UNIT I: THE ENVIRONMENT AND ECOSYSTEM

1.1 Environment and Environmental studies: Definition, Concept, Components and Importance
1.2 Ecosystem: Structure and function of Ecosystem
1.3 Food Chain, Food web and Ecological pyramids
1.4 Biogeochemical cycles in Ecosystem: Carbon, Nitrogen and Phosphorous
1.5 Ecological Succession: Definition, types, concept and process (Hydrosere, Xerosere)

THE ENVIRONMENT

The word '*Environment'* is derived from the French word 'Environ', which means '*the surroundings.'* The environment constitutes everything (living as well as non-living) that surrounds us. As per the definition given by Environment Protection Act (EPA, 1986), it is defined as "the sum total of water, air and land and the inter-relationships that exist among them and with the human beings, other living organisms, and materials." So, environment refers to the interaction between man and his surroundings. According to P. Gisbert, "Environment is anything immediately surrounding an object and exerting a direct influence on it." As per E. J. Ross "Environment is an external force which influences us."

The environment can be roughly divided into micro-environment and macro-environment. *Micro-environment* refers to the immediate local surroundings of an organism, while *Macro-environment* refers to all the conditions that surround the organism externally. The environment can also be divided into physical/abiotic and living/biotic components. The abiotic environment includes the atmosphere, lithosphere, and hydrosphere, while the biotic environment includes the living forms, i.e., plants, animals, and microorganisms.

Environmental Studies:

Environmental studies include all the disciplines associated with the physical, chemical, and biological surroundings of an organism. It can be defined as the extensive and systematic study of nature/environment and its physical, biological, social, and cultural factors, and the nature and characteristics of the relationship between man and environment. On the other hand, Environmental Science is the application of scientific/technological tools for solving the environmental problems faced, particularly by humans.

COMPONENTS OF ENVIRONMENT

The basic components of the environment are the Atmosphere, Hydrosphere, Lithosphere, and Biosphere.

Atmosphere*:* Atmosphere is the blanket of a fluid system that surrounds the earth. It consists of gases like Nitrogen (78.08%), Oxygen (20.95%), Argon (0.93%), Carbon-di-oxide (0.042%), traces of Hydrogen, Helium, other noble gases, etc. and suspended particles such as dust and soot. Water vapour is also an important constituent of the lower atmosphere. The composition of the atmosphere varies with time and space. The atmosphere has several advantages as it has oxygen to breathe, shelters us from harmful UV radiations, and warms the earth's surface via the greenhouse effect. The atmosphere can be divided into different layers, which include troposphere (0-12 km), stratosphere

(12-50 km), mesosphere (50-85 km), thermosphere (85-700 km), and exosphere (700 km onwards).

Lithosphere: The word 'Lithos' is a Greek word that means 'Rocks.' The lithosphere is the outermost layer of earth's crust consisting of minerals and soils, and its depth can reach up to 100 km. The lithosphere has two components: the terrestrial crust and the oceanic crust. The terrestrial crust includes the layer of rocks that form the continents, and the oceanic crust is the part of the earth's lithosphere that lies below ocean waters.

Hydrosphere: The word 'hydro' is derived from a Greek word that means 'water'. Water is the most abundant substance on the earth's surface. It Includes oceans, lakes, rivers, wetlands, icecaps, clouds, etc. About 71% of the earth's surface is covered with water, out of which 97.5% is found in oceans. Of the remaining 2.5% freshwater, 68.9% is in frozen forms as in glaciers, 30.8% is available as groundwater, while only 0.3% is available in rivers, reservoirs, and lakes and easily accessible to man

Biosphere: The word 'bio' is also a Greek word that means 'life'. The biosphere consists of the living parts of the environment, including the animal community, the plant community, and the microbial community. The living organisms can be found in the atmosphere, hydrosphere, and lithosphere, and hence biosphere overlaps all these spheres.

IMPORTANCE OF ENVIRONMENTAL STUDIES

Environment has important significance in our life. The health of humans is directly related to the health of environment because we inhale air, drink water and cultivate all our foods on soil. Also, it has been rightly mentioned by Henry D Thorean, "*What is the use of beautiful house, if you don't have a decent planet to put it on*". So, the public has to be educated about the fact that degrading our environment will harm us directly. Keeping in view our dependency on the environment and its importance in our life, it becomes necessary to make every human environmentally educated and environmental studies plays an important role in achieving the goal. Environmental studies is important because:

- It helps us to understand the importance of our environment
- To use natural resources efficiently
- To minimize the pollutions
- To know the value of biodiversity
- It helps in solving crucial environmental problems like climate change, global warming, ozone deletion, biodiversity reduction etc.

The goal of environmental education is to develop a world population that is aware of and concerned about environment as a whole and the problem associated with it, and committed to work individually as well as collectively towards solutions of current problems and prevention of future problems. Creating environmental awareness is essential because environment belongs to all.

1.2 ECOSYSTEM: STRUCTURE AND FUNCTION

ECOSYSTEM

The word ecosystem is derived from two words, 'eco' meaning 'home' and 'system' meaning 'orderly arrangement'. An ecosystem is a functional unit comprising all the organisms in a particular place interacting with one another and with their physical environment and inter-connected by an ongoing flow of energy and a cycling of materials. The concept of ecosystem was proposed by Arthur G Tansley (1935) who described ecosystem as, "self-regulating group of biotic communities of species interacting with one another and with their non-living environment exchanging energy and matter". In a broadest sense, an ecosystem is the interacting system made up of all the living and non-living objects in a physically defined space. It comprises of physical and biological components which are necessary for survival.

The study of ecosystems is often defined as Ecology. The term Ecology (Greek word 'Oikos' means 'home' and 'logos' means 'to study') was coined by Ernst Haeckel in 1869. It is defined as the study of their organisms in their natural home interacting with their surroundings. Francis Evans (1956) mentioned the ecosystem as the basic unit in ecology. All ecosystems are open systems because the energy as well as matter are exchanged with their surroundings. Ecosystems are also dynamic and they keep on changing with time. The science dealing with the study of flow of energy and cycling of nutrients among organisms within a community and between organisms and the environment is called as Ecosystems ecology. The study of ecosystem includes the biotic and abiotic components and the relationship that exists between them.

There are so many ecosystems functioning in nature. They vary from each other in their climate, soil, water, land and vegetation. Various types of ecosystems present on the earth are:

1. **Natural ecosystems**: Ecosystems that operate themselves under natural conditions without human influence are termed as natural ecosystems. They are divided as:
   a. ***Terrestrial ecosystems***: e.g., Forest, grassland, desert ecosystem
   b. ***Aquatic ecosystems***: They are further divided into:
      i) Freshwater: Freshwater ecosystems may be lotic (running water e.g., spring, stream, river etc.) or lentic (standing water e.g., lake, pond, swamp etc.)
      ii) Marine ecosystems: These include deep water bodies like ocean, sea etc.
2. **Artificial ecosystems**: These are maintained artificially by man e.g., croplands like maize, wheat, rice fields etc., where man tries to control the biotic community as well as the physic-chemical environment of the ecosystem.

STRUCTURE OF ECOSYSTEM

An ecosystem has two major structural components: Biotic and Abiotic

Biotic component*:* It includes the living part of an ecosystem and forms its trophic structure with flow of energy from one organism to another organism. On the basis of their role in an ecosystem, living organisms are further divided into:

a) Autotrophs/ Producers: Autotrophs are the organisms which can produce their own food. These organisms produce their food by converting radiant/chemical energy into carbohydrates. Based on the intake energy these organisms are further divided into:
   i) Phototrophs:
   ii) Chemotrophs:
b) Heterotrophs/Consumers: Heterotrophs are organisms who obtain their energy from other organisms mostly autotrophs.

i) Primary consumers: these organisms are also called as herbivores. They obtain their food directly from autotrophs.
ii) Secondary consumers
iii) Tertiary consumers:

c) Decomposers/Saprotrophs:

Abiotic component:

ECOSYSTEM FUNCTIONS: Functions of an ecosystem define the operation or working of an ecosystem under natural conditions. It also depicts how the biotic and abiotic factors of an ecosystem are related to each other. The functions of an ecosystem include:

- Energy flow
- Nutrient cycling
- Productivity and
- Ecosystem regulation and services

The two processes i.e., flow of energy and cycling of materials in an ecosystem may be thought as the heart of the ecosystem dynamics.

Energy flow in an ecosystem: The most fundamental process in an ecosystem is its energy flow. It is the behaviour or movement of energy through producers and consumers in an ecosystem. Producers like plants, algae and cyanobacteria consume radiant and chemical energy from environment and convert it into biochemical energy while as consumers (herbivores, carnivores and decomposers) get their energy from producers. The diagram depicts the flow of energy and material cycling in an ecosystem.

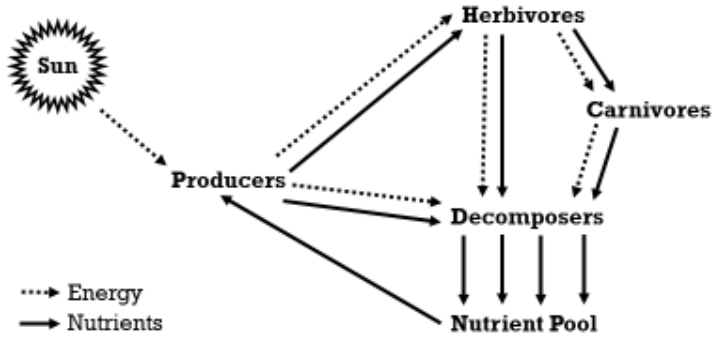


FIGURE 1.1 The flow of energy and cycling of materials in an ecosystem.

It must be noted that energy flow in an ecosystem is a unidirectional process and it cannot be recycled. Sun is the major source of energy and the ultimate fate of all energy in an ecosystem is to be lost as heat.

The flow of energy in an ecosystem follows the laws of thermodynamics. The *First Law of Thermodynamics* or *Law of Conservation of Energy* states that energy can neither be created nor be destroyed but can be converted from one form to another and the *Second Law of Thermodynamics* states that the energy dissipates as it is used. During the energy flow of an ecosystem, the radiant energy of sun is converted into biochemical energy by plants (producers) and when it flows from one trophic level to another trophic level it gets dispersed as part of it is lost at each trophic level via physiological and metabolic activities.

Only about 1-5% of incident solar radiation or 2-10% of PAR (Photosynthetically Active Radiations) is actually captured during the photosynthetic process and the energy transferred from one trophic level to another trophic level is only 10% and remaining 90% is lost in biological activities.

The energy flow in an ecosystem is explained by energy flow models. Lindeman (1942) proposed one way passage of energy flow for freshwater ecosystem and later Odum (1983) proposed a Y-shaped energy model which separated the grazing and detritus food chain in time and space.

1.3 FOOD CHAIN, FOOD WEB AND ECOLOGICAL PYRAMIDS

FOOD CHAIN:

The food chain describes the relationship between one trophic level and the adjacent trophic level. The first level in food chain belongs to producers, the second level to primary consumers, third level to secondary consumers and so on. Some consumers occupy a single trophic level, but many others, such as omnivores, occupy more than one trophic level. The transfer of food energy from producers through a series of organisms that consume and are consumed is termed as a food chain. In other terms it can also be defined as the sequence of eating and being eaten up in an ecosystem.

The food chain shows the movement of energy in the form of food through the ecosystem. The number of species in an ecosystem depends on the ecosystem for example artic landscape has shorter food chains than tropical forests. There are two types of food chains found in an ecosystem: the *grazing food chain* and the *detritus food chain*. The source of energy is the difference between the two. Living plant biomass is the source of energy for grazing food chain. An example of simple food chain can be given as:

Grass ⟶ Insect ⟶ Frog ⟶ Snake ⟶ Hawk

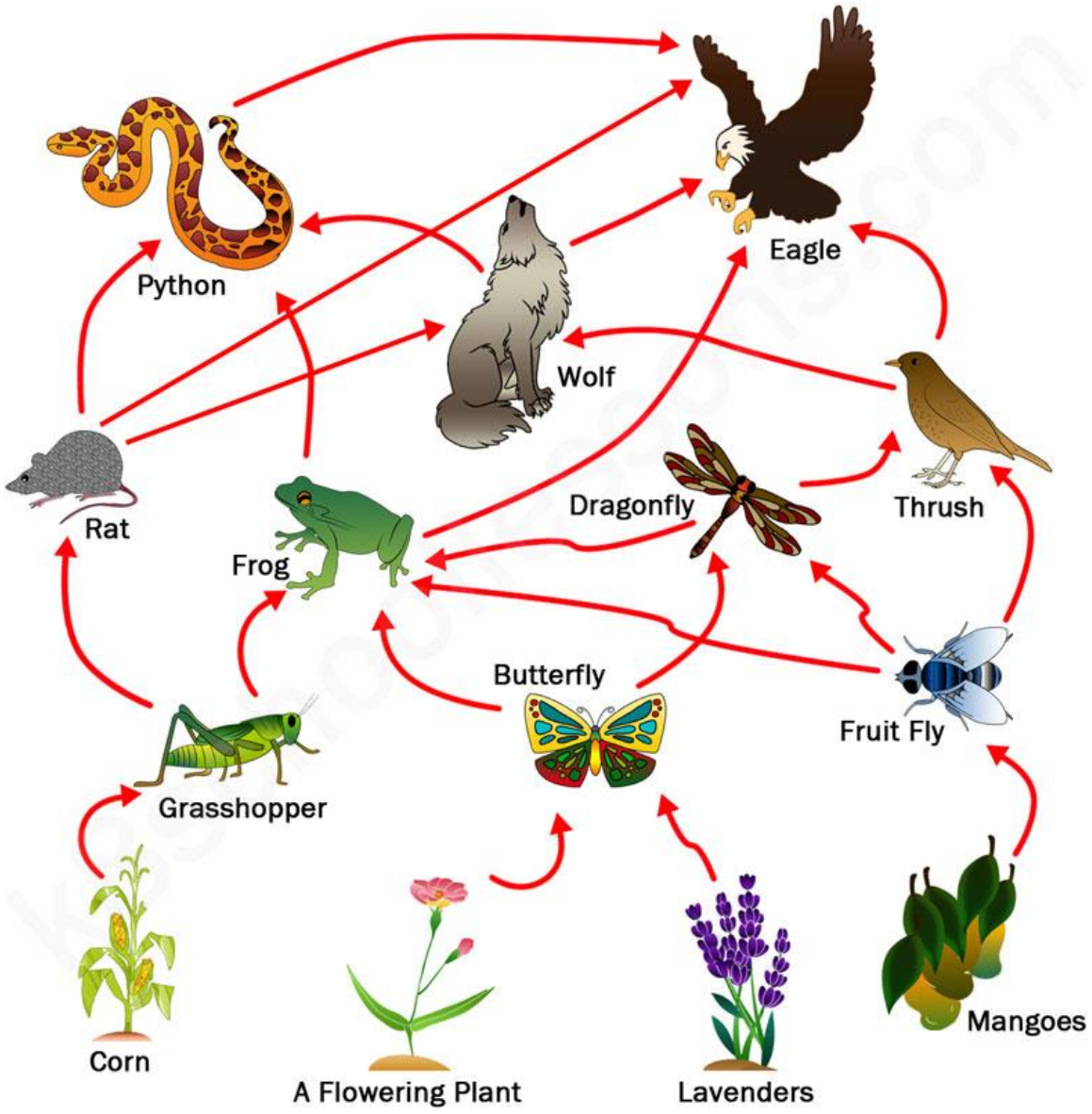
The basic source of energy for detritus food chain is dead organic matter (detritus). Organic matter in the form of the excretion by-products and dead parts of living organisms is commonly found everywhere in environment. Hence, detritus food chain is present in all ecosystems. An example of detritus food chain can be given as;

Dead leaves ⟶ Microorganisms ⟶ Crabs ⟶ small fish ⟶ large fish

Under natural conditions, the detritus and grazing food chains are not isolated from each other and their relative importance varies from one ecosystem to another. In terrestrial ecosystems grazing food chain dominates while as in case of tidal marshes detritus food chain becomes dominant.

FOOD WEB:

The natural ecosystems are not linear and food chain operating in an isolated manner can be rarely found. There are multiple and interconnecting pathways as well as number of different species involved at each trophic level. The actual structure resembles a web rather than a simple chain and is hence referred as food web. So, a food web is an interconnected network of food chains in which various organisms are connected at various trophic levels and there are multiple options of feeding or being eaten at each level. Simple food webs are present in ecosystems with less species diversity for example artic landscapes but food webs are very complex and are present in ecosystems with rich species diversity like forests.



In a food chain all trophic levels will be affected if one species becomes extinct while as the extinction of species in a food web will not affect other trophic levels because of availability of several other food options. Hence, food webs add stability to an ecosystem and are very vital for its functioning. Food chains and food webs provide several other benefits like energy flow, nutrient cycling, maintaining ecological balance and biomagnification of chemicals.

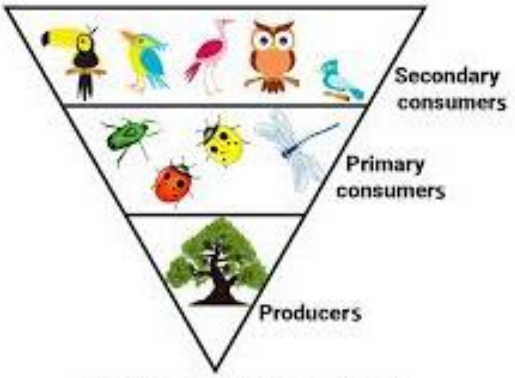
ECOLOGICAL PYRAMIDS

The concept of ecological pyramids was given by Charles Elton and so they are also called as Eltonian pyramids. Ecological pyramids are the representation of trophic structure

and function of an ecosystem. All pyramids begin with producers at the base, consumers at the apex and other trophic levels in between. There are three types of ecological pyramids:

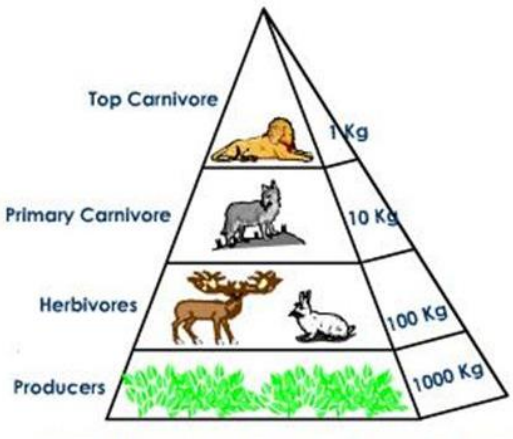
Pyramid of numbers: It represents the number of individual organisms at each trophic level. Depending upon the type of the ecosystem and food chain, the pyramid of number could be upright (grassland ecosystem) or inverted (forest ecosystem).

Upright Pyramid

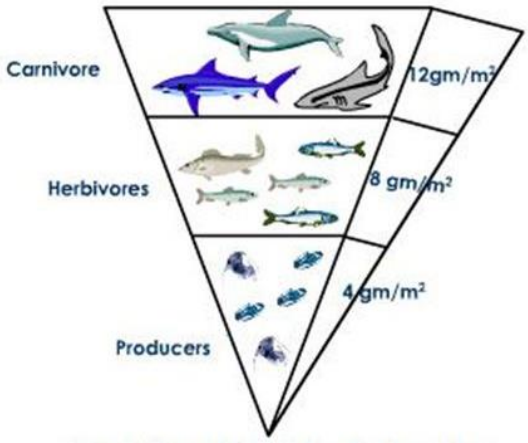


Inverted Pyramid

Pyramid of biomass: It represents the total biomass at each trophic level in a food chain. It is more fundamental as it represents the standing crops. It can also be upright (forest ecosystem) or inverted (pond ecosystem).

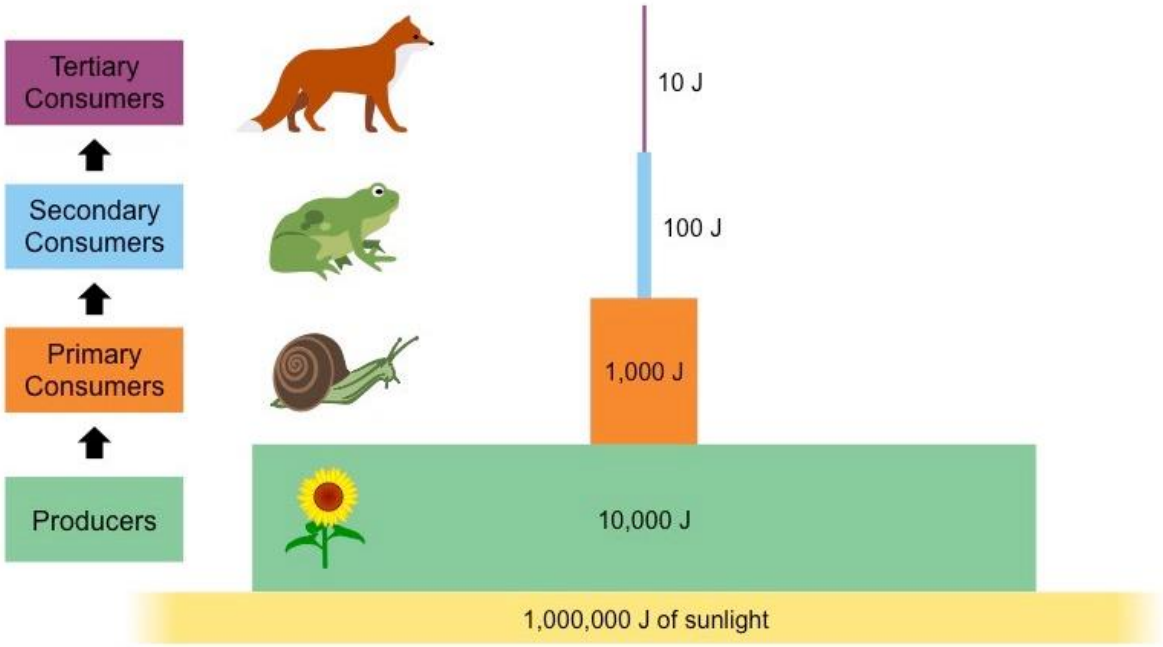


Upright Pyramid



Inverted Pyramid

Pyramid of energy: It represents the amount of energy present at each trophic level and hence describes the overall nature of the ecosystem. The pyramid of energy is always upright because at every trophic level there is a loss of about 90% of energy.



1.4 BIOGEOCHEMICAL CYCLES (C, N and P)

Earth is a close system for matter. The elements/matter continuously cycle through Earth's systems and these cycles are called as biogeochemical cycles because they involve several biological, geological and chemical processes. The word "*bio"* means "*life"* and "*geo"* means "*earth"* (that includes air, water and land). Hence, biogeochemical cycle refers to the process of constant cycling or turnover of chemicals/substances (which includes water, carbon, nitrogen, oxygen, sulphur, phosphorous, hydrogen) between abiotic and biotic components of earth is termed as biogeochemical cycle.

Based on the phase of chemical, biogeochemical cycles are of two types:

1) Gaseous (Carbon, Nitrogen) and
2) Sedimentary (Phosphorous, Sulphur etc.)

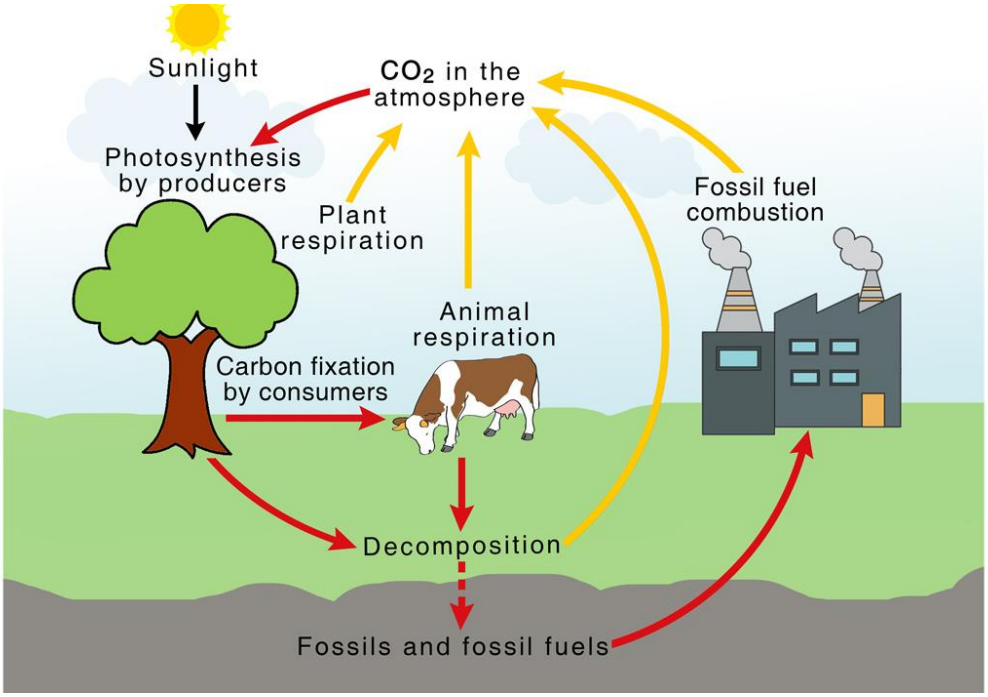
Gaseous cycles have atmosphere as their main reservoir and examples include carbon cycle, nitrogen cycle etc. while as sedimentary cycle has sedimentary rock as the main reservoir and the examples include phosphorous cycle, sulphur cycle etc.

