting trees, shrubs, and other vegetation around urban areas to improve the environment and promote sustainable development. Green belt design can help reduce air pollution, provide habitat for wildlife, and improve the overall quality of life for urban residents. It can also provide economic benefits by creating jobs in the green sector and attracting tourists to green spaces. However, there are challenges associated with green belt design, including the need for effective planning and management, and the need for public awareness and engagement.

12.11. Terminal questions

Q.1: What is the ecotourism? Discuss its importance for society

Answer:--

Q.2: What is the ecotourism protected area? Discuss the characteristics of ecotourism protected area.

Answer:--

Q.3: Write the examples of ecotourism protected area in India.

Answer:--

Q.4: What is the ecolabelling, Discuss it's characteristics with examples.

Answer:--

Q.5: What is the Symbol of eco labeling discuss with examples.

Answer:--

Q.6: What is the green belt? discuss the green belt design for house

Answer:--

12.12.Further suggested readings

16. Environmental Science, Subhas Chandra Santra, new central book agency, 3rd Edition, 2011

17. A text Book of Environment Studies, Asthana, D. K. and Asthana, M. 2006, S. Chand & Co

18. Atmosphere, Weather and Climate, Barry, R. G. 2003, Routledge Press, UK.

19. Ecology: Theories and Applications (4th Edition) by Peter Stiling; Prentice Hall.

20. Biodiversity: a beginner's guide, john I. spicer, One world Publications.