ENVIRONMENTAL SCIENCES AND SUSTAINABILITY

UNIT - I ENVIRONMENT AND BIODIVERSITY

Definition, scope and importance of environment – need for public awareness. Eco-system and Energy flow– ecological succession. Introduction to biodiversity: genetic, species and ecosystem diversity– values of biodiversity, threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts – endangered and endemic species of India – conservation of biodiversity: In-situ and ex-situ.

INTRODUCTION

What's the use of a beautiful house if you don't have a decent planet to put it on?

Environment belongs to all and is thus important for all. Whatever be the occupation or age of a person, he or she will be affected by environment and will also affect the environment by his or her deeds. Thus, environment is one subject that is actually global in nature. For example,

- Atmosphere has no boundaries and the pollutants produced at one place can be dispersed and transported to another place.
- The river water polluted by industrial or municipal discharge at one point would seriously affect the downstream aquatic life.
- Damage to the forests in a hilly region will have far reaching effect not only on the hills but also on the plains.

This is because environment is a closely and intricately woven network of components and functions. Environmental studies is very important since it deals with the most mundane issues like

1. Safe and clean drinking water,
2. Hygienic living conditions,
3. Clean and fresh air,
4. Fertile land,
5. Healthy food and
6. Development that is sustainable.

There is a need for trained manpower at every level to deal with environmental issues. Environmental law, business administration and environmental engineering are emerging as new career opportunities for environmental protection and management.

Environment:

Descending from the Middle French preposition *environ* "around," *environment*, in its most basic meaning, is "that which surrounds."

When preceded by *the*, it usually refers to the natural world ("please don't litter if you care about *the environment")*

Environment is sum total of water, air and land, inter-relationships among themselves and also with the human beings, other living organisms and property.

Thus, in order to study environment one needs input/information about Biotic and Abiotic components and their interaction.

Mathematics, Statistics and Computer Science serve as effective tools in environmental modeling and management.

Scope:

1. Natural Resources - their conservation and management
2. Ecology and biodiversity
3. Environmental pollution and control
4. Social issues in relation to development and environment
5. Human population and environment

Need for Public Awareness:

Any government at its own level cannot achieve the goals of sustainable development until the public has a participatory role in it. Public participation is possible only when the public is aware about the ecological and environmental issues

- Littering of polythene
- Stubble burning

The public has to be educated about the fact that if we are degrading our environment we are actually harming our ownselves.

It is all the more important to educate the people that some- times the adverse impact of environment are not experienced or noticed until a threshold is crossed.

Ecosystem

Ecology deals with the study of organisms in their natural home interacting with their surroundings. The surroundings or environment consists of other living organisms (biotic) and physical (abiotic) components.

An **ecosystem** is a group of biotic communities of species interacting with one another and with their non-living environment exchanging energy and matter.

In other words, an ecosystem is a chain of interactions between organisms and their environment. The term "Ecosystem" was first coined by A.G.Tansley, an English botanist, in 1935.

Now ecology is often defined as the study of ecosystems.

The ecosystem is thus, a unit or a system which is composed of a number of subunits that are all directly or indirectly linked with each other. They may be freely exchanging energy and matter from outside an open ecosystem or may be isolated from outside a closed ecosystem.

Ecosystem Characteristics

Ecosystems show large variations in their size, structure, composition etc. However, all the ecosystems are characterized by certain basic structural and functional features which are common.

An ecosystem is a structural and functional unit of ecology where the living organisms interact with each other and the surrounding environment.

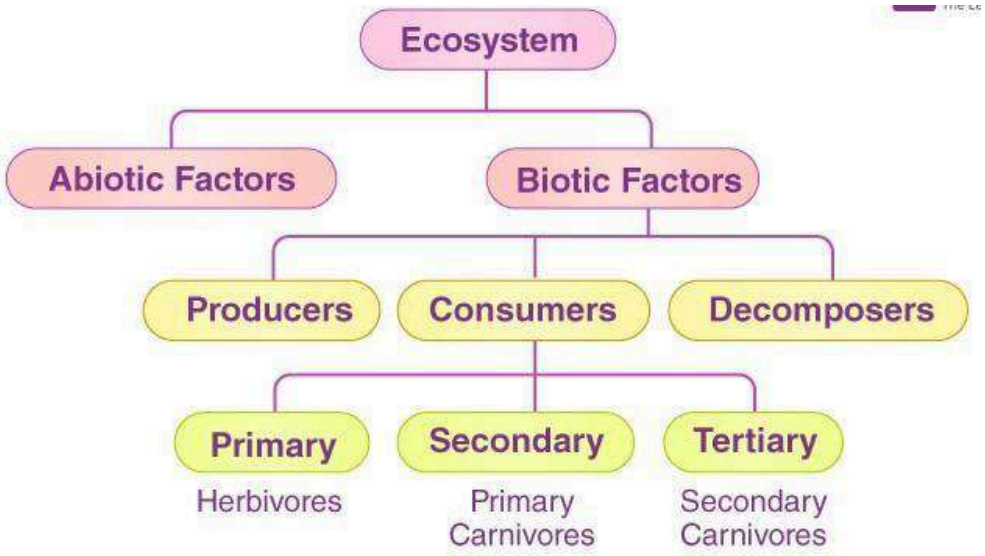
Structure of the Ecosystem

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

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

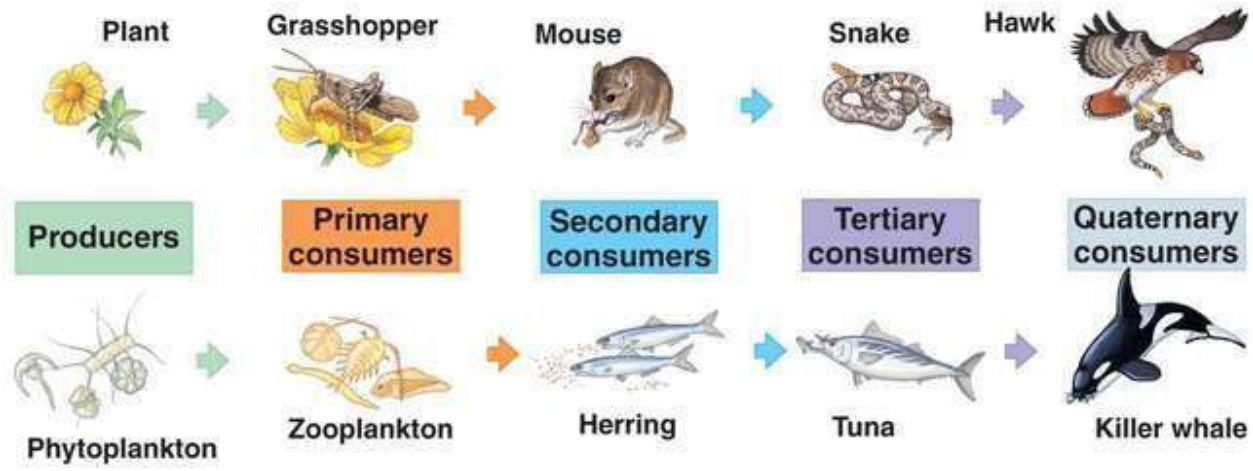
- Biotic Components
- Abiotic Components

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



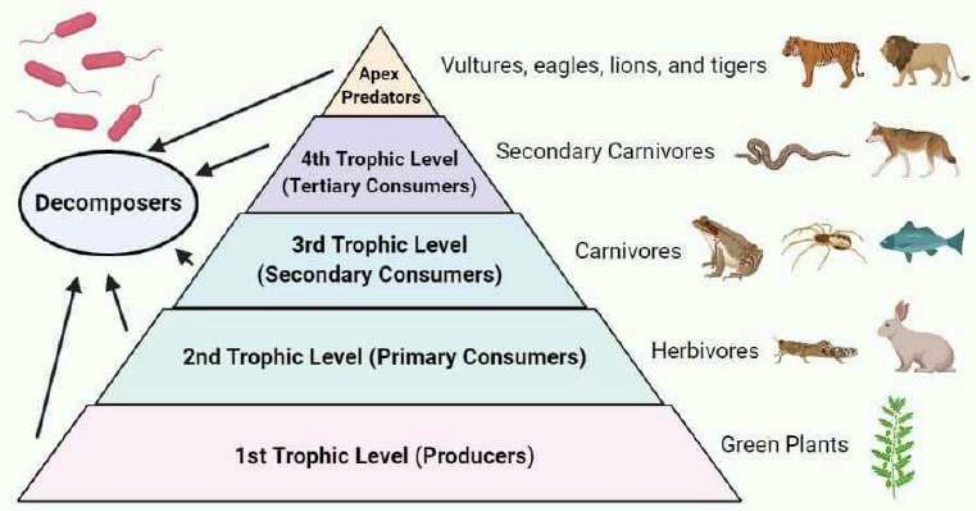
Biotic Components

Biotic components refer to all living components in an ecosystem. Based on nutrition, biotic components can be categorized into autotrophs (auto=self, troph=food), heterotrophs and saprotrophs (or decomposers).



