NESI101 Environmental Science: Unit 1

What is an Ecosystem?

An ecosystem is a structural and functional unit of ecology where living organisms interact with each other and the surrounding environment. In other words, an ecosystem is a chain of interactions between organisms and their environment. The term "Ecosystem" was first coined by A.G. Tansley, an English botanist, in 1935.

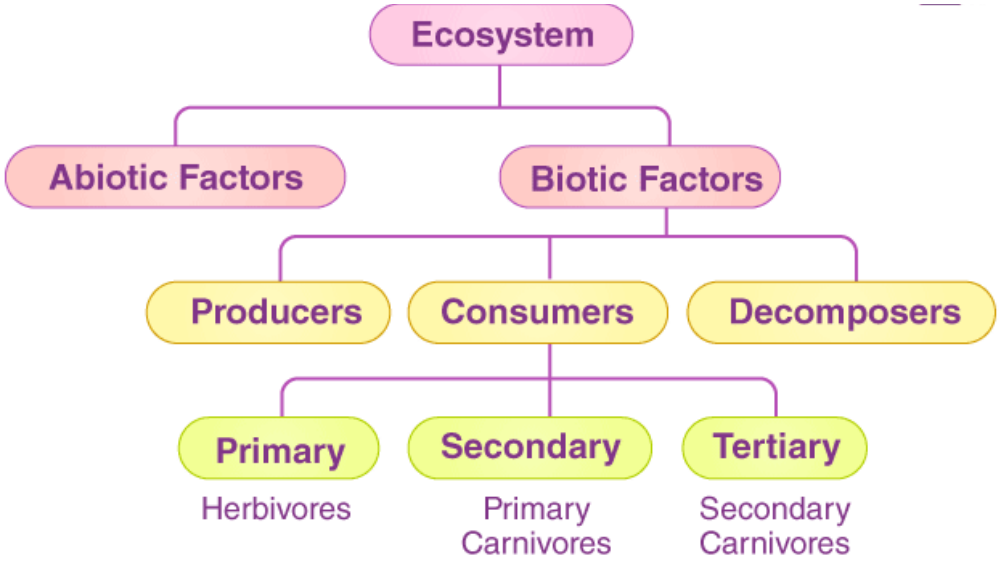
Structure of the Ecosystem

The structure of an ecosystem is characterised by the organization of both biotic and abiotic components. This includes the distribution of energy in our environment. It also includes the climatic conditions prevailing in that particular environment.

The structure of an ecosystem can be split into two main components, namely:

- Biotic Components
- Abiotic Components

The biotic and abiotic components are interrelated in an ecosystem. It is an open system where the energy and components can flow throughout the boundaries.



Biotic Components

Biotic components refer to all living components in an ecosystem. Based on nutrition, biotic components can be categorised into autotrophs, heterotrophs and saprotrophs (or decomposers).

- **Producers** include all autotrophs such as plants. They are called autotrophs as they can produce food through the process of photosynthesis. Consequently, all other organisms higher up on the food chain rely on producers for food.
- **Consumers** or heterotrophs are organisms that depend on other organisms for food. Consumers are further classified into primary consumers, secondary consumers and tertiary consumers.
    - ***Primary consumers*** are always herbivores as they rely on producers for food.
    - ***Secondary consumers*** depend on primary consumers for energy. They can either be carnivores or omnivores.
    - ***Tertiary consumers*** are organisms that depend on secondary consumers for food. Tertiary consumers can also be carnivores or omnivores.

      Quaternary consumers are present in some food chains. These organisms prey on tertiary consumers for energy. Furthermore, they are usually at the top of a food chain as they have no natural predators.
- **Decomposers** include saprophytes such as fungi and bacteria. They directly thrive on the dead and decaying organic matter. Decomposers are essential for the ecosystem as they help in recycling nutrients to be reused by plants.

Abiotic Components

Abiotic components are the non-living component of an ecosystem. It includes air, water, soil, minerals, sunlight, temperature, nutrients, wind, altitude, turbidity, etc.

Functions of Ecosystem

The functions of the ecosystem are as follows:

1. It regulates the essential ecological processes, supports life systems and renders stability.
2. It is also responsible for the cycling of nutrients between biotic and abiotic components.
3. It maintains a balance among the various trophic levels in the ecosystem.
4. It cycles the minerals through the biosphere.
5. The abiotic components help in the synthesis of organic components that involve the exchange of energy.

So the functional units of an ecosystem or functional components that work together in an ecosystem are:

- **Productivity –** It refers to the rate of biomass production.
- **Energy flow –** It is the sequential process through which energy flows from one trophic level to another. The energy captured from the sun flows from producers to consumers and then to decomposers and finally back to the environment.
- **Decomposition –** It is the process of breakdown of dead organic material. The topsoil is the major site for decomposition.
- **Nutrient cycling –** In ecosystem nutrients are consumed and recycled back in various forms for the utilisation by various organisms.

Types of Ecosystems

An ecosystem can be as small as an oasis in a desert, or as big as an ocean, spanning thousands of miles. There are two types of ecosystems:

- Terrestrial Ecosystem
- Aquatic Ecosystem

Terrestrial Ecosystem

Terrestrial ecosystems are exclusively land-based ecosystems. There are different types of terrestrial ecosystems distributed around various geological zones. They are as follows:

1. Forest Ecosystem
2. Grassland Ecosystem
3. Tundra Ecosystem
4. Desert Ecosystem

Forest Ecosystem

A forest ecosystem consists of several plants, particularly trees, animals, and microorganisms, that live in coordination with the abiotic factors of the environment. Forests help in maintaining the temperature of the earth and are the major carbon sink.