On the basis of spatial scale they are also divided into:

1) Local (P) and
2) Global (N)

CARBON CYCLE

Carbon constitutes 49% of dry weight of organisms. It is found in all organic macromolecules and is also a key component of fossil fuels. Its cycle is very balanced in nature. Carbon is found in various forms like carbon-di-oxide in air, as organic carbon in living organisms etc. Carbon cycle has four important steps: Photosynthesis, Respiration, Decomposition and combustion. In photosynthesis carbon in the form of carbon-di-oxide from air is taken-up by the plants and converted into organic substances. Then this carbon moves through food chain and is finally returned to the atmosphere again by microorganisms/decomposers. Respiration is another important step in which animals inhale oxygen and produce carbon-di-oxide which is used by plants for photosynthesis. Carbon stored in plants and animals that are not eaten up in food chain eventually die and they undergo decomposition. By decomposition the organic carbon is converted into inorganic carbon and it gets added either to the soil or is released back to the atmosphere. Another significant reservoir of carbon is fossil fuels. When these fossil fuels are extracted and combusted for harvesting energy, they release carbon compounds to the atmosphere.

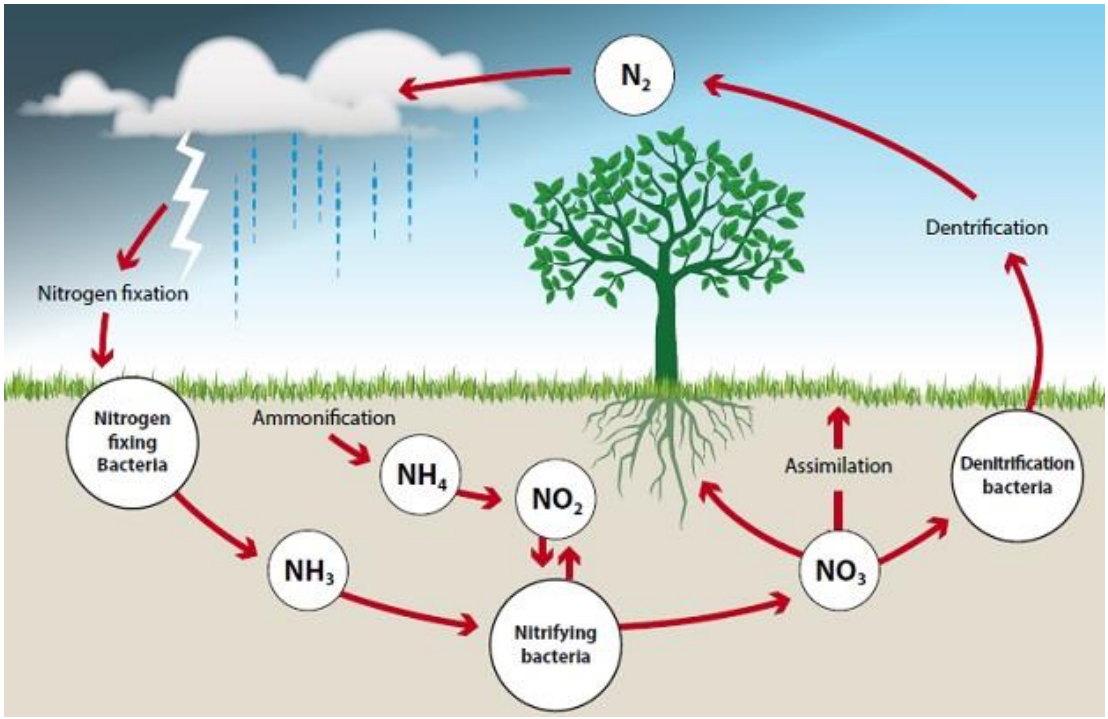


71% of total carbon is dissolved in the oceans. This oceanic reservoir regulates the amount of carbon-di-oxide present in the atmosphere. Geological processes like volcanic eruptions also release large quantities of carbon to the atmosphere.

NITROGEN CYCLE

Nitrogen is the most abundant gas and it constitutes 78% of atmosphere. The important processes in nitrogen cycle are nitrogen fixation, ammonification, nitrification and denitrification. Atmospheric nitrogen is inert and cannot be used by plants directly. In *Nitrogen fixation* the atmospheric nitrogen is converted into nitrates and nitrites to facilitate its use by various life forms. It could be converted either by biological or non-biological fixation. The non-biological process is lightning during which nitrogen is converted into its oxides by high temperature and pressure. These oxides react with water and rain to form nitric and nitrous acid which are taken up by plants. Biological process involves use of bacteria and/or cyanobacteria. Example of biological process are leguminous plants (e.g., soyabean, alfalfa) and animals (e.g., termites and shipworms) which have nitrogen fixing bacteria (Azatobacter, Anabeana, Nostoc) to help them to convert atmospheric nitrogen into nitrates and nitrites. In plants these nitrates and nitrites are converted into biological molecules like proteins, amino acids, DNA, RNA, and vitamins etc. They pass through the food chain as organic nitrogen and are finally returned to soil as ammonia, nitrates and nitrites by decomposers like ammonifying and nitrifying bacteria. By industrial fixation also atmospheric nitrogen is converted into ammonia which is directly used as fertilizer or further processed to urea and ammonium nitrate. *Ammonification*

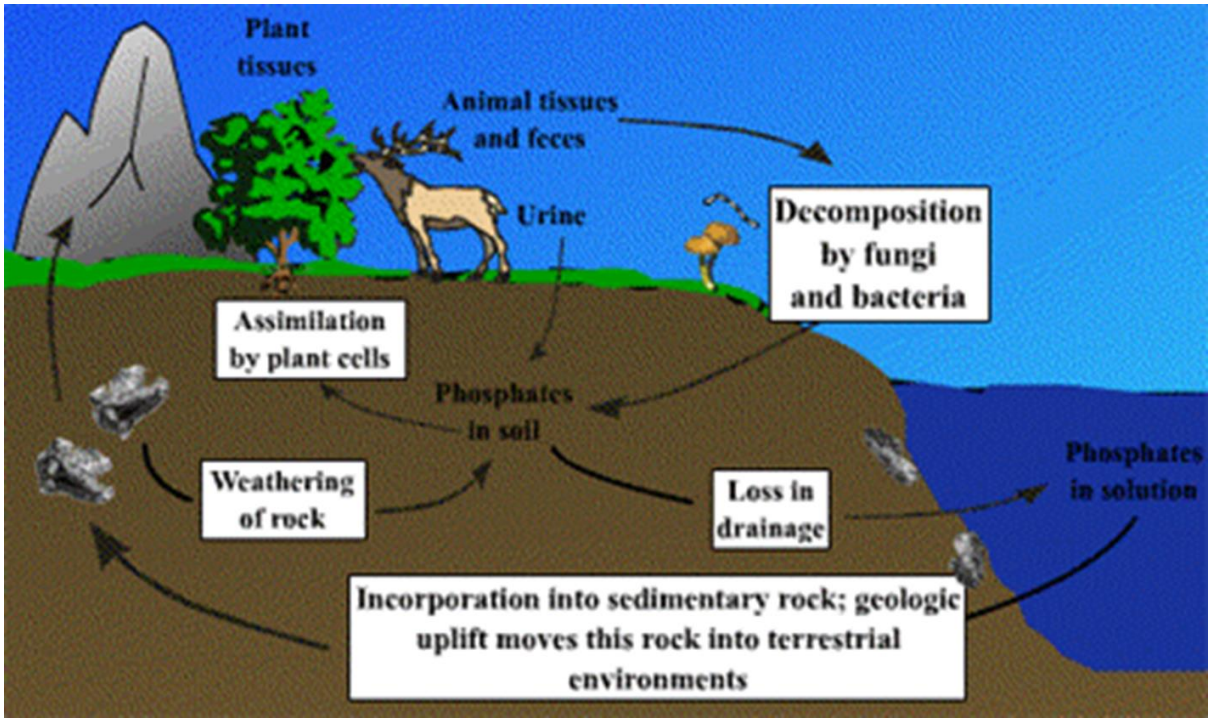
or mineralization is the process of conversion of organic nitrogen into ammonium ions by bacteria and fungi. *Nitrification* is the process of oxidation of ammonium ions to nitrite and subsequent oxidation of nitrite to nitrate. The first step is carried out by nitrifying bacteria (*Nitrosomonas, Nitrosospira* and *Nitrosococcus*) and the second step is carried out by nitrifying bacteria (*Nitrospira, Nitrobacter* and *Nitrococcus*). Nitrospira genus of bacteria are able to carry out both steps and the ability is called as "comammox". *Denitrification* is the process of reduction of nitrates and nitrites to nitrogen gas and thereby completing the nitrogen cycle by releasing it to the atmosphere.



PHOSPHOROUS CYCLE

Phosphorous is an essential component of all enzymatic reactions, ATP, DNA, RNA, biological membranes and nucleic acids. Additionally many animals need phosphorus to make shells, bones and teeth. Phosphorous cycle is a sedimentary cycle and its chief reservoirs are rocks and fossils. When rocks are weathered phosphorous dissolves and adds to soil and plants take up this phosphorous from there. The phosphorus enters into the food chain and is finally released back to the soil by decomposers (phosphate-solubilising bacteria). This phosphorous can be used again by the plants or it can get carried away to the water bodies by rain and running water. The phosphorus also returns back to the soil in the form of phosphates through animal excreta. Due to leaching and erosion, some of the phosphorous from soil is carried away and gets deposited in oceans. To overcome this loss, phosphorous from phosphate rocks is

overexploited by man for making fertilizers. Sea birds also play an important role in phosphorous cycling by eating sea food rich of phosphorous and returning it to the soil in the form of excreta. The Guano deposits on the coasts of Peru are very rich sources of phosphorous. The phosphorous cycle can be explained as:



ECOLOGICAL SUCCESSION:

Ecological succession is a universal process of natural change in the community structure on an ecological time scale. Ecological communities are dynamic because they consist of living organisms. Their structure constantly change with respect to changing environmental conditions. The changes are directional, sequential and finally lead to the development of climax community that is near equilibrium with the environment.

So, ecological succession is defined as a sequence of changes in which one type of ecosystem replaces another in a given area until an ecosystem is established that is best adapted to that environment. The initial stage/community of an ecological succession is termed as pioneer stage/community, the final established community is termed as climax community and the communities that replace one another in the successional process are termed as seres or serel stages. The climax community is considered as the most stable community that can exist in that particular environment and marks the end point of succession. Each seral stage has its characteristic species composition.

The ecological succession can be classified into Hydrarch and Xerarch on the basis of nature of habitat from which primary succession starts. Succession initiated with the establishment of pioneer communities in aquatic body and land is termed as hydrarch and xerarch succession respectively.

TYPES OF SUCCESSION:

- **Primary succession:** Succession in any area which has not been previously inhabited by any life form is called as primary succession. The habitat is first colonized by a few pioneer species which are often microbes, lichens and mosses. The pioneer species must be able to grow on substrates that are nutrient poor and that often have unfavourable moisture conditions. Primary succession is a slow process as because the pioneers have to transform the environment into suitable one for other species to colonize it.
- **Secondary succession:** The secondary succession occurs in a habitat where an already established community is disturbed/destroyed/changed and new community develops. Disturbance which may be defined as a process that that results in the partial or complete removal of the existing community and it could be natural (fire, flood etc.) or anthropogenic. Secondary succession is relatively faster than the primary succession because it starts in an area having well developed soil.
- **Autogenic succession:** Or self-generated succession. It is a self-driven succession in which a community itself modifies its environment to such an extent that it gets replaced by new communities.
- **Allogenic succession:** Or externally-generated succession. It is a process in which the existing community is replaced by new communities as a result of external factors (like fire, volcanic eruption, storms etc) that modify its environment.

PROCESS OF SUCCESSION

Succession is a systematic process and occurs in following sequential steps:

- **Nudation:** Succession begins from the development of a bare area without any life form. Bare area may be developed because of landslides, volcanic eruption, drought, glaciers, overgrazing, disease outbreak etc. The causes of nudation may be topographic (e.g. water), climatic (e.g. glaciers) or biotic (human induced).
- **Invasion:** it refers to the successful establishment of one or more species on a barren land and it involves dispersion/migration followed by ecesis and aggregation:
  - Dispersal or migration: It is a process in which a new form invades a baren land. The dispersal of seeds or spores can occur by means of wind, water, insects or birds.
  - Ecesis: It is the process of successful establishment of any species after making adjustments with the prevailing conditions. Ecesis process is considered to be complete only if the plant/animal species is able to sexually reproduce in the particular environment.

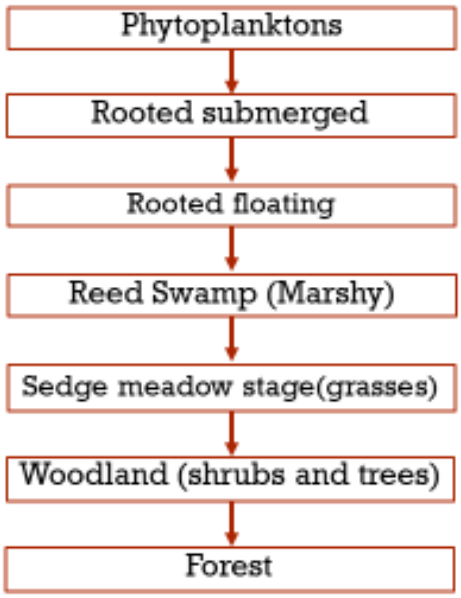
    - Aggregation: The number of individuals of species increases due to reproduction and forms groups or aggregations.
- **Competition & coaction:** As the number of individuals increase there is intra-specific and inter-specific competition for food, water, radiant energy, space, etc. The individuals of a species influence each other in a number of ways and this is called as coaction.
- **Reaction:** The modification of environment by the influence of living organisms is called as reaction. The modifications in environment factors (like soil, water, light, temperature etc.) are favourable for the new species but unsuitable for the existing ones. As a result of reaction the existing species are replaced by another new community. The whole sequence of communities that replaces one another in the given area is called as sere and various communities constituting the sere as seral communities/seral stages/developmental stages.
- **Stabilization:** The more or less stable community that is in equilibrium with the environment and is not replaced by any other community is called as climax community and the process is called as stabilization.

The pioneer species as compared to developmental stages are relatively small organisms, with rapid growth, more dynamic, have predominantly linear and grazing food chain, have low nutrient requirement, and have less demand from environment. The term climax was used by Clements to describe the idealized end point of process of succession. Three theories i.e., mono-climax theory, poly-climax theory and climax-pattern theory were proposed to explain the climax concept.

- **Mono-climax theory:** This theory is also called as climate-climax theory and it was proposed by F. Clements (1916). According to this theory the succession process results in only one climax which is determined solely by climate.
- **Poly-climax theory:** the ploy-climax theory was given by A. G. Tansley (1935). According to this theory the climax community of a region consists of a mosaic of climaxes which are controlled by several factors like climate, topography, edaphic etc.
- **Climax-pattern theory:** The climax pattern theory was proposed by R. H. Whittaker (1953). The theory proposes a continuity of climax types, varying gradually along environmental gradients and not neatly packaged into discrete climax types.

HYDROSERE

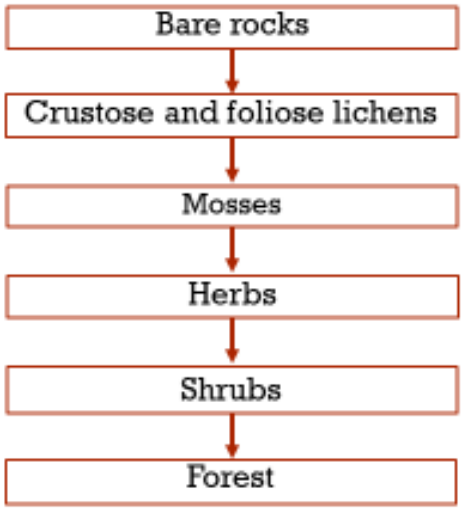
Hydrosere is the succession that starts in a water body such as ponds, lakes, streams, swamps, bogs etc. The hydrosere starts with phytoplanktons as pioneer species and ends up into a forest which is a climax community. Various seral communities involved in hydrosere are:



- **Phytoplankton stage:** They constitute the pioneer community and includes the simpler life forms as blue-green algae, blue algae, diatoms and bacteria. Due to their various life activities and death these organisms add organic matter and nutrients to the water bodies.
- **Rooted submerged stage:** The water bodies becomes a bit shallower and suitable for rooted submerged plants to grow. The common rooted submerged plant species are *Ceratophyllum, Chara, Elodea, Hydrilla, Myriophyllum, Potamogeton, Ranunculus, Utricularia, Vallisneria,* etc. These species due to their death and decay further add up the substratum to water bodies, and make them shallower.
- **Rooted floating stage:** When the depth of water body reaches to 2-5 feet rooted floating plants emerge. Plants like *Aponogeton, Limnanthemum, Monochoria, Nelumbo, Nymphaea, Pistea,* and *Trapa* are rooted hydrophytes with leaves floating on the water surface. Some free floating species like *Azola, Lemna, Pistia, Salvinia, Spirodella, Wolffia* etc also become associated with these species.
- **Reed-swamp stage:** The plant community at this stage is rooted but their most parts are above water surface and hence this stage is also called as amphibious stage. The plants (for example *Phragmites, Sagittaria, Scirpus, Typha* etc) have well developed rhizomes and form a dense vegetation. The water level at this stage is also very much reduced.
- **Sedge-meadow stage:** Species of Cyperaceae and Gramineae colonize the area. These species have much branched rhizomatous systems and they form mat like vegetation towards the centre of the water body. Marshy soil/mud forms during this stage.
- **Woodland stage:** The area is invaded with herbs and shrubs like *Acacia, Buteazon, Cassia, Cephalanthus, Cornus, Salix, Terminalia* etc. resulting in humus accumulation and soil mineralization.
- **Forest stage:** This is the climax community and it rapidly invades the woodland stage.

XEROSERE

The succession that occurs on areas of minimal moisture content like rocks, dry deserts etc. is called as xerosere. These habitats lack water and organic matter. Different communities involved in xerosere are:



- **Bare rocks:** The bare rock surfaces lack water and organic matter and they only have minerals in disintegrated unweathered state.
- **Crustose and foliose lichens:** The crustose lichens like *Lecanora, Rhizocarpon,* and *Rinodina* are the pioneer species and they help in weathering of rock by producing some weak acids. The dead crustose lichens are added as organic matter. The foliose lichens like *Dermatocarpon, Parmelia* etc appear on the substratum built up by crustose lichens. The foliose lichens have leaf like thalli and they have capacity to absorb water and accumulate dust particles. These communities build up the substratum and results in the development of fine thin soil layer on rock surface.
- **Mosses:** The thin soil layer favours the growth of mosses like *Grimmia, Plytrichum, Tortula* etc. The death and decay of these species adds up more organic matter to the soil leading to the increase in thickness of soil layer.
- **Herbs:** The herbaceous weeds chiefly annuals replace the mosses which are in turn replaced by some biennials and perennials. The stage mostly constitutes of rooted grasses like *Aristida, Cynodon, Euphorbia, Festuca, Leucas, Poa, Solidago* etc.
- **Shrubs:** The soil quantity in the area increases with increased humus, soil living bacteria, fungus, and soil moisture. The habitat becomes suitable for shrubs like *Croton, Cassia, Phytocarpus, Rhus, Solanum* etc.
- **Forest:** Like hydrosere the climax community of xerosere is also forest. The forest community developed is of xerophytic tree species.

2.1

BIODIVERSITY AND ITS CONSERVATION

Faculty Incharge
Dr. Mohd Yousuf Rather

BIODIVERSITY

- Thomas Lovejoy, in the foreword to the book "Conservation Biology" introduced the term 'Biological Diversity'
- Biodiversity or Biological diversity refers to the variety and variability among all groups of living organisms and the ecosystem complexes in which they occur.
- The term was coined by Walter G. Rosen in 1985.
- In the Convention of Biological Diversity (1992), biodiversity has been defined as the variability among living organisms from all sources inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part.
- According to IUCN, "The totality of genes, species and ecosystems of a region is called Biodiversity "

- The warm climate and high primary productivity near the equator help in supporting greater terrestrial biodiversity
- The **tropical forests** thrive about 90% of the world's biodiversity
- The coasts along the **Western Pacific** contain higher marine biodiversity
- The **Biological Diversity Act 2002** was passed to conserve biological diversity in India
- The decade 2011-2020 is declared by the United Nations as the **United Nations Decade on Biodiversity**

- More than 70% of all the recorded species are animals
- Among animals, insects are the most species-rich taxonomic group making up to 70% of the total
- The number of fungi species in the world is more than the combined total of the species of the fishes, amphibians, reptiles and mammals
- Tropical moist forest are one of the worlds richest habitats constituting only 7% of world's surface with at least 50% and possibly up to 90% of all plant and animal species
- Although India has only 2.4% of the worlds land area, its share of the global species diversity is 8.1%

LEVELS OF BIODIVERSITY

Genetic diversity: It is the basic source of biodiversity. Genes are the basic units of hereditary information transmitted from one generation to other. Genetic diversity refers to the variety of genes within a species. Each species has their own specific genetic composition, when the genes within the same species show different versions due to new combinations, it is called genetic variability for example rice varieties (*Oryza sativa*). To conserve the genetic diversity within a species, different populations must be conserved. India has more than 50,000 genetically different strains of rice and 1,000 varieties of mango.

Species diversity: The variability found within the species or between the species in a region is termed as species diversity. Or in other words the number of species that are present in a region constitute its species biodiversity. For example tiger (*Panthera tigris*), lion (*Panthera leo*) and leopard (*Panthera uncia*) are different species but belong to same genus.

- Species diversity is a measurement of:
  - **species richness**: it is the number of different species in an ecosystem
  - **species evenness**: it is the variation in the abundance of individuals per species within a community. The more even the number of individuals per species within an ecosystem the greater the species diversity
- Species diversity is not evenly distributed and it varies from region to region. It is measured by *Shannon-Wiener Index* and *Simpson Index*.

Ecosystem diversity:

- It refers to variety of ecosystems in a given place.
- The diversity of ecological complexity showing variations in ecological niches, trophic structure, food webs, nutrient cycling etc. is defined as ecosystem diversity.
- The ecosystems also show variations with respect to physical parameters like moisture, temperature, altitude, precipitation etc.
- There occurs tremendous diversity within the ecosystem along these gradients.
- At the ecosystem level, India, for instance with its deserts, rain-forests, mangroves, coral reefs, wetlands, estuaries, and alpine meadows has a greater ecosystem diversity

MEASURING BIODIVERSITY

- ***Alpha diversity:*** It is the biodiversity within a particular area, community or ecosystem. It is usually expressed by the number of species in that ecosystem
- ***Beta diversity:*** It is the species diversity between ecosystems or along environmental gradients. It is the rate of change in species composition across habitats or along communities and gives a quantitative measure of diversity of communities that experience changing environments
- ***Gamma diversity:*** It refers to the total species richness over a large area. It is a measure of overall diversity for the different ecosystems within a region.

VALUES OF BIODIVERSITY

- ***Consumptive use value:*** Natural products that are used directly e.g., fuel food, drugs, fibre etc. About 75% of world's population depends upon plants or plant extracts for medicines.
- ***Productive use value:*** It includes the products that are commercially harvested and marketed e.g., paper, silk, wool, honey, etc. It may also include products like tusk from elephants, musk from musk deer, skin of animals (snake, crocodile, tiger, cheetah and leopard).
- ***Social value:*** Biodiversity is of greater importance in cultural, spiritual values, research and academic values. Scientists carry out researches on plants and animals in order to discover new things for the welfare of the society. A few plants (mango, peepal, tusli, banana) and animals (cow, snake, peacock) occupy a significant place in Indian culture.

- ***Ethical value:*** All life must be preserved. Live and let others live. It is very necessary to preserve all the creatures in order to maintain the ecological balance.
- ***Aesthetic value:*** The more the biodiversity, the more beautiful the areas look. Biodiversity has great contribution to quality of life, outdoor recreation and scenic enjoyment. They provide opportunities for recreational activities such as hiking, bird watching, river rafting, rock climbing, trekking, nature photography etc
- ***Option value:*** Values which we don't know. Option values means keeping future possibilities open. It is impossible to predict which of our species or traditional varieties of crops and domestic animals, will be of our greatest use in the future.
- ***Ecosystem service value:*** nutrient cycling, carbon sequestration, oxygen production, control of soil erosion and floods, pollination, decomposition. Nitrogen fixation etc.

There are 20,000 species of wild bees in the world that contribute to pollination. More than 40% of the invertebrate pollinator species particularly bees and butterflies face extinction

2.2 BIODIVERSITY OF INDIA

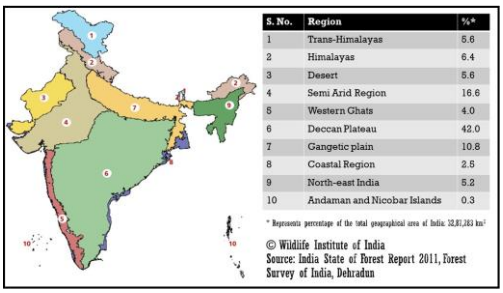
Dr. Mohd Yousuf Rather

BIODIVERSITY OF INDIA

- Currently, 1.8 million species have been documented by scientists in the world
- Estimated number of total species could vary from 1.5 to 20 billion
- Countries such as Brazil, Malaysia, Indonesia, etc. are more diverse than India
- India has two major realms called the Palaearctic and the Indo-Malayan; and three biomes – the tropical humid forests, the tropical dry deciduous forests and the warm deserts/semi-deserts
- International agreements such as World Heritage Convention have attempted to protect the areas with high biological diversity.
- India is a signatory to the convention and has included several protected areas such as **Kaziranga** in Assam, **Bharatpur** in U.P., **Nandadevi** in the Himalayas and the **Sunderbans** in the Ganges delta in West Bengal as World Heritage Sites.
- India has also signed the Convention in the Trade of Endangered Species (CITES)
- Biologically there are several rich ecosystems in India among which **Western Ghats and Himalayas** are the important ones.

- At least 166 species of crops and 320 species of wild relatives of crops are known to have originated in India
- 10% of India's recorded flora and possibly more of its wild fauna are on the list of threatened species, many on the verge of extinction
- 47,513 species of plants and over 91,200 species of animals together comprising of about 6.5% of world's known wildlife
- Along with species richness, India also possesses high rates of endemism
- The region is the stronghold of three cat predators – the lion, leopard and tiger.
- Of the 140 species of known birds, the Great Indian Bustard is a globally threatened species
- The flora of the Indian desert comprises of 682 species, with over 6% of the total plant species being endemic

BIOGEOGRAPHIC ZONES OF INDIA



S. No.	Region	%*
1	Trans-Himalayas	5.6
2	Himalayas	6.4
3	Desert	5.6
4	Semi Arid Region	16.6
5	Western Ghats	4.0
6	Deccan Plateau	42.0
7	Gangetic plain	10.8
8	Coastal Region	2.5
9	North-east India	5.2
10	Andaman and Nicobar Islands	0.3

* Represents percentage of the total geographical area of India: 32,87,263 km²

© Wildlife Institute of India
Source: India State of Forest Report 2011, Forest Survey of India, Dehradun

Based on the geography, climate and pattern of vegetation seen and the communities of mammals, birds, reptiles, Amphibia, insects and other invertebrates that live in them.

MEGA-DIVERSITY COUNTRY

- Countries which have a relatively large proportion of hotspots of diversity
- The main criterion for mega-diverse countries is endemism.
- A megadiverse country must have:
  - At least 5000 species of endemic plants and
  - Must border marine ecosystem

17 MEGA BIODIVERSITY COUNTRIES OF THE WORLD

- Australia
- Brazil
- China
- Colombia
- Ecuador
- United States
- Philippines
- India
- Indonesia
- Madagascar
- Malaysia
- Mexico
- Papua New Guinea
- Peru
- Democratic Republic of Congo
- South Africa and
- Venezuela

INDIA AS A MEGA-DIVERSITY COUNTRY

- India has 2.4% of total land area of the world and 8.6 % of the global biodiversity
- 47,513 plant species (BSI) and 91,000 animal species (ZSI)
- It is estimated that 32% of Indian plants are endemic to the country
- Among the plant species the flowering plants have a much high degree of endemism ($1/3^{rd}$).
- Andaman and Nicobar Island alone have as many as 2200 species of flowering plants and 120 species of ferns
- India has total geographical area about 32,87,263 km^2 and a forest cover of about 7,01,673 sq km which is 21.34% of geographical area
- There are 104 national parks, 553 wildlife sanctuaries and 18 biosphere reserves in India
- Among animals insects are the most species-rich taxonomic groups making up more than 70% of the total

- In terms of endemic vertebrate groups, India's global ranking is:
  - 10th in birds (1,266 species),
  - 8th in mammals (350 species)
  - 5th in reptiles (526 species) and
  - 7th in amphibians (405 species) and
  - 15th in plants (47,513 species)
- 63% of mammals are found in NE
- 62% of amphibians are unique to this country
- Avifauna (1200 birds) cover 14% of world avifauna

Endemism

Endemism is the ecological state of a species being unique to a defined geographic location such as an island, nation, country or other defined zone. Organism that are indigenous to a place are not endemic to it, if they are also found elsewhere. India ranks among the top ten species-rich nations and shows high endemism. The extreme opposite of endemism is cosmopolitan distribution.

BIODIVERSITY HOTSPOTS

- There are thousands of eco-regions in the world. Of these, 200 are said to be the richest, rarest and most distinctive natural areas. These are referred as *Global 200*.
- Hotspot is a biogeographic region having a significant level of biodiversity
- Countries which have a relatively large proportion of these hotspots of diversity are referred to as '*megadiversity nations*'
- The term hotspot was introduced by Norman Myers in 1988 for regions particularly rich in 'endemic' 'rare' and 'threatened' species
- He identified them as priority areas for in-situ conservation
- Areas which exhibit high species richness along with high species endemism are called as hotspots of biodiversity

- Hence hotspots are defined as region of rich biodiversity which have been declared sensitive due to direct or indirect interference of human activities and are priority areas for in-situ conservation
- According to Myers et al. (2000) an area is designated as hotspot when it contains at least 0.5% of the plant species as endemics
- There are four main criteria's for determining an area as hotspot:
  - A) rich species diversity B) number of endemic species C) degree of threat in terms of habitat loss and D) degree of exploitation
- To qualify as a biodiversity hotspot a region must have at least 1500 endemic vascular plants and it must have 30% or less of its original vegetation.

- 36 biodiversity hotspots have been identified in the world
- Comprising just 2.3% of Earth's land surface yet hold especially high number of species that occur nowhere else
- 50% of the world's plant species and 42% of all animal species are endemic to these hotspots
- India represents 4 biodiversity hotspots:
  - **Himalaya:** entire Himalayan region (China, India, Pakistan, Nepal, Tibet, Bhutan)
  - **Indo-Burma:** North-east India (except Assam) and Andaman Islands, Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China
  - **Western Ghats and Sri Lanka**:
  - **Sundalands:** Nicobar group of islands, Indonesia, Malaysia, Singapore, Brunei, Philippines
- The Indian hotspots are not only rich in floral wealth and endemic species of plants but also reptiles, amphibians, swallow tailed butterflies and some mammals

HIMALAYAS

- Considered as the highest in the world, the Himalayas comprises of the entire Indian Himalayan region, Tibet, Nepal, Bhutan, Yunnan Province of South Western China
- Evergreen and semi-evergreen vegetation
- As many as 10,000 plant species, of which 3160 are endemic
- In Indian region there are about 5800 plant species and of which about 2000 are endemic
- This region holds a record of having 163 endangered species which includes the Wild Asian Water Buffalo, One-horned Rhino,
- This mountain range covers nearly 750,000 km^2

WESTERN GHATS

- Region of high rainfall characterized with evergreen and semi-evergreen vegetation
- Region has moist deciduous forests and rain forests
- 17,000 km^2 strip of forests of Maharashtra, Karnataka, Tamil Nadu and Kerala
- Major centres of diversity are: Agastyamalai Hills and Silent Valley
- 40% of the total endemic plant species, 77% amphibians, 62% of reptiles and 50% lizards
- There are over 6000 vascular plants of which 3000 are endemic
- It is reported that only 6.8% of the original forests are existing today

- The region harbours 450 bird species, about 140 mammalian species, 260 reptiles and 175 amphibians
- Lion tailed Macaque (*Macaca silenus*) is one of the world's most endangered primates - only 800 remaining
- Nilgiri langur (*Presbytis johnii*), Flying squirrels, Nilgiri mongoose, Strip-necked mongoose, the Malabar civet and Spiny mouse

INDO-BURMA

- North-east India (except Assam) and Andaman Islands, Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China
- This region has been an active centre of evolution of flowering plants and origin of many crop plants
- Mixed wet evergreen, dry evergreen, deciduous and montane forests
- Patches of shrublands and wood lands
- Lowland floodplain swamps, mangroves and seasonally inundated grasslands
- Endemic freshwater turtles
- Monkeys, langurs, and gibbons (population only in hundreds)
- 1300 bird species including threatened white-eared night-heron, the grey-crowned crocias, and the orange necked partridge

SUNDALANDS

- Nicobar group of islands, Indonesia, Malaysia, Singapore, Brunei, Philippines
- India represents the Nicobar Islands which was declared as World Biosphere Reserve in 2012 by the UN
- The Island is rich in terrestrial and marine ecosystems that include mangroves, coral reefs and sea grass beds
- Whales, dolphins, dugong, turtles, crocodiles, fishes, prawns, lobsters, corals and sea shells
- Primary threat is over-exploitation of marine resources

2.3

THREATS OF BIODIVERSITY (HABITAT LOSS, POACHING OF WILDLIFE AND MAN-WILDLIFE CONFLICTS)

Dr. Mohd Yousuf Rather

THREATS TO BIODIVERSITY

- Biological resources serve about 40% of the worlds economy and nearly 80% of the needs of the people
- It provides great opportunity in the field of medical, research, education and economic development. Declining biodiversity is therefore a concern for countless reasons
- One of the estimates by noted ecologist, E. O. Wilson puts the figure of extinction at 10,000 species per year or 27 per day. If the current continues we would loose 1/3rd or 2/3rd of our current biodiversity by the middle of the 21st century

HABITAT LOSS

- Habitat destruction/Deforestation is the major cause for biodiversity loss
- Responsible for 73% of biodiversity loss (IUCN, 2000)
- There has been a rapid disappearance of tropical forests in our country also, at a rate of about 0.6% per year
- With the current rate of loss of forest habitat, it is estimated that 20-25% of global flora would last only a few years
- Wild animals are left with no alternative but to adopt, migrate or perish
- Reasons of habitat loss
  - Environmental pollutions, Deforestation, Soil erosion, Agricultural expansion, Overgrazing, Increasing urbanization, Forest fires and Development works

POACHING

- Poaching is the hunting of wildlife for their commercial trade in markets
- Poaching is illegal
- High demand and value of animal parts such as 100$ for elephant tusks, 100,000$ for leopard fur coat,
- Ivory, rhinoceros, horn, hides, skins, antlers, meat etc.
- Second biggest threat to species diversity after habitat destruction
- Excessive hunting has caused extinction of Dodo bird in Mauritius and Cheetah in India
- The illegal trade has been responsible for the destruction of a large number of tigers, leopards, deer, fishing cat, crocodiles, snakes and birds with beautiful plumage

- According to Wildlife protection society of India (WSPI), more than 60 tigers were poached in country during 1994-95
- Wildlife society of Orissa has reported that 57 elephants were shot dead by poachers for ivory between 1992-96
- When one animal population changes or becomes extinct, all other parts of the ecosystem are affected as the rate of specific predators versus prey will change
- Two serious problems that are being faced by human beings due to poaching are:
  - Spread of food-borne illness as seen with the country wide spread of Ebola from monkey meat in Congo and the outbreak of Anthrax in Uganda
  - Lack of natural resources

MAN-WILDLIFE CONFLICTS

- WWF defines conflict as "any interaction between humans and wildlife that results in a negative impact on human, social, economic or cultural life or on the conservation of wildlife population or on the environment"
- Normally reduction in the natural prey/food sources leads to wild animals seeking alternate sources
- According to TERI University, the incidents of man-animal conflicts can be categorized into fallowing major types:
  - Human beings get killed or injured by wild animals
  - Livestock/Cattle reared by man get killed or injured
  - Crop cultivated by man gets damaged
  - Wild animals get killed or injured

- Samblapur Orissa; Elephants
  195 humans and 98 elephants killed and 30 injured
- In 2004 Man eating tiger killed 16 Nepalese people and one 4 year old child in Kathmandu
- Human wildlife conflict is most concentrated and impactful within agricultural regions
- This is a big problem in rural parts of Africa and some parts of Kerala in India
- Every year 100 humans (in some years it may be 300 people) and 40-50 elephants are killed during crop raiding in India

- **Causes of conflicts**:
  - Fragmentation and Shrinking of habitat
  - Road kills
  - Land use transformation
  - Infestation of wildlife habitat by invasive exotic species
  - Human activities
  - Livestock grazing
  - Decreased prey base caused by poaching of herbivores
- **Consequences for human beings**:
  - Injury or loss of human lives
  - Crop depredation
  - Killing of live stock
  - Damage to human property

- **Consequences for wildlife and environment:**
  - Destruction of habitat
  - Killing of wild animals
- **Preventive measures:**
  - Control over poaching
  - Wildlife corridors
  - Awareness programmes
  - Solar fencing around agricultural fields
  - Paying compensation to the people
  - Eco-development activities
  - Ecotourism
  - Use of Information Technology and Remote sensing

2.4

CONSERVATION OF BIODIVERSITY: IN-SITU AND EX-SITU CONSERVATION

Dr. Mohd Yousuf Rather

CONSERVATION OF BIODIVERSITY

- Biodiversity is under immense pressure
- We already have lost 10% of global biodiversity
- Biodiversity conservation is important not only because it has immense potential for human benefits but also because every species has an intrinsic value and right to survive and share this planet earth
- Conservation of biodiversity involves not only the living organisms but also the abiotic factors of the environment so as to maintain the life supporting systems of the wildlife
- Biodiversity conservation refers to the protection, upliftment and management of biodiversity in order to derive sustainable benefits for present and future generations

Preservation simply means the complete protection and leaving the natural resources totally untouched. Conservation implies the management of resources on a sustainable yield basis

Objectives of biodiversity conservation:

- To preserve the diversity of species
- To ensure sustainable utilization of species and ecosystems
- To maintain life supporting systems and essential ecological processes

There are two main methods for biodiversity conservation

In-situ

Ex-situ

IN-SITU CONSERVATION

- Conservation of species at its original or natural environment
- It can be achieved by establishing protected areas
- In India the protected area include National Parks, Wildlife Sanctuaries and biosphere reserves
- The protected area network in India is 5.06% of its total geographical area

Protected Area	Number	Area	Indian total SA %
National Parks	104	43,716 km²	1.33%
Wildlife Sanctuaries	566	1,22,420 km²	3.72%
Biosphere Reserves	18	89,217.78 km²	2.71%

National Wildlife Database, Dec.2020

NATIONAL PARKS

- Under section 35 of the Wildlife Protection Act 172, a national park is declared for the purpose of protecting, propagating or developing wildlife or its environment
- According to the Indian Board for Wildlife (IBWL), "A national park is an area dedicated by statue for all time to conserve the scenery, natural and historical objects, to conserve the wildlife there in and to provide for enjoyment of the same in such a manner and by such means, that will leave them unimpaired for the enjoyment of future generations with such modifications as local conditions may demand"
- State Government can declare any area as National Park under the Wildlife Protection Act, 1972 for the purpose of protection, propagation and development of wildlife and its habitat
- The history of National Parks in India began in 1936 when the Hailey (now Corbett) national park was established at Uttarakhand

- The boundaries of national park are well demarcated and human activities like forestry, grazing, hunting, agricultural activities etc. are strictly prohibited
- No human activity is allowed in national park except in buffer zone where limited ecotourism is allowed

National Park	State	Important Wildlife
Kaziranga	Assam	One horned Rhino
Ghir National Park	Gujarat	Indian Lion
Dachigam	J and K	Hangul
Bandipur	Karnataka	Elephant
Periyar	Kerala	Elephant, Tiger
Kanha	MP	Tiger
Corbett	Uttarakhand	Tiger

WILDLIFE SANCTUARIES

- A wildlife sanctuary is declared under Section 18 of Wildlife Protection Act, 1972
- IWBL has defined a Sanctuary as, "an area where killing, hunting, shooting or capturing of any species of bird or animal is prohibited except by or under the control of highest authority in the department responsible for the management of the sanctuary and whose boundaries and character should be sacrosanct as far as possible"
- These are the regions which are reserved for the conservation of wild animals only
- Forestry activities and private ownership activities are permissible in wildlife sanctuaries as far as they don't affect the wildlife adversely
- Research, photography and tourism is permitted after obtaining permission from chief wildlife warden of the state
- 566 existing wildlife sanctuaries in India covering an area of 122,420 km^2 which is 3.72 % of the geographical area of the country (National Wildlife Database, May 2016)

- In India sanctuary is usually created by an order or gazette notification of State government and the same can be desanctuarized merely by another order or gazette notification because it is not safeguard by nay proper legislation.
- The idea behind a wildlife sanctuary and National Park is same i.e., maximum protection, preservation and conservation of wild animals. But the fundamental difference between the two is that a National Park is created by order of a competent authority who may be the chief conservator of forest: or minister of a state while wildlife sanctuary can be harmed, abolished or changed only by the legislation of the state
- In Union territory of J and K, the wildlife sanctuaries include Nandini WLS, Jasrota WLS, Abohar WLS, Wild Ass WLS etc.
- The idea behind a wildlife sanctuary and a national park is same i.e., maximum protection, preservation and conservation of wild animals

Name of Sanctuary	State	Major Wildlife
Ghana BS	Rajasthan	300 species of birds
Hazaribagh WS	Bihar	Tiger, Leopard
Sultanpur BS	Haryana	Migratory birds
Nal Sarovar BS	Gujarat	Water birds
Abohar WS	Punjab	Black buck
Mudumalai WS	Tamil Nadu	Tiger, Elephant, Leopard
Vedanthangal BS	Tamil Nadu	Water birds
Jaldapara WS	West Bengal	Rhinoceros, Elephant, Tiger
Wild Ass Sanctuary	Gujarat	Wild ass, Wolf, Nilgai

National Park

- The aim of national park is to protect historic and natural objects as well as the wildlife of the territory
- No human activities are allowed
- Official permission is required
- Can include flora, fauna or any other objects of historical/geographic significance
- Boundaries are fixed and defined
- Not usually open to the public
- National Parks are formed by the State or central Legislature
- A national park cannot be downgraded to a sanctuary

Wildlife Sanctuary

- The aim of wildlife sanctuary is to ensure that the population of wildlife and their respective habitats are sustained
- Human activities are allowed
- Official permission is not required
- The main aim is to protect a particular flora or fauna
- There are no fixed boundaries
- It is open to the general public
- Sanctuaries are usually formed by the order of Central or the State Government
- A sanctuary can be upgraded to a national park

BIOSPHERE RESERVES

- They are the representatives of natural and cultural landscapes extending over large areas of terrestrial or coastal/marine ecosystems or combination of both
- Biosphere reserves are multi-purpose protected areas where the wildlife, traditional life style of the inhabitants and domesticated plants and animals are protected
- They have been described as undisturbed natural areas for scientific study as well as areas in which conditions of disturbance are under control.
- They serve as the centres for ecological research and habitat protection
- Biosphere reserves conserve some representative ecosystems as a whole for long-term in-situ conservation

- The purpose of the formation of the biosphere reserve is to conserve in situ forms of life, along with its support system, in its totality, so that it could serve as a model system for monitoring and evaluating changes in natural ecossytems
- Within a biosphere we may have more than 1 National Park for example Nilgiri Biosphere Reserve has two National parks, Bandipore and Nagarhole National Park
- Each biosphere reserve is intended to fulfil 3 basic functions which are conservation, development and logistic function
- A biosphere reserve has three zones: the core, the buffer and the transition area

There are 18 biosphere reserves in India

Nanda devi – UP
Nokrek – Meghalaya
Manas – Assam
Sunderbans – West Bengal
Gulf of Mannar – Tamil Nadu
Nilgiri – Karnataka, TN, Kerala
Great Nicobars and Similipal – Orissa

Concept of Biosphere Reserve originated in The Man and Biosphere (MAB) programme initiated by UNESCO in 1972. The main objectives of the programme are:

- Conserve biological diversity
- Safeguard genetic diversity
- Provide areas for basic and applied research
- Opportunity for environmental science and training
- Promote international cooperation
- Promote management of biotic communities

EX-SITU CONSERVATION

- Offsite conservation
- It is the process of protecting an endangered species by removing part of the population from the threatened habitat and placing it in a new location, which may be a wild area or within the care of humans
- The stresses on living organisms due to competition for food, water, space etc. can be avoided by ex-situ conservation thereby providing conditions necessary for a secure life and breeding
  - Gene Bank and Seed bank
  - Botanical gardens
  - Zoological parks
  - Culture collections
  - Long-term captive breeding

GENE BANK/SEED BANK

- **Gene Bank**: These are cold storages where germplasm are kept under controlled temperature and humidity for storage. The Indian National Gene Bank established by the Indian Council of Agricultural Research (ICAR) as part of National Bureau of Plant Genetic Resources (NBPGR) has conserved more than 4 lakh samples.
- **Seed Bank**: These are cold storages where seeds are kept under controlled temperature and humidity for storage. Seeds preserved under controlled conditions remain viable for long duration of time. An example of seed bank is Svalbard Global Seed Vault in which about 10000 seed samples of more than 2000 cultivators for 300 different species has been preserved.

- The preservation is done at very low temperature of -196°C in liquid nitrogen – ***Cryopreservation***. The metabolic activities of the organisms are suspended under low temperature.
- Germplasm conservation in the form of seed is most convenient since seeds occupy a relatively small space
- Their transportation to various introduction centres and gene banks is also economical but the drawbacks in conservation of seed are:
  - Loss of viability over passage of time and susceptibility due to insect or pathogen attack
  - Non applicability of vegetatively propagated crop e.g., Ipomea, potato etc

BOTANICAL GARDENS

- Botanical gardens are defined as, "Institutions holding documented collections of living parts for the purpose of scientific research, conservation, display and education".
- Long before Botanical Gardens were used to describe new species and discover its potential uses in industry, horticulture, educational or research and also conserve species of rare wild plants.
- The presence of rare species in botanical gardens reduces the anthropogenic effect on wild populations.

ZOOLOGICAL PARKS

- Zoos are aimed to maintain wild animals in captivity for their conservation especially rare and endangered species.

Botanical gardens and Zoos act as storehouse for protected specimens for breeding and reintroduction into the wild when necessary and possible. These facilities provide not only housing and care for specimens of endangered species but also have an educational value

LONG-TERM CAPTIVE BREEDING

- The method involves capture, maintenance and captive breeding on long term basis of individuals of the endangered species which have lost their habitat permanently or the available conditions in their habitat are highly unfavourable.

ADVANTAGES OF EX-SITU CONSERVATION

- It helps in the rescue of threatened germplasm
- It removes and reduces the pressure of material collection from wild
- It helps to grow those species with recalcitrant seeds that cannot be maintained in a seed store
- It makes available material for conservation, education and display
- It produces material fro reintroduction, reinforcement, habitat restoration and management

2.5

ECOTOURISM

Dr. Mohd Yousuf Rather

Ecotourism, Concept of protected area network with special reference to Kishtwar, Dachigam and Hemis National parks

ECOTOURISM

- The term ecotourism was coined by Mexican Environmentalist **Hector Cebellos Lascurian** in 1983
- He used to word to describe travelling to undisturbed areas in order to enjoy their natural beauty and culture
- In simple words the meaning of ecotourism is travel that makes a positive impact on both the ecology and economy of a given region
- In 1984 he founded the first Mexican ecotourism agency "ecotours"
- IUCN also published a book on, "Tourism, Ecotourism and Protected Areas" in 1996
- Ecotourism is essentially all about bringing nature/wildlife conservationists, local communities and the responsible travel industry together to ensure development focused ion long-term sustainability rather than short-term profits

- According to IUCN (1996) ecotourism is an environmentally responsible travel and visitation to relatively undisturbed natural areas in or order to enjoy and appreciate nature, that promotes conservation, has low negative visitor impact, and provides beneficially active socio-economic involvement of local population
- It involves a wide range of activities such as trekking, hiking, mountaineering, bird watching, rafting, biological exploration sand visiting wildlife sanctuaries

Ecotourism should satisfy several criteria:

1. Conservation of biological diversity and cultural diversity through ecosystem protection
2. Promotion of sustainable use of biodiversity by providing jobs to local populations
3. Sharing of socio-economic benefits with local communities, and indigenous people by having their informed consent and participation in the management of ecotourism enterprises
4. Tourism to untouched natural resources, with minimal impact on the environment as one of its primary concerns
5. Special focus should be made on local culture, flora and fauna

Positive impacts of Ecotourism:

1. Ecotourism stimulates the tourists to respect wild species and visualize conservation schemes
2. It can increase the level of education and activism among travellers, making them more enthusiastic and effective agents of conservation
3. It will also encourage the local community to value its natural and cultural assets
4. It provides employment opportunities to local people
5. It will promote environmental awareness and ethics in the visitors

Negative impacts of Ecotourism:

1. It may cause degradation of the habitat by polluting waterways, accumulation of garbage, over harvesting of flora etc.
2. Unregulated tourist activity may cause disturbance to the flora and fauna
3. Arrival of outsiders as tourists and entrepreneurs may cause social and cultural degradation of the local population

PROTECTED AREA NETWORK

- Protected areas are locations which receive protection because of their recognized natural, ecological or cultural values. A network of these areas is termed as protected area network
- India has a network of 981 protected Areas including 104 National Parks, 556 Wildlife Sanctuaries, 97 Conservation Reserves and 214 Community reserves covering a total of 1,71,921 km^2 of geographical area of the country which is approximately 5.03%
- These areas are essential for biodiversity conservation, often providing habitat and protection from hunting for threatened and endangered species
- According to IUCN Definition 2008, a protected area is a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values
- In these areas human occupation or at least the exploitation of resources is limited
- The term "Protected Areas" also include Marine Protected Areas and Transboundary Protected Areas (multiple countries which remove the borders inside the area for conservation and economic purposes)

KISHTWAR NATIONAL PARK

- It is located in the Kishtwar district of J&KUT
- It is spread over an area of 219.5 km^2 and its altitude ranges between 1700-4800m abmsl
- It is bounded on North by Rinnay river, South by Kibar Nala catchments, East by main divide of great Himalayas and in West by Marwah river
- It has beautiful waterfalls, trekking paths and sapphire mine of Paddar

Flora: Silver fir and spruce, mixed with cedar and blue pine form predominant vegetation. The prominent flora consists of *Pinus gerardiana, Cedrus deodara, Pinus wallichiana, Quercus baloot, Daphne paniculata, Juglans regia, Desmodium elegans, Dipsacus innermis, Artemisia vulgaris* etc.

Fauna: It is a renowned snow leopard reserve. Fauna includes Brown bear, Himalayan black bear, musk deer, ibex, markhor, snow leopard, wild boar, bharal, serow and rhesus macaque. Hangul or Kashmiri Stag migrates in winters from Dachigam National Park

Major Avifauna: Himalayan monal, koklass, Himalayan snowcock, Western tragopan, Himalayan jungle crow, bearded vulture, griffon vulture, paradise flycatcher, golden oriole, white cheeked bulbul and black bulbul

DACHIGAM NATIONAL PARK

- Dachigam literally means 'ten villages' and the name could be in memory of the 10 villages that were relocated in order to create the park
- It covers an area of 141 km^2
- The park has been a protected area since 1910
- The park boasts over 500 species of herbs, 20 species of shrubs and 50 species of trees

Flora: Wild cherry, pear, plum, peach, apple, apricot, walnut, chestnut, oak, willow, poplar, chinar, birch, pine and elm

Fauna: Hangul (Kashmir Stag – a critically endangered species), musk deer, brown bear, leopards, jungle cats, Himalayan black bear and few species of wild goat (markhor and ibex)

Major Avifauna: Black bulbuls, cinnamon sparrows, Himalayan monals, Kashmir flycatcher and colourful pheasants (including the crimson Tragopan, the Iridescent Monal pheasant, the Blood Pheasant and the Koklass Pheasant), the Golden Eagle and the Bearded Vulture or Lammergeier

HEMIS NATIONAL PARK

- It is the best place to see snow leopard in the wild.
- It is also known as snow leopard capital of Indian and is named after famous Ladakh Hemis Gompa
- It is spread over an area of 4400 km^2
- The park has the distinction of being the largest national park in South Asia
- It was established as a national park in the year 1987
- There are around 11 faunal species and 30 species of avifauna

Flora: Dry forest of Juniper, Poplus and Salix forest are present at lower altitudes.The upper altitudes are characterized by alpine vegetation including *Anemone, Gentiana, Lloydia, Veronica, Delphinum, Carex* and *Kobresia*. Other parts of the park support steppe vegetation dominated by *Caragana, Artemisia, Stachys* and *Ephedra*

Fauna: viable population of 200 snow leopards, Argali (Great Tibetan Sheep), Bharal (Blue sheep), Shapu (Ladakhi Urial), Asiatic Ibex, The Tibetan Wolf, the Eurasian Brown Bear (endangered in India), the Red Fox etc. The small mammals include the Himalayan Marmot, Mountain Weasel, Wolly Hare and the Himalayan Mouse Hare.

Major Avifauna: Golden Eagle, Himalayan Griffon Vulture, Tibetan Snow Finch, Red Billed Chough, Tibetan Snow Cock, Himalayan Snow Cock, Brown Accentor, Robin Accentor, Tickell's Leaf Warbler, Streaked Rosefinch, Black winged Snowfinch, Chukar, Blyth's Swift and the Fire Fronted Serin

UNIT 3: NATURAL RESOURCES AND THEIR CONSERVATION

3.1 **Forest resources**: uses and overexploitation of forests and consequences of deforestation
3.2 **Water resources**: use and consequences of over-utilization, concept of rainwater harvesting and watershed management, water conflicts
3.3 **Food resources**: sources of food, impact of modern agriculture on environment (Fertilizer-Pesticide problem, water logging and salinity), organic farming
3.4 **Energy resources**: renewable and non-renewable energy resources, growing energy needs and alternate energy sources
3.5 **Land resources**: global land use patterns, soil erosion, desertification, wasteland reclamation

RESOURCE

All means of satisfying human needs, at a given time and place. It also means 'a source of supply or support generally held in reserve'. For man, resources are those materials which are needed for survival and prosperity. A major global concern has been whether the present rate of global population growth will be sufficient to meet up the resources needs for mankind's survival and comfort? There is a need for sustainable use of resources to meet up the ever-inversing needs of human population. Technological innovations helped a lot in solving the problems of resource depletion at a faster rate. The strength of nations – social, economic or political – is chiefly determined by the resources they conquered and their capacity to utilize and conserve these resources.

The quality of human life and the quality of ecosystems on earth are indicators of the sustainable use of resources. There are clear indicators of sustainable lifestyles in human life.

- Increased longevity
- An increase in knowledge
- An enhancement of income.

These three together are known as the '**Human development index'**. The quality of the ecosystems have indicators that are more difficult to assess.

- A stabilized population.
- The long term conservation of biodiversity.
- The careful long-term use of natural resources.
- The prevention of degradation and pollution of the environment.

TYPES OF RESOURCES:

- **Continuous resources**: These resources continue to be available , cannot be degraded even with gross mismanagement e.g., solar energy, wind, tidal energy, geothermal energy
- **Renewable resources**: These resources are capable of natural regeneration within a timespan relevant to man. These resources could be indefinitely available, provided their capacity to regenerate is not damaged by natural catastrophe or

human activities. Once degraded beyond a certain critical point, a renewable resource may never recover e.g., clean water, flora, fauna, soil and clean air

- **Non-renewable resources**: these resources are available only in finite quantities or else the rate of renewal is so slow that they must be regarded as available only in fixed quantities e.g., minerals, etc.
- **Extrinsic resources**: These are fickle resources and prone to breakdown and degradation, yet can be continuous resources if managed well e.g., human resources, management abilities etc.

Depending on their abundance and availability:

- **Inexhaustible resources**: they are unlimited e.g., wind, tidal energy, soil
- **Exhaustible resources**: they are limited and can be diminished and degraded if not used properly

Depending on their nature:

- **Inorganic**: air, water, ores
- **Organic**: plants, animals, fossil fuels

Depending on their location:

- **National**: land forests, minerals
- **Multinational**: rivers, oceans and seas, migratory animals
- **International**: air, solar energy

FOREST RESOURCES

Forest is derived from a Latin word ‘foris’ which means ‘outside’. Forests are any area outside cultivated land which is covered by dense trees. A forest can be defined as a biotic community predominant of trees, shrubs or any other woody vegetation usually in a closed canopy. FAO has defined forests as, ‘all land bearing vegetation dominated by trees of any size, exploited or unexploited, capable of producing wood or other forest products’.

According to Indian State of Forest Report 2015, the forest cover of country is 21.34% of its geographical area. The tree cover of the country is 2.82% of the geographical area. Similarly our state Jammu and Kashmir has 19.1% of land under forests. The Himalayan forests are most biologically diverse habitats. As they cover only 18% of the geographical area of India but they account for more than 50% of the India's forest cover and 40% of the species endemic to Indian subcontinent. Scientists estimate that India should ideally have 33 percent of its land under forests but today we have only about 12 percent. Thus we need not only to protect existing forests but also to increase our forest cover.

Uses

- Watershed protection: Reduce the rate of surface run-off of water, Prevent flash floods and soil erosion. Produces prolonged gradual run-off and thus prevent effects of drought.
- Atmospheric regulation: Absorption of solar heat during evapo-transpiration. Maintaining carbon dioxide levels for plant growth. Maintaining the local climatic conditions.
- Erosion control: Holding soil (by preventing rain from directly washing soil away).
- Land bank: Maintenance of soil nutrients and structure.
- Local use - Consumption of forest produce by local people who collect it for subsistence – (Consumptive use). Food, Fodder - for cattle, Fuel wood and charcoal, Poles, Timber, Fiber, Sericulture, Apiculture, Medicinal plants.
- Market use - (Productive use)
- Regulatory uses: Gaseous cycling, provides habitat for wild animals, climate regulation

Overexploitation of forests

Forests can feed world's hungry and over-exploitation for timber must be curbed – UN. The increase in human population and industrialization demanding raw materials from forest have put enormous pressure on forests. This have resulted in overexploitation of forest and their decline. Overexploitation is mainly because of increasing human greed. This has resulted in deforestation, desertification and loss of wildlife. Deforestation became a major concern in British times when a large amount of timber was extracted for building their ships.

Consequences of deforestation

Deforestation is the permanent destruction of indigenous forests (In forest the corns of individual trees touch to form a single canopy) and woodlands (Trees are far apart so that the canopy is open). The term does not include the removal of industrial forest such as plantation of gums and pines

- FAO defines tropical deforestation as, 'Change of forest with depletion of tree crown cover more than 90%'
- Depletion of forest crown cover less than 90% is considered a forest degradation
- Deforestation is the removal of forest or stand of trees where the land is thereafter converted to no-forest use e.g., to farms, ranches or urban use
- Deforestation has resulted in the reduction of indigenous forests to 4-5ths of their pre-agricultural area
- Currently 12 million hectares of forest cleared annually
- Almost all of this deforestation occurs in the moist forests and open woodlands of the tropics
- At this rate the moist tropical forest could be lost by the year 2050 except few isolated areas in- Amazonia, the Zaire basin as well as few protected areas
- The destruction of forests due to unscrupulous and indiscriminate felling of trees has lead to an overall deterioration of our environment and is posing a serious threat to the quality of life in future

- Deforestation causes extinction, changes to climatic conditions, desertification and displacement of populations.
- According to IPCC, deforestation mainly in tropical areas could account for up to 1/3rd of total anthropogenic CO_2 emissions

Causes of deforestation are:

- **Population explosion**: Growing population increases the demand for forest products
- **Agriculture**: It contributes to 5% of total deforestation
- **Demand for firewood**: 54% of the total global wood produced fulfils fuel requirements of the world. Developed countries utilize 16% while as developing countries use 82% of their forest produce as firewood. India consumes nearly 135-170 million tonnes of firewood annually and 10-15 hectares of forest cover is being cleared every year to meet the minimum fuel needs of urban and rural poor.
- **Commercial logging**: Making boxes, crates, packing cases, furniture, match boxes, paper and pulp, plywood etc. Nearly 46% of the annual recorded production of wood is used for industrial purposes.
- **Mining**: Mining operations for extracting minerals and fossil fuels like coal often involves vast forest areas.
- **Urbanization and industrialization**:
- **Development projects:** Roads, railways, buildings, dams, townships, electric supply, irrigation dams and canals, etc
- **Shifting cultivation**: Slash and burn method of farming. Annually about 5 lac hectares of forest is cleared for this type of farming. After 2-3 years of tilling, the land is left to the mercy of nature to recover. Even today, sifting cultivation is practiced in North-east India.
- **Forest fires**: cause by natural as well as human activities and they may become uncontrolled
- **Grazing by livestock**: Overgrazing by the livestock especially by cattle and goats leads to destruction of young saplings. The results in loss of porosity of soil, soil erosion and desertification of the previously fertile forest area.
- **Pest attack**: they destroy trees by eating them up and by spreading diseases
- **Natural calamities**: Floods, storms, snow, lightening etc.

Effects of Deforestation:

- Habitat destruction
- Soil erosion due to reduction of vegetation cover
- Climate change
- Reduction in oxygen level
- Increase in pollution due to burning of wood
- Water cycle disruption
- Decrease in rainfall
- Loss of fertile land
- Migration of species
- Decrease in availability of forest products
- Loss of biodiversity
- Scarcity of fuel wood and deterioration in economy and quality if life

- Lowering of water table due to more runoff and thereby increased chances of drought
- Rise in carbon-di-oxide level due to reduction in fixation by plants

Conservation strategies:

- Restraining cutting of trees and submerging the forests
- Reforestation
- afforestation
- Control forest diseases and forest fires
- Recycling forest products
- Replacing forest products
- Implementing various acts like Forest Conservation Act, Wildlife (Protection) Act
- Creating awareness among people e.g., Chipko movement, Narmada Bachao Andolan
- Implementing peoples participatory programmes like JFM

WATER RESOURCES

The water cycle maintains hydrological systems which support a variety of aquatic ecosystems. Water is an indispensable natural resource on earth. The UN has recognized access to water as basic human right, stating that water is a social and cultural good, not merely an economic commodity. Water covers 70% of the earth's surface but only 3% of this is fresh water. Of this, 2% is in polar ice caps and only 1% is usable water in rivers, lakes and subsoil aquifers. Only a fraction of this can be actually used. The water cycle maintains hydrological systems which support a variety of aquatic ecosystems.

Uses

No plant or animal species can survive without water. Uses of water include agricultural, industrial, household, recreational and environmental activities. At a global level 70% of water is used for agriculture about 25% for industry and only 5% for domestic use. India uses 90% for agriculture, 7% for industry and 3% for domestic use. Other uses of water include:

- **Commercial**: Hotels, motels, restaurants, office building, other commercial facilities and civilian and military institutions
- **Domestic**: household purposes such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets and watering lawns and gardens
- **Industrial**: processing, cleaning, transportation, dilution and cooling. Major water using industries include steel, chemical, paper, and petroleum refining
- **Irrigation**: Farm, orchard, pasture and horticulture crops. Irrigation of public and private golf courses, parks, nurseries, turf farms, cemeteries, and other landscape irrigation uses
- **Livestock**: stock animals, feed lots, diaries, fish farms etc
- **Mining**: for extraction of naturally occurring minerals
- **Thermoelectric Power generation**

Consequences of over-utilization

More than 99% of earth's water is unavailable or unsuitable for beneficial human use. Over exploitation of fresh water resources has resulted in many serious problems which directly affect the present and future needs of the people. It has resulted in water scarcity, water logging, deterioration of water quality etc. As per United Nations estimation, about one billion people don't have access to safe drinking water. India is expected to face critical levels of water stress by 2025. At the global level 31 countries are already short of water and by 2025 there will be 48 countries facing serious water shortages. The UN has estimated that by the year 2050, 4 billion people will be seriously affected by water shortages.

The rapid increase in population and industrial growth led to severe demand on water resources. The various consequences of over-utilization of water include:

- The increased extraction of groundwater results in its decreased level
- Construction activities reduce the area of percolation of rainwater thereby increasing surface run-off
- If groundwater removal rate is higher than the recharge rate, sediments in aquifers get compacted resulting in sinking of overlaying land surface. This is called *land subsidence* which leads to structural damage in buildings, fractures in pipes and reverses the flow of canals leading to tidal flooding
- Over-utilization of groundwater in arid and semi-arid regions for agriculture disturbs equilibrium of reservoir in the region causing problems like lowering of water table and decreased pressure in aquifers coupled with changes in speed and direction of water flow
- Over-utilization of groundwater in coastal areas leads to *rapid intrusion of salt water* from the sea thereby rendering it unusable for drinking and agriculture
- Over-utilization of groundwater leads to drying-up of dug wells as well as bore wells
- Due to excessive use of groundwater near agricultural fields, nitrogen (fertilizers) percolates rapidly and pollutes the groundwater thereby rendering the water unfit for portable use

The over exploitation of ground water for drinking, irrigation and other purposes has resulted in serious problems like;

- Declining of water levels
- Ground subsidence
- Declining of well yield
- Drying of shallow wells
- Deterioration of ground water quality
- Sea water intrusion into coastal aquifers
- High cost of energy required to lift the water from great depths.

Rainwater harvesting

Rain water harvesting is the activity of collection of rain water. The rain water collected can be stored and then directly used or can be recharged into ground water. It can be undertaken through a number of ways like;

- Capturing runoff from roof tops

- Capturing runoff from local catchments
- Capturing seasonal flood water from local streams

Various objectives of rain water harvesting are as follows

- To reduce loss of water through run off
- To avoid flooding of roads
- To meet the increasing demands of water
- To help in ground water recharging

Methods of rainwater harvesting:

Rain water can be mainly harvested by storing it tanks or reservoirs, by constructing pits, dug wells, check dams, trenches, lagoons etc. and also by recharging the ground water. Some of the methods are discussed as follows:

1. **Traditional Rain water harvesting**: This simply involves storing the rain water in lakes, ponds, irrigation tanks etc. This method is a simple one, and is being practiced from ancient times.

2. **Modern methods of Rain Water harvesting**: This involves;

    - Percolation pit method
    - Dug wells
    - Check dams
    - Open well method with filter bed sump
    - Roof top harvesting

    Roof top Harvesting: This has become a very popular method of water conservation especially in the urban areas. Rain water harvesting essentially means collecting rain water on the roofs of building and storing it underground for later use. This is known as roof top harvesting and is the most common method of harvesting the water especially in the cities. The flow of rainwater from the roofs of the buildings is directed into a storage tank. Thus the rain water can be stored and alter used for various purposes.

The rain water harvesting can serve many functions like;

1) Reduces runoff losses
2) Avoids over flooding of roads
3) It can be used to meet the demands of people
4) It can be used to recharge the ground water and thereby raises the water table
5) The water stored can be used during the dry seasons

Watershed management

A watershed is simply the geographic area through which water flows across the land and drains into a common water body whether a stream, river, lake or ocean. In other words watershed is the catchment area of a stream or a river. People and livestock are the integral part of watershed and their activities affect the productive status of watersheds and vice versa. Watershed management is the study of relevant characteristics of watershed. It is aimed at the sustainable distribution of its resources.

The various objectives of water shed management are:

1. To protect, conserve and improve the land of watershed for more efficient and sustained production.
2. To protect and enhance the water resource originating in the water shed.
3. To check soil erosion
4. To increase infiltration of rain water
5. To improve and increase the production of timbers, fodder and wild life resources.
6. To enhance the ground water recharge.
7. To reduce the occurrence of floods and the resultant damage by adopting strategies for flood management.
8. To provide standard quality of water by encouraging vegetation and waste disposal facilities.

Watershed Management can be done through;

- Proper farming and forestry practices to reduce runoff
- Minimizing ploughing and forest cutting on steep slopes
- Retaining of crop residue on fields reduces flooding
- Conservation of wetlands
- Control of soil erosion through various practices

Water conflicts

As we know that water is necessary for many purposes and still a great population of people do not have the proper access to this resource. This results in the conflicts over water between various parties, groups, states and countries. Water conflict means a fight or a disagreement between groups, states or countries over the water resource. Such conflict may arise due to dispute over the usage and allocation of water resource. Conflicts may also arise when a country tries to control the water resources of other country, thus making water resources a political issue. Conflicts can be seen over rivers and river basins shared by many countries around the world.

International water conflict in the Middle East*:* Three countries – Ethiopia, Sudan and Egypt – use most of the water that flows in Africa's river Nile. Egypt being the last in line is mainly desert because it is being affected due to overuse of water by other two countries. Egypt cannot exist without irrigation from the Nile and could go to war with Sudan and Ethiopia if there are more water cuts. Similarly, Syria is planning to build dam and withdraw more water from the Jordan River which would decrease the downstream water supply to Jordan and Israel. Israel has also given a warning that it may destroy the largest dam that Syria plans to build.

Water dispute between India and Bangladesh on river Ganga*:* The Ganga water dispute is connected with the Kolkata port. In 1974, the Farakka barrage was constructed on the water entering Bangladesh. India want to make it available for the Kolkata port, so that ships can sail upto the dock even during the dry seasons and the dock remains free of silt whereas Bangladesh wants the water managed in such a way as to minimize flooding during monsoon months and water shortages during dry months.

***Indus Water Treaty**:* According to Indus Water Treaty (1960) Indus, Jhelum and Chenab were allocated to Pakistan but they may be used by India for non-consumptive purposes. India got the share of Satluj, Ravi and Beas. Due to construction of dams and barrages like Sukkur barrage (1932), Ghulam Mohmmad barrage at Kotri and Tarbela and Chasma Dams on Jhelum, Indus delta has considerably decreased

In India there are many inter-state river water disputes. Some of which are briefly described below:

- ***The Cauvery dispute:*** The core of the Cauvery dispute relates to the re-sharing of waters that are already being fully utilized. Here the two parties to the dispute are Karnataka and Tamil Nadu. Between 1968 and 1990, 26 meetings were held at the ministerial level but no consensus could be reached.
- ***The Ravi-Beas dispute:*** The main current parties in this dispute are Punjab and Haryana. Both of these two states are both agricultural surplus states, providing large quantities of grain for the rest of India. Because of the scarcity and uncertainty of rainfall, the agricultural activities mostly depend on the irrigation
- ***SYL Canal dispute**:* Satluj-Yamuna link canal dispute between Punjab and Haryana. The conflict is that Punjab being the riparian state for Beas, Ravi and Satluj stakes its claim. Haryana has faced acute shortage of water after 1966 and has been trying to help it by signing MoU with UP, Rajasthan and Delhi for allocation of Yamuna waters.
- ***Krishna river water dispute**:* The dispute is linked with 4 states – Karnataka, Andhra Pradesh, Telangana and Maharashtra. The basic reason of the dispute is Almati dam constructed in 1968 over river Krishna in the Bijapur district of Karnataka. Karnataka wishes to raise the height of the dam which would adversely affect the other states.

FOOD RESOURCES:

We have thousands of edible plants and animals around the world. The main food resources include wheat, rice, maize, potato, barley, oats, cassava, sweet potato, sugarcane, pulses, sorghum, millet, fruits, vegetables, milk, meat, fish and seafood. Among these rice, wheat and maize constitute half of all agricultural crops. About 4 billion people in the developing countries have wheat and rice as their staple food. Meat and milk (80% of the total) are mainly consumed by more developed nations of North America, Europe and Japan. Fish and sea-food contribute about 70 million metric tons of high quality protein to the world's diet. The FAO of UN estimated that on an average the minimum caloric intake on a global scale is 2,500 calories/day. People receiving less than 90% of these minimum dietary calories are called undernourished and if it is less than 80% they are said to be seriously undernourished.

Sources of food

Impact of modern agriculture on environment

Fertilizer-Pesticide problem

Water logging

Salinity

Organic farming

ENERGY RESOURCES:

Energy is the basic requirement for domestic, industrial and economic development. It is needed by all living organisms and vegetation for biochemical reactions of their cells. We use energy for household use, agriculture, production of industrial goods and for running transport. The fire was the first form of known energy used for cooking and heating purposes. The need of energy resources is increasing day by day. The invention of steam engines replaced the burning of wood by coal an coal was later replaced to a great extent by oil. In 1970's due to Iranian revolution and Arab oil embargo the prices of oil shot up. This ultimately led to exploration and sue of several alternate sources of energy. From last few decades the energy consumptions has increased by many folds. *Energy consumