Biodiversity

Biodiversity: definition, levels and importance

Biodiversity is a combination of two words – biological and diversity, meaning diversity of life forms.

Bio = Life;

Diversity = Variety;

The 1992 Earth Summit in Rio de Janeiro defined biodiversity as:

The variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems.

Biodiversity is the variety of life on Earth and the essential interdependence of all living things among themselves and with their environment. Biodiversity is an important factor for the successful functioning of the ecosystem.

Current estimates of no. of species on earth:

- 10-14 million
- Till date the scientists have identified more than 2 million species. Tens of millions -- remain unknown
- ~1 million are insects
- 99.9% (5 billion) of species extinct since the beginning of life on earth

What is biodiversity and why is it important?

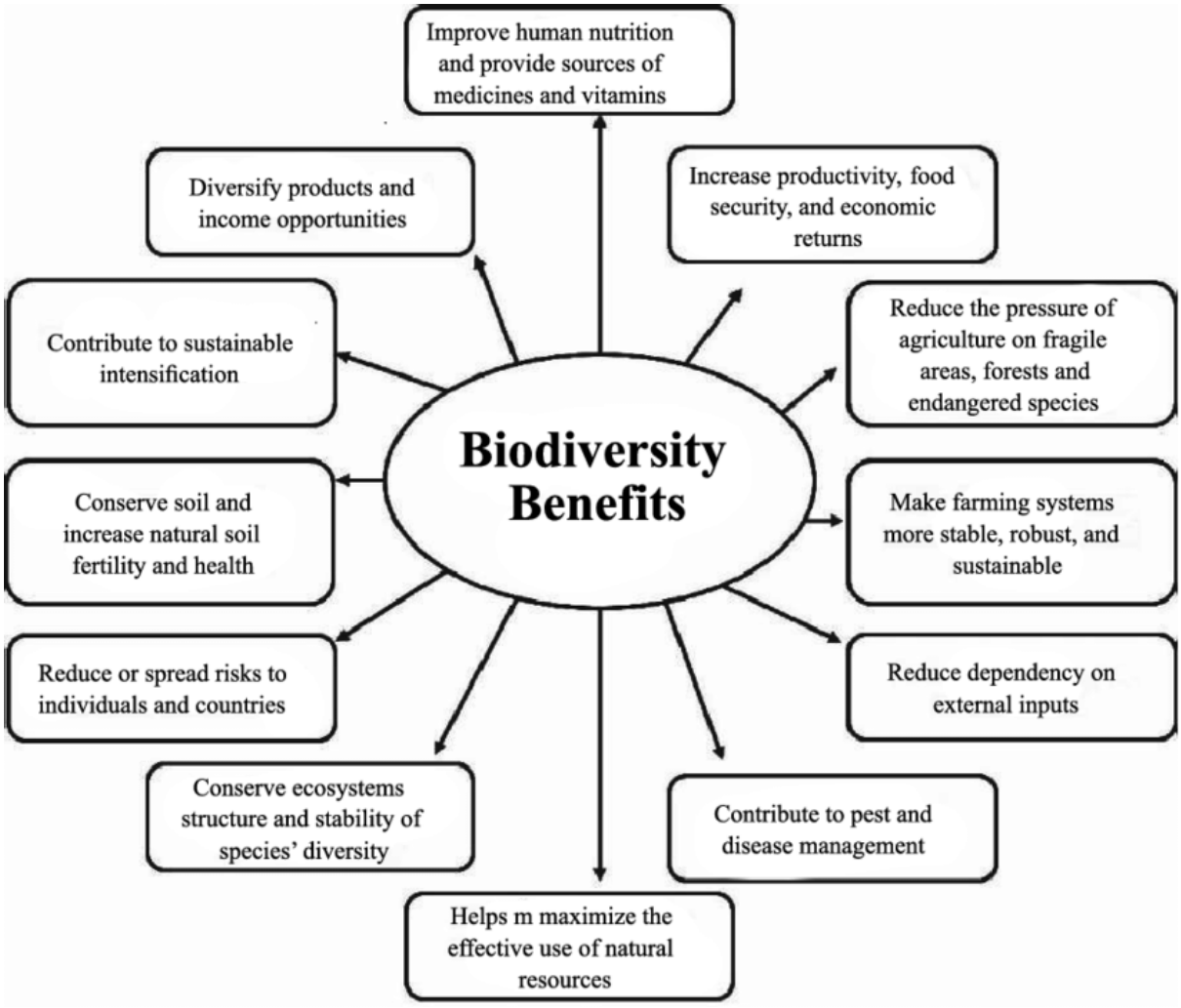
Biodiversity is generally defined as the number and variability of all the life forms pertaining to plants, animals and micro-organisms and the ecological complex they inhabit.

The two documented benefits of biodiversity are:

I. Consumptive and productive uses - grains, vegetables, fruits, plants, medicines, timber, oils, forest products, milk products, eggs, the list of items on this account is endless.
II. Non consumptive benefit where we have biodiversity's role in providing raw materials for biotechnology, regulation of water and other nutrient cycles, regulation of climatic conditions, carbon fixation etc.

The economic value of biodiversity is also of great benefit. "Each species is of potential value to humans. So are healthy ecosystems. The global collection of genes, species, habitats and ecosystems is a resource that provides for human needs now, and is essential for human

survival in the future. Human depend on other species for all of their food and for many medicines and industrial products.



There are three levels of diversity 1) Genetic diversity, 2) Species diversity, 3) Ecosystem diversity

1. Genetic Diversity:

Genetic diversity is the "fundamental currency of diversity" that is responsible for variation. Genetic diversity is defined as genetic variability present within the species. It is the ability of an organism to adapt to changes in the local environment. They adapt by possession of different alleles suitable to the environment.

E.g., Different breeds of dogs, different varieties of roses, wheat, rice, mangoes, etc

Biodiversity

Genetic diversity is very important. It will ensure the survival and adaptability of the species during unfavorable survival conditions in the environment such as disease, or climate change

2. Species Diversity:

Species diversity is a major component of biodiversity and tends to increase the sustainability of some ecosystems. It is the most visible component of biodiversity as implied by the word 'species' which literally means outward or visible form.

How we will define the species diversity: Species diversity is the number of different species that are represented in a given community.

Or

Species diversity is defined as the number of different species present in an ecosystem and relative abundance of each of those species.

Diversity is greatest when all the species present are equally abundant in the area. There are two constituents of species diversity: i.e 1) Species richness, 2) Species evenness

Species richness:

The number of different species present in an ecosystem is species richness. Tropical areas have greater species richness as the environment is helpful for a large number of species.

Species evenness:

Species evenness is a description of the distribution of abundance across the species in a community. Species evenness is highest when all species in a sample have the same abundance. Evenness approaches zero as relative abundances vary.

It is possible in an ecosystem to have high species richness, but low species evenness.

Example:

In a forest, there may have a large number of different species (high species richness) but have only a few members of each species (low species evenness)

In a forest, there may be only a few plant species (low species richness) but a large number of each species (high species evenness)

Species richness increases with increasing explored area.

Why the species diversity is very important: Greater species diversity ensures sustainability in an ecosystem. Since each species is intertwined intricately uniquely with the ecosystem, each performing a unique role, extinction of even one species can have countless ripple effects on the entire ecosystem.

3. Ecosystem Diversity:

Ecosystem Diversity can be defined as the variety of different habitats, communities and ecological processes. A biological community is defined by the species that occupy a particular area and the interactions between those species. Groups of organisms and their non-living

environment, and the interactions between them, form functional dynamic and complex units that are termed ecosystems. These systems help maintain life processes vital for organisms to survive on earth.

Species are not evenly distributed around the globe. Some ecosystems such as tropical rain forests and coral reefs are very complex and host a large number of species. Other ecosystems such as deserts and arctic regions have less biodiversity but are equally important.

Variations in food webs, nutrient cycles, trophic structure etc, this diversity has developed along with evolution

Eg: Tropical rainforests, deserts, ponds, oceans etc.

Prairies, Ponds, and tropical rain forests are all ecosystems. Each one is different, with its own set of species living in it.

How ecosystem diversity is very Importance: Biodiversity is the variety of life in an area that is determined by the number of different species in that area.

- Biodiversity increases the stability of an ecosystem and contributes to the health of the biosphere.
- Variations in ecosystems in a region, and its overall impact on human existence and environment

E.g: deserts, forests, grasslands, wetlands, oceans

- Greater diversity ensures sustainability and ecosystems capable of withstanding environmental stresses like floods, draughts, pests etc.
- Ecosystem diversity ensures availability of oxygen by photosynthesis
- In an aquatic environment, water purification is carried out by the various plant species
- Greater variety of plants, means a greater variety of crops

An ecosystem having higher diversity means the number of species and interactions between them which constitute the food web, is large. In such a situation, the elimination of one species would have little effect on ecosystem balance. In sharp contrast, the number of species in the food web of a simple ecosystem is small. So, loss of any one species has far more serious repercussions for the integrity of the ecosystem itself.

Values of biodiversity:

It has two different values. i. e intrinsic and utilitarian values

Intrinsic Value = Something that has value in and of itself

Utilitarian Value = It is useful to others

Biodiversity is the most precious gift of nature. We all know that all the organisms in an ecosystem are interlinked and interdependent. The importance of biodiversity in the life of all the organisms including humans is huge.

We all are getting benefits from biodiversity mainly in two ways.

Biodiversity

Firstly, biodiversity is directly used as a source for food, fibre, fuel and other extractable resources.

Secondly, biodiversity plays an important role in ecosystem processes providing the regulating, cultural and supporting services.

For example, vegetation cover protects the soil from erosion by binding soil particles and minimizing the effects of water runoff. Similarly, cultivation of crops is to a large extent dependent on the availability of pollinating insects.

Biodiversity has a fundamental value to humans because we are so dependent on it for our cultural, economic, and environmental well-being.

In the field of medicine alone, approximately 50% of current prescription medicines are derived from or modelled on natural substances. The health and diversity of ecosystems can have a significant effect on the overall stability of nearby communities.

Some of the major values of biodiversity are as follows:

Direct values:

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).

Generally, it divided into two categories-

1. Consumptive use value
2. Productive Use Value

Indirect values:

1. Cultural and Social Value
2. Ecosystem Services
3. Economic Value
4. Ethical and Moral Value
5. Aesthetic Value.

Biodiversity

Direct values:

1. Consumptive use value:

These are direct use values where the biodiversity products are consumed or harvested directly. E.g.: fuel, food, drugs, fibre etc.

Humans use at least 40,000 species of plants and animals on a daily basis. Many people around the world still depend on wild species for most of their needs like food, shelter and clothing. The tribal people are completely dependent on the forests for their daily needs.

2. Productive Use Value

These are commercially usable values where the product is marketed and sold, often resulting in the exploitation of rich biodiversity.

This is assigned to products that are commercially harvested and marketed. Almost all the present date agricultural crops have originated from wild varieties. Biodiversity represents the original stock from which new varieties are being developed. The biotechnologists continuously use the wild species of plants for developing new, better yielding and disease resistant varieties.

Indirect values:

1. Cultural and Social Value:

Social value of biodiversity refers to its religious and cultural importance.

Certain customs and religious practices utilize plants for their rituals, and worship them as well. It revolves around utilization of either plants and/or animals for either rituals or are worshipped

Example: Trees like Peepal, Banyan and Tulsi are still worshipped. Ladies offering water to Tulsi daily is considered good and there are festivals when ladies tie sacred threads around Peepal and Banyan trees and pray for the welfare of their families.

Flowers and tulsi leaves are offered during poojas

Animals such as cows, snakes and other animals are worshipped in different religions

2. Ecosystem Services:

These services also support human needs and activities such as intensely managed production ecosystems.

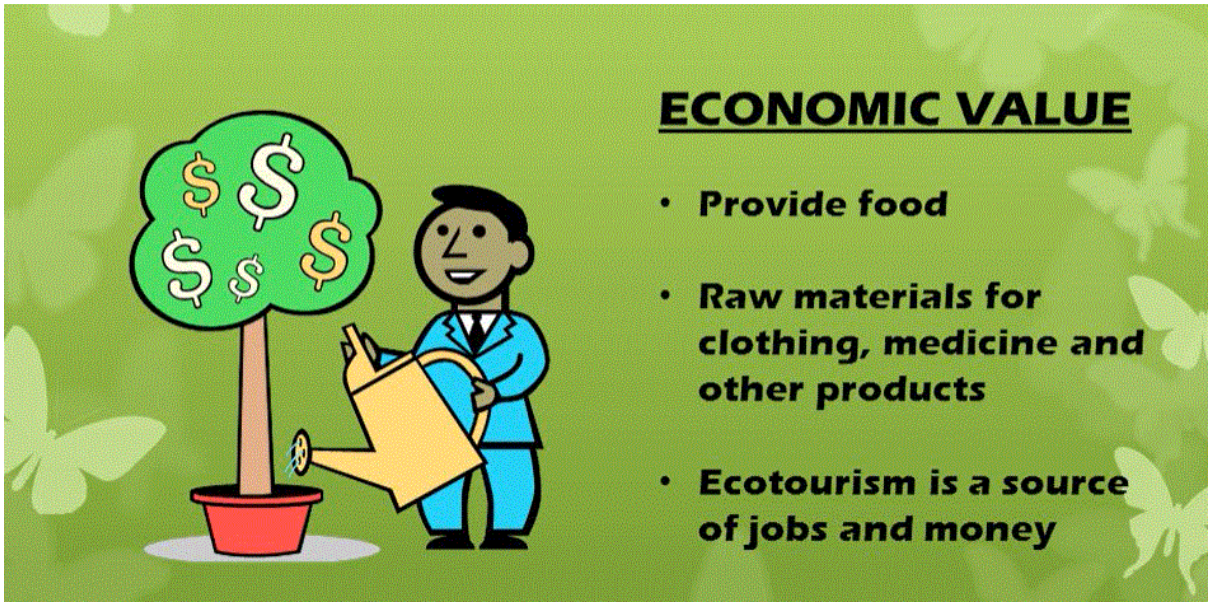
Ecosystem service includes:

1. The production of oxygen by land-based plants and marine algae.
1. The provision of native species and genes used in industry research and development, for instance, in traditional breeding and biotechnology applications in agriculture, forestry, horticulture, mariculture, pharmacy, chemicals production and bioremediation;

2. Pollination of agricultural crops, forest trees and native flowering plants by native insects, birds and other creatures;
3. Maintenance of habitats for native plants and animals; and Maintenance of habitats that are attractive to humans for recreation, tourism and cultural activities and that has spiritual importance.

3. Economic Value:

The economic potential of biodiversity is immense in terms of food~~, fodder~~, medicinal, ethical and social values. Biodiversity forms the major resource for different industries, which govern the world economy.



The salient features regarding the economical potential of biodiversity are given below:

1. The major fuel sources of the world including wood and fossil fuels have their origin due to biodiversity.

2. It is the source of food for all animals and humans.

3. Many important chemicals have their origin from the diverse flora and fauna, used in various industries.

4. Ethical and Moral Value:

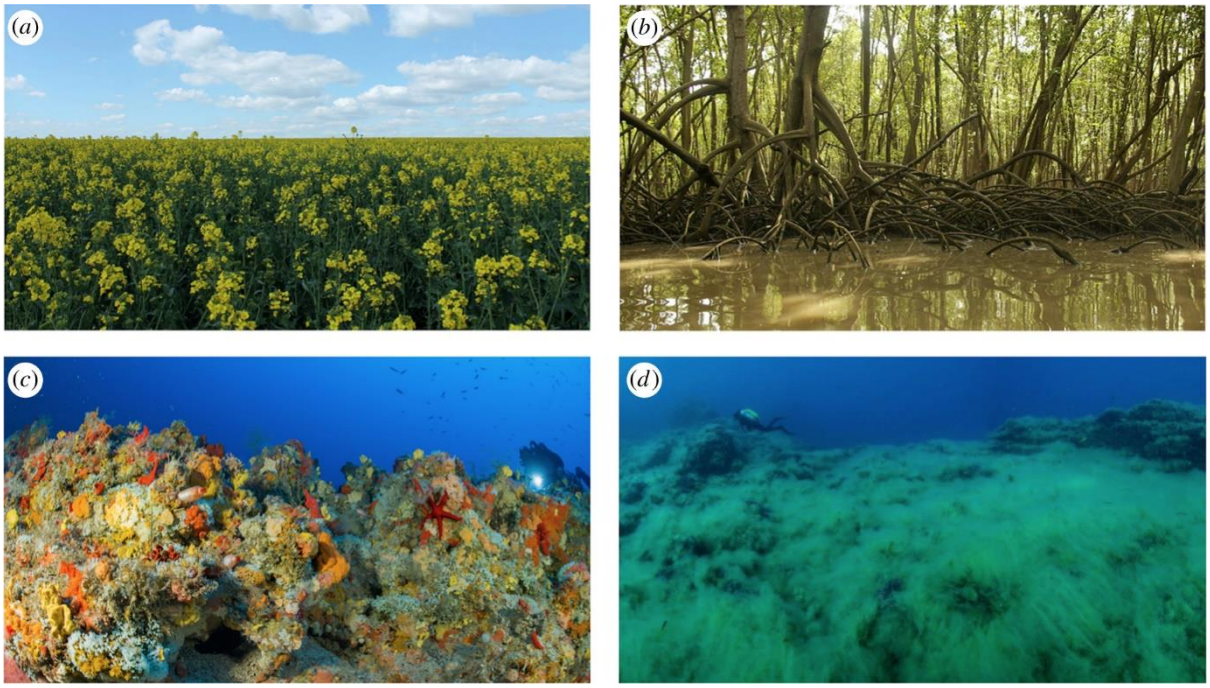
It is based on the principle of 'live and let others live'. Ethical values related to biodiversity conservation are based on the importance of protecting all forms of life. All forms of life have the right to exist on earth. Man is only a small part of the Earth's great family of species.