Grassland Ecosystem

In a grassland ecosystem, the vegetation is dominated by grasses and herbs. Temperate grasslands and tropical or savanna grasslands are examples of grassland ecosystems.

Tundra Ecosystem

Tundra ecosystems are devoid of trees and are found in cold climates or where rainfall is scarce. These are covered with snow for most of the year. Tundra type of ecosystem is found in the Arctic or mountain tops.

Desert Ecosystem

Deserts are found throughout the world. These are regions with little rainfall and scarce vegetation. The days are hot, and the nights are cold.

Aquatic Ecosystem

Aquatic ecosystems are ecosystems present in a body of water. These can be further divided into two types, namely:

1. Freshwater Ecosystem 2. Marine Ecosystem

Freshwater Ecosystem: *The freshwater ecosystem is an aquatic ecosystem that includes lakes, ponds, rivers, streams and wetlands. These have no salt content in contrast with the marine ecosystem.*

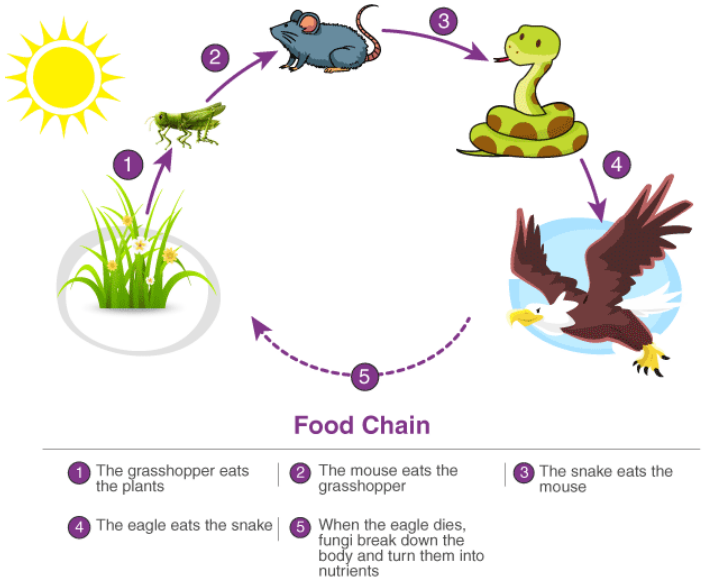
Marine Ecosystem: *The marine ecosystem includes seas and oceans. These have a more substantial salt content and greater biodiversity in comparison to the freshwater ecosystem.*

Also check: Habitat Diversity

Important Ecological Concepts

1. Food Chain

The sun is the ultimate source of energy on Earth. It provides the energy required for all plant life. The plants utilise this energy for the process of photosynthesis, which is used to synthesise their food. During this biological process, light energy is converted into chemical energy and



is passed on through successive trophic levels. The flow of energy from a producer, to a consumer and eventually, to an apex predator or a detritivore is called the food chain. Dead and decaying matter, along with organic debris, is broken down into its constituents by scavengers. The reducers then absorb these constituents. After gaining the energy, the reducers liberate molecules to the environment, which can be utilised again by the producers.

2. Ecological Pyramids

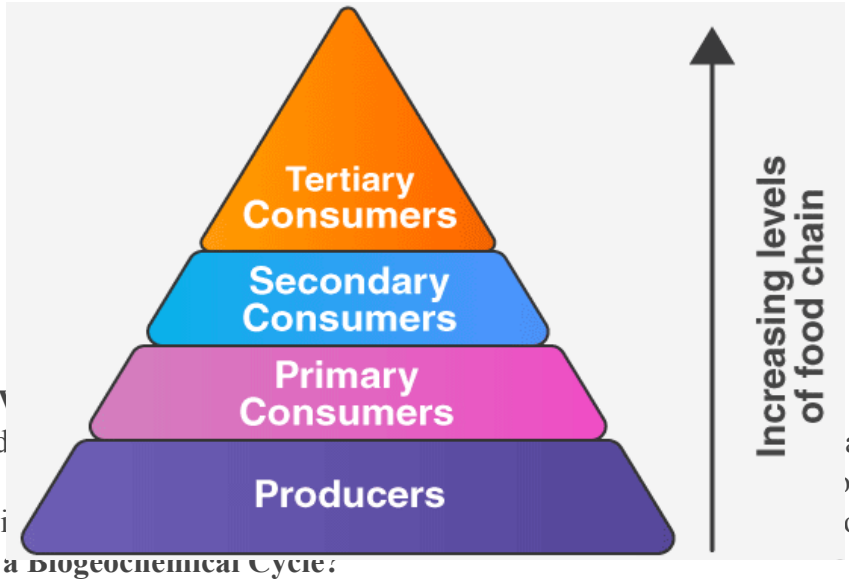
An ecological pyramid is the graphical representation of the number, energy, and biomass of the successive trophic levels of an ecosystem. Charles Elton was the first ecologist to describe the ecological pyramid and its principals in 1927. The biomass, number, and energy of organisms ranging from the producer level to the consumer level are represented in the form of a pyramid; hence, it is known as the ecological pyramid.

The base of the ecological pyramid comprises the producers, followed by primary and secondary consumers. The tertiary consumers hold the apex. In some food chains, the quaternary consumers are at the very apex of the food chain.

The producers generally outnumber the primary consumers and similarly, the primary consumers outnumber the secondary consumers. And lastly, apex predators also follow the same trend as the other consumers, wherein their numbers are considerably lower than the secondary consumers.