- **Producers** They are mainly the green plants, which can synthesize their food themselves by making use of carbon dioxide, water and sunlight through the process of photosynthesis. Consequently, all other organisms higher up on the food chain rely on producers for food.
- **Consumers** or **heterotrophs** are organisms that depend on other organisms for food. Consumers are further classified into primary consumers, secondary consumers and tertiary consumers.
    - ***Primary consumers*** (plant eaters) are always **herbivores** as they rely on producers for food.
    - ***Secondary consumers*** depend on primary consumers for energy. They can either be **carnivores or omnivores.**
    - ***Tertiary consumers*** are organisms that depend on secondary consumers for food. Tertiary consumers can also be carnivores or omnivores.
    - ***Quaternary consumers*** are present in some food chains. These organisms prey on tertiary consumers for energy. Furthermore, they are usually at the top of a food chain as they have no natural predators.
- **Decomposers** include saprophytes such as fungi and bacteria. They directly thrive on the dead and decaying organic matter. Decomposers are essential for the ecosystem as they help in recycling nutrients to be reused by plants.

The trophic level of an organism is the number of steps it is from the point when the food chain begins. A food chain begins at trophic level 1 which involves primary producers. Then it moves on to level 2 which consists of the herbivorous. From then on, the food chain continues to level 3 of the carnivorous organisms. Finally, the food chain ends at level 4 or 5 with the apex predators.



(The Trophic level Diagram) Abiotic Components (non-living component of an ecosystem)

The physical and chemical components of an ecosystem constitute its abiotic structure. It includes air, water, soil, minerals, sunlight, temperature, nutrients, wind, altitude, turbidity, etc. All the biotic components of an ecosystem are influenced by the abiotic components and vice versa.

Abiotic components are sub divided into three categories

1. Atmosphere:

The cover of air that envelopes the earth is known as the atmosphere. The atmosphere extends up to 500 kms from the earth surface. It is essential for all living organism and atmosphere comprises 78% of nitrogen, 21% of oxygen and 1% of other gases.

2. Lithosphere:

The soil and rock components of the earth is called lithosphere. Functions:

1. Home for human beings and wildlife.
2. Store house of minerals and organic matters.

3. Hydrosphere:

The portion of the earth which is surrounded by water is called hydrosphere. Ocean, lakes, rivers and water vapour constitute hydrosphere. Out of 100% only 3% of water is available as fresh water remaining 97% of water is in Ocean.

Functions:

1. Used for drinking purpose and supports the aquatic life
2. Used for irrigation, power production, industries and transport.

Functions of Ecosystem

Every ecosystem performs under natural conditions in a systematic way. It receives energy from the sun and passes it on through various biotic components and in fact, all life depends upon this flow of energy. Besides energy, various nutrients and water are also required for life processes which are exchanged by the biotic components within themselves and with their abiotic components within or outside the ecosystem. So the functional units of an ecosystem or functional components that work together in an ecosystem are:

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

Types of Ecosystem

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

- Terrestrial Ecosystem
- Aquatic Ecosystem

Terrestrial Ecosystem

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

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

Forest Ecosystem

A forest ecosystem consists of several plants, particularly trees, animals and microorganisms that live in coordination with the abiotic factors of the environment. Forests help in maintaining the temperature of the earth and are the major carbon sink. In a forest ecosystem, big trees are the producers, which are less in number and hence form a narrow base. A larger number of herbivores including birds, insects and several species of animals feed upon the trees (on leaves, fruits, flowers, bark etc.) and form a much broader middle level. The secondary consumers like fox, snakes, lizards etc. are less in number than herbivores while top carnivores like lion, tiger etc. are still smaller in number. So the pyramid is narrow on both sides and broader in the middle

Grassland Ecosystem

In a grassland ecosystem, the vegetation is dominated by grasses and herbs. Temperate grasslands and tropical or savanna grasslands are examples of grassland ecosystems. Grassland ecosystem shows an upright pyramid of numbers. The producers in the grasslands are grasses which are small in size and very large in number. So the producers form a broad base. The herbivores in a grassland are insects while tertiary carnivores are hawks or other birds which are gradually less and less in number and hence the pyramid apex becomes gradually narrower forming an upright pyramid.

Tundra Ecosystem

Tundra ecosystems are devoid of trees and are found in cold climates or where rainfall is scarce. These are covered with snow for most of the year. Tundra type of ecosystem is found in the Arctic or mountain tops. Tundra lands are covered with snow for much of the year, but summer brings bursts of wildflowers. The Arctic tundra, where the average temperature is -34 to -6 degrees Celsius (-30 to 20 degrees Fahrenheit), supports a variety of animal species, including Arctic foxes (*Vulpes lagopus*), polar bears (*Ursus maritimus*), gray wolves (*Canis lupus*). The summer growing season is just 50 to 60 days, when the sun shines up to 24 hours a day.

Desert Ecosystem

Deserts are found throughout the world. These are regions with high evaporation, little rainfall and scarce vegetation. The days are hot, and the nights are cold. The precipitation is less than 25 cm per year. Deserts have little species diversity and consist of drought resistant or drought avoiding plants. Desert plants and animals are having most typical adaptations for conservation of water. Desert animals like insects and reptiles have thick outer coverings to minimize loss of water. They usually live inside burrows where humidity is better and heat is less. Desert soil is rich in nutrients but deficient in water.

Aquatic Ecosystem

Aquatic ecosystems dealing with water bodies and the biotic communities present in them are either freshwater or marine. Freshwater ecosystems are further of standing type (lentic) like ponds and lakes or free-flowing type (lotic), like rivers.

Freshwater Ecosystem

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

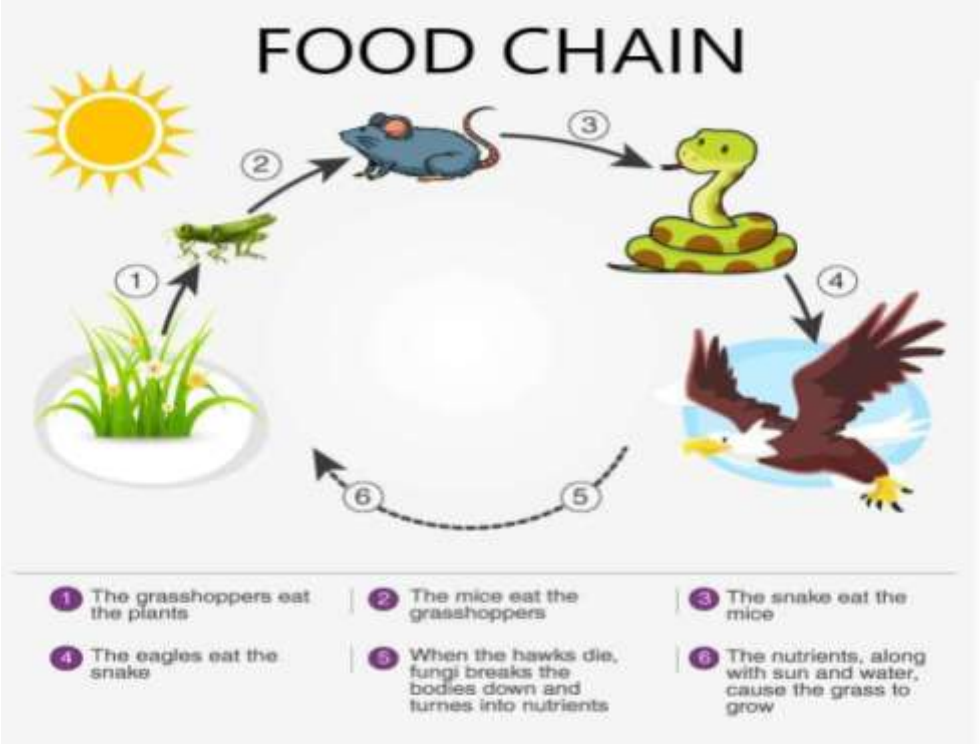
Marine Ecosystem

The marine ecosystem includes seas and oceans. These have a more substantial salt content and greater biodiversity in comparison to the freshwater ecosystem. Oceans provide us iron, phosphorus, magnesium, oil, natural gas, sand and gravel. Oceans are the major sinks of carbon dioxide and play an important role in regulating many biogeochemical cycles and hydrological cycle, thereby regulating the earth's climate.