Morality and ethics teach us to preserve all forms of life and not to harm any organism unnecessarily. Some people take pleasure in the hunting of animals. People also sometimes degrade and pollute the environment by their unethical actions.

Biodiversity

5. Aesthetic Value:

The beauty of our planet is because of biodiversity, which otherwise would have resembled other barren planets dotted around the universe. Biological diversity adds to the quality of life and provides some of the most beautiful aspects of our existence. Biodiversity is responsible for the beauty of a landscape.



People go far off places to enjoy the natural surroundings and wildlife. This type of tourism is referred to as eco-tourism, which has now become a major source of income in many countries. In many societies, the diversity of flora and fauna has become a part of the traditions and culture of the region and has added to the aesthetic values of the place.

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"There is enough for everyone's need but not for anyone's greed"

-Mahatma Gandhi

Biodiversity

Biodiversity conservation methods

There are many factors that underlie the need to conserve biodiversity, such as,

- present and potential uses of the components of biological diversity - especially as we have no way of knowing or predicting what will be of use in the future.
- biodiversity is essential to maintain the earth's life support systems that enable the biosphere to support human life.
- It is ethically important to maintain all of the earth's biological diversity, including all the other extant (currently existing) life forms.

Biodiversity conservation:

Biodiversity conservation refers to the protection, upliftment, and management of biodiversity in order to derive sustainable benefits for present and future generations. A wide variety of species will cope better with threats than a limited number of them in large populations. Even if certain species are affected by pollution, climate change or human activities, the ecosystem as a whole may adapt and survive.

It is the practice of **protecting** and **preserving** the wealth and variety of species, habitats, ecosystems and the genetic diversity on the planet.

- In addition to protection of resources, it is also the **rational use** of natural resources.
- It is essential for our health, wealth, food, fuel and services we depend on
- It also plays an important role in supporting several sectors of development.

Fig: - Biodiversity

Aim of conservation?

1. **Minimize** depletion of **resources.**
2. **Preserve resources** for use by future generations.

Approach for biodiversity conservation:

1. **In-situ conservation**
2. **Ex-situ conservation**

Ways of conservation:

- **By law:** giving protection to animals and plants or special areas of land or water

- **Restoration** of unattractive countryside like waste spills, slag heaps, etc.
- **Rewilding:** allowing areas to restore themselves naturally without human interference.
- **Alternative energy:** a need to find alternative resources to replace coal, oil, etc.
- **Nature reserves & Zoos.**
- **Recycling:** Reusing of unwanted products such as newspapers, scrap metal, glass, sewage, etc.
- **Education and awareness:** Spreading the message of conservation to schools, youth organizations and the media to achieve maximum results.

1. In-situ conservation:

In-situ conservation means "on-site conservation". It is the process of protecting an endangered plant or animal species in its natural habitat, either by protecting or cleaning up the habitat itself, or by defending the species from predators. The benefit to in-situ conservation is that it maintains recovering populations in the surroundings where they have developed their distinctive properties. Wildlife conservation is mostly based on in-situ conservation. This involves the protection of wildlife habitats. Also, sufficiently large reserves are maintained to enable the target species to exist in large numbers.

- In situ conservation is the preservation of species and populations of living organisms in a natural state in the habitat where they naturally occur.
- This can be achieved either by:
    - Protecting or cleaning up the habitat itself.
    - Defending the species from predators.

Methods of in-situ conservation:

1. Biosphere reserves
2. National parks
3. Wildlife sanctuaries
4. Tiger reserves
5. Gene sanctuaries
6. Community reserves
7. Sacred groves

1. Biosphere reserves:

Biosphere reserves cover very large areas, often **more than 5000 km^2**. They are used to protect species for a long time. Currently, there are **18 in India**.

Example: Manas (Assam), Gulf of Mannar (Tamil Nadu), Nanda Devi (U.P)

2. National parks:

A national park is an area dedicated for the **conservation of wildlife along with its environment**, including its scenery, natural and historical objects. It ranges from **100-500 km^2**. Within biosphere reserves, one or more national parks may also exist. Currently, there are **106 national parks** in India.

Example: Gir National Park (Gujarat), Bandipur (Karnataka), Periyar (Keral)

National parks are largely natural and unchanged by human activities, but many of them already had existing human impacts before they were designated for protection and human activities have often been allowed to continue. People have no rights in a National Park.

3. Wildlife sanctuaries:

A wildlife sanctuary is an area which is **reserved for the conservation of animals only**. Currently, there are **551 wildlife sanctuaries** in India. The first wildlife sanctuary was the Vedanthangal Bird Sanctuary near Madras, set up in 1878, which merely formalised the traditional protection afforded by villagers for pelicans, herons and other birds breeding at Vedanthangal. Another such sanctuary was set up at Ranganathittu near Mysore, in 1942.

Reserves for specific animals:

Several projects have been setup in our country for the protection of specific animals

Example: Project Tiger, Gir Lion Project, Crocodile Breeding Project, Project Elephant, Snow Leopard Project, etc.

4. Tiger reserves:

Project Tiger was launched in 1973 to save the tiger. Starting from 9 reserves in 1973, it has grown to 29 in 2006 covering a **geographical area of 1.17%**

E. g.: Periyar, Kanha, Corbett

5. Gene sanctuary:

Gene sanctuary is an area where plants are conserved, including both biosphere reserves and national parks. The first gene sanctuary in India has been setup in the Garo hills, Meghalaya for wild relatives of citrus.

6. Community reserves:

It is a kind of protected area to provide legal support to community/privately owned reserves that cannot be designated as national parks or wildlife sanctuaries. There are 218 existing

Community Reserves in India covering an area of 1445 km^2, which is 0.044% of the geographical area of the country. (National Wildlife Database, Dec. 2021). Keshopur chamb gurdaspur (Punjab) conservation reserve India's first community reserve.

7. Sacred groves:

They are areas of forests set aside, usually for tribal communities, where all trees and wildlife within are venerated and given total protection. The examples of sacred groves are Khasi and Jaintia Hills in Meghalaya and Aravalli Hills of Rajasthan. - India has a history of religious and cultural traditions that emphasized the protection of nature.

2. Ex-situ conservation:

Ex-situ conservation means, literally "off-site conservation". It is the process of protecting population of an endangered species of plant or animal by removing it from an unsafe or threatened habitat and placing it, or part of it, under the care of humans. While ex-situ conservation is comprised of some of the oldest and best-known conservation methods known to human, it also involves newer, sometimes controversial laboratory methods. Ex-situ conservation, while helpful in human's efforts to sustain and protect our environment, is rarely enough to save a species from extinction. It is to be used as a last resort or as a supplement to in-situ conservation because it cannot recreate the habitat as a whole: the entire genetic variation of a species, its symbiotic counterparts, or those elements which, over time, might help a species adapt to its changing surroundings. Furthermore, ex-situ conservation techniques are often costly. Plants and animals living in ex-situ breeding grounds have no natural defense to the diseases and pests new to the species.

This is usually done by **removing a part of the population** from a threatened habitat and placing it in a new location.

Different ex-situ conservation methods:

1. Botanical gardens
2. Zoos
3. Seed banking
4. Cryopreservation
5. Herbal gardens
6. Plant herbariums

1. Botanical gardens:

They are one of the most conventional methods of ex-situ conservation of plants. India has more than **100 botanical gardens** under different management systems located in different bio-geographical regions. Globally, there are around 2000 botanical gardens in ~148 countries. Central and state governments manage 33 botanical gardens that maintain the diversity in the form of plants or plant populations. These facilities provide not only **housing and care** for

specimens of endangered species, but also have an **educational value**, informing the public of the threatened status of endangered species.

Example: Hyderabad Botanical Garden (Telangana), Panjab University Botanical Garden (Chandigarh).

2. Zoos:

Zoos are some of most publicly visited ex situ conservation sites, with the WZCS (World Zoo Conservation Strategy) estimating that the 1100 organized zoos in the world receive more than 600 million visitors annually. It has been estimated to be a total of **2,107 aquaria and zoos** in **125 countries**, in addition to privately owned facilities. According to the Zoo Authority of India, there are **~164 zoos in India.** Example: national zoological park (Delhi), Rajiv Gandhi Zoological Park (Pune).

3. Seed banking:

A seed bank stores seeds to preserve genetic diversity. One of the most efficient methods of ex-situ conservation for sexually reproducing plants is the storage of conservation material in form of seeds. In this process we need to store the seeds in a temperature and moisture-controlled environment.

4. Cryopreservation:

Cryopreservation is the only ex situ conservation method for long-term preservation of species that cannot be stored in seed banks. Plant cryopreservation consist of the storage of seeds, pollen, tissue, or embryos in liquid nitrogen.

5. Herbal gardens:

Herbal gardens refer to gardens that conserve herbs, shrubs that are of **medicinal value and aromatic value.**

6. Plant herbariums:

- Herbariums preserve plant diversity for research and breeding purposes, often acting as dictionaries of plant kingdoms
- The Botanical Survey of India has the largest holding of 1,500,000 specimens.
    - E.g.: Presidency College Madras (1,00,000)
    - St. Joseph's College, Tiruchirapally (60,000)

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Environment and Ecosystem

Lecture 1 comprises of the following

i. Environment Definition
ii. Earth-life support system.
iii. Ecosystem definition, the various components and types of ecosystem.

1.The Environment :

The word Environment originated from the French word **Environner (encircle or Surroundings**).

1.1: The Definition of Environment, as per Environment (Protection) Act, 1986

The sum of water, air, and land and the inter-relationships that exist among them and with the human beings, other living organisms and materials

From this **word etymology** we understand that environment means all that **surrounds** us.

So simply putting it together,

ENVIRONMENT is defined as the social, cultural and physical conditions that surround, affect and influence the survival, the growth, and the development of people, animals or plants.
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2. Understanding the Terminologies

2.1 Environmental Science:-

Environmental science is the study of the environment, its biotic & abiotic component's & their relationship.

Wikipedia defines Environmental Sciences: as an interdisciplinary academic field that integrates Physics, Biology and Geography to the study of the environment, and the solution of environmental problems.

In simple words: **Environmental science** is an interdisciplinary study of how humans interact with the living and non-living parts of their environment.

2.2 Environmental Engineering:-

Environmental Engineering is the application of engineering principles to the protection & enhancement of the quality of the environment and to the enhancement and protection of public health & welfare.

2.3 Environmental Studies (or) Environmental education:-

Environmental studies is the process of educating the people for preserving the quality of the environment.

- **Scope *and Importance of* Environmental *Science***

3.1 Scope of Environmental Science:

1) To be aware and sensitive to the total environment & its related problems.

2) To motivate active participation in environmental protection & improvement.

3) To develop skills to identify & solve environmental related problems.

4) To know the necessity of conservation of natural resources.

5) To evaluate environmental programmes in terms of social, economic, ecological & aesthetic factors.

6) To promote the value & necessity of local, national & international co-operation in the prevention and solution for environmental problems.

7) To give a clear picture about the current potential of resources & environmental situations.

8) Environmental studies gives us an idea and understanding of the interdependent connection of nature and people.

3.2 Importance of Environmental Sciences

1) It has a direct relation to the quality of life we live.

2) People understand the need of development without destruction of the environment.

3).People gain knowledge of different types of environment & effects of different environmental hazards.

4) People are informed about their effective role in protecting the environment by demanding changes in laws and enforcement systems.

5) It develops a concern & respect for the environment.

- **Earth life support systems**

The earth system is itself an integrated system, but it can be sub-divided into four main components, sub-systems or spheres: the **geosphere, atmosphere, hydrosphere and biosphere**. These components are also systems in their own ways and they are tightly interconnected. Life is sustained by the flow of energy from the sun through the biosphere, the cycling of nutrients within the biosphere and gravity

The main components (called **spheres**) of the environment are:

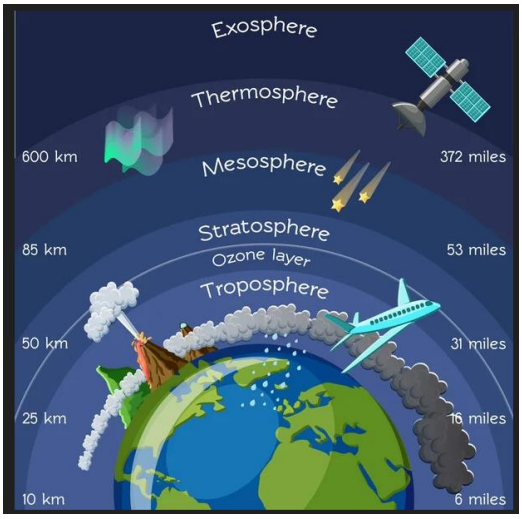
i. Atmosphere: The blanket of air that surrounds us.
ii. Hydrosphere: The various water bodies on the earth for eg the oceans, the rivers, lakes and ponds.
iii. Lithosphere talks of the various types of soil and rocks on the earth's surface.
iv. Biosphere: It contains all living organisms, their interactions with the environment and all that is capable of supporting life.

4.1.Atmosphere:

The blanket of air upto 1500 km surrounding the earth is known as atmosphere

4.1.1 Layers of the Atmosphere

Based on the distribution of temperature with height, our atmosphere is said to have the following layers.



4.1.2 Importance of the Atmosphere:

(i) Oxygen is very important for the living beings.
(ii) Carbon dioxide is very useful for the plants.
(iii) Dust particles present in the atmosphere create suitable conditions for the precipitation
(iv) The amount of water vapour in the atmosphere goes on changing and directly affects the plants and living beings. (v) Ozone protects all kinds of life on the earth from the harmful ultra violet rays of the sun.

4.2 Hydrosphere:is the discontinuous layer of water at or near the Earth's surface. It includes all liquid and frozen surface waters, and groundwater held in the soil

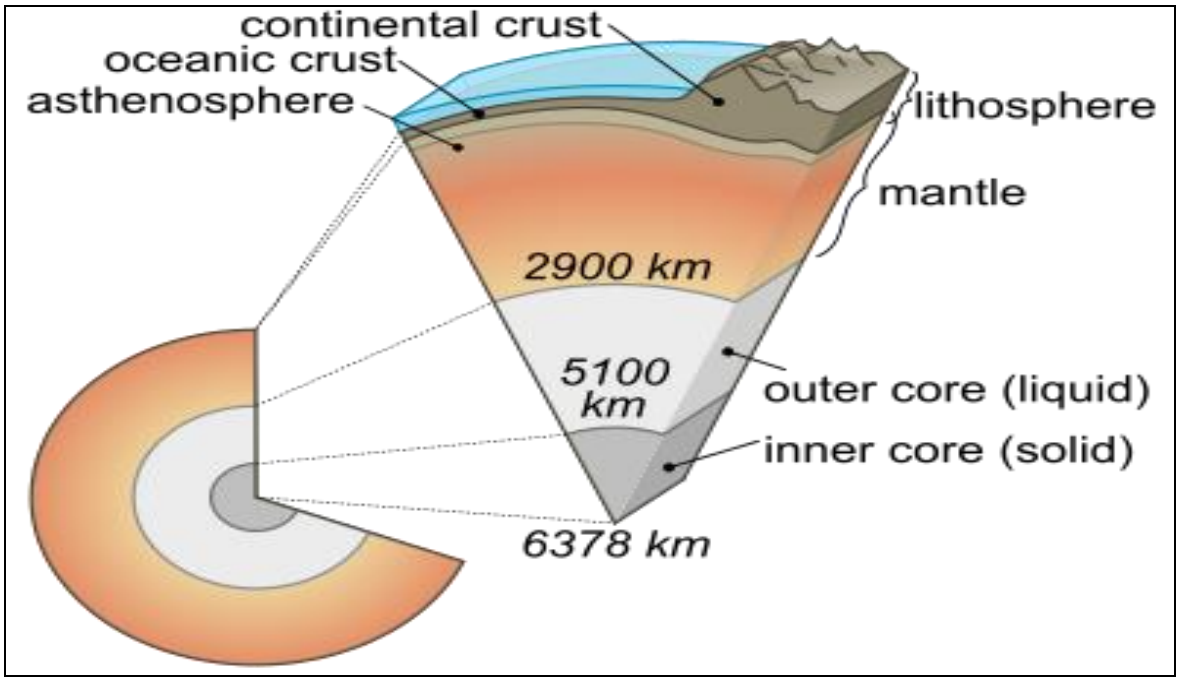
The existence of hydrosphere depends on an important phenomenon called the water cycle or the hydrological cycle.