For example, Grasshoppers feed on crops such as cotton and wheat, which are plentiful. These grasshoppers are then preyed upon by common mouse, which are comparatively less in number. The mice are preyed upon by snakes such as cobras. Snakes are ultimately preyed on by apex predators such as the brown snake eagle.

Grasshopper →Mouse→ Cobra → Brown Snake Eagle



3. Food V

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What is a Biogeochemical Cycle?

"Biogeochemical cycles mainly refer to the movement of nutrients and other elements between biotic and abiotic factors."

The term biogeochemical is derived from **"bio"** meaning **biosphere**, **"geo"** meaning the **geological components** and "**chemical**" meaning the **elements that move through a cycle**.

The matter on Earth is conserved and present in the form of atoms. Since matter can neither be created nor destroyed, it is recycled in the earth's system in various forms.

The earth obtains energy from the sun which is radiated back as heat, rest all other elements are present in a closed system. The major elements include:

- Carbon
- Hydrogen
- Nitrogen
- Oxygen
- Phosphorus
- Sulphur

These elements are recycled through the biotic and abiotic components of the ecosystem. The atmosphere, hydrosphere, and lithosphere are the abiotic components of the ecosystem.

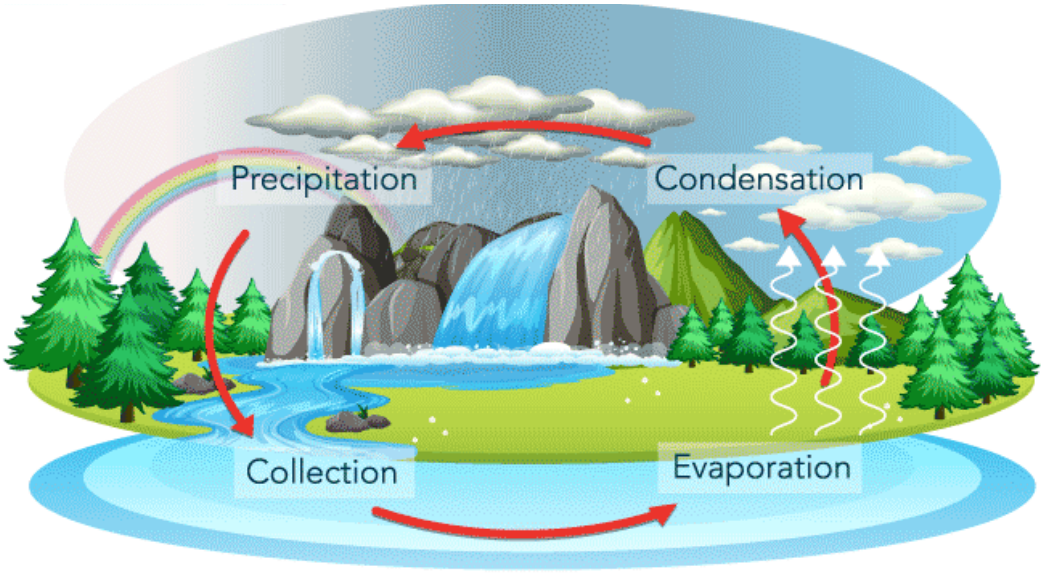
Types of Biogeochemical Cycles

Biogeochemical cycles are basically divided into two types:

- **Gaseous cycles** – Includes Carbon, Oxygen, Nitrogen, and the Water cycle.
- **Sedimentary cycles** – Includes Sulphur, Phosphorus, Rock cycle, etc.

Water Cycle

The water from the different water bodies evaporates, cools, condenses and falls back to the earth as rain. This biogeochemical cycle is responsible for maintaining weather conditions. The water in its various forms interacts with the surroundings and changes the temperature and pressure of the atmosphere. There's another process called Evapotranspiration (i.e. vapour produced from leaves) which aids this process. It is the evaporation of water from the leaves, soil and water bodies to the atmosphere which again condenses and falls as rain.