What is Ecosystem? | Different Types of Ecosystem | Environmental Science | EVS | Letstute - YouTube

Food Chains

All organisms, living or dead, are potential food for some other organism and thus, there is essentially no waste in the functioning of a natural ecosystem. A caterpillar eats a plant leaf, a rat eats the caterpillar, a snake eats the rat, an eagle eats the snake and when they all die, they are all consumed by microorganisms like bacteria or fungi (decomposers) which break down the organic matter and convert it into simple inorganic substances that can again be used by the plants- the primary producers.



Continuous line ( ) – Energy flow (unidirectional)

Dashed line (——) – Nutrient cycle (cyclic process)

Food Web:

Food web is a network of food chains where different types of organisms are connected at different trophic levels, so that there are a number of options of eating and being eaten at each trophic level. A more realistic representation of who eats whom is called a food web. Food web shows how many food chains are connected to each other.

Difference Between Food Chain And Food Web	
Food Chain	**Food Web**
A linear pathway showing the flow of energy	A multitude of networks showing the flow of energy
An organism of higher level trophic feeds on a specific organism of lower trophic level	An organism of a higher trophic level has access to more members of a lower trophic level.
Does not affect the adaptability and competitiveness of organisms.	It has a role in improving the adaptability and competitiveness of an organism.

Ecology: the scientific study of the processes influencing natural life and habitats.

Ecosystem: a natural environment which includes the flora (plants) and fauna (animals) that live and interact within that environment.

Biodiversity: the variety of natural life and habitats on Earth.

ENERGY FLOW IN AN ECOSYSTEM

Flow of energy in an ecosystem takes place through the food chain and it is this energy flow which keeps the ecosystem going. The most important feature of this energy flow is that it is unidirectional or one - way flow. Energy flows from the lowest trophic level (primary producers) to the top (apex predators).

Energy "flows" through the ecosystem in the form of carbon-carbon bonds. When respiration occurs, the carbon-carbon bonds are broken and the carbon is combined with oxygen to form carbon dioxide. This process releases the energy, which is either used by the organism (to move its muscles, digest food, excrete wastes, think, etc.) or the energy may be lost as heat.

All energy comes from the sun, and the ultimate fate of all energy in ecosystems is to be lost as heat. Energy does not recycle.

The flow of energy follows the two laws of Thermodynamics:

Ist law of Thermodynamics states that energy can neither be created nor be destroyed but it can be transformed from one form to another. The solar energy captured by the green plants (producers) gets converted into biochemical energy of plants and later into that of consumers.

IInd law of Thermodynamics states that energy dissipates as it is used or in other words, its gets converted from a more concentrated to dispersed form. As energy flows through the food chain, there occurs dissipation of energy at every trophic level. The loss of energy takes place through respiration, loss of energy in locomotion, running, hunting and other activities. At every level there is about 90% loss of energy and the energy transferred from one trophic level to the other is only about 10%.

ENERGY FLOW | TAMIL | ECOSYSTEM | STD 12 - YouTube

Energy flow models: The flow of energy through various trophic levels in an ecosystem can be explained with the help of various energy flow models.

CHARACTERISTICS of ENERGY FLOW

- **UNIDIRECTIONAL FLOW OF ENERGY:** The most important characteristic is the one-way street along which energy flows. The energy that is captured by the autotrophs does not revert back to solar input; that which passes to the herbivores does not pass back to the autotrophs; and so on.
- **PROGRESSIVE DECREASE IN ENERGY:** In each trophic level there is progressive decrease in energy. This is because at the time of energy transfer from one trophic level to

the other a substantial amount of energy is lost as it is dissipated as heat during metabolic activity.

- ➢ **RESPIRATORY LOSS HIGH IN HIGHER TROPHIC LEVELS:** Respiratory loss gets higher and higher in higher trophic levels due to carnivores greater locomotory activity.
- ➢ **HIGHER EFFICIENCY OF ASSIMILATION AT HIGHER TRPHIC LEVEL:** In the higher trophic levels there is greater efficiency of energy assimilation.
- ➢ **UNUTILISED ENERGY:** In all ecosystems, despite the utilization of energy in various metabolisms by different organisms, large amount of energy always remains in the system as standing crop. This indicates that the ecosystem is under grazed.
- ➢ Energy flow in an ecosystem follows the first and second laws of thermodynamics. The energy flow through any trophic level equals the total assimilation at that level, which in turn, equals the production of biomass plus respiratory loss.

MODELS OF ENERGY FLOW

There are basically three types of energy flow models:

- ❖ **SINGLE CHANNEL ENERGY FLOW MODEL**
- ❖ **Y-SHAPED/ TWO-CHANNEL ENERGY FLOW MODEL**
- ❖ **UNIVERSAL MODEL.**

(I) SINGLE CHANNEL ENERGY FLOW MODEL

The single or linear channel energy flow model is one of the first published models pioneered by H. T. Odum in 1956. As can be seen in Fig. 4.4, this model depicts a community boundary and, in addition to light and heat flows, it also includes import, export and storage of organic matter.

Decomposer organisms are placed in a separate box as a means of partially separating the grazing and detritus food chains. Decomposers are actually a mixed group in terms of energy levels and their importance in this energy flow model is overlooked. This model will suffice as long as only the imports and exports are considered.

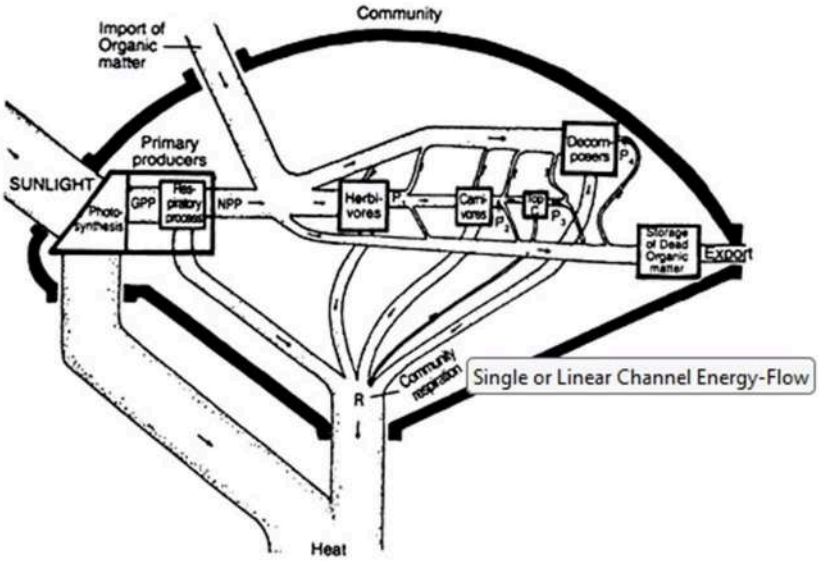


Fig. 4.4 : Single or linear channel energy-flow diagram (P_1, P_2, P_3 and P_4 – secondary production of the indicated level (H. T. Odum, 1956)

BOX-PIPE MODEL:

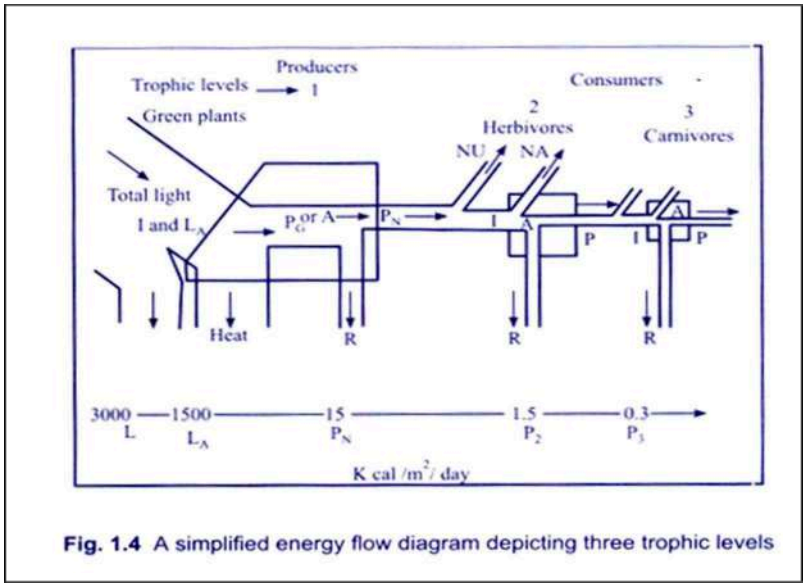


Fig. 1.4 A simplified energy flow diagram depicting three trophic levels

- Box-pipe energy flow model is a very simplified energy flow model of three trophic levels; it was suggested by
  E.P. Odum in 1953. In such single-channel energy flow model, "boxes" represent the trophic levels (i.e., population mass or biomass) and the "pipes" depict the energy flow in and out of each level.
- Energy inflows balance outflows as required by the first law of thermodynamics, and energy transfer is accompanied by dispersion of
  energy into unavailable heat (i.e., respiration) as required by the second law.
- From this model it also becomes evident that the energy flow is greatly reduced at each successive trophic level from predators to herbivores and then to carnivores.
- At each transfer of energy from one level to another major part of energy is lost as heat or other form. A closer examination of the diagram reveals that all the energy available to a trophic level is not consumed but a good portion of its left unutilized.