4.2.1 Importance of the hydrosphere

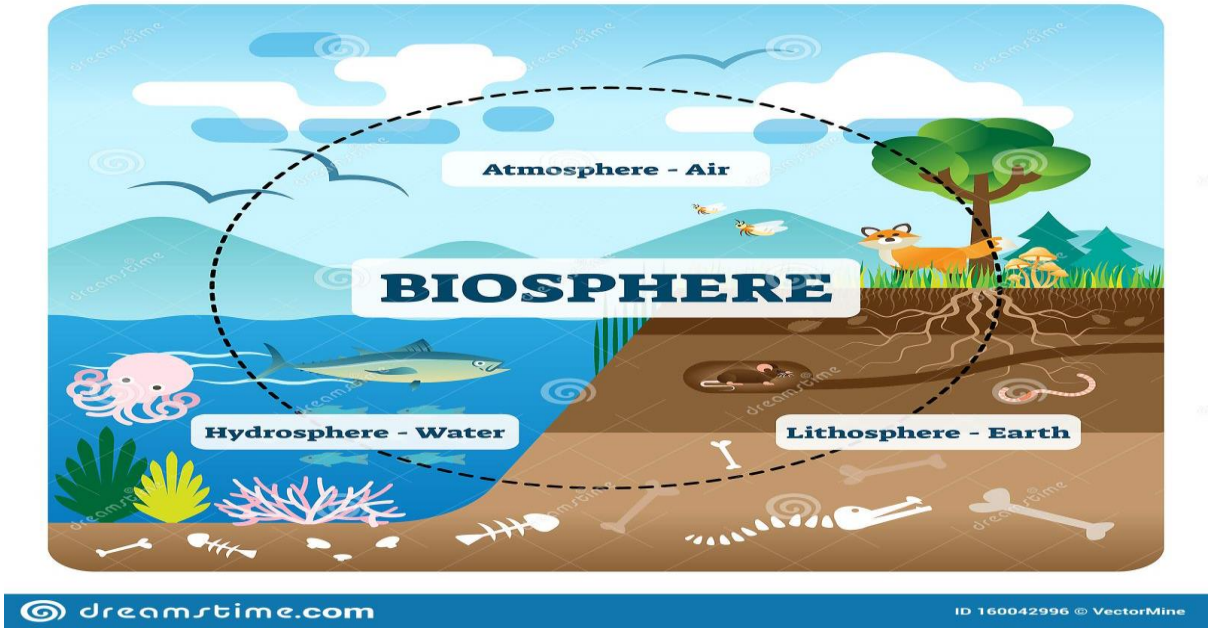
(i) One of the Basic Needs of Human
(ii) Part of a Living Cell
(iii) Habitat for Many Organisms
(iv) Regulates Temperature
(v) Atmosphere Existence

4.3Lithosphere: is the solid rock that covers the planet. This includes the crust, as well as the uppermost part of the mantle, which is the solid rock. The significance of the lithosphere is the activity of the tectonic plates.

The lithosphere



4.4The biosphere: is the zone where the lithosphere, the hydrosphere and the atmosphere interact with each other. This narrow sphere of the Earth supports life due to the presence of land, water and air. Therefore, the biosphere is important for living organisms as it supports life.



Source courtesy: dreamstime.com

These four components are main earth-life support system and constitute to make our earth A Living planet.

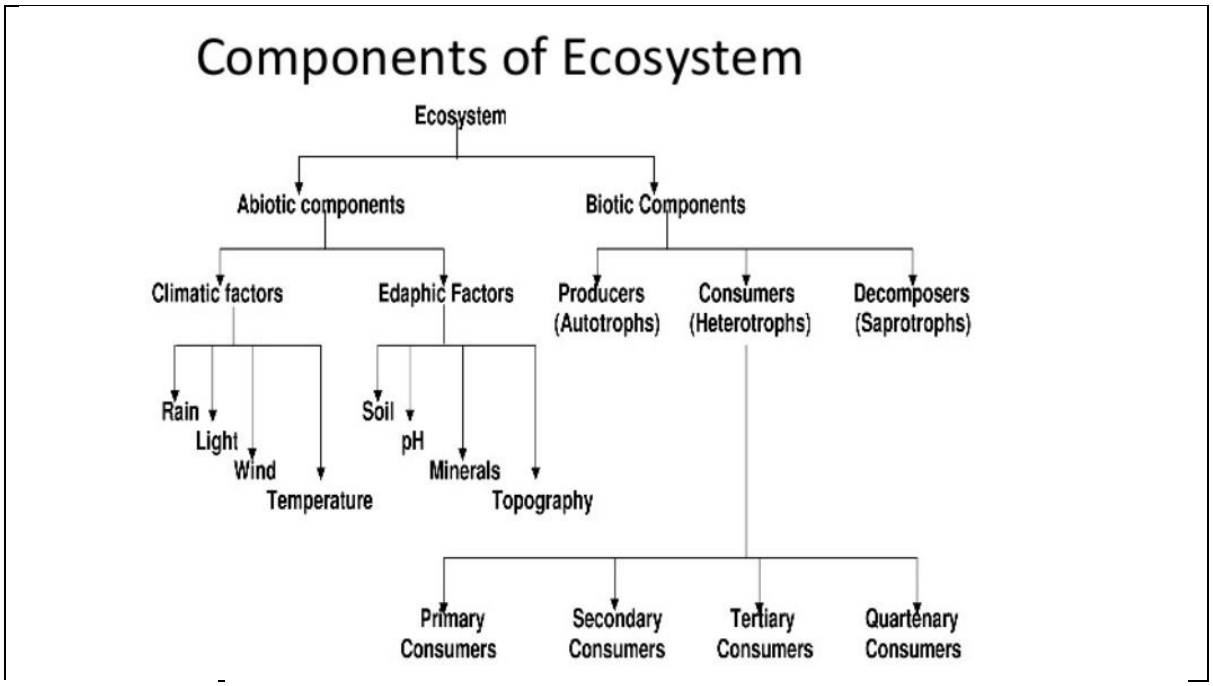
5. ECOSYSTEM

The term Ecosystem was first coined by **AG Tansley** in 1935. It is made up of 2 words: Eco meaning environment and system means a complex coordinated unit.

An **ecosystem** is defined as a natural unit that consists of the biotic components (living) and the non-living parts which interact with each other , probably allow exchange of materials to form a stable system. Eg. Pond ecosystem

Ecosystem is the basic functional unit of the organisms.

5.1 Structure and composition of an ecosystem:



Source courtesy: https://www.jagranjosh.com/general-knowledge/components-of-ecosystem

5.1.1 Ecosystems: Fundamental Characteristics

•**Structure**:

 Living (biotic)

 Nonliving (abiotic)

•**Process:**

 Energy flow

 Cycling of matter (chemicals)

• **Change**:

 Dynamic (not static)

 Succession, etc.

5.1.2 Components of an ecosystem ●

Ecosystem=biotic components + abiotic components

Abiotic Components: constitute the following

♦ Climatic factors: light, temperature, precipitation, wind, humidity ♦ Edaphic(soil) factors: soil pH, soil moisture, soil nutrients ♦ Topographic factors: aspect, altitude

Biotic Components: constitute the following
♦ Producers: green plants, algae
♦ Consumers: herbivores, carnivores, omnivores
♦ Decomposers: bacteria, fungi
Any ecosystem is made up of

Biotic Structure

- •**Producers(Autotrophs)** – Green plants which can synthesize their food themselves (Plants), chemoautotrophs

- .**Autotrophs** :• A groups of organisms that can use the energy in sunlight to convert water and carbon dioxide into Glucose (food) Autotrophs are also called Producers because they produce all of the food that heterotrophs use Without autotrophs, there would be no life on this planet **Examples**: Plants and Algae. **Photoautotrophs**(photosynthesis) **Chemoautotrophs**(chemical energy) Chemoautotrophs – Autotrophs that get their energy from inorganic substances, such as salt – Live deep down in the ocean where there is no sunlight – **Examples**: Bacteria and Deep Sea Worms

- **Consumers** – All organisms which get their organic food by feeding upon other organisms (Rabbit, man) **Heterotrophs** • Organisms that do not make their own food • Another term for heterotroph is consumer because they consume other organisms in order to live • Example: Rabbits, Deer, Mushrooms

- **Decomposers** – They derive their nutrition by breaking down the complex organic molecule to simpler organic compound (earthworms, ants).

5.2 Functions of an ecosystem:

- It regulates flow rates of biological energy.
- It regulates flow rates of nutrients, by controlling the production and comsumption of minerals and materials.
- It helps in biological regulation like nitrogen-fixing organism.

6.Types of Ecosystem

A natural ecosystem is a setup of animals and plants which functions as a unit and is capable of maintaining its identity. A natural ecosystem is totally dependent on solar energy. There are two main categories of ecosystems. They are:

6.1Terrestrial ecosystem – Ecosystems found on land e.g. forest, grasslands, deserts, tundra.

6.2 Aquatic ecosystem – Plants and animal communities that are found in water bodies. These can be further classified into two subgroups.

- Freshwater ecosystems, such as rivers, lakes and ponds.
- Marine ecosystems, such as oceans, estuaries.

All Ecosystems are either land-based (terrestrial) or water-based (aquatic)

6.1.1 FOREST ECOSYSTEM:

In the Indian continent, forests can be classified as coniferous and broadleaved forests. The type of the forests will depend upon abiotic factors such as soil, sunlight and soil nature in a particular region.

Depending upon the tree species: evergreen, deciduous, xerophytic and mangroves, forests classification can be attempted.

The structure and components of the forest ecosystem:

A. **Biotic Components**: The living components in a forest ecosystem are in the following order:

Producers: Different types of trees, shrubs and ground vegetation are the producers. Based on the climatic conditions, they are classified as: tropical, subtropical, temperate and alpine forests.

Consumers:

Primary: Herbivores such as ants, flies, spiders, dogs, beetles, elephants, deer, mongooses.

Secondary: Snakes, birds, foxes

Tertiary: Owl, peacock, lion, tiger.

Decomposers: Fungi and bacteria, essential to nature as they decompose the dead organisms of and release the essential nutrients for reuse.

B. **Abiotic components**: Soil, air, sunlight, inorganic and organic components and decaying organic matter.

6.1.2 GRASSLAND ECOSYSTEM

Grasslands are areas dominated by grasses. They occupy about 20% of the land on the earth surface. Grasslands occur in both in tropical and temperate regions where rainfall is not enough to support the growth of trees. The low rainfall prevents the growth of numerous trees and shrubs but is sufficient to support the growth of grass cover during the monsoon

Grasslands are found in areas having well-defined hot and dry, warm and rainy seasons.

Grasslands are one of the intermediate stages in ecological succession and cover a part of the land on all the altitudes and latitudes at which climatic and soil conditions (soil depth and quality) do not allow the growth of trees. The types of plants that grow here greatly depend on what the climate and soil are like.

Different Names of Grasslands

Grasslands are known by various names in different parts of the world.

The common ones are:

The Prairies of North America, The Steppes of Eurasia, The Savannas of Africa, The Pampas of South America,The Savanna of India and The Downs of Australia.

Tropical grasslands are commonly called Savannas. They occur in eastern Africa, South America, Australia and India. Savannas form a complex ecosystem with scattered medium-size trees in grasslands.

The structure and components of the grassland ecosystem:

Biotic Components

- **Producers** – In grassland, producers are mainly grasses; though, a few herbs & shrubs also contribute to the primary production of biomass.
- **Consumers** – In a grassland, consumers are of three main types:
    - **Primary Consumers** – The primary consumers are herbivores feeding directly on grasses. Herbivores such as grazing mammals (e.g., cows, sheep, deer, rabbit, buffaloes, etc), insects (e.g., Dysdercus, Coccinella), some termites and millipedes are the primary consumers.
    - **Secondary Consumers** – These are carnivores that feed on primary consumers (Herbivores). The animals like foxes, jackals, snakes, frogs, lizards, birds etc., are the carnivores feeding on the herbivores. These are the secondary consumers of the grassland ecosystem.
    - **Tertiary Consumers** – These include hawks etc. which feed on secondary consumers.
- **Decomposers** – These include bacteria of death and decay, moulds and fungi (e.g., Mucor, Penicillium, Aspergillus, Rhizopus, etc). These bring the minerals back to the soil to be available to the producers again.

Abiotic Components

- These include the nutrients present in the soil and the aerial environment.
- The elements required by plants are hydrogen, oxygen, nitrogen, phosphorus and sulphur.
- These are supplied by the soil and air in the form of CO2, water, nitrates, phosphates and sulphates.
- In addition to these, some trace elements are also present in the soil.

Flora and Fauna of Grassland Ecosystem

- Grasses are the dominating plants, with scattered drought resistant thorny trees in the tropical grasslands.
- Badgers, fox, ass, zebra, antelope are found grazing on grasslands that support the dairy and leather industries.
- Grasslands also support the large population of rodents, reptiles and insects.

Functions of Grassland Ecosystem

- Energy flow through the food chain
- Nutrient cycling (biogeochemical cycles)
- Ecological succession or ecosystem development
- Homeostasis (or cybernetic) or feedback control mechanisms
- To increase the fertility of the soil and to regulate the productivity of the ecosystem.
- To reduce the leaching of minerals due to low rainfall.

Economic Importance of Grasslands

- Grasslands are the grazing areas of many rural communities.
- Farmers who keep cattle or goats, as well as shepherds who keep sheep, are highly dependent on grasslands.
- Domestic animals are grazed in the 'common' land of the village.
- Fodder is collected and stored to feed cattle when there is no grass left for them to graze in summer.
- The grass is also used to thatch houses and farm sheds.
- The thorny bushes and branches of the few trees that are seen in grasslands are used as a major source of fuelwood.
- Overgrazing by huge herds of domestic livestock has degraded many grasslands.
- Grasslands have diverse species of insects that pollinate crops.
- There are also predators of these insects such as small mammals like shrews, reptiles like lizards, birds of prey, and amphibia such as frogs and toads.
- All these carnivorous animals help to control insect pests in adjoining agricultural lands.

Classification of Grasslands

As climate plays an important role in the formation of grasslands, it is generally used as a basis to divide the world's grasslands into two broad categories: those that occur in the **temperate region** and those that occur in the **tropical regions.**

Tropical Grasslands

- These occur on either side of the equator and extend to the tropics.
- This vegetation grows in areas of moderate to a low amount of rainfall.
- The grass can grow very tall, about 3 to 4 metres in height.

- Savannah grasslands of Africa are of this type.
- Elephants, zebras, giraffes, deer, leopards are common in tropical grasslands

Temperate Grasslands

- These are found in the mid latitudinal zones and in the interior part of the continents.
- Usually, the grass here is short and nutritious.
- Wild buffaloes, bison, antelopes are common in the temperate region.

Grasslands in India

- In India, grasslands are found as village grazing grounds (Gauchar) and extensive low pastures of dry regions of the western part of the country and also in Alpine Himalayas.
- Perennial grasses are the dominant plant community.
- In the Himalayan mountains, there are high, cold Himalayan pastures.
- There are tracts of tall elephant grass in the low-lying **Terai belt** south of the Himalayan foothills.
- There are semi-arid grasslands in Western India, parts of Central India, and the Deccan Plateau.
- Grasslands support numerous herbivores, from minute insects to very large mammals.
- Rats, mice, rodents, deer, elephants, dogs, buffalo, tigers, lions, ferrets are some common mammals of grasslands.
- In northeast India, the one-horned rhinoceros is amongst the threatened animal of grassland in this region.

6.1.3 Desert Ecosystems: are found in regions where the annual rainfall is in the range of 250 to 500 mm and the rate of evaporation is very high. Occupy about 30% of the land area. They are characterized by extremely hot days and cold nights. The desert soils have very little organic matter and are rich in minerals. The desert plants have adapted to the dry conditions by having few or no leaves.