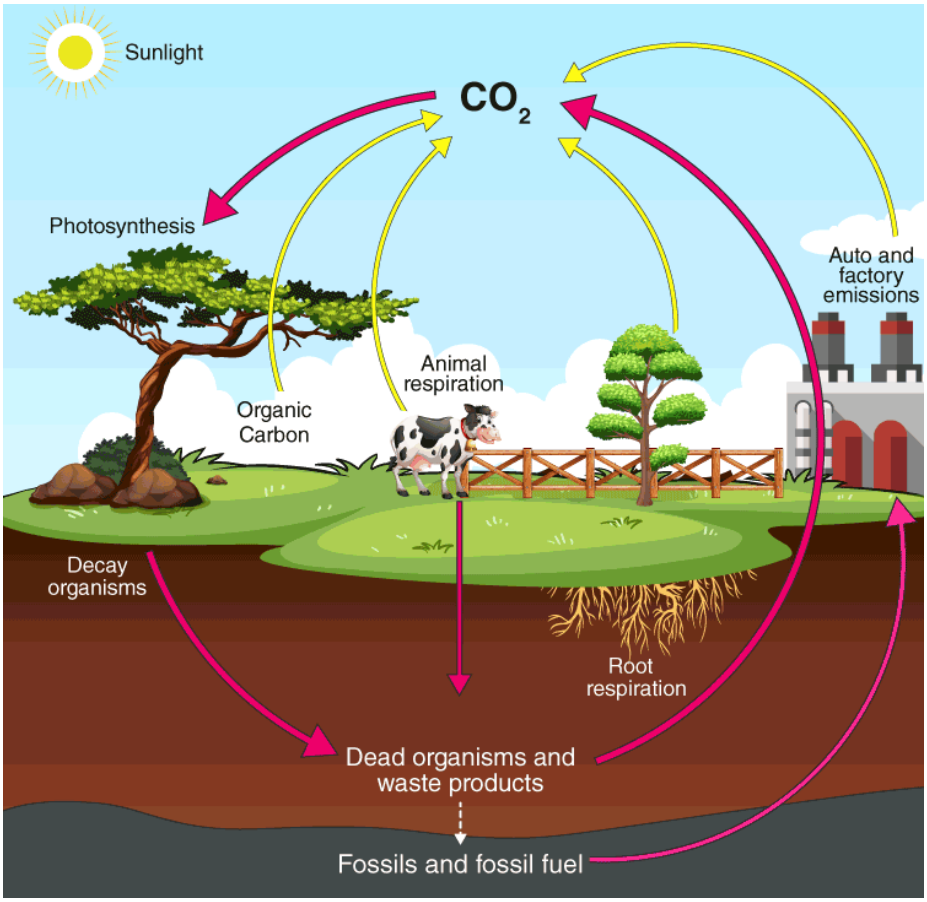
Carbon Cycle

It is one of the biogeochemical cycles in which carbon is exchanged among the biosphere, geosphere, hydrosphere, atmosphere, and pedosphere.

All green plants use carbon dioxide and sunlight for photosynthesis. Carbon is thus stored in the plant. The green plants, when dead, are buried in the soil, which gets converted into fossil fuels made from carbon. These fossil fuels when burnt, release carbon dioxide into the atmosphere.

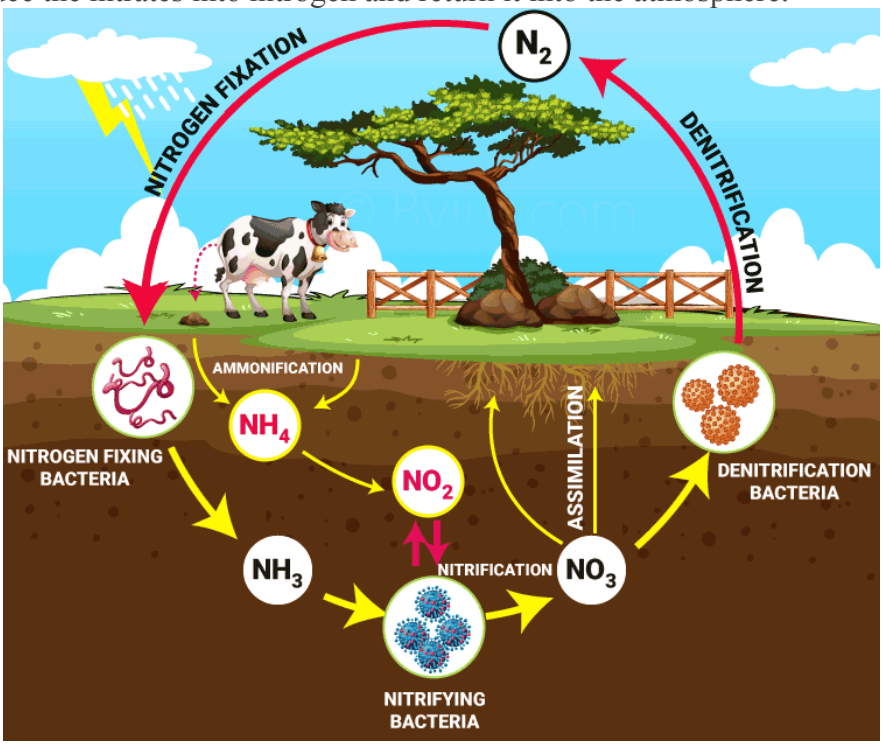
Also, the animals that consume plants, obtain the carbon stored in the plants. This carbon is returned to the atmosphere when these animals decompose after death. The carbon also returns to the environment through cellular respiration by animals.

Huge carbon content in the form of carbon dioxide is produced that is stored in the form of fossil fuel (coal & oil) and can be extracted for various commercial and non-commercial purposes. When factories use these fuels, the carbon is again released back into the atmosphere during combustion.



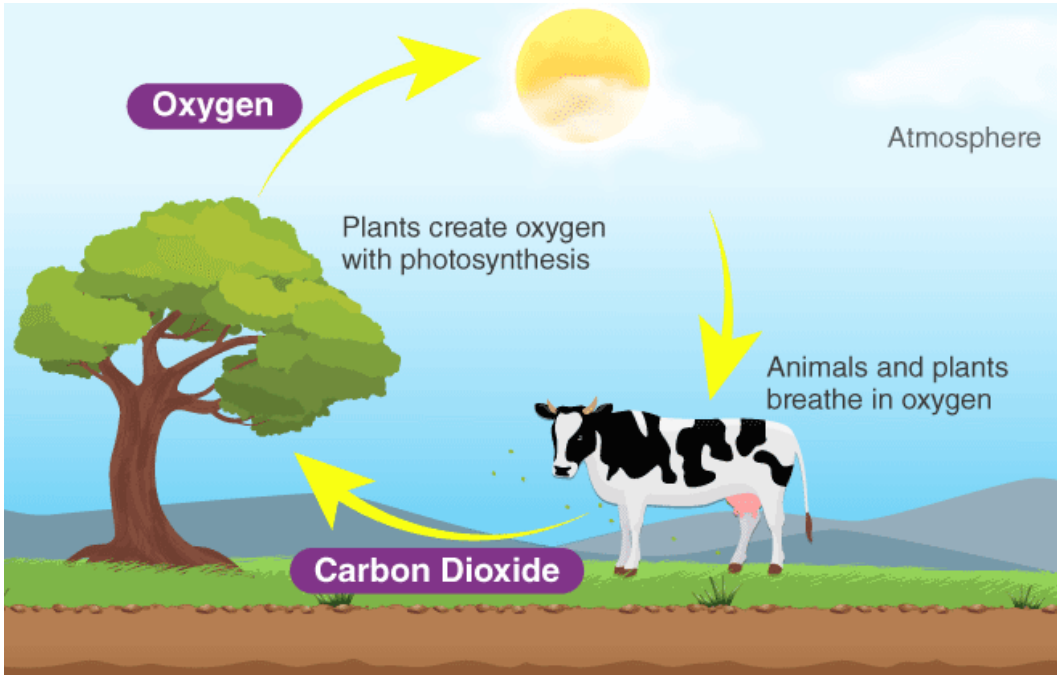
Nitrogen Cycle

It is the biogeochemical cycle by which nitrogen is converted into several forms and it gets circulated through the atmosphere and various ecosystems such as terrestrial and marine ecosystems. Nitrogen is an essential element of life. The nitrogen in the atmosphere is fixed by the nitrogen-fixing bacteria present in the root nodules of the leguminous plants and made available to the soil and plants. The bacteria present in the roots of the plants convert this nitrogen gas into a usable compound called ammonia. Ammonia is also supplied to plants in the form of fertilizers. This ammonia is converted into nitrites and nitrates. The denitrifying bacteria reduce the nitrates into nitrogen and return it into the atmosphere.



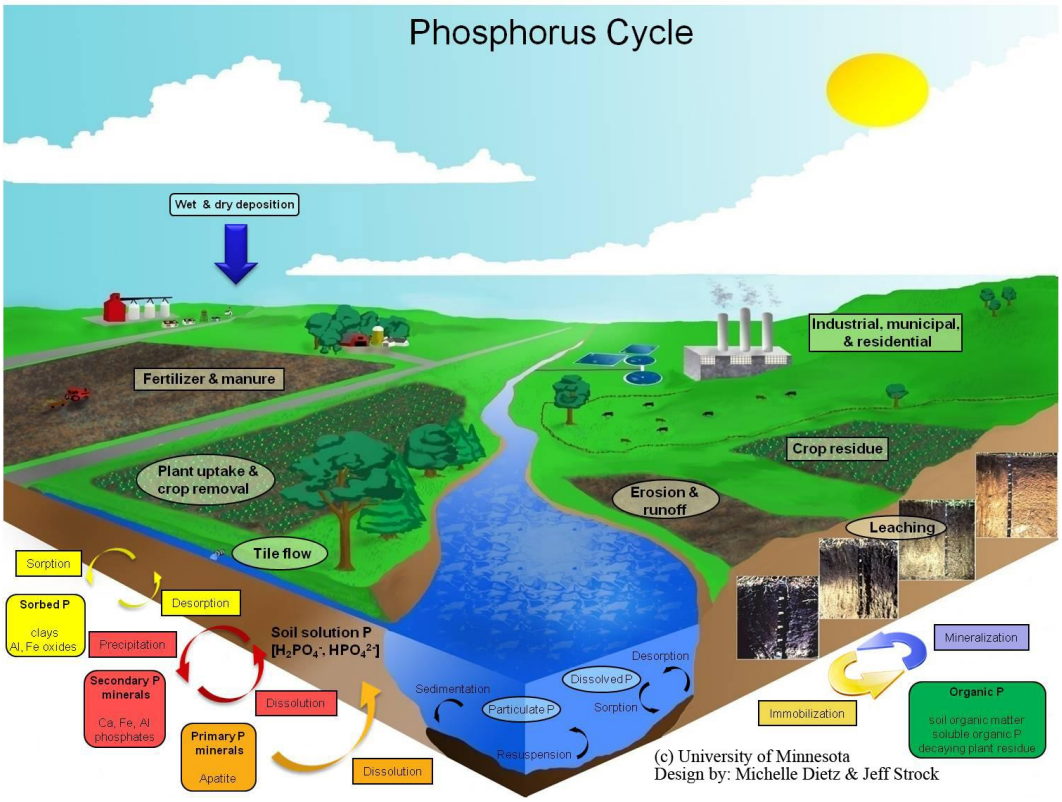
Oxygen Cycle

This biogeochemical cycle moves through the atmosphere, the lithosphere and the biosphere. Oxygen is an abundant element on our Earth. It is found in the elemental form in the atmosphere to the extent of 21%. Oxygen is released by the plants during photosynthesis. Humans and other animals inhale the oxygen exhale carbon dioxide which is again taken up by the plants. They utilise this carbon dioxide in photosynthesis to produce oxygen, and the cycle continues.



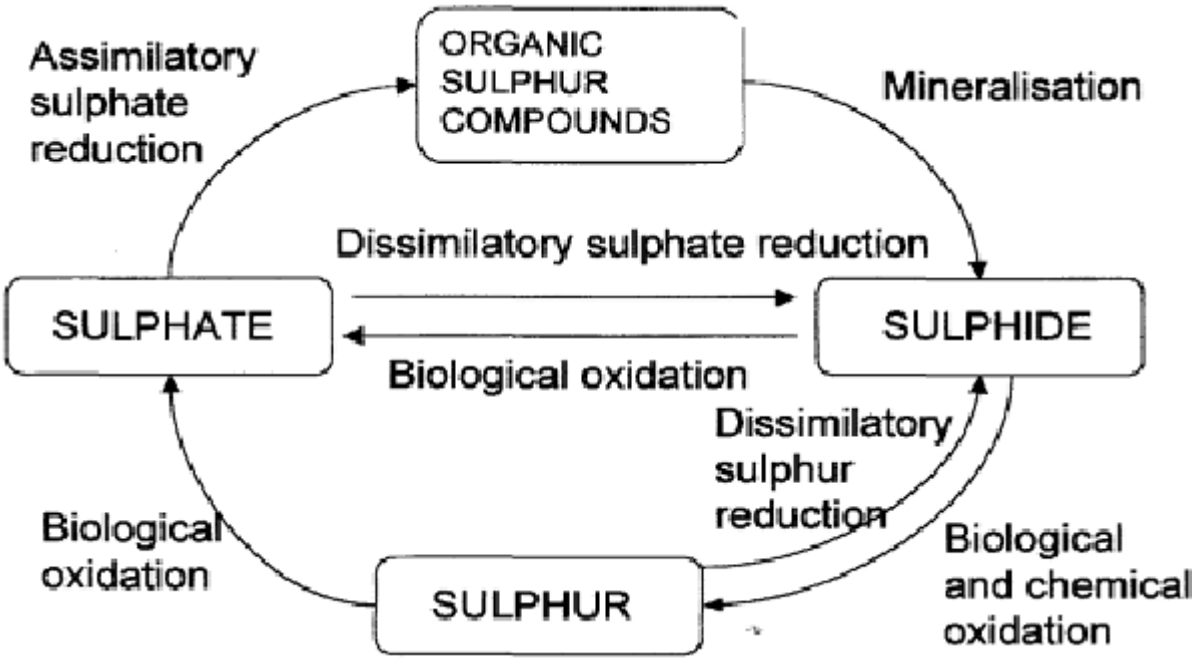
Phosphorous Cycle

In this biogeochemical cycle, phosphorus moves through the hydrosphere, lithosphere and biosphere. Phosphorus is extracted by the weathering of rocks. Due to rains and erosion phosphorus is washed away in the soil and water bodies. Plants and animals obtain this phosphorus through the soil and water and grow. Microorganisms also require phosphorus for their growth. When the plants and animals die they decompose, and the stored phosphorus is returned to the soil and water bodies which is again consumed by plants and animals and the cycle continues.



Sulphur Cycle

This biogeochemical cycle moves through the rocks, water bodies and living systems. Sulphur is released into the atmosphere by the weathering of rocks and is converted into sulphates. These sulphates are taken up by the microorganisms and plants and converted into organic forms. Organic sulphur is consumed by animals through food. When the animals die and decompose, sulphur is returned to the soil, which is again obtained by the plants and microbes, and the cycle continues.



Importance of Biogeochemical Cycles

These cycles demonstrate the way in which the energy is used. Through the ecosystem, these cycles move the essential elements for life to sustain. They are vital as they recycle elements and store them too, and regulate the vital elements through the physical facets. These cycles depict the association between living and non-living things in the ecosystems and enable the continuous survival of ecosystems.

It is important to comprehend these cycles to learn their effect on living entities. Some activities of humans disturb a few of these natural cycles and thereby affecting related ecosystems. A closer look at these mechanisms can help us restrict and stop their dangerous impact.

What is Biodiversity?

Biodiversity describes the richness and variety of life on earth. It is the most complex and important feature of our planet. Without biodiversity, life would not sustain.

The term biodiversity was coined in 1985. It is important in natural as well as artificial ecosystems. It deals with nature's variety, the biosphere. It refers to variabilities among plants, animals and microorganism species.

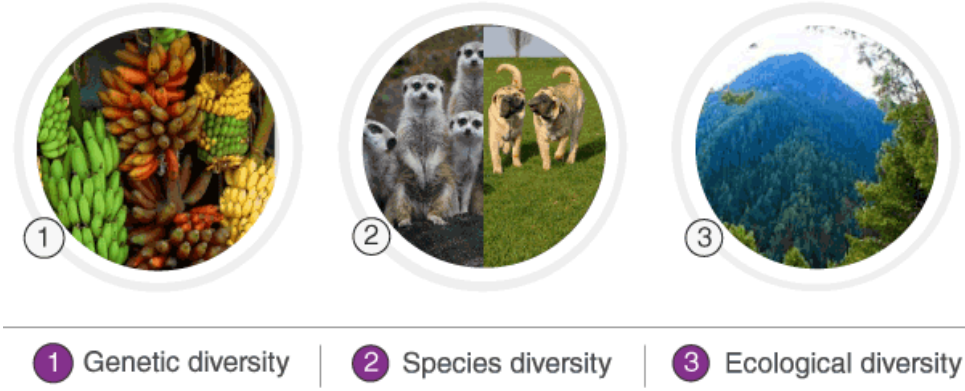
Biodiversity includes the number of different organisms and their relative frequencies in an ecosystem. It also reflects the organization of organisms at different levels.

Biodiversity holds ecological and economic significance. It provides us with nourishment, housing, fuel, clothing and several other resources. It also extracts monetary benefits through tourism. Therefore, it is very important to have a good knowledge of biodiversity for a sustainable livelihood.

Types of Biodiversity

There are the following three different types of biodiversity:

- Genetic Biodiversity
- Species Biodiversity
- Ecological Biodiversity



Species diversity

Species diversity refers to the variety of different types of species found in a particular area. It is the biodiversity at the most basic level. It includes all the species ranging from plants to different microorganisms. No two individuals of the same species are exactly similar. For example, humans show a lot of diversity among themselves.

Genetic diversity

It refers to the variations among the genetic resources of the organisms. Every individual of a particular species differs from each other in their genetic constitution. That is why every human looks different from each other. Similarly, there are different varieties in the same species of rice, wheat, maize, barley, etc.

Ecological diversity

An ecosystem is a collection of living and non-living organisms and their interaction with each other. Ecological biodiversity refers to the variations in the plant and animal species living together and connected by food chains and food webs. It is the diversity observed among the different ecosystems in a region. Diversity in different ecosystems, like deserts, rainforests, mangroves, etc., includes ecological diversity.

Importance of Biodiversity

Biodiversity and its maintenance are very important for sustaining life on Earth. A few of the reasons explaining the importance of biodiversity are:

Ecological Stability

Every species has a specific role in an ecosystem. They capture and store energy and also produce and decompose organic matter. The ecosystem supports the services without which humans cannot survive. A diverse ecosystem is more productive and can withstand environmental stress.

Economic Importance

Biodiversity is a reservoir of resources for the manufacture of food, cosmetic products, and pharmaceuticals. Crops, livestock, fishery, and forests are rich sources of food. Wild plants such as Cinchona and Foxglove plant are used for medicinal purposes. Wood, fibers, perfumes, lubricants, rubber, resins, poison, and cork, are all derived from different plant species. The national parks and sanctuaries are a source of tourism. They are a source of beauty and joy for many people.

Ethical Importance

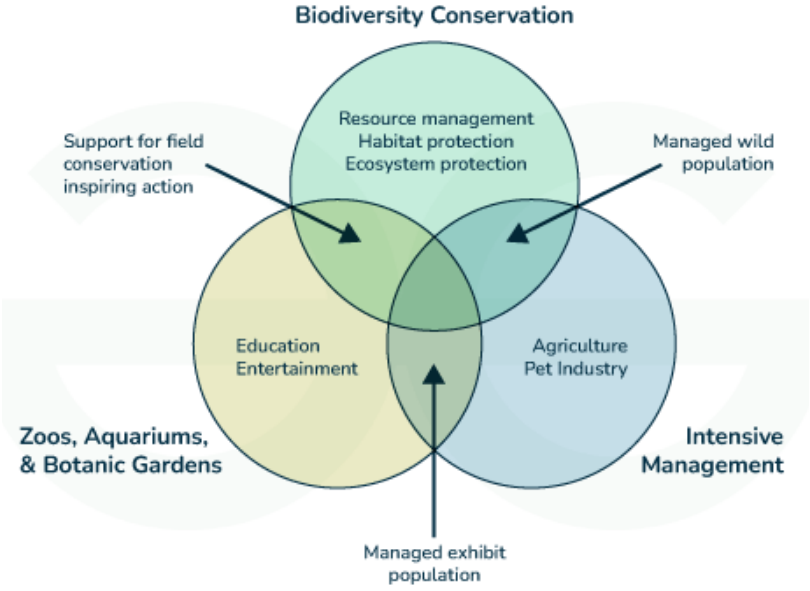
All species have a right to exist. Humans should not cause their voluntary extinction. Biodiversity preserves different cultures and spiritual heritage. Therefore, it is very important to conserve biodiversity.

Biodiversity in India

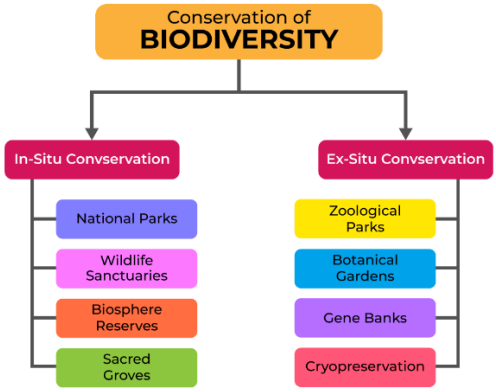
India is one of the most diverse nations in the world. It ranks ninth in terms of plant species richness. Two of the world's 25 biodiversity hotspots are found in India. It is the origin of important crop species such as pigeon pea, eggplant, cucumber, cotton and sesame. India is also a center of various domesticated species such as millets, cereals, legumes, vegetables, medicinal and aromatic crops, etc.

India is equally diverse in its faunal wealth. There are about 91000 animal species found here. However, diversity is depleting at a drastic rate and various programmes on biodiversity conservation are being launched to conserve nature.

Biodiversity conservation involves the protection, management, and restoration of biodiversity. Biodiversity is a measure of variation at the genetic, species, and ecosystem levels. Biodiversity can be conserved by various methods including in situ and ex situ conservation methods that include establishing national parks, wildlife sanctuaries, etc. Biodiversity should be conserved as it provides us with both economic and aesthetic benefits.



In-situ and ex-situ conservation of biodiversity are two approaches to the conservation of biodiversity. In-situ conservation mainly focuses on protecting the organism in its natural habitat whereas ex-situ conservation mainly focuses on protecting the organism by relocating it into an ideal protective habitat. In-situ and ex-situ conservation both focus on the protection of an organism however utilizing different means.



Advantages of In-situ Conservation

The advantages of the in-situ conservation approach are:

- The wildlife species are preserved within their natural habitat. They easily adjust and adapt to their surroundings.
- It conserves the entire ecosystem, not just one particular species.
- It is a more economical and convenient method.
- Useful in conserving large populations of a species
- The chances of recovery are high.

Disadvantages of In-situ Conservation

The disadvantages of the in-situ approaches are:

- Conditions that threaten the survival of the organism will still be present.
- The genetic diversity of the region may already have decreased.

- Endangered habitats may be fragmented and may affect the survival of the species.

Advantages of Ex-situ Conservation

The advantages of ex-situ conservation are:

- It protects endangered species from external threats like predation and poaching.
- Selective breeding programs can be implemented.
- It is a focused approach, as the health of individual animals can be monitored.
- The genetic diversity of the population is preserved
- It is invaluable for research and public education.
- It has the potential to reintroduce organisms back into their natural habitat.

Disadvantages of Ex-situ Conservation

The disadvantages of the above approach are:

- The individual is living outside its natural habitat.
- Animals may not adjust to the new environment.
- Captive animal populations have limited genetic diversity.
- It is expensive to maintain.
- Animals may not survive reintroduction into the wild.

Threats to global biodiversity are a global concern these days. In recent years, extinction rates have increased dramatically. Human activity has led to the extinction of thousands of species and variations every year. Over the last 150 years, the rate of extinction has increased significantly. If current trends continue, we could lose 1/3rd to 2/3rd of our current biodiversity by the middle of the 21st century. The main causes of biodiversity loss include invasive alien species, unsustainable natural resource use and exploitation, pollution, and land use changes.

Biodiversity Hotspots are biogeographical areas that have rich biodiversity and are threatened by different destruction like overexploitation, climate change, pollution, and other human activities. The word "Biodiversity Hotspot" was first coined by the British biologist Norman Myers in 1988. As per the IUCN "Red Data List," there are around 36 areas in the world that are qualified as the Biodiversity Hotspots. These Biodiversity Hotspots represent only 2.3% of the total Earth's surface. They contain around 50 % endemic flora and 42 % endemic fauna of the whole Earth.

Biodiversity Hotspot Qualification Criteria- Conservation International

Myers' hotspot theory was adopted by Conservation International (CI) in 1996. The organization works to protect nature for the benefit of the people. Their mission is to conserve the planet's biodiversity. Their work is mainly focused on making a balance between the planet's biodiversity and humans. According to Conservation International (CI), there are two strict criteria by which a region can be declared as a Biodiversity Hotspot as mentioned below.

- It must contain at least 1,500 species of vascular plants, of which more than 0.5% should be the world's total endemic vascular plants.
- The place should have lost at least 70% of its original habitat. In other words, the habitat must be threatened somehow.

What is the IUCN Red List?

The IUCN Red List is a complete list of the threatened species. It is an information archive on the global extinction risk status. The list includes of all animal, fungus, and plant species. It is generally maintained by the International Union for Conservation of Nature (IUCN) organisation.

There are some levels of the division:

- Least Concern
- Near Threatened
- Vulnerable

- Endangered
- Critically Endangered
- Extinct in the Wild
- Extinct
- Not evaluated

The National Biodiversity Authority (NBA) was established in 2003 by the Central Government to implement India's Biological Diversity Act (2002). The NBA is a Statutory body that performs facilitative, regulatory, and advisory functions for the Government of India on the issues of Conservation, sustainable use of biological resources, and fair, equitable sharing of benefits of use.

The Biological diversity Act (2002) mandates the implementation of the provisions of the Act through a decentralized system with the NBA focusing on advice to the Central Government on matters relating to the conservation of biodiversity, sustainable use of its components, and equitable sharing of benefits arising out of the utilization of biological resources; advice the State Government in the selection of areas of biodiversity importance to be notified under Sub-Section (1) of Section 37 as heritage sites and measures for the management of such heritage sites.

The State Biodiversity Board (SBBs) focus on advice the State Governments, subject to any guidelines issued by the Central Government, on matters relating to the conservation of biodiversity, sustainable use of its components and equitable sharing of the benefits arising out of the utilization of biological resources. The NBA considers requests by granting approval or otherwise for undertaking an activity referred to in Sections 3,4 and 6 of the Act.

The SBBs also regulate by granting of approvals or otherwise upon requests for commercial utilization or bio-survey and bio-utilization of any biological resource by the Indians. The Local Level Biodiversity Management committees (BMCs) are responsible for promoting conservation, sustainable use, and documentation of biological diversity, including preservation of habitats, conservation of land races, folk varieties, and cultivators, domesticated stocks and breeds of animals and microorganisms besides chronicling of knowledge relating to biological diversity.

The NBA, with its Headquarters in Chennai, Tamil Nadu, India, delivers its mandate through a structure that comprises the Authority, secretariat, SBBs, BMCs, and Expert Committees. Since its establishment, the NBA has supported the creation of SBBs in 28 States, 8 UTs and facilitated the establishment of around 2,77,688 BMCs.

Once constituted, the major responsibility of a BMC is to prepare a Peoples' Biodiversity Register (PBR) in consultation with local people. A PBR comprehensively documents information on the availability and knowledge of local biological resources (those falling within the territorial jurisdiction of the BMC), their medicinal or any other use of traditional knowledge associated with them. The PBR thus prepared then serves as a legal document which confirms the sovereign rights of that BMC over the resources documented in the PBR. It serves as a legal basis which proves that the traditional knowledge associated with a biological resource is the 'prior art' of that village and therefore, cannot be patented.

The BD Act authorizes the BMCs to operate Local Biodiversity Fund (LBF) consisting of grants and loans made by State Biodiversity Boards (SBBs) and fees collected by them. These funds are strictly used by BMCs for conservation of local biodiversity and community development (as long it is consistent with conservation). The LBF accounts are audited and the same are presented to the concerned local body.

As per Clause 1 of Article 243 B of Indian Constitution, the term local body in rural areas means Panchayats constituted at village level, intermediate level and district level. Further, as per clause 1 of Article 243 Q of the Indian Constitution, the term local body in an urban area means Nagar Panchayats (constituted for a transitional area, i.e. an area in transition from a rural area to an urban area), Municipal Council (for a smaller urban area) and municipal corporation (for a larger urban area).