Thus, of the 3000 Kcal of total light falling upon the green plants, approximately 50% (1500 Kcal) is absorbed, of which only 1% (15 Kcal) is converted at first trophic level. Hence net primary production is merely 15 Kcal. Secondary productivity (P_2 and P_3 in fig) tends to be about 10% at successive consumer trophic levels,(i.e., herbivores and carnivores) although efficiency may be sometimes higher, as 20%, at the carnivore level as shown (or P3=0.3 Kcal) in the diagram.

It becomes evident from Figures 1.3 and 1.4 that there is a successive reduction in energy flow at successive trophic levels. Thus shorter the food chain, greater would be the available food energy as with an increase in the length of food chain there is a corresponding more loss of energy.

(II) Y-SHAPED/ TWO-CHANNEL ENERGY FLOW MODEL

- The Y-shaped model further indicates that the two food chains namely the grazing food chain and detritus food chain are in fact, under natural conditions, not completely isolated from one another. The grazing food chain beginning with green plant base going to herbivores and the detritus food chain beginning with dead organic matter acted by microbes, then passing to detrivores and their consumers.
- For instance, dead bodies of small animals that were once part of the grazing food chain become incorporated in the detritus food chain as do the feces of grazing food animals. Functionally, the distinction between the two is of time lag between the direct consumption of living plants and ultimate utilization of dead organic matter. The importance of the two food chains may differ in different ecosystems, in some grazing is more important, in others detritus is major pathway.

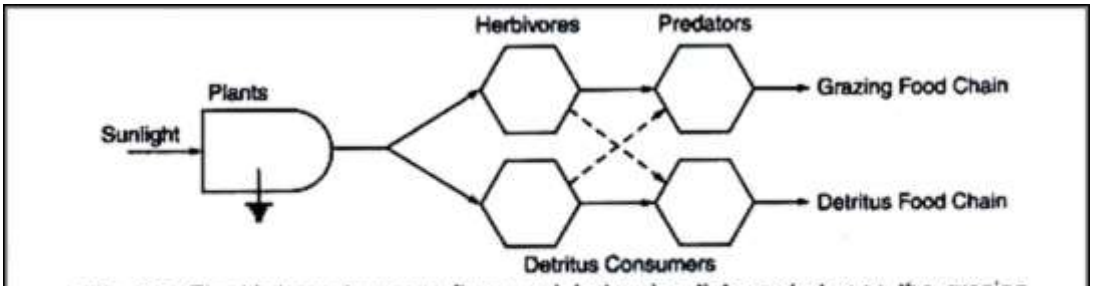


Fig. 3.2. The Y-shaped energy flow model showing linkage between the grazing and detritus food chains

The important point in Y-shaped model is that the two food chains are not isolated from each other. This Y- shaped model is more realistic and practical working model than the single-channel model because,

- ✓ It confirms to stratified structure of ecosystems,
- ✓ It separates the grazing and detritus chains (direct consumption of living plants and utilization of dead organic matter respectively) in both time and space, and

- ✓ That the micro-consumers (absorptive bacteria, fungi) and the macro-consumers (phagotrophic animals) differ greatly size-metabolism relations. (E.P. Odum. 1983).

It must however, be remembered that these models depict the basic pattern of energy flow in ecosystem. In practice, under natural conditions, the organisms are interrelated in a way that several food chains become interlocked results into a complex food web. We have already referred to food webs in grassland and in pond ecosystems. The complexity of food web depends on the length of the food chains.

Thus in nature there operates multi-channel energy flows, but in these the channels belong to either of the two basic food chains i.e., will be either a grazing or a detritus food chain. Interlocking pattern of such several chains in food web of an ecosystem would lead to a multi-channel flow of energy. Thus in practice, under field conditions, we might face difficulties in measuring energetic of ecosystem.

(III) UNIVERSAL MODEL

The universal model is applicable to any living component, which may be plant, animal, microorganism, individual, population or trophic group (E. P. Odum 1968).

The shaded box represents the living, standing crop biomass of the component which should be expressed in calories, so that its relation with rates of energy flow can be established. The total energy input or intake or ingestion varies. For strict autotrophs, it is light, while, for strict heterotrophs, it is organic food.

A key feature of the model is the separation of assimilated energy (A) into the production (P) and respiration ® components. R is the energy that is lost as heat (maintenance energy) and P is the portion transformed to new or different organic matter and is the part that is available to the next trophic level. At the same time, the non-assimilated component (NU-not utilized), such as faeces, enters the detritus food chain. P component is energy that is available to the next trophic level while NU component is energy that is still available at the same trophic level.

This model can be used in two ways:

- ➢ It can represent a species population in which case the appropriate energy inputs and links with other species would be shown as a conventional species oriented food-web diagram, or
- ➢ The model can represent a discrete energy level in which case the biomass and energy channels represent all or parts of many populations supported by same energy source.

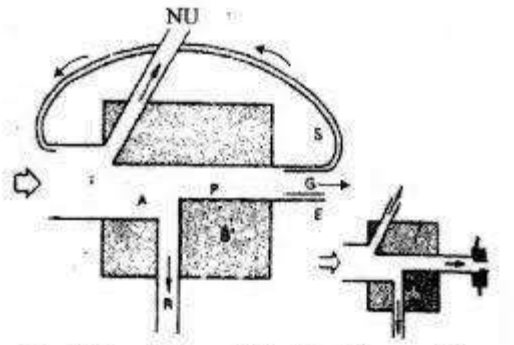


Fig. 40.11 : Universal Model of Energy Flow

ECOLOGICAL SUCCESSION

Ecological succession is the process by which natural communities replace (or "succeed") one another over time. For example, when an old farm field in the midwestern U.S. is abandoned and left alone for many years, it gradually becomes a meadow, then a few bushes grow, and eventually, trees completely fill in the field, producing a forest.

Each plant community creates conditions that subsequently allow different plant communities to thrive. For example, early colonizers like grasses might add nutrients to the soil, whereas later ones like shrubs and trees might create cover and shade. Succession stops temporarily when a "climax" community forms; such communities remain in relative equilibrium until a disturbance restarts the succession process.

The whole sequence of communities which are transitory are known as **Seral stages or seres** whereas the community establishing first of all in the area is called a **pioneer community.**

Ecological successions starting on different types of areas or substrata are named differently as follows:
(i) Hydrarch or Hydrosere: Starting in watery area like pond, swamp, bog
(ii) Mesarch: starting in an area of adequate moisture.
(iii) Xerarch or Xerosere: Starting in a dry area with little moisture.
(iv) Lithosere: starting on a bare rock
(v) Psammosere: starting on sand
(vi) Halosere: starting on saline soil

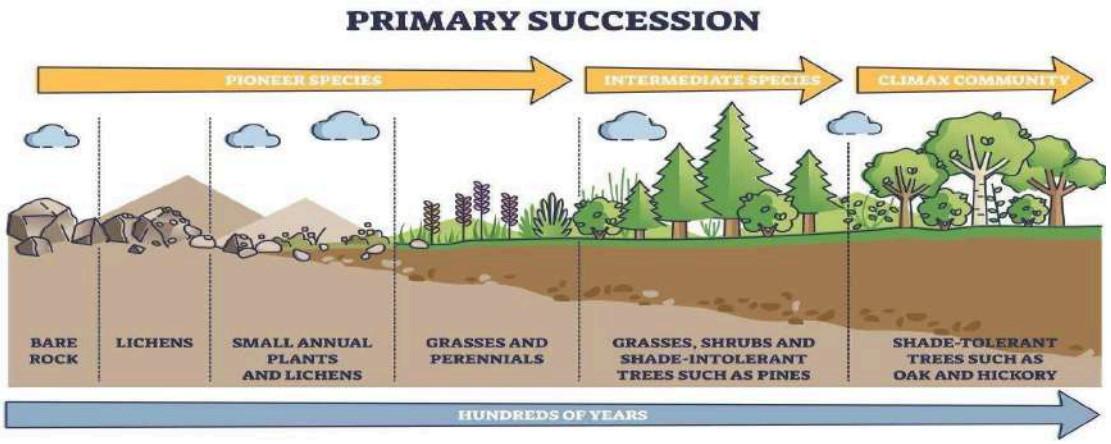
Process of Succession:
The process of succession takes place in a systematic order of sequential steps as follows:

(i) **Nudation:** It is the development of a bare area without any life form. The bare area may be caused due to landslides, volcanic eruption etc. (topographic factor), or due to drought, glaciers, frost etc. (Climatic factor), or due to overgrazing, disease outbreak, agricultural/ industrial activities (biotic factors).
(ii) **Invasion:** It is the successful establishment of one or more species on a bare area through dispersal or migration, followed by ecesis or establishment. Dispersal of the seeds, spores etc. is brought about by wind, water, insects or birds. Then the seeds germinate and grow on the land. As growth and reproduction start, these pioneer species increase in number and form groups or aggregations.
(iii) **Competition and coaction:** As the number of individuals grows there is competition, both inter-specific (between different species) and intra-specific (within the same species), for space, water and nutrition. They influence each other in a number of ways, known as coaction.
(iv) **Reaction:** The living organisms grow, use water and nutrients from the substratum, and in turn, they have a strong influence on the environment which is modified to a large extent and this is known as reaction. The modifications are very often such that they become unsuitable for the existing species and favor some new species, which replace them. Thus, reaction leads to several seral communities.
(v) **Stabilization:** The succession ultimately culminates in a more or less stable community called climax which is in equilibrium with the environment. The climax community is characterized by maximum biomass and symbiotic (mutually beneficial) linkages between organisms and are maintained quite efficiently per unit of available energy

There are two major types of ecological succession:

- ***Primary succession***
- ***Secondary succession.***

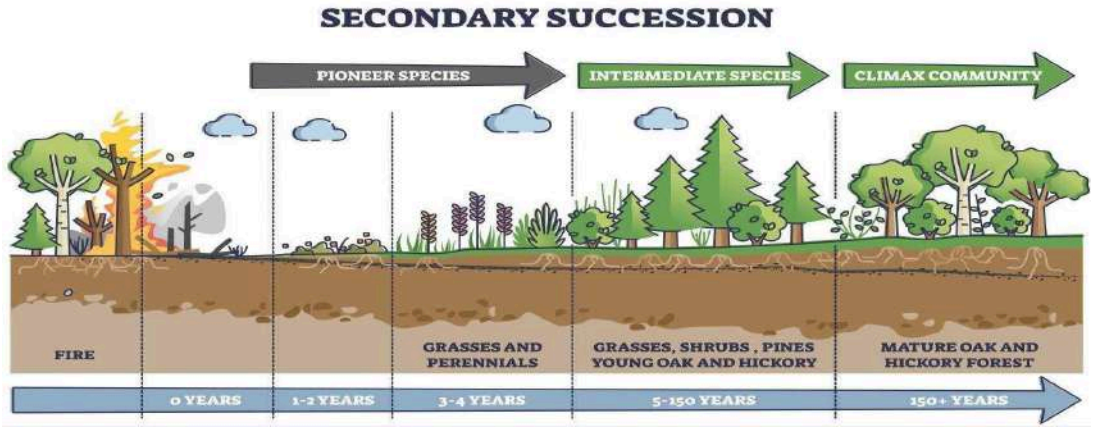
Primary succession happens when a new patch of land is created or exposed for the first time. This can happen, for example, when lava cools and creates new rocks, or when a glacier retreats and exposes rocks without any soil. During primary succession, organisms must start from scratch. First, lichens might attach themselves to rocks, and a few small plants able to live without much soil might appear. These are known as “pioneer species.”



(**Primary succession** begins when no plant life is present on the landscape, such as after a lava flow or glacial retreat. Over centuries, soil forms and deepens and successive communities of plants grow)

Gradually, the decomposition of those plants contributes to soil formation, and more and larger plants begin to colonize the area. Eventually, enough soil forms and enough nutrients become available such that a ***climax community***, like a forest, is formed. If the site is disturbed after this point, secondary succession occurs.

Secondary succession happens when a climax community or intermediate community is impacted by a disturbance. This restarts the cycle of succession, but not back to the beginning—soil and nutrients are still present.



(Secondary succession begins after a disturbance, like a fire. Crucially, some soil and nutrients remain present—fire, in fact, may help recycle those nutrients.)

For example, after a forest fire that kills all the mature trees on a particular landscape, grasses might grow, followed by shrubs and a variety of tree species, until eventually the community that existed before the fire is present again.

What is a climax community?
A climax community is the "endpoint" of succession within the context of a particular climate and geography.

What is an example of ecological succession?
Ecological succession can occur in many contexts and over many time spans.

In Hawaii and Iceland, primary succession occurs on lava flows where new land has formed; in Canada's Athabasca Dunes, it happens when new sand is deposited along a lakeshore; in the Andes, it occurs when glaciers retreat.

In many regions, secondary succession occurs where wildfires have destroyed conifer forests, or where former agricultural land is reverting to meadow or scrubland.

BIODIVERSITY

Bio – Life

Diversity - Variety

Biodiversity is all the different kinds of life you'll find in one area—the variety of animals, plants, fungi, and even microorganisms like bacteria that make up our natural world. Each of these species and organisms work together in ecosystems, like an intricate web, to maintain balance and support life. Biodiversity supports everything in nature that we need to survive: food, clean water, medicine, and shelter.

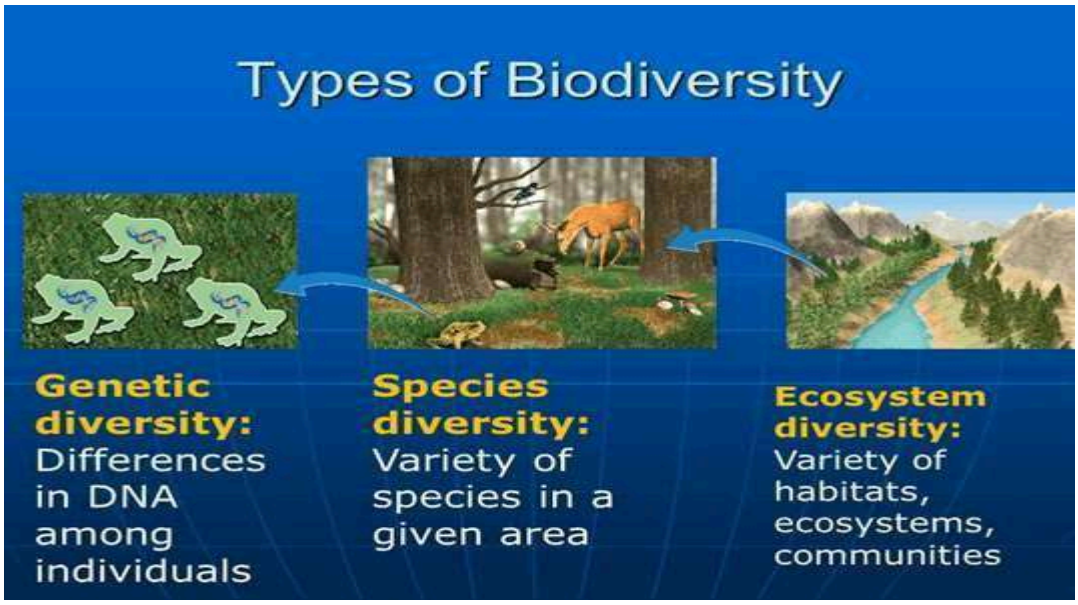
Importance of Biodiversity

Biodiversity is a crucial part of any ecosystem and plays a vital role in ecosystems' function and services. An environment rich in biodiversity is essential for supporting human life. Due to an ever-increasing population, the demand for food and energy production is also increasing, leading to a degradation, fragmentation and loss of natural habitats. With this decrease in biodiversity and degradation of ecosystems, the natural environment becomes less productive, less resilient and adaptable, and is at real risk of sustaining long term damage or collapse.

Types of Biodiversity

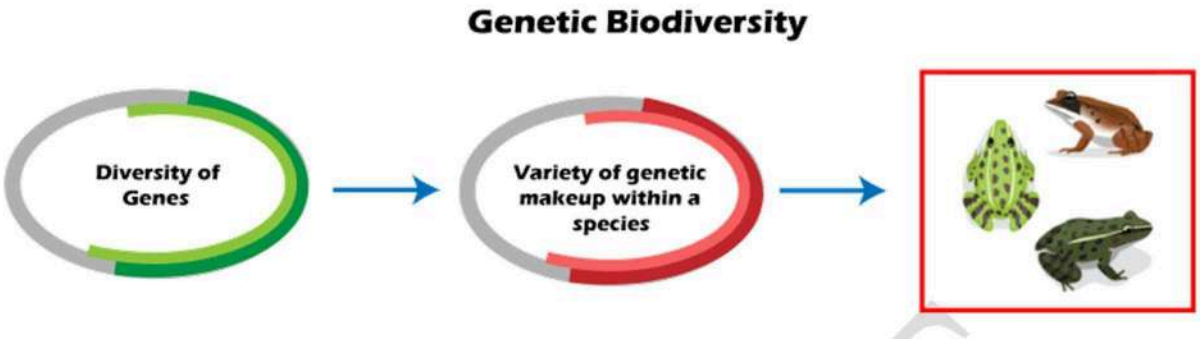
There are the following three different types of biodiversity:

- Genetic Biodiversity
- Species Biodiversity
- Ecosystem Biodiversity



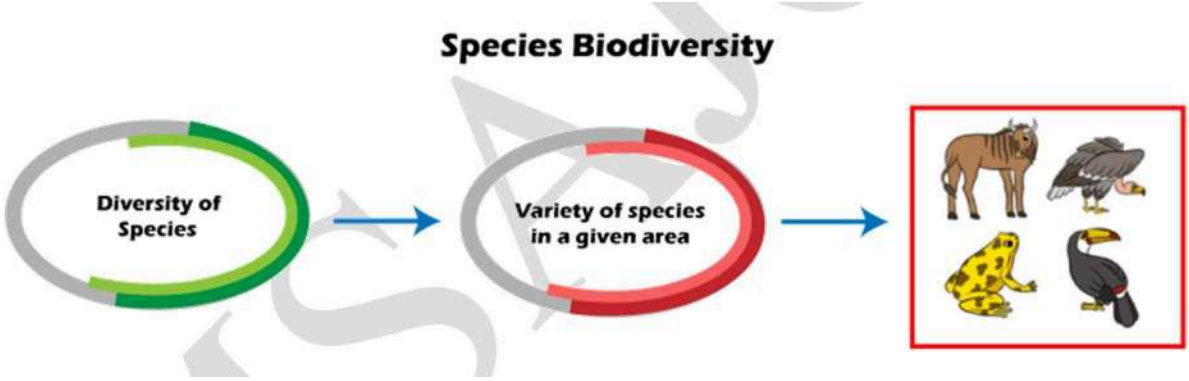
Genetic Biodiversity:

Genes are the basic units of hereditary information transmitted from one generation to other. When the genes within the same species show different versions due to new combinations, it is called genetic variability. For example, all rice varieties belong to the Genes are the basic units of hereditary information transmitted from one generation to other. That is why every human is different from another. Similarly, the species of rice, wheat, maize, barley, etc., have different varieties.



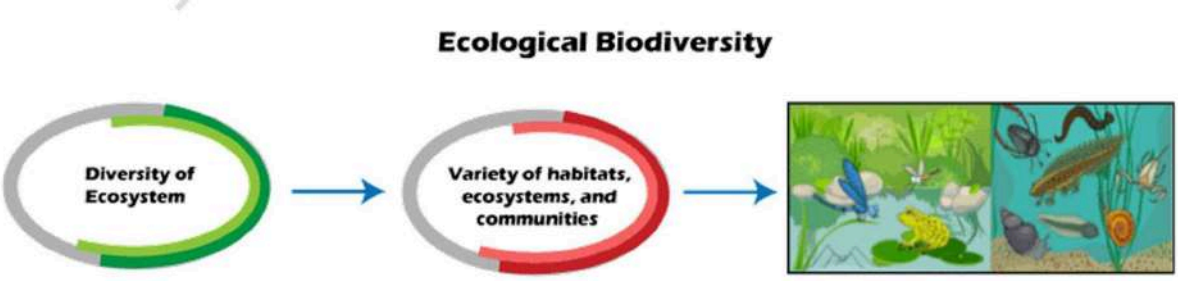
Species diversity

Species diversity refers to the variety of different types of species found in a particular area. It is the biodiversity at the most basic level. It includes all the species ranging from plants to different microorganisms. As species diversity is seen in natural and agricultural ecosystems, the total numbers of different species of plants and animals located in an area form this type of diversity. It is believed that there are about 5-10 million species in the world; however, only 1.75 million of those species have been named scientifically so far on Earth. Some areas have more species than others. Areas with more species diversity are generally referred to as 'hotspots' of diversity.



Ecological Biodiversity:

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



VALUE OF BIODIVERSITY

Biodiversity provides a variety of environmental services from its species and ecosystems that are essential at the global, regional and local levels. Biodiversity is essential for preserving ecological processes, such as fixing and recycling of nutrients, soil formation, circulation and cleansing of air and water, global life support, maintaining the water balance within ecosystems, watershed protection, maintaining stream and river flows throughout the year, erosion control and local flood reduction. Food, clothing, housing, energy, medicines are all resources that are directly or indirectly linked to the biological variety present in the biosphere.

- **Consumptive use value:** These are direct use values where the biodiversity product can be harvested and consumed directly e.g. fuel, food, drugs, fibre etc . A straight consumptive use is the direct utilization of timber, food, fuelwood and fodder by local communities. The diversity of organisms provide food, clothing, shelter, medicines, proteins, enzymes, papers, sports goods, musical instruments, beverages, narcotics, pets, zoo specimens, tourism and raw material for business prospects etc.

- **Productive use value:** This category comprises of marketable goods. The biotechnologist uses bio-rich areas to prospect and search for potential genetic properties in plants or animals that can be used to develop better varieties of crops for use in farming and plantation programs or to develop better live stock. To the pharmacist, biological diversity is the raw material from which new drugs can be identified from plant or animal products. To industrialists, biodiversity is rich storehouse from which to develop new products. For the agricultural scientist, the biodiversity is the basis for developing better crops. A variety of industries, like pharmaceuticals are highly dependent on identifying compounds of great economic value from the wide variety of wild species of plants located in undisturbed natural forests called “biological prospecting”.

- **Social values:** Social value of biodiversity prospecting motivated habitat conservation in some areas, as traditional societies valued it as a resource. Ecosystem people value biodiversity as a part of their livelihood as well as through cultural and religious sentiments. A great variety of crops have been cultivated in traditional agricultural systems and permitted a wide range of produce to be grown and marketed throughout the year and acted as an insurance against the failure of one crop. In recent years, farmers have begun to receive economic incentives to grow cash crops for national or international markets, rather than to supply local needs. This has resulted in local food shortages, unemployment, landlessness, and increased vulnerability to drought and floods.

- **Ethical and moral values:** Ethical values related to biodiversity conservation are based on the importance of protecting all forms of life against illegal activities like cloning of animals, smuggling of valuable biodiversity instances, bio-piracy, illicit trade etc. In India, several generations have preserved nature through local traditions. However, immediate benefit rather than ethics appears to be modern man’s objective.

- **Aesthetic value:** Aesthetic value is a judgment of value based on the appearance of an object and the emotional responses it evokes. Biodiversity is a direct source of pleasure and aesthetic satisfaction – its contribution to quality of life, outdoor recreation and scenic enjoyment. They provide opportunities for recreational activities such as hiking, canoeing, bird watching, river rafting, rock climbing, trekking, parasailing, bird watching and nature photography. The designing of thousands of new horticultural species, wild life conservation, landscape luxury, national parks, zoological and botanical gardens, snake, crocodile, butterfly parks, and biotechnologically manipulated novel curios species added to the existing aesthetics.

- **Option value:** Keeping future possibilities open for their use is called 'option value'. It is impossible to predict which of our species or traditional varieties of crops and domestic animals will be of greatest use in the future. Important ecosystem services and uses for plants and animals are still unknown and await discovery. It becomes valuable if targets are based on policy of obtaining wealth from wastes.

Indian Biodiversity:

India ranks 10th among the plant rich countries of the world, 11^{th} in terms of number of endemic species of higher vertebrates and 6^{th} among the centers of diversity and origin of agricultural crops. The total number of living species identified in our country is 150,000. Out of a total of 25 biodiversity hot-spots in the world, India possesses two, one in the north-east region and one in the Western Ghats. Indian is also one of the 17 mega-biodiversity countries in the world.

REGIONAL OR LOCAL BIODIVERSITY:

Biodiversity at regional level is better understood by categorizing species richness into four types, based upon their spatial distribution as discussed below

(i) **Point richness** refers to the number of species that can be found at a single point in a given space.
(ii) **Alpha (α-) richness** refers to the number of species found in a small homogeneous area
(iii) **Beta (β-) richness** refers to the rate of change in species com-position across different habitats.
(iv) **Gamma (γ-) richness** refers to the rate of change across large landscape gradients

THREATS TO BIODIVERSITY

Extinction or elimination of a species is a natural process of evolution. In the geologic period the earth has experienced mass extinctions. During evolution, species have died out and have been replaced by others. However, the rate of loss of species in geologic past has been a slow process, keeping in view the vast span of time going back to 444 million years. The process of extinction has become particularly fast in the recent years of human civilization. Major causes and issues related to threats to biodiversity:

1) LOSS OF HABITAT:

Destruction and loss of natural habitat is the single largest cause of biodiversity loss. Billions of hectares of forests and grasslands have been cleared over the past 10,000 years for conversion into agriculture lands, pastures, settlement areas or development projects. These natural forests

and grasslands were the natural homes of thousands of species which perished due to loss of their natural habitat. Severe damage has been caused to wetlands thinking them to be useless ecosystems. The unique rich biodiversity of the wetlands, estuaries and mangroves are under the most serious threat today. The wetlands are destroyed due to draining, filling and pollution thereby causing huge biodiversity loss.

2) POACHING:

Illegal trade of wildlife products by killing prohibited endangered animals i.e. poaching is another threat to wildlife. Despite international ban on trade in products from endangered species, smuggling of wildlife items like furs, hides, horns, tusks, live specimens and herbal products worth crores per year continues. The trading of such wild life products is highly profit making for the poachers who just hunt these prohibited wild life and smuggle it to other countries mediated through a mafia. Do not purchase furcoat, purse or bag, or items made of crocodile skin or python skin. You will certainly help in preserving biodiversity by doing so.

3) MAN-WILDLIFE CONFLICTS:

Human-wildlife conflict is when encounters between humans and wildlife lead to negative results, such as loss of property, livelihoods, and even life. Defensive and retaliatory killing may eventually drive these species to extinction. Instances of man animal conflicts keep on coming to lime light from several states in our country. In Sambalpur, Orissa 195 humans were killed in the last 5 years by elephants. In retaliation the villagers killed 98 elephants and badly injured 30 elephants.

3.1. CAUSES OF MAN-ANIMAL CONFLICTS:

The root causes of these conflicts are discussed below:

(i) Dwindling habitats of tigers, elephants, rhinos and bears **due to shrinking forest cover** compels them to move outside the forest and attack the field or sometimes even humans. Human encroachment into the forest areas raises a conflict between man and the wildlife, perhaps because it is an issue of survival of both.

(ii) Usually the **ill, weak and injured animals have a tendency to attack man**. Also, the female tigress attacks the human if she feels that her newborn cubs are in danger. But the biggest problem is that if human-flesh is tasted once then the tiger does not eat any other animal.

At the same time, it is very difficult to trace and cull the man-eating tiger and in the process many innocent tigers are also killed.

(iii) Earlier, **forest departments used to cultivate paddy, sugarcane etc. within the sanctuaries** when the favourite staple food of elephants i.e. bamboo leaves were not available. Now due to lack of such practices the animals move out of the forest in search of food. It may be noted that, One adult elephant needs 2 quintals of green fodder and 150 kg of clean water daily and if it is not available, the animal strays out.

(iv) Very often the villagers put electric wiring around their ripe crop fields. The **elephants get injured, suffer in pain and turn violent**.

(v) Earlier there used to be wild-life corridors through which the wild animals used to migrate seasonally in groups to other areas. **Due to development of human settlements in these corridors, the path of wildlife has been disrupted** and the animals attack the settlements.

(vi) The cash compensation paid by the government in lieu of the damage caused to the farmers' crop is not enough. In Mysore, a farmer gets a compensation of Rs. 400/- per quintal of expected yield while the market price is Rs. 2400/- per quintal. The agonized farmer therefore gets revengeful and kills the wild animals.

3.2. REMEDIAL MEASURES TO CURB THE CONFLICT:

(i) Tiger Conservation Project (TCP) has made provisions for making available vehicles, tranquillizer guns, binoculars and radio sets etc. to tactfully deal with any imminent danger.

(ii) Adequate crop compensation and cattle compensation scheme must be started, along with substantial cash compensation for loss of human life.

(iii) Solar powered fencing should be provided along with electric current proof trenches to prevent the animals from straying into fields.

(iv) Cropping pattern should be changed near the forest borders and adequate fodder, fruit and water should be made available for the elephants within forest zones.

(v) Wild life corridors should be provided for mass migration of big animals during unfavorable periods. About 300 km^2 area is required for elephant corridors for their

seasonal migration.

(vi) In Similipal Sanctuary, Orissa there is a ritual of wild animal hunting during the months of April-May for which forest is burnt to flush out the animals. Due to massive hunting by people, there is a decline in prey of tigers and they start coming out of the forest in search of prey. Now there is WWF-TCP initiative to curb this ritual in Orissa.

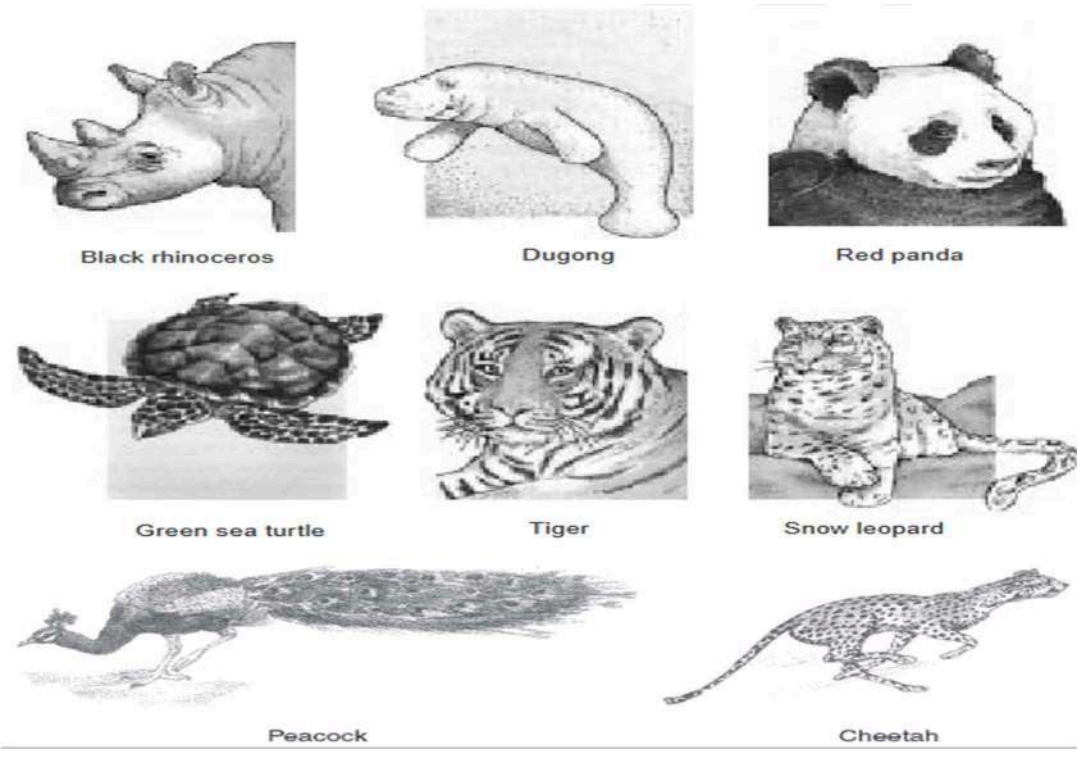
ENDANGERED SPECIES OF INDIA

The Red Data Book is referred to as the public document that records the information about all rare and endangered species of plants, animals, and fungi existing within the boundary of a state or territory. It can be considered as a catalogue of species facing the risk of extinction.

An endangered species is an animal or plant that's considered at risk of extinction. In India, nearly 450 plant species have been identified in the categories of endangered, threatened or rare. Existence of about 150 mammals and 150 species of birds is estimated to be threatened while an unknown number of species of insects are endangered.

A few species of endangered reptiles, birds, mammals and plants are given below:

(a) **Reptiles :** Gharial, green sea turtle, tortoise, python
(b) **Birds :** Great Indian bustard, Peacock, Pelican, Great Indian Hornbill, Siberian White Crane
(c) **Carnivorous :** Indian wolf, red fox, Sloth bear, red panda, Mammals tiger, leopard, striped hyena, Indian lion, golden cat, desert cat, dugong
(d) **Primates :** Hoolock gibbon, lion-tailed macaque, Nilgiri langur, Capped monkey, golden monkey
(e) **Plants :** A large number of species of orchids, Rhododendrons, medicinal plants like Rauvolfia serpentina, the sandal wood tree Santalum, Cycas beddonei etc.

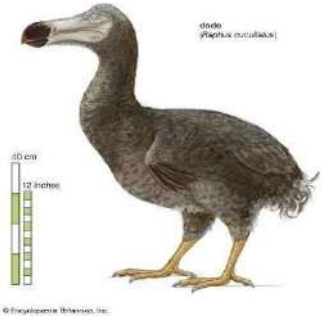


1) A species is said to be **extinct** when it is not seen in the wild for 50 years at a stretch e.g. Dodo, passenger pigeon.
2) A species is said to be **endangered** when its number has been reduced to a critical level or whose habitats, have been drastically reduced and if such a species is not protected and conserved, it is in immediate danger of extinction.
3) A species is said to be in **vulnerable** category if its population is facing continuous decline due to overexploitation or habitat destruction. Such a species is still abundant, but under a serious threat of becoming endangered if causal factors are not checked.
4) Species which are not endangered or vulnerable at present, but are at a **risk** are categorized as rare species.
5) These taxa are usually localized within restricted areas i.e. they are usually **endemic**. Sometimes they are thinly scattered over a more extensive area.

Extinct species:

1. **Passenger Pigeon:** The passenger pigeon or wild pigeon is an extinct species of pigeon that was endemic to North America. Its common name is derived from the French word passenger, meaning "passing by", due to the migratory habits of the species.

2. **Dodo:** The *dodo* (Raphus cucullatus) is an extinct flightless bird that was endemic to the island of Mauritius, which is east of Madagascar in the Indian Ocean.



ENDEMIC SPECIES OF INDIA

India has two biodiversity hot spots and thus possesses a large number of endemic species. Out of about 47,000 species of plants in our country 7000 are endemic. Thus, Indian subcontinent has about 62% endemic flora, restricted mainly to Himalayas, Khasi Hills and Western Ghats. Some of the important endemic flora include orchids and species like

- Sapria himalayana,
- Uvaria lurida,
- Nepenthes khasiana,
- Pedicularis perroter etc.

A large number out of a total of 81,000 species of animals in our country is endemic.

The western ghats are particularly rich in amphibians (frogs, toads etc.) and reptiles (lizards, crocodiles etc.). About 62% amphibians and 50% lizards are endemic to Western Ghats.

- Different species of monitor lizards (Varanus),
- reticulated python and
- Indian Salamander and
- Viviparous toad
- Nectophhryne

are some important endemic species of our country.

CONSERVATION OF BIODIVERSITY

The enormous value of biodiversity due to their genetic, commercial, medical, aesthetic, ecological and optional importance emphasizes the need to conserve biodiversity. A number of measures are now being taken the world over to conserve biodiversity including plants and wildlife. There are two approaches of biodiversity conservation:

(A) **In situ conservation (within habitat):** This is achieved by protection of wild flora and fauna in nature itself. e.g. Biosphere Reserves, National Parks, Sanctuaries, Reserve Forests etc. At present we have 7 major Biosphere reserves, 80 National Parks, 420 wild-life sanctuaries and 120 Botanical gardens in our country covering 4% of the geographic area.

The Biosphere Reserves conserve some representative ecosystems as a whole for long-term in situ conservation. In India we have Nanda Devi (U.P.), Nokrek (Meghalaya), Manas (Assam), Sunderbans (West Bengal), Gulf of Mannar (Tamil Nadu), Nilgiri (Karnataka, Kerala, Tamil Nadu), Great Nicobars and Similipal (Orrisa) biosphere Reserves. Within the Biosphere reserves we may have one or more National Parks. For example, Nilgiri Biosphere Reserve has two National Parks viz Bandipur and Nagarhole National Park.

A National Park is an area dedicated for the conservation of wildlife along with its environment. It is also meant for enjoyment through tourism but without impairing the environment. Grazing of domestic animals, all private rights and forestry activities are prohibited within a National Park. Each National Park usually aims at conservation specifically of some particular species of wildlife along with others.

Table 4.5. Some important National parks in India

Name of National Park	State	Important Wildlife
Kaziranga	Assam	One horned Rhino
Gir National Park	Gujarat	Indian Lion
Dachigam	J & K	Hangul
Bandipur	Karnataka	Elephant
Periyar	Kerala	Elephant, Tiger
Kanha	M.P.	Tiger
Corbett	U.P.	Tiger
Dudwa	U.P.	Tiger
Ranthambore	Rajasthan	Tiger
Sariska	Rajasthan	Tiger

Wildlife sanctuaries are also protected areas where killing, hunting, shooting or capturing of wildlife is prohibited except under the control of highest authority. However, private ownership rights are permissible and forestry operations are also permitted to an extent that they do not affect the wildlife adversely.

For plants, there is one gene sanctuary for Citrus (Lemon family) and one for pitcher plant (an insect eating plant) in Northeast India. For the protection and conservation of certain animals, there have been specific projects in our country e.g. Project Tiger, Gir Lion Project, Crocodile Breeding Project, Project Elephant, Snow Leopard Project etc.

Table 4.6. Some Important Wildlife Sanctuaries of India

Name of Sanctuary	State	Major Wild Life
Ghana Bird Sanctuary	Rajasthan	300 species of birds (including migratory)
Hazaribagh Sanctuary	Bihar	Tiger, Leopard
Sultanpur Bird Sanctuary	Haryana	Migratory birds
Nal Sarovar Bird Sanctuary	Gujarat	Water birds
Abohar Wildlife Sanctuary	Punjab	Black buck
Mudamalai Wildlife Sanctuary	Tamil Nadu	Tiger, elephant, Leopard
Vedanthangal Bird Sanctuary	Tamil Nadu	Water birds
Jaldapara Wild Life Sanctuary	W. Bengal	Rhinoceros, elephant, Tiger
Wild Ass Sanctuary	Gujarat	Wild ass, wolf, nilgai, chinkara

(B) **Ex situ conservation (outside habitats)** this is done by establishment of gene banks, seed banks, zoos, botanical gardens, culture collections etc.

This type of conservation is mainly done for conservation of crop varieties, the wild relatives of crops and all the local varieties with the main objective of conserving the total genetic variability of the crop species for future crop improvement or afforestation programmes. In India, we have the following important gene bank/seed bank facilities:

(i) **National Bureau of Plant Genetic Resources (NBPGR)** is located in New Delhi. Here agricultural and horticultural crops and their wild relatives are preserved by ***cryo-preservation*** of seeds, pollen etc. by using liquid nitrogen at a temperature as low as -196^0C. Varieties of rice, pearl millet, Brassica, turnip, radish, tomato, onion, carrot, chilli, tobacco, poppy etc. have been preserved successfully in liquid nitrogen for several years without losing seed viability.

(ii) **National Bureau of Animal Genetic Resources (NBAGR)** located at Karnal, Haryana. It preserves the semen of domesticated bovine animals.

(iii) **National Facility for Plant Tissue Culture Repository (NFPTCR)** for the development of a facility of conservation of varieties of crop plants/trees by tissue culture. This facility has been created within the NBPGR. The G-15 countries have also resolved to set up a network of gene banks to facilitate the conservation of various varieties of aromatic and medicinal plants for which India is the networking coordinator country.

Book:

1. Anubha Kaushik and C. P. Kaushik's "Perspectives in Environmental Studies", 6th Edition, New Age International Publishers ,2018.