The structure and components of the desert ecosystem:

Biotic components:Producers: include xerophytic plants like cacti, shrubs, bushes, grasses, few trees, mosses and lichens.

Consumers: Primary Birds, camel, mouse.

Secondary: Lizards, snakes, birds.

Tertiary: Jungle cats, jackals, panthers

Decomposers: Some fungi and bacteria.

Functions of desert ecosystem

The dry condition of deserts helps **promote the formation and concentration of important minerals**. Gypsum, borates, nitrates, potassium and other salts build up in deserts when water carrying these minerals evaporates. Minimal vegetation has also made it easier to extract important minerals from desert regions.

6.2 Aquatic Ecosystems

Aquatic ecosystem is a water-based habitat. Many organisms rely on water for their livelihood and other life functions.

- The aquatic ecosystem is the basic functional unit facilitating the sustenance of aquatic organisms.
- The unique physicochemical features of this ecosystem allow the material transfer, carrying out significant chemical reactions, and other key functions needed for the survival of the life forms.
- Nekton, plankton, and benthos are some of the most prevalent aquatic creatures.
- Lakes, oceans, ponds, rivers, swamps, coral reefs, wetlands, and popular examples of freshwater aquatic ecosystems.
- While marine habitats include oceans, intertidal zones, reefs, and the seabed.

Types of Aquatic Ecosystems:

6.2.1 Freshwater ecosystems only cover about 1 percent of the earth's surface.

- Lakes, ponds, rivers and streams, marshes, swamps, bogs, and ephemeral pools are all . examples of freshwater.

- Freshwater ecosystems are divided into three types: lotic, lentic, wetlands, and swamps.

Lentic habitats are bodies of standing water such as lakes, ponds, pools, bogs, and other reservoirs. Flowing water bodies such as rivers and streams are represented by **lotic** ecosystems.

Lotic: Lotic ecosystems primarily refer to unidirectional, quickly flowing waterways such as rivers and streams.

- Several insect species, such as beetles, mayflies and stoneflies, as well as several fish species, such as trout, eel, and minnow, live in these settings.
- These ecosystems also include mammals such as beavers, river dolphins, and otters, in addition to aquatic species.

Lentic ecosystems:encompass all ecosystems with standing water.

- The principal examples of the Lentic Ecosystem are lakes and ponds.
- The term lentic is used to describe water that is stationary or relatively still.
- Algae, crabs, shrimps, amphibians like frogs and salamanders, rooted and floating-leaved plants and reptiles like alligators and other water snakes can all be found in these

6.22Marine Ecosystem: The marine environment covers the majority of the earth's surface area.

- Oceans, seas, the intertidal zone, reefs, the seabed, estuaries, hydrothermal vents, and rock pools make up two-thirds of the earth's surface.
- Aquatic animals cannot exist outside of water.
- Salt concentrations are higher in the marine habitat, making it difficult for freshwater creatures to survive.
- In addition, marine species are unable to survive in freshwater.
- Their bodies are designed to survive in salt water and will swell if placed in less salty water due to osmosis..
- They can be further classified as ocean ecosystems, estuaries, coral reefs, and coastal ecosystems.

6.2.3 Ocean Ecosystems:

- The Pacific, Indian, Arctic, and Atlantic Oceans are the five primary oceans on earth.
- The Pacific and Atlantic Oceans are the largest and deepest of these five oceans.
- More than five lakh aquatic species call these oceans home.
- Shellfish, sharks, tube worms, crabs, turtles, crustaceans, blue whales, reptiles, marine mammals, seagulls, plankton, corals, and other ocean plants are just a few of the organisms that live in these environments.
- **6. 2.4 Estuaries Ecosystems**
- Estuaries are critical forms of natural habitats which are typically formed where the sea and the rivers meet.
- The transition from land to sea happens in this region.

- As a result, the water here is more saline in comparison to freshwater ecosystems but more dilute than the marine ecosystems.
- Estuaries have more economic importance as they are capable of trapping plant nutrients and generating quality organic matter in comparison to all other land-based ecosystems.
- Estuaries today have also become hot spots for recreational activities and scientific studies.
- Some examples are tidal marshes, coastal bays, and river mouths.

6.2.5 Coral reefs

Coral reefs are underwater structures built from the skeletons of marine vertebrate, and are also called corals.These are found in most of the world's oceans.

- These corals form reefs called hermatypic or hard reefs as they give out hard calcium carbonate exoskeletons that protect their structure and support important life functions. Sea anemones are classic examples of hard coral reefs. The other species form soft reefs that are comparatively flexible organisms like plants and trees. Sea fans and sea whips are some of the most found varieties of soft reefs.
- The environmental conditions needed for the survival of coral reefs are warm, shallow, clear, and moving waters with ample sunlight.
- The Great Barrier Reef in Australia is the world's largest coral reef with a length of approximately 1500 miles.

6.2. A.Functions of Aquatic Ecosystem

- Allows nutrients to be recycled more easily.
- Aids in the purification of water
- Recharges thegroundwater table
- Provides a home for aquatic vegetation and fauna.
- Prevents flooding

ECOLOGICAL SUCCESSION

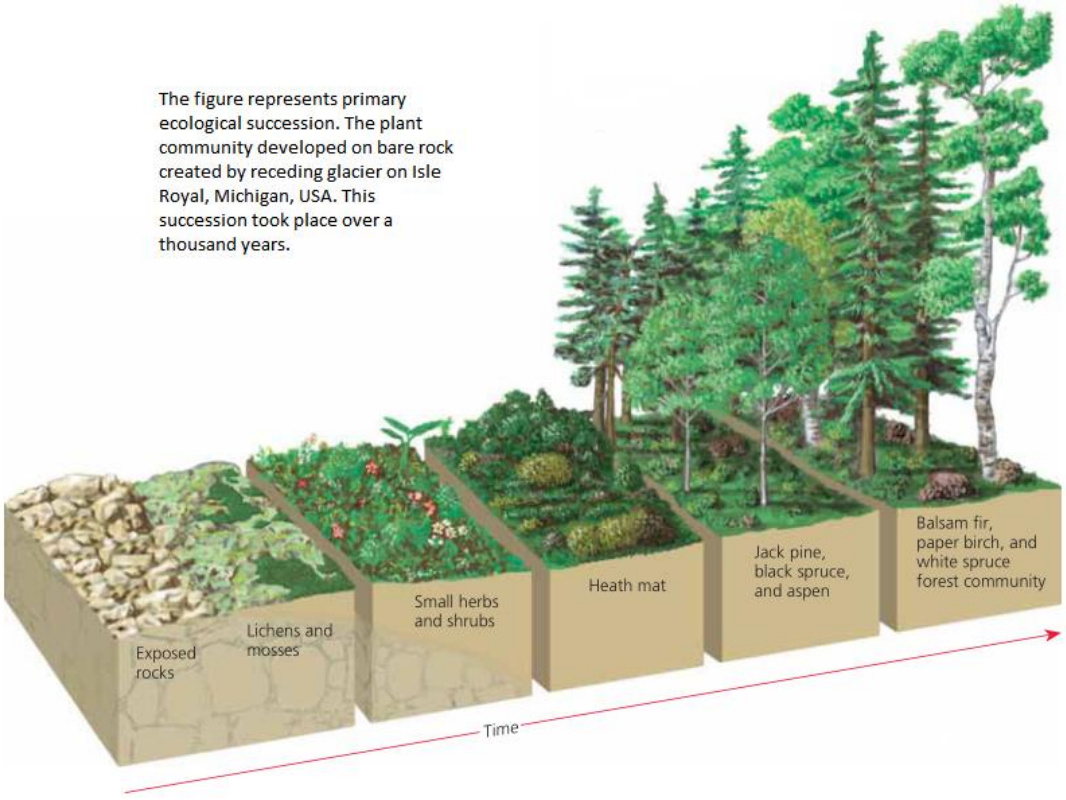
Gradual changes happening in species composition and processes of communities over time is known as ecological succession or community development. It is important to learn the process, rates, and pattern of ecological succession for the management of ecosystems.

Ecological succession can be divided into two major categories

(i) Changes occurring over geological timescale (millions of years); also called paleo-ecological changes and
(ii) Changes occurring over medium timescale (1 – 1000 years)

In another way, succession can also be classified into two types such as Primary and Secondary successions. Primary successions begins at a bare land where there is no life, whereas the secondary succession occurs at a place where the pre-existed ecosystem was either partially or fully destroyed by natural or unnatural means.

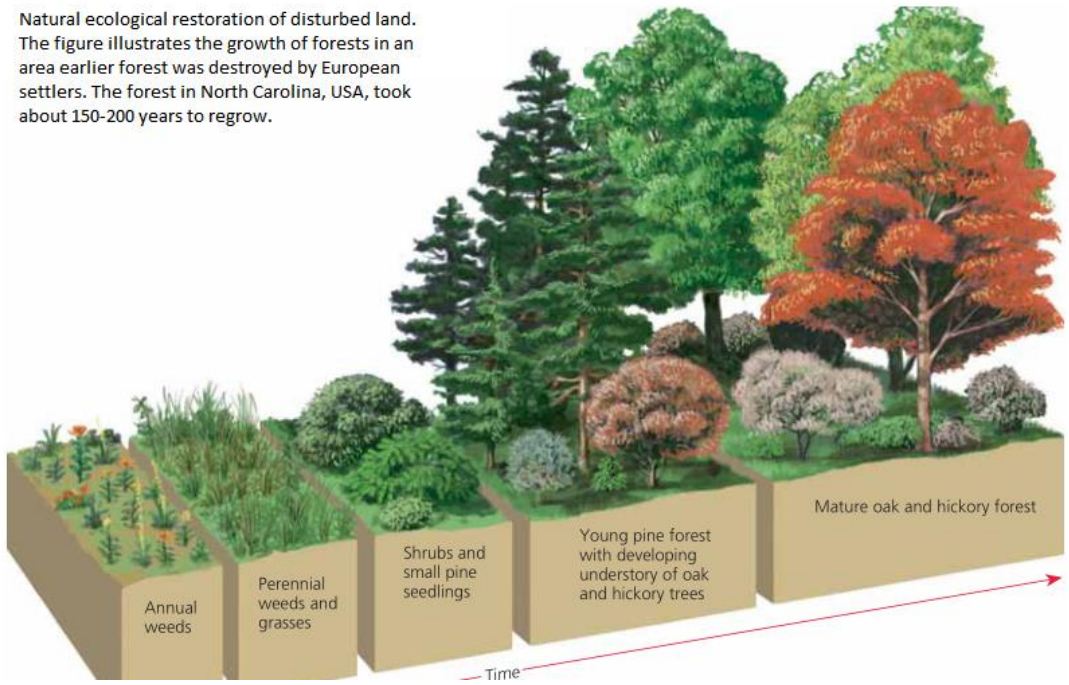
Primary Ecological Succession



In primary succession, the slow process of soil formation begins with pioneer or early successional species, which arrive and attach themselves to inhospitable patches of the weathered rock. Lichens and mosses are examples of pioneer species. These species secrete mild chemicals and acids that penetrate the rocks and eventually make the soil fertile. Over time, the soil may be fertile and moist enough to support other plant species. Mid successional species such as herbs, grasses and low shrubs grow in the environment after lichens and mosses. Next, trees replace these shrubs over the next hundred to thousand years.

Secondary Ecological Succession:

In the secondary succession process, plant species grow in an area that has earlier been destroyed by natural wildfires, floods, or human intervention. Even though the surface species are destroyed, life remains under the soil, which eventually take foothold after the area is abandoned. We can consider the example of mature oak and pine forests of North Carolina, USA, which were destroyed by European settlers. They used the cleared forest for farming. As the nutrients of the land started to dwindle, the settlers moved on. The abandoned farmland underwent secondary succession as shown in the figure below.



Natural ecological restoration of disturbed land. The figure illustrates the growth of forests in an area earlier forest was destroyed by European settlers. The forest in North Carolina, USA, took about 150-200 years to regrow.

Secondary succession can take place 5-10 times faster than primary successions are most of the nutrients in the soil is still present, albeit at a much lower level than what is found at a live forest. The species that take hold as the leader at the end of the succession is called climax species.

The process of succession takes place via these steps:

1. **Nudation**: In this, the bare area is formed by one of several factors: volcanic eruption, landslide, flooding, fire, or other catastrophic event
2. **Invasion**: In this process, the arrival of an organism or many to the bare land takes place. These immigrant species are called “pioneers”
3. **Competition**: When the number of living organisms increases, the space, nutrients, etc. in the area are shared. The competition or struggle for existence can be intraspecific or interspecific. Because of the competition, the environment is modified unsuitably for existing community, which is eventually replaced by the immigrant species. Co-action and co-existence is another seral that follows the competition seral.
4. **Climax**: The end process is called “climax” or “stabilization”. When the climax community takes hold, the environment does not undergo further change unless by natural catastrophes or human intervention.

There are several other types of succession as well:

a. Hydrosere – succession starting in a water environment
b. Xerosere – succession starting in a dry, waterless environment
c. Lithosere – succession starting in rocks
d. Halosere – succession starting in a saline environment

Difference between xerosere and hydrosere

Xerosere (Dry)	Lithoseres	where the plants colonise bare rock	e.g. after glacial retreat, Snowdonia or a rocky shore, Oxwich Point, Gower or a newly created volcanic island (e.g. Surtsey, Iceland)
	Psammosere	where plants colonise coastal sand dunes	e.g. The south Gower - Oxwich Bay.
Hydrosere (Wet)	Hydroseres	where the plants colonise fresh water, as at a pond margin	e.g. Llanfihangel Gobion, Monmouthshire - ox-bow lakes
	Haloseres	where plants colonise salt marshes and sea estuaries	e.g. The North shore of the Gower, Lanrhidian salt marsh

Source courtesy: https://qsstudy.com/difference-hydrosere-xerosere/

Hydrosere

- Succession takes place in wet habitats
- Its first step is the submerged plant stage
- Plants of the first stage are- Elodia, Hydrilla, etc.
- Succession is limited to six steps such as- Submerged stage, floating stage, reed swamp stage, woodland stage, and climax forest stage.
- A hydrosere is a plant succession which occurs in an area of fresh water such as in oxbow lakes and kettle lakes.

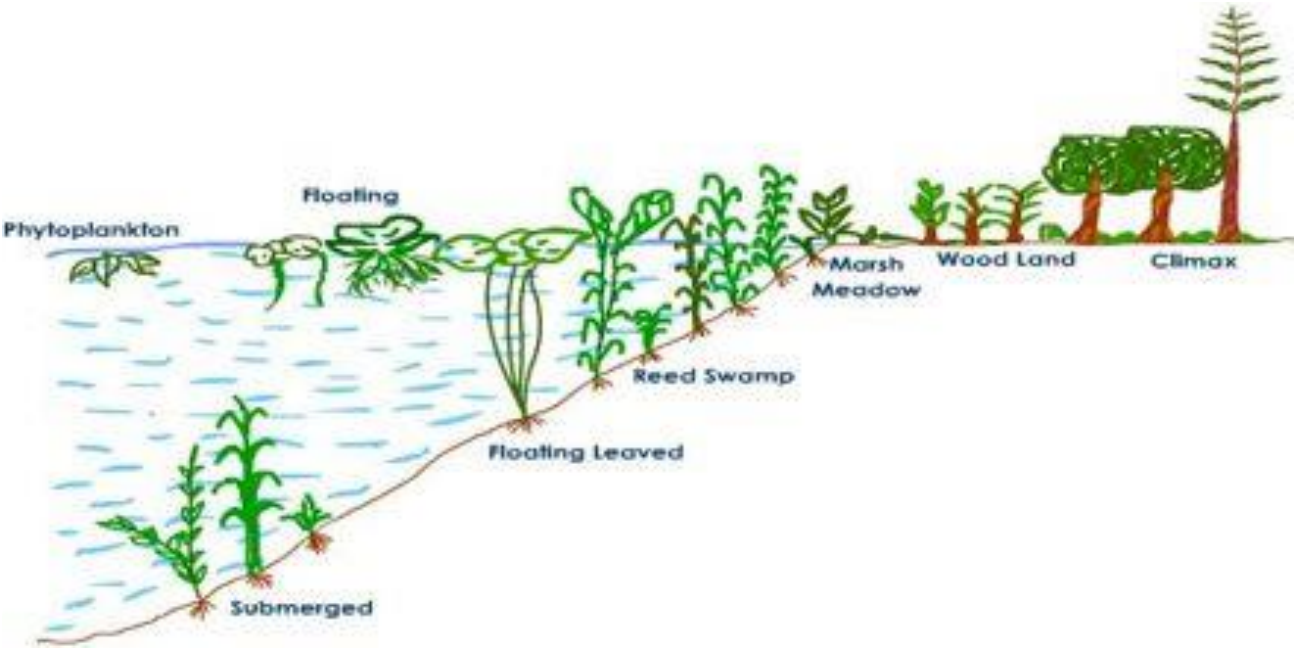


Fig: The different stage of Hydrosere (**Source courtesy:** https://qsstudy.com/difference-hydrosere-xerosere/)

Xerosere

- Succession begins with bare rocks, deserts; example: dry places.
- Its first step is the blue-green algae as well as thalloid licken plant stage
- Plants of the first stage are Rhizocarpon, Rhinodina, etc.
- This succession is ended by six stages, such as – thalluid, licken stage, leafy licken stage, moss stage, herb stage, shrub stage, and climax forest Stage.
- The xerarch succession of ecological communities originated in the extremely dry situation such as sand deserts, sand dunes, salt deserts, rock deserts, etc.

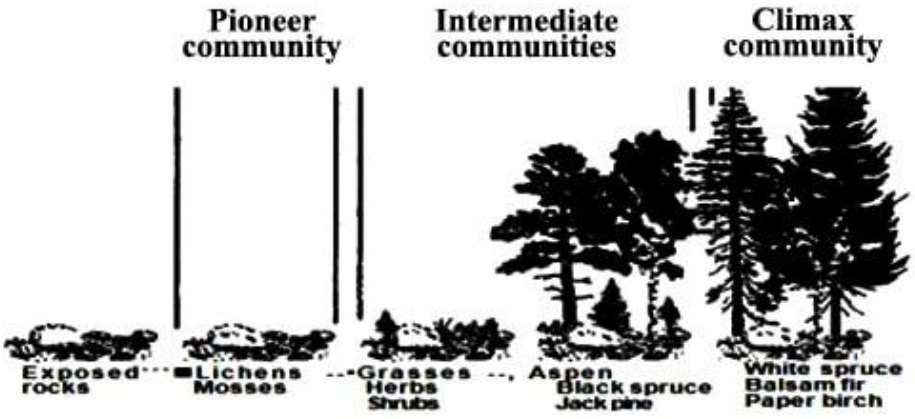


Fig: The different stage of Xerosere(**Source courtesy:** https://qsstudy.com/difference-hydrosere-xerosere/)

CLIMAX THEORY

1. MONOCLIMAX THEORY

- This Theory was given by F.E. Clemens.
- According to this theory, within a given region all land surface is eventually covered by a single type of community. This type of climax is determined by climate.

2. POLYCLIMAX THEORY

- This theory was given by Tansley.
- In this type, the climax vegetation does not consist of numerous type vegetation controlled by many factors .

FEATURES OF PIONEER SPECIES

The pioneer species should:

- have the habit of exploring new habitat.
- should be agile in nature.
- have greater ability to adapt to new environment.
- Have a wide choice of food.
- be a good breeder.
- be a tolerant species .

Summary:

The process of succession shows how a new community is established.

By the process of succession and by of the species of that area the factors responsible for succession can be determined.

The process of succession helps us in the conservation of the climax community.

Differences between primary and secondary succession

Primary succession	**Secondary succession**
Occurs in areas where there is no life and barren	Occurs in areas that were previously occupied, but devastated completely
Takes more than 1000 plus years	Takes just 50 to 100 years
No humus as no soil is seen in the initial step	Humus is present as there were previous occupants and decomposition took place between organisms that existed.
Goes through several seral communities	Less number of seral communities when compared to primary succession
Unfavourable starting point	Favourable and conducive environment
Eg: Bare rock, ponds, desert	Eg. The area affected by natural calamities, covered under deforestation

Biodiversity

Hot spots: Significance, mega-biodiversity

The term "biodiversity hotspot" was first introduced by British Biologist **Norman Myers** in 1988. A biodiversity hotspot is a biogeographic region with significant levels of biodiversity that is threatened by human habitation.

Criteria for recognizing **biodiversity hot spots:**

1. A region must have **at least 1500 vascular plants** as endemics.
2. It must have >**70%** of its original natural vegetation threatened.

An endemic species is a species that's found in a certain area and nowhere else on earth. To identify hotspot why plants are so important? We know Plants are the primary producers. Animals go where the plants are. Plants are the base of food webs. Life attracts other life and it depends on other life. That's why the plants are very important. At the moment Conservation International formally recognizes 36 biodiversity hotspot areas on earth. The interesting thing about this is that less than three percent of the earth's land surface area is represented by these hotspots.

What is the Significance of hotspots?

- Biodiversity is the building blocks of all life on earth. Without species, there would be no air to breathe, no food to eat, no water to drink. There would be no human society at all. And as the places on Earth where the most biodiversity is under the most threat, hotspots are critical to human survival.
- There would be no life on Earth without biodiversity, making these biodiverse hotspots, even more critical for our survival
- The maps of hotspots overlap with maps of natural places that most benefit people.
- That's because hotspots are among the richest and most important ecosystems in the world — and they are home to many vulnerable populations who are directly dependent on nature to survive. By one estimate, in spite of containing 2.5% of Earth's land surface, the forests, wetlands and other ecosystems in hotspots account for 35% of the "ecosystem services" that vulnerable human populations depend on.

What are the most threatened hotspots?

- Most hotspots are located in tropical forests.
- **Atlantic forest, Brazil:** 20,000 plant species, about half of which, are endemic. Of the original 1.2 million km^2, only 8% remains.
- **Polynesia-Micronesia, South Pacific Ocean:** It includes coastal wetlands, coral atolls, savannas and tropical rainforests.

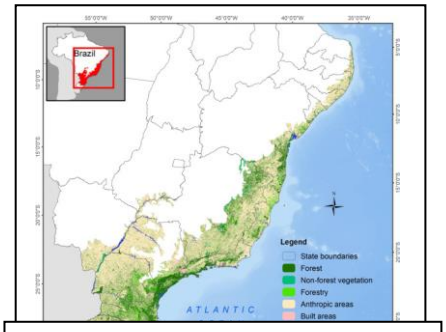


Fig: - Atlantic forest, Brazil

- Some other notable hotspots are **Columbia**, which has the highest rate of species by area unit worldwide and the largest number of endemics; ~20% species can be found here.

Mega-biodiversity:

India is one among the seventeen 'megadiversity' countries in the world, a concept which was introduced by R.A. Mittermier and T.B. Vernier. Megadiversity is a much less discussed subject than biodiversity. This term and another term 'Hot Spots' have recently been used by World Bank and other World bodies for species diversity and endemism in the World's selected few rich floral and faunal zones. "Just as the G-7 countries concentrate a major portion of the world's economic wealth, the 17 Megadiversity Countries have within their borders more than two thirds of our planet's biological wealth, its biodiversity," explains Conservation International's President Dr. Russell A. Mittermeier.

The Megadiversity concept was created in an attempt to prioritise conservation efforts around the world. More than half of the world's forests have already disappeared, and more are destroyed each year. Megadiversity is not only a concept, it is a call for action to ensure the survival of all forms of life on earth. Two spots identified as 'Megadiversity' and 'Hot Spots' in India are North-eastern

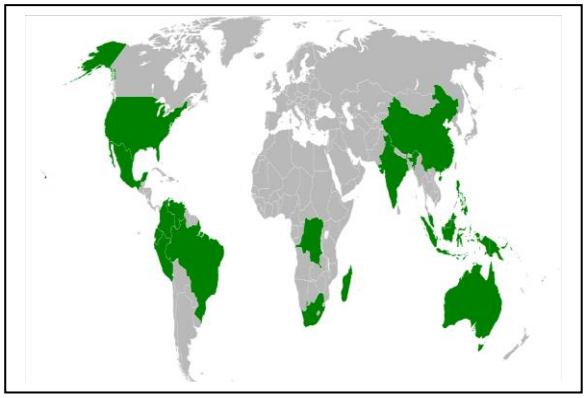


Fig: - Megadiversity of world

Himalayas and Western Ghat. But India as a whole has been marked a megadiversity area. Indians are not yet very much conscious and concerned about biodiversity loss and degradation of entire ecosystem. As the conservation need is urgent in the face of depletion India needs a well-designed strategy to protect these resources. The distribution of biodiversity in India is also important. India, which occupies just two percent (2.4%) of the total landmass of the world, harbors a rich biodiversity comprising about 8% of the known biodiversity of the world.

Conservation International identified **17 megadiverse countries** in 1998. Many of them are located in, or partially in, tropical or subtropical regions. Megadiversity means exhibiting great biodiversity. The main criterion for megadiverse countries is endemism at the level of species, genera and families. A megadiverse country must have at least 5,000 species of endemic plants and must border marine ecosystems. Nations that harbor most of Earth's species and high numbers of endemic species.

Biodiversity

Biodiversity in India:

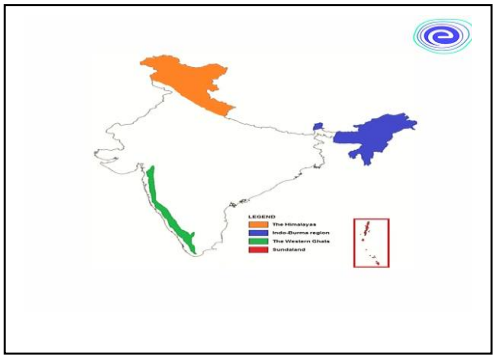
- **What makes India a mega-biodiversity nation?**

  1. Species richness
  2. Species endemism
  3. Biogeographically different regions
  4. Biodiversity Hot spots
  5. Biodiversity conservation efforts

- India has **diverse geographical features**, ranging from desert, mountains, highlands, tropical and temperate forests, swamp lands, plains and grasslands each spanning different climates.
- India has **23.39% of geographical area** under forest cover.
- 7.6% of mammalian, 12.6% of all avian, 6.2% of all reptilian, 4.4% of all amphibian, 11.7% of all fish and 6% of all flowering plant species.
- Within **2.4% of land area**, it accounts for nearly **7%** of recorded species and almost **18%** of the human population
- In terms of **species richness**, India ranks 7th, 9th in birds, 5th in reptiles.
- In terms of **endemism**, India is 10th in birds with 69 species, 5th in reptiles with 156 species and 7th in amphibians with 110 species

Biodiversity hotspots in India:

Overall, 36 biodiversity hotspot areas are there on earth. India contains **4 of the 36 biodiversity hotspots**, they are found in:



1. Western Ghats
2. Himalayas
3. Sundaland
4. Indo-Burma region

1. Western Ghats and Sri Lanka:

- The mountainous zones and the monsoons make a substantial contribution to the biodiversity of the Western Ghats which consists of a rich variety of plant, reptile, and amphibian species.
- It is among the **top 8 biodiversity hotspots** in the world.
- It has original reserve of 2 lakh km^2, only ~143,611 km^2 remain.
- 1600 km long chain of hills running along the western peninsular coast of India, including Kerala, Tamil Nadu and Karnataka.

- Western Ghats is characterized by **heavy rainfall**, and contain moist deciduous and rain forests.
- The region is home to 450 birds (species), 140 mammals, 260 reptiles and 175 amphibians, now rapidly heading towards extinction.
- **How western ghats are Importance to us:** Any reduction in rainfall due to deforestation of the Western Ghats would lead to a warming of the peninsula as well.

2. Himalayas:

- The Himalaya Hotspot has some of the **highest peaks** in the world including Mt. Everest and K2. The varied topography of this hotspot supports a wide range of ecosystems like alluvial grasslands, subtropical broadleaf forests and alpine meadows.
- Significant feature of this hotspot is the occurrence of vascular plants at altitudes as high as 6,000 meters. Vultures, tigers, elephants, rhinos and wild water buffalo are some of the species found in this hotspot.
- Region comprising **Bhutan, Northeast India, southern, central and eastern Nepal.**
- It is geologically young and shows **high altitudinal variation.**
- Of the estimated 10,000 species of plants in the Himalayan hotspot, 3160 are endemic, as well as 71 genera.
- Despite icy zones starting at ~5500-6000 m, there are some species of vascular plants occurring at such high altitudes.
- Nearly 980 birds (15 endemic), 300 mammals (12 endemic), 175 reptiles (50 endemic), 105 amphibians (40 endemic) have been observed here.

3. Sundaland:

- Sundaland is one of the biologically richest hotspots on Earth, The Sundaland hotspot has over 25,000 plants, 2,000 species of orchids and some of the world's largest flowers belonging to the Rafflesia family.
- Sundaland hotspot covers the western half of the Indo-Malayan archipelago. It includes islands of Malaysia, parts of Thailand, Singapore. It is represented by the Andaman & Nicobar Islands from India.
- Of the original reserve of 1.5 million km^2, only ~1 lakh km^2 remain.
- They have a rich terrestrial and marine ecosystem comprising mangroves, coral reefs and sea grass beds, with a wide variety of flora and fauna.

Andaman and Nicobar Islands:

- These constitute a group of **572 islands**, falling under the **Indo-Malayan biogeographic realm**, with Andaman resembling Myanmar and Thailand, while Nicobar was similar to Indonesia and South east Asia, and closer to the sundaland region.
- The islands harbour around **9130 animal species**, in terrestrial habitats, of which, 5859 are marine species.
- A high percentage of endemism (24.95%, 816 species) has been observed in terrestrial fauna, which is 4 times higher than marine habitat endemism.
- These **high rates of endemism** can be attributed to isolation of land masses, while the low rates of marine endemism can be due to continuity in the water medium.
- Some of the endangered species include **whales, dolphins, dugong, saltwater crocodile, hornbills, marine turtles, seashells of the Trochus species.**

4. Indo-Burma:

Indo-Burma: encompasses several countries, spread out from Eastern Bangladesh to Malaysia and includes Northeast India south of Brahmaputra River, covering ~ 2.4 million km^2 of tropical Asia, east of the Ganges-Brahmaputra lowlands.

- They include tropical and subtropical moist, dry and broadleaf forests, temperate and coniferous forests, mangroves, swamps and seasonally inundated grasslands.
- Most of this region is characterized by distinct seasonal weather patterns, such as cool, dry, northern winter months, and rains during spring as a result of Southwest monsoons.

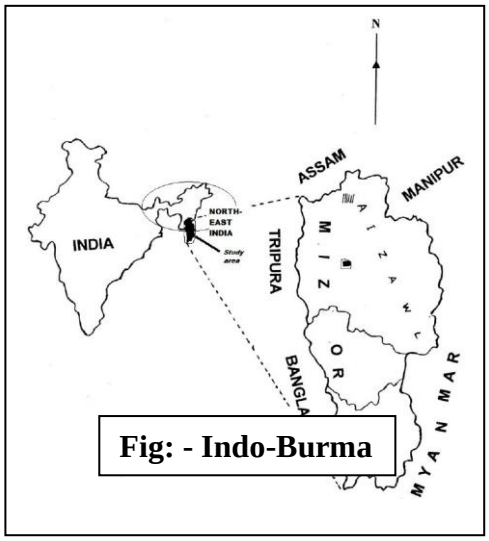


Fig: - Indo-Burma

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ENERGY FLOW IN AN ECOSYSTEM

The transfer of energy from the source in plants through a series of organisms by eating and being eaten constitutes **food chains**. At each transfer, a large proportion of energy is lost in the form of heat. These food chains are not isolated sequences but are inter-connected with each other. This interlocking pattern is known as the **food web**. Each step of the food web is called a **trophic level**. Hence green plants occupy the first level, herbivores the second level, carnivores the third level and secondary carnivores the fourth level. These trophic levels to-together form the ecological pyramid.

The food chains

The most obvious aspect of nature is that energy must pass from one living organism to another. When herbivorous animals feed on plants, energy is transferred from plants to animals. In an ecosystem, some of the animals feed on other living organisms, while some feed on dead organic matter. At each linkage in the chain, a major part of the energy from the food is lost for daily activities. Each chain usually has only four to five such links. However, a single species may be linked to a large number of species.

The food chains are mostly sequential and begin from green plants followed by herbivores and two successive sets of carnivores or predate. Such food chains are called Grazing food chain or Predator food chain (Fig. 1a). In addition, the food chains that start from dead organic materials that are consumed by a series of parasites and hyperparasites is called Detritus food chain or the Saprophytic food chain (Fig. 1b). These food chains are invariably linked to one another in nature (Fig. 1c).

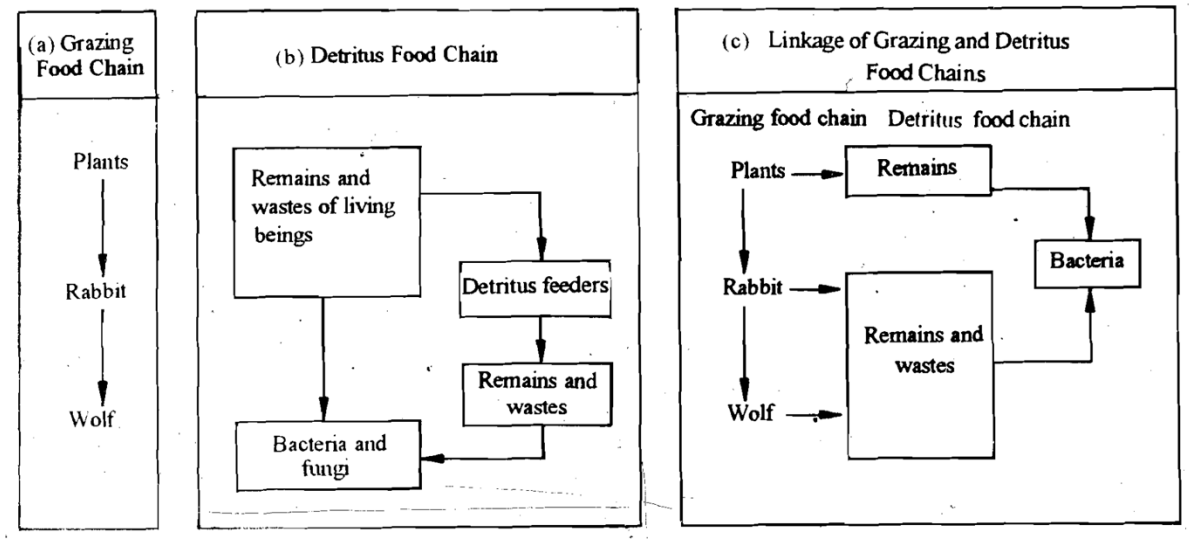


Figure 1. (a) Grazing food chain; (b) Detritus food chain. Bacteria and other organisms fed on plants and animals remain; (c) The Grazing and Detritus food chains are linked.

How Food Chains Work

Every biological community can have multiple and diverse food chains, but every food chain starts with a primary source of energy. The most obvious source of energy is the big ball in the sky, the sun. Other food chains may begin with a boiling-hot deep sea vent as a source of energy.

The next organism to benefit from this initial source is called the primary producer. These are organisms that can create their own food from the main energy source. Some examples include plants and algae. For example, plants are primary producers because they can harness and use the energy from the sun through a process called photosynthesis.

After the plant goes through the work of photosynthesis, another organism may come along and eat the plant, taking its energy to use as its own. As human beings, we are not primary producers because we cannot create our energy to survive, and must consume energy from other sources, like plants. By eating plants, we are part of the next sequence in the food chain, called the primary consumer, or organisms that consume primary producers.

With each transition of energy, the food chain moves up levels. These levels are called trophic levels. Here is a list of the order of trophic levels.

Primary Producers: The one that gathers energy from an energy spot such as the sun; an example may be grass.
Primary Consumer: The one that gets its energy directly from the primary producer, such as a grasshopper who eats the grass
Secondary Consumer: The one that gets its energy directly from the primary consumer, such as the rat who eats the grasshopper
Tertiary Consumer: The one that gets its energy directly from the secondary consumer, such as the snake who eats the rat
Quaternary Consumer: I think you are catching on now. This is the one that gets its energy directly from the tertiary consumer, such as the hawk that eats the snake.

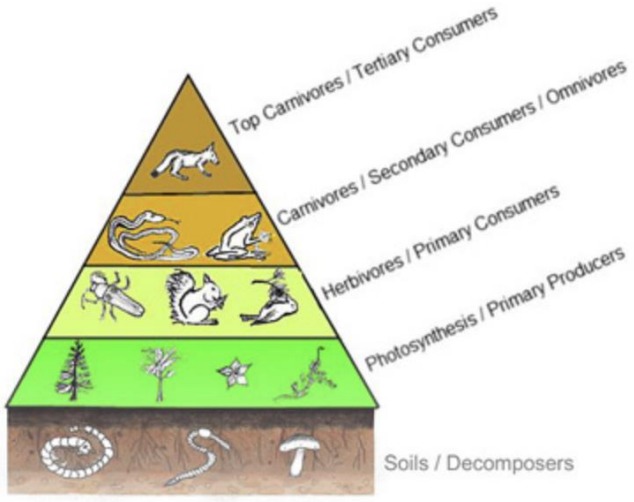


Figure 2. Examples of trophic levels some species may be on.

The Flow of Energy in the Food Chain

As we go along the trophic levels, at each step, a large portion of the energy is lost as heat and only a small fraction about 10% goes on to the next level. Therefore, the quantity of energy decreases successively at a rapid rate from primary producers to the top consumer (carnivores). This explains why the food chains have fewer links. After the fourth or fifth link, not enough energy is available to support another trophic level.

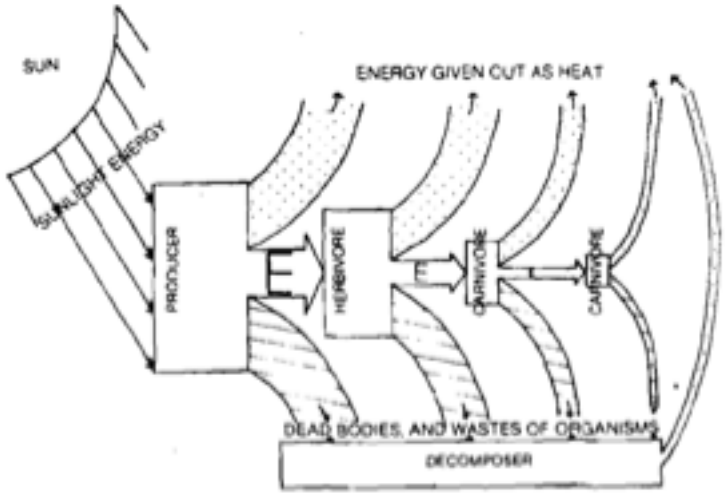


Figure 4. Energy flow in a food chain.

Extending this concept a bit further, in case we want to support more human population on earth, this could be possible by providing them with a vegetarian diet rather than non-vegetarian food. This way maximum energy can be made available as it involves one step in the energy transfer from a primary producer, thus minimizing energy loss at subsequent transfer.

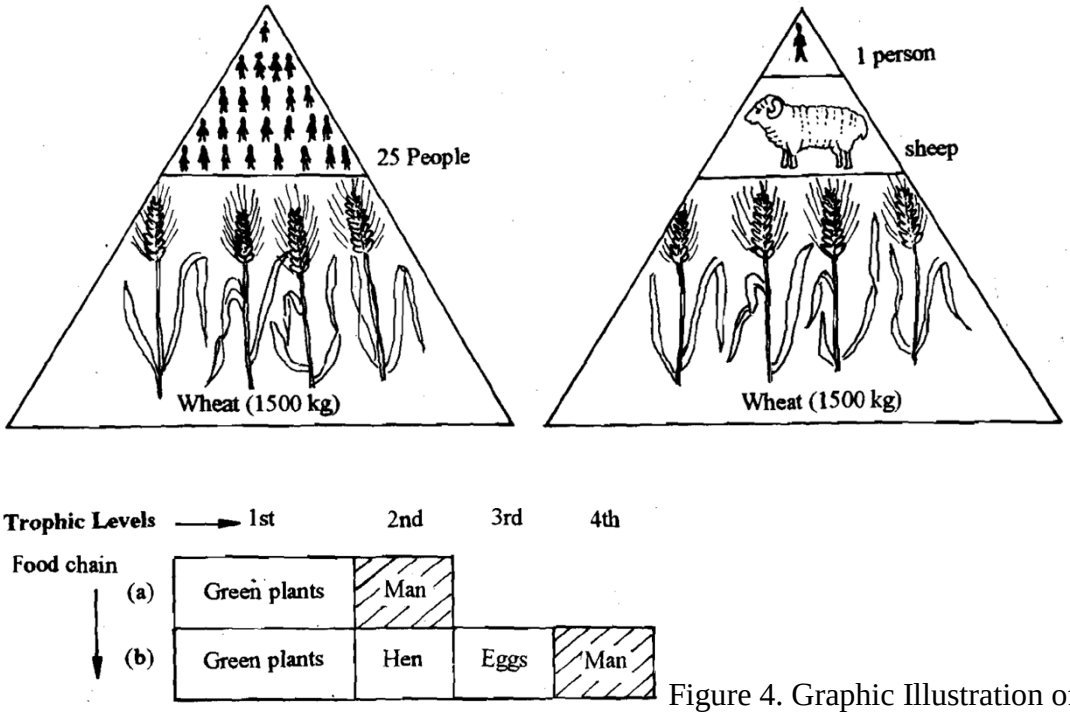


Figure 4. Graphic Illustration of vegetarian and carnivorous diet for supporting the human population.

The Food Web

From the above discussion, you should not be tempted to believe that the food relations in an ecosystem are simple having only linear food chains. Actually, in nearly all natural ecosystems, the patterns of consumption are so complicated that there are many cross-links connecting various organisms. So when the consumers have more than one food source, this results in branching off of food chains, In this way chains become interconnected to form a food web (Fig. 5). The food web is a composite of all the food chains giving us a complete picture of who consumes whom own ecosystem. Food webs represent the transfer of energy and nutrients among the organisms through the ecosystem, whereas a food chain traces only one pathway or represents one strand of the food web.

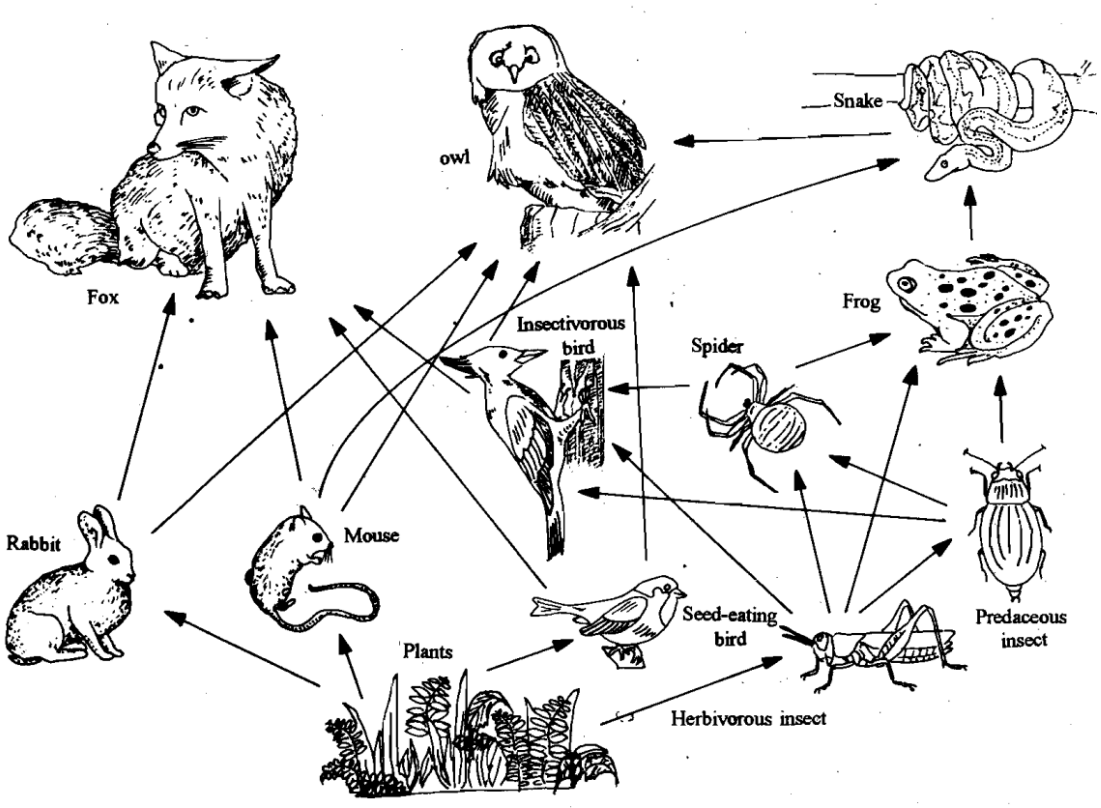


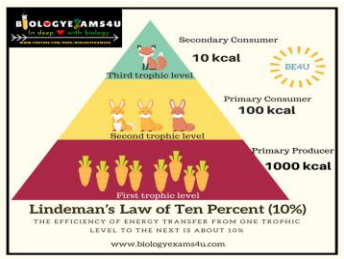
Figure 5. A simplified food web showing the interconnected network of food chains.

In a food web, many species can occupy more than one trophic level. They are known as multilevel consumers or omnivores. Humans are good examples of this situation. Humans, when they consume food derived from plants - they are primary consumers occupying the 2nd trophic level, and when they consume animal products they may occupy 3rd or higher trophic levels.

Energy flow in the ecosystem

- energy is needed for each and every biological activity
- The transfer of energy from one trophic level to another trophic level is called energy flow. Solar energy is transformed into chemical energy by process called photosynthesis. In a biological world the energy flows from the sun to the plants and

then to all heterotrophic organisms like Nitro- organisms, that is energy flows from the producers to the consumers

- Only 1% of total light falling on the green plants is utilized for photosynthesis. This is sufficient to maintain all life on this earth. There is no 100% flow of energy from one trophic level to the other. Some energy is always lost to the environment, because of this energy cannot be recycled in an ecosystem. It can only flow one way and can never take place in the reverse direction. Energy flow is unidirectional.
- Sun is the ultimate source of energy. A large amount of energy is lost at each Tropic level. It is estimated that upto 90% energy is lost during transfer from one trophic level to another. Therefore the amount of energy available decreases from each trophic level to the other. When a food chain is very small or short the final consumer may receive a large amount of energy, but in a food chain which is long the final consumer may get very less energy.
- This law of 10% was proposed by Lindeman in the year 1942 says that only 10% of food energy is transferred to the next level of consumers the rest is wasted.
- 

- Source courtesy:biologyexams4u.com

The illustration shows the progressive loss of energy in a food chain

The flow of energy follows the **two** laws of thermodynamics

The **I law** of thermodynamics states that energy can neither be created nor be destroyed but can be transformed from one form to another

For example: the plants which are the producers utilize the solar energy and convert this energy through photosynthesis into biochemical energy, later the consumers feed on the plants and uses this biochemical energy for their mechanical activities

II law of the second law of thermodynamics: states that energy transformation involves degradation or dissipation of energy from a concentrated to a dissipated form .We see that energy is lost at each and every trophic level

This energy flow supplies energy to all organisms at each trophic level.

Consequences of Food Webs: Biological Magnification

One of the most important consequences of ecosystem dynamics in terms of human impact is biomagnification. **Biomagnification** is the increasing concentration of persistent, toxic substances in organisms at each successive trophic level. These are substances that are fat soluble, not water soluble, and are stored in the fat reserves of each organism. Many substances have been shown to biomagnify, including classical studies with the pesticide dichlorodiphenyltrichloroethane (DDT), which was described in the 1960s bestseller, **Silent Spring by Rachel Carson**. DDT was a commonly used pesticide before its dangers to apex consumers, such as the bald eagle, became known. In aquatic ecosystems, organisms from each trophic level consumed many organisms in the lower level, which caused DDT to increase in birds (apex consumers) that ate fish. Thus, the bird's accumulated sufficient amounts of DDT to cause fragility in their egg shells. This effect increased egg breakage during nesting and was shown to have devastating effects on these bird populations. The use of DDT was banned in the United States in the 1970s.

Other substances that biomagnify are polychlorinated biphenyls (PCB), which were used as coolant liquids in the United States until their use was banned in 1979, and heavy metals, such as mercury, lead, and cadmium. These substances are best studied in aquatic ecosystems, where predatory fish species accumulate very high concentrations of toxic substances that are at quite low concentrations in the environment and in producers.

Key environmental problems

Environmental problems: are issues caused by human activities and cause damage to the environment.

Definition of environmental problems:

It is any change or disturbance to the environment considered to be undesirable or dangerous. It brings down or reduces the capacity of the environment to meet the social and ecological needs.

Environmental problems can be categorized into **2** major factors:

1) A **natural factor**: like drought, sea storms, volcanic eruptions etc.
2) **anthropogenic factors**: means man made activities: which include deforestation industrialisation, urbanisation actually causing damage to the elements of the Earth which is air water and soil.

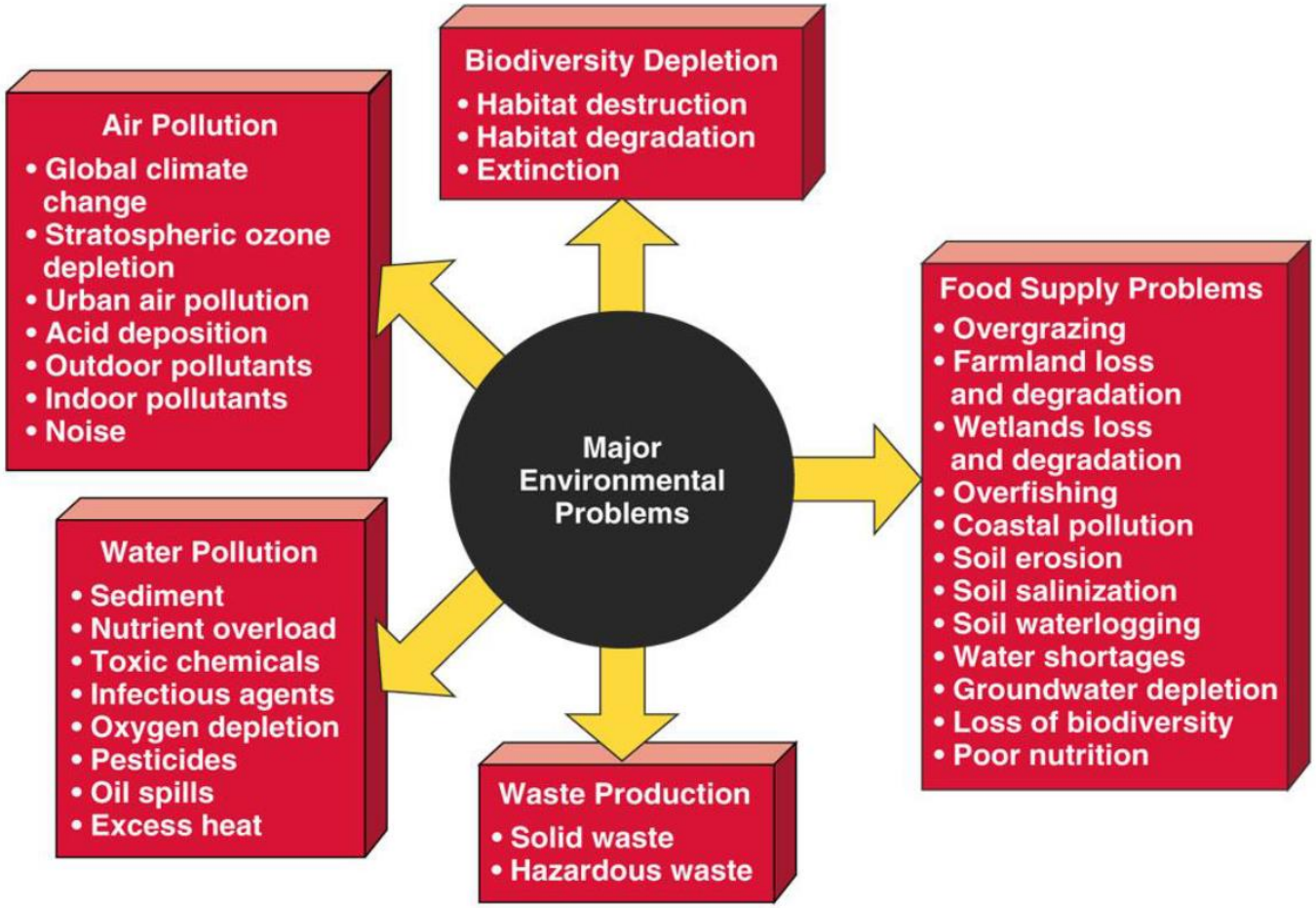
Causes of Environmental Problems: There are several causes: Like population, ozone layer depletion, acid rain, food scarcity, biodiversity loss, waste production, and use of unsustainable resources.

However, **four major causes** of environmental problems are:

- Population growth
- Poverty
- Affluence based on wasteful and unsustainable resource use
- Exclusion of harmful environmental costs from the market prices of goods and services.

The below illustrations brings to us a plethora of environmental problems:

Environmental Problems



One must know about **Natural Resources and Natural Services – key components in nature's sustainability**

• **Natural resources** are materials and energy in nature that are essential or useful to humans. They are often classified as renewable resources (such as air, water, soil, plants, and wind) or non-renewable resources (such as mineral ores, oil, coal).

• **Natural services** are processes in nature, such as purification of air and water and renewal of topsoil, which support life and human economies.

Natural capital is the world's stock of natural resources, which includes geology, soils, air, water and all living organisms. Natural capital assets provide people with a wide range of **free goods and services**, often called ecosystem services, which underpin our economy and society and some of which even make human life possible.

Optimal utilization of natural capital

• In economic terms, *capital refers to money and* other forms of wealth that can support a person, a population, or an economy. It can provide a sustainable income if we use it properly—that is, if we do not spend it too quickly. If we protect capital by careful investment and spending, it can last indefinitely. • Similarly, **natural capital** can support the earth's diversity of species as long as we use its natural resources and services in a sustainable fashion.

Overuse of natural capital – causes Unsustainability • Over exploitation of non-renewable resources - petroleum - coal - natural gas – minerals

Ecological Footprints: A Model of Unsustainable Use of Resources • Supplying people with renewable resources results in wastes and pollution, and can have an enormous environmental impact this is taken as an **ecological footprint.**

• **Ecological footprint is nothing but the amount of** biologically productive land and water needed to provide the people in a particular country or area with an indefinite supply of renewable resources and to absorb and recycle the wastes and pollution produced by such resource use. It considers only renewable resources though use of non-renewable resources also causes pollution.

- **Population growth**: A population is defined as a group of individuals of the same species living and interbreeding within a given area. The population rely on similar resources and get subjected to similar environmental constraints and depend on the availability of the other members to persist over time. Therefore one must limit the population explosion and use the natural resources wisely.
- **Affluence** comes from the Latin verb affiliate meaning receiving an incoming flood of riches In terms of environmental science, affluence is the abundance of wealth and goods or the consumption of high volumes of goods, those taken from the Earth.
- One must be conscious of how we utilize the natural resources judiciously

- **Affluence Has Harmful Environmental Effects ●**The lifestyles of many consumers in more-developed countries and in less-developed countries such as India and China are built upon growing affluence, which results in high levels of consumption and unnecessary waste of resources. Such affluence is based mostly on the assumption—fueled by mass advertising—that buying more and more material goods will bring fulfillment and happiness.

- The harmful environmental effects of affluence are dramatic. The U.S. population is only about one-fourth that of India. But the average American consumes about 30 times as much as the average Indian and 100 times as much as the average person in the world's poorest countries. As a result, the average environmental impact, or ecological footprint per person, in the United States is much larger than the average impact per person in less-developed countries.

- The authors of the book, Minimalism stresses us to identify the essentials and eliminate the rest.

- **Poverty:** It is a state of being poor, always in want of money, living space and access to quality air, water, food and basic sanitation.

Environmental Impact: is very challenging. Desperate for short-term survival, some individuals in poverty degrade potentially renewable forests, soils, grasslands, fisheries, and wildlife at an ever-growing demand. Poaching for animal skins for a large price, succumbing to unethical practices for some quick money all these impact the earth. The poor have a tendency to have larger families. This leads to over exploitation of natural resources too! We musts act and achieve a world of **ZERO Poverty**—the first sustainable development goal.

- **Excluding cost of environment and natural resources:** Prices Do Not Include the Value of Natural Capital. Companies using resources to provide goods for consumers generally ignore the harmful environmental costs of supplying such goods. Like the leather industry does not worry about the chromium impacts or the ecological index.

- **Consumerism:** is the latest addict affecting the world. The responsible human being must buy only what he needs. Imbibing a culture of green consumerism will benefit us and the earth too!

- **Global warming and climate change:** The green house effect is a natural process that heats up the earth's surface and the atmosphere. Green house gases CO_2, H_2O vapour and CH_4 impact the energy balance of the planet. The amount of heat energy added to the atmosphere by green house effect is controlled by the concentration of greenhouse gases like CO2, CFCs, nitrous oxide, methane etc. in the earth's atmosphere. As a result of this higher concentration, the green house effect will be enhanced and the earth's climate will become warmer and this is referred to as global warming.

These issues can be addressed only by responsible citizens and the ecological index can be promising only with all our cumulative effort. May we live and bequeath this planet in a better way.

Biodiversity

Genetically Modified-crops: advantages and disadvantages

Genetically modified (GM) crops:

GM crops are genetically improved and contain a gene or genes from the same or a different species artificially inserted in its genome. Genetically modified crops (GM crops) are **plants used in agriculture, the DNA of which has been modified using genetic engineering methods**. GM crops contain gene(s) artificially inserted instead of the plant acquiring it through pollination or other natural methods.

Fig: - Genetically modified crops

The first GM plant was introduced in 1982, which was an antibiotic-resistant tobacco plant. The first commercially produced GM plant was introduced in the US in 1994, the *FlavrSavr* tomato, which had longer shelf-lives.

Transgenic crops and conventionally-bred crops can directly affect the environment in different ways which include: gene transfer to wild relatives or conventional crops, weediness and trait effects on non-target species. Transgenic crops can also indirectly affect the environment as they have specific requirements in terms of pesticide and herbicide use and cropping patterns which requires changes to be introduced in existing agricultural practices.

Transgenic trees are a cause of concern for the environment, more so because of their long-life cycle. Transgenic micro-organisms used in food processing are normally used under confined conditions and are generally not considered as environmental risks. Some kinds of microorganisms can be used in the environment as biological control agents or for bioremediation of environmental damage (e.g., oil spills). The implications to the environment must be assessed before such organisms are released. The main concern with transgenic fish is their potential to breed with and out- compete wild relatives. Transgenic farm animals on the other hand, are generally reared in highly confined conditions and therefore do not pose a risk to the environment.

What is the difference between Traditional vs GM

Traditional breeding methods:

Traditional plant breeding techniques allows for gene exchange via transfer of male (pollen) of one plant to the female organ of another.

Disadvantages

- This method limited to exchanges between same or very closely related species.
- Time consuming to achieve desired set of traits, which may or may not be available in related species.

Biodiversity

Advantages of GM technology

GM technology enables plant breeders to bring together useful genes for the creation of superior plant varieties, from a wide range of living sources, not limited to closely related species.

Benefits of GM crops:

1. Improved nutritional value
2. Toxin reduction
3. Stress resistance
4. Useful by-products
5. Bioremediation

1. Improved nutritional value:

The nutritional content of the crops can be altered as well, providing a more nutritional profile than what previous generations were able to enjoy. This means people in the future could gain the same nutrition from eating lesser amounts of food. For example, rice can be genetically modified to produce high levels of Vitamin A. This can help reduce global vitamin deficiencies.

2. Toxin reduction

Potato that prevents bruising and produces lesser acrylamide on frying.

3. Stress resistance:

One of the main advantages of GM technology is that crops can be engineered to withstand weather extremes. This means that there will be good quality and sufficient yields even under poor or severe weather conditions. Herbicide resistance, pest resistance, resistance to cold. Plants capable of withstanding stressors like draught, frost, high soil salinity.

E.g., DroughGard maize: draught resistant maize, introduced in the US.

Fig: - DroughGard maize

4. Useful by-products

- Plants engineered to produce useful by-products such as drugs, biofuel (algae), bioplastics

Biodiversity

5. Bioremediation:

Bioremediation is a process used to treat contaminated media, including water, soil and subsurface material, by altering environmental conditions to stimulate growth of microorganisms that degrade the target pollutants. GM plants for bioremediation of contaminated soils containing Hg, Se, PCBs, TNT, RDX etc.

e.g., switchgrass and bentgrass

Other advantages:

If we are using GM foods, there is several other advantages also there. Like.

- Cheaper and faster to grow crops.
- GMO crops are bred to grow efficiently. This means that farmers can produce the same amount of food using less land, less water, and fewer pesticides than conventional crops. Because they can save on resources, food producers can also charge lower prices for GMO foods.
- **Easier to transport:** Because GMOs have a prolonged shelf life, it is easier to transport them greater distances. GMO food gives us the opportunity to limit food waste, especially in the developing world, so that hunger can be reduced and potentially eliminated. No more malnutrition or lack of availability of food.
- **Endless possibilities:** anything alive can be genetically modified.

Gene Flow:

In the short term, the spread of transgenic herbicide resistance via gene flow can lead to logistical and/or economic problems for farmers. In the long run, transgenes that confer resistance to pests and environmental stress and/or lead to greater seed production are most likely to favour weeds or have a negative impact on non-target species. A number of transgenic traits have the potential to contribute to sustainability in agricultural systems. The benefits and risks associated with the use of transgenic crops need to be studied carefully in a comprehensive manner and systematically analysed. There is an urgent need to make this exercise a top priority.

Environmental risks of genetically modified organism (GMO):

1. Unexpected gene flow
2. Horizontal Gene Transfer
3. Competition with natural species
4. Increased selection pressure on target and non-target organisms
5. Ecosystem impacts

1. Unexpected gene flow:

Interbreeding between genetically modified organism (GMO) and wild type weeds and/or related species, can result in uncontrollable or **irreversible escape of genes** into neighboring wild plants by pollen.

E.g.: Hybrid rice crossbreeding with a weedy relative, confers on the latter, the competitive advantages of higher photosynthetic rates, more shoots, flowers and seeds.

2. Horizontal Gene Transfer:

The transfer of **foreign genes** to other organisms such as bacteria/virus that can cause harm to environment.

E.g.: Transfer of an antibiotic resistance gene to a pathogen can be terrible to humans/animals.

3. Competition with natural species:

Genetically modified organism (GMO) has favorable traits built-in, such as higher yields or resistance to environmental stress, presenting them with a natural advantage over native organisms, allowing them to become invasive, spread into new habitats unchecked and cause ecological damage.

4. Increased selection pressure on target and non-target organisms:

Evolution of resistant pests and weeds, termed **superbugs**, in response to herbicide-resistant crops. Constant spraying of herbicide on such crops would result in **acquired resistance** by surrounding weeds, resulting in a higher dose of the same, or a different type.

5. Ecosystem impacts:

- Genetic modification produces genetically modified animals, plants and organisms. If they are introduced into the environment, they can affect biodiversity. For example, existing species can be overrun by more dominant new species.
- Effect of a single species may extend beyond a single ecosystem, carrying with it risks of ecosystem damage and destruction.

In summary,

Advantages of GMO's:

- Enhance desired traits
- Pest resistance
- Improve nutritional content
- Less time than controlled breeding
- Improve accuracy
- Herbicide tolerance
- Cold tolerance

- Medical advantage e.g., Edible vaccines
- Virtual end of world hunger. E.g., No malnutrition
- Cheaper or faster to grow and don't have to be rich in plant
- Endless possibilities and anything alive can be genetically modified
- Reduce production cost to reduced chemical and mechanical need in planting, maintenance and harvest.

Disadvantages of GMO's:

- Harm to organisms
- Does not taste natural
- Spread of superweeds
- Spread of superbugs
- New trade, tariff and quota issues
- May cause health problems ϖ Larger companies have more power
- Possible greed to GMO manufacturers
- Unforeseen allergen risks
- Allergies may become more intense
- New allergies may arise
- Widening corporate size gaps between food producing giants and smaller ones.

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Biodiversity

Species: roles; Types: extinct, endemic, endangered and rare species

Roles of species: Each species plays a specific ecological role called its ecological niche.

The roles of the species are classified into 5 types.

1. Native species
2. Non-native species
3. Indicator species
4. Keystone species
5. Foundation species

1. Native species: Those that live and develop in a particular ecosystem.

E.g.: Lions in the forest,

2. Non-native species: Those that are either accidently or forcefully introduced into a different environment. These may be migratory as well.

E.g.: Domesticated species such as cattle, chicken.

3. Indicator species: Those that provide information about the change in the environment and climate of a particular ecosystem.

Amphibians, like frogs, toads and salamanders, are known as indicator species. They are extremely sensitive to changes in the environment and can give scientists valuable insight into how an ecosystem is functioning.

4. Keystone species: Those that are abundant and have a great effect on other species.When the activities of a species determine community structure that species is called keystone species. For example, consider the case of the starfish, Pisaster ochraceous. When this starfish removed from the rocky intertidal areas of western north America, the mussel Mytilus californianus was able to occupy the space and excluded other invertebrates and algae which require attachment sites. However, under natural conditions, predation of mussels by starfish keeps their population under control and does not allow it to become dominant. This permits other species requiring attachment sites to survive in such habitats. Other examples of a keystone species could be of the African elephant wolves, leopards, alligators.

Keystone species may be relatively rare in natural communities or may not be easily recognised. At present, few terrestrial communities are believed to be organised by keystone species, but in aquatic community's keystone species may be common.

Biodiversity

5. Foundation species: Those that have a large contribution towards creating and maintaining habitats that support other species.

E.g.: corals, earthworms,

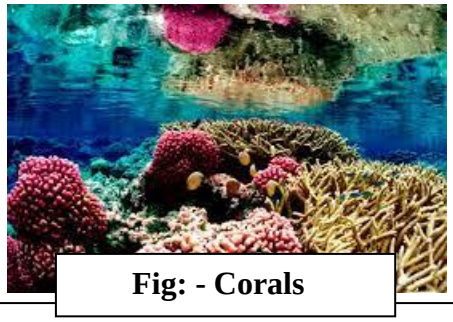

Fig: - Corals

Types of species:

1. Endemic
2. Extinct
3. Endangered
4. Rare
5. Exotic

1. Endemic species:

- Native to a particular place. E.g.: Asiatic Lion, Red Panda
- Endemic species are those plants/animals unique to a defined geographic location, such as an island, nation, or a defined zone or habitat type.
- Areas containing endemic species are often isolated in some way preventing easy spread of species to other areas
- E.g., Islands in Hawaii, New Zealand and southern tip of Africa contain almost 90% endemic species
- Due to the geographic restrictions of such species, endemic species are often endangered

2. Extinct species:

- Species where the last remaining member of the species has died, or is presumed beyond reasonable doubt to have died.
- If not seen for 50 years. Used for species which are no longer known to exist in the world. E.g.: Dinasour, Dodo, Himalayan Quail, Indian Cheetah Extinction of an animal or plant occurs when no more individuals of that species are alive anywhere in the world.
- This is a natural part of evolution, but certain extinctions happen at a much faster rate.

- E.g., the end of the Cretaceous period 65 million years ago saw a mass extinction that caused the death of several plants and animals, including dinosaurs.
- Why this extinction happens so fast. Human interference in the form of hunting, over-exploitation and habitat destruction is also causing rapid extinction.

3. Endangered/vulnerable species:

- Endangered or threatened species is one that is considered at the risk of extinction.
- A species can be listed as endangered at the state, national or international level.
- We can save those species if we identify them in the early stage.

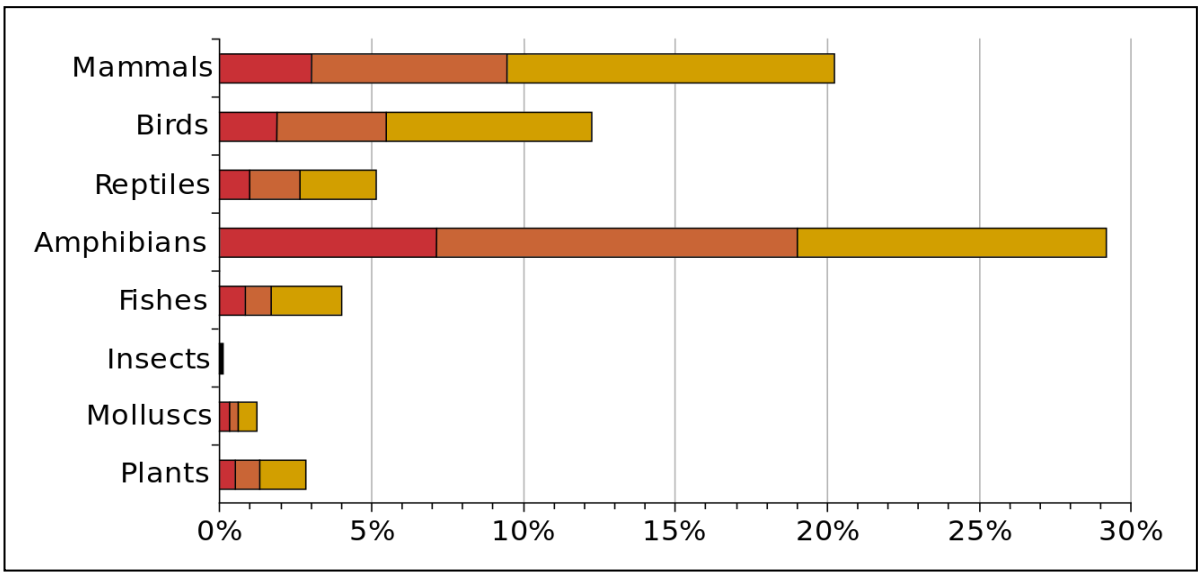

Fig: - Endangered species

4. Rare species:

- Species with small world populations that are not at present endangered or vulnerable but are at risk. E.g.: Sparrows, black buck.
- This is distinct from the term endangered or threatened. Rare species are a group of organisms that are uncommon, scarce or infrequently encountered.
- They are normally species with small populations, and several move into the endangered category if negative factors operate against them

5. Exotic species:

- Non- native species which have been moved by human being from their native place to non-native environment. E.g.: Orchids, Cacti.
- Exotic species are a group of organisms that are non-native, moved into the particular area by humans from their native environment.
- E.g., orchids, cacti, caged animals in zoos, etc.

Fig: - Caged animal

Species interactions:

Biological interaction is the effect that a pair of organisms living together in a community have on each other. They can be of the same species (intraspecific) or different species (interspecific).

The effects may be **short-term** like pollination and predation or **long-term**, strongly influencing the evolution of the other species.

Important types of interactions:

- Predation
- Parasitism
- Competition

Predation:

- In addition to competing for food or space, species in a community may interact by predation which literally means plundering.
- Requires one organism, the predator, to kill and eat another organism, its prey.
- In most cases, both are animals, both of different species (inter-specific); but if both are of same species, (intra-specific), it is called cannibalism.
- It is a short-lived interaction, but very durable in terms of influence on the evolution of both partners, resulting in both partners co-evolving.
- predators have sharp claws or jaws to grip the prey, with other adaptations to improve hunting efficiency.

Ex: Crocodiles are some of the evolutionarily oldest and dangerous predators

The effect of predation on population has been studied theoretically and practically because it has economic implication for our own species. Predation may affect populations mainly in three ways: restricts distribution or reduces abundance affects structure of community is a major selective force, and many adaptations that we see in organisms such as mimicry or warning colouration have their explanation in predator - prey coevolutions.

2. Parasitism:

Parasitism is a relationship between species where one organism, the parasite, lives on/in another organism, the host, causing it harm, and is adapted structurally to this way of life.

Ex: A tick living on a dog is an example of parasitism. In this relationship, the tick gains a food source by drinking the dog's blood.

3. Competition:

- Competition is the interaction between organisms where the fitness of one is lowered by the presence of the other.
- Competition occurs over resources. For plants light, nutrients, and water may be important resources. Plants may compete for pollinators or for attachment sites. Water, food and mates are possible resources for animals, and they may compete for space such as nesting sites, wintering sites or places that are safe from predators. Thus, we see that resources can be complex and diverse.
- Competition is often for a resource such as water, food, territory or access to females for reproduction.
- There are two types of competitive interactions: Exploitative or scramble competition occurs when a number of organisms of same or different species utilise common resources that are in short supply.
- Interference or contest competition occurs when organisms seeking a resource will harm one another in the process even if the resource is not in short supply.
- Competition could be intra-species competition or inter-species competition.

Fig: - Inter-species competition

Fig: - Intra-species competition

- According to evolution, the species less suited to compete for resources either adapts or dies out; competition plays an important role in natural selection.

Biodiversity

Threats due to natural and anthropogenic activities

In 2014, the estimate was just over seven billion people on the earth. Human population growth is exponential. The more people you have, the more reproduction you have going on. If you have more reproduction happening, then the curve on a graph of population versus time is going to get steeper and steeper to the point where we're looking at about nine billion people by the year 2050. As the population increases, so does the need to exploit the natural resources, these factors that threaten the biodiversity.

There are 7 major anthropogenic activities that needs to be discussed.

1. **Habitat destruction**
2. **Poaching**
3. **Man-wildlife conflicts**
4. **Pollution**
5. **Species introductions**
6. **Global climactic change**
7. **Exploitation of resources**

1. Habitat destruction:

There are various reasons that lead to habitat destruction. They are:

a. Loss of habitat
b. Habitat fragmentation
c. Deforestation
d. Raw materials
e. Production of drugs and medicines

Fig: - Habitat destruction

a. Loss of habitat:

Forests and grasslands have been cleared for various reasons such as agriculture, pasturing, human settlement, developmental projects, etc. Because of this kind of activities, we are losing the habitat. Habitat refers to the area where species seek food, get shelter and reproduce. The greatest threat to wild plant and animal species is due to destruction or alteration of their habitat. If an animal's habitat is destroyed or disrupted, it must adapt to the new changes, move elsewhere or die. When it is forced out of its territory, and if it finds a suitable habitat there is a possibility that the habitat is already in use. Consequently, it must compete with the local population of the same species as well as other animals. The other option is that it must migrate into a marginal habitat where it may succumb to predation, starvation or disease. Some organisms such as pigeon, house sparrows, rodents (like rat and mice) and deer flourish in the modified habitats provided by human activities but many others do not. Some habitats are more vulnerable to species extinction, these are called fragile habitats. Coral reefs, oceanic islands and mountain tops are important fragile habitats.

b. Habitat fragmentation:

What is meant by habitat fragmentation? It is the removal of small sections of the habitat for reasons such as road construction, urbanization, agriculture, resulting in the division of forests into smaller fragments. This kind of activity will affect the biodiversity.

Habitat fragmentation is commonly defined as "the process whereby a large, continuous habitat is both reduced in area and divided into two or more fragments".

Fragmentation often refers to an extreme reduction in habitat area, but it can also occur when an area is reduced only by a small degree when the original habitat is divided by roads, railroads, power lines, fences, or other barriers obstructing the free movement of species. There are two ways in which the fragments differ from the original habitat – first, fragments have a greater amount of edge for the area of habitat; second, the centre of each habitat fragment is closer to an edge.

Fig: - Habitat fragmentation

In terrestrial and inland water ecosystems, human activities often lead to the fragmentation of habitats. Habitat fragmentation may speed up the decline of a population and push it to extinction by splitting an existing widespread population into two or more subpopulations, each in a restricted area. The smaller populations often experience various problems associated with their small size like inbreeding depression and genetic drift. Even though a larger area would be able to support a large population, sometimes the smaller fragments of these areas are unable to support smaller groups, which may normally be able to persist for a long period of time. Some animals such as bears and tigers need larger territories, and cannot survive when their habitat is fragmented into smaller sections.

c. Deforestation:

It is a direct cause of extinction and biodiversity. Around 18 million acres of forest are lost every year due to logging and other human practices. Deforestation is happening due to cutting trees for timber, removal of medicinal plants, dam constructions, etc. Deforestation can directly lead to biodiversity loss when animal species that live in the trees no longer have their habitat, cannot relocate, and therefore become extinct. Deforestation can lead certain tree species to permanently disappear, which affects biodiversity of plant species in an environment.

d. Raw materials:

Biodiversity contributes directly or indirectly to many aspects of human well-being, for instance by providing raw materials and contributing to health. Over the past century, many people have benefited from the conversion of natural ecosystems to agricultural land and from

the exploitation of biodiversity. Wild plants used as raw materials for the production of hybrid seeds as a result of which plant species become endangered.

e. Production of drugs:

Biodiversity plays vital roles in maintaining human and animal health. A wide variety of plants, animals and fungi are used as medicine, essential vitamins, painkillers etc. Natural products have been recognized and used as medicines by ancient cultures all around the world. Many animals are also known to self-medicate using plants and other materials available to them. More than 60% of the world population depend on almost entirely on the plant medicine for primary health care. About 119 pure chemicals are extracted from less than 90 species of higher plants and used as medicines throughout the world, for example, caffeine, methyl salicylate and quinine. Wild plants are used for production of drugs; therefore, several medicinal plants become extinct.

2. Poaching:

Poaching, in law, the illegal shooting, trapping, or taking of game, fish, or plants from private property or from a place where such practices are specially reserved or forbidden. Poaching is a major existential threat to numerous wild organisms worldwide and is an important contributor to biodiversity loss.

The hunting and export of excessive numbers of certain animal species is another important factor leading to dangerous reductions in numbers. There are three main types of hunting:

i) Commercial hunting – in which the animals are killed for profit from sale of their furs, bones or other parts;

ii) Subsistence hunting – the killing of animals to provide food for survival; and

iii) Sport hunting – the killing of animals for recreation. Although subsistence hunting was once a major cause of extinction of some species, it has now declined sharply in most areas. Sport hunting is now closely regulated in most countries; species are endangered only when protective regulation does not exist or are not enforced.

What is the main reason for poaching and killing/hunting of animals?

- Illegal trade of wild-life.
- Despite bans, animals are killed for furs, horns, tusks, skins (crocodile).
- Live specimens are smuggled.
- Existence poaching: Killing animals for food.
- Commercial poaching, hunting & killing animals to sell their products.

3. Man-wildlife conflicts

Fig: - Man-wildlife conflicts

Humans have taken care of the living beings which are useful to them through extensive breeding programmes, to derive maximum benefit of their products. During the process, the species have lost certain useful characteristics so much so that these forms cannot survive on their own in nature. A very good example is corn, which is pampered so much by human that if it is left on its own, it cannot survive.

Today human has large herds of domestic animals. These animals can also play a significant part in the reduction of animal populations by overgrazing the land, thus destroying the vegetation on which both they and the wild animals depend. The native wildlife of a particular area is capable of utilising the native plant life much more efficiently than introduced domestic cattle, and is thus much less likely to convert fertile areas into deserts.

The other important parameter is that the domestic cattle are carriers of several diseases which they can transmit to wild animals. For example, the steady rehabilitation of the Great Indian Rhinoceros was seriously hampered by the rinderpest disease which they contracted from the local domestic cattle

They arise when wildlife starts causing immense damage and danger to the man. During such conditions, it becomes very difficult for the forest department to compromise the affected villagers & gain village support for wild life conservations.

E.g.: In, Orissa, Sambalpur village 200 humans killed by elephants. In revenge the villagers killed 100 elephants

How to control this man-wildlife conflicts:

- Tiger conservation projects: Making available tranquilizers guns, binoculars and radiosets, etc., to deal with danger.
- Solar powered fencing instead of electric.
- Cropping near forests should be prevented.
- Sufficient food should be made available for animals within the forest.
- Wild animal hunting rituals should be stopped.

4. Pollution:

Fig: - Pollution

All forms of pollution pose a serious threat to biodiversity, but in particular nutrient loading, primarily of nitrogen and phosphorus, which is a major and increasing cause of biodiversity loss and ecosystem dysfunction.

Burning of fossil fuels that releases harmful chemicals, depleting the ozone layer, excessive waste production

disrupts, fragments, and degrades the ecosystem. Eutrophication, the process of accumulation of nutrients, including nitrogen, in water bodies, often results in water pollution. Nutrient overloads in aquatic ecosystems can cause algal blooms and ultimately a loss of dissolved oxygen, and of life. As ecosystems are impacted, so is the biological diversity.

5. Species introductions:

Introduction of non-native, predatory species that compete for resources can threaten endemic wildlife. Invasive alien species are animals, plants, fungi and microorganisms that entered and established in the environment from outside of their natural habitat. They reproduce rapidly, out-compete native species for food, water and space, and are one of the main causes of global biodiversity loss. For example, Western honey bee, brown rat.

6. Global climactic change:

Climate change caused by global warming represents one of the most serious threats to biodiversity. The high levels of carbon dioxide are likely to cause more extreme weather events like cyclones, hurricanes and droughts. It can also lead to warmer and shorter winters as well as unpredictable monsoons.

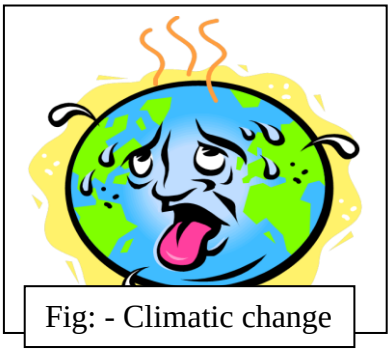

Fig: - Climatic change

The changed atmospheric conditions that result from global warming could create greater numbers of intense storms and prolonged droughts. On the other hand, the expected speed of climate changes coupled with direct loss of natural habitat may prevent some species from adapting quickly enough. They are likely to become extinct, locally or more broadly, and their roles in natural systems will be lost forever.

Rapid artificial climate change does not allow ecosystems and species to adapt. Rising ocean temperatures, diminishing Arctic Sea ice, can affect rising ocean temperatures, affecting marine biodiversity and shift vegetation zones. Rising temperatures are likely to result in widespread ecological change. Many animal and plant species are likely to become extinct as ecosystems adjust to climate change. While adaptable species will survive, the others migrate, the end result will be a lost biodiversity.

7. Exploitation of resources

The unsustainable use of natural resources and overexploitation, which occurs when harvesting exceeds reproduction of wild plant and animal species, continues to be a major threat to biodiversity. Over-hunting, over-fishing, over-harvesting, poaching, and other forms of hunting for profit contribute greatly to loss of biodiversity and death of numerous species.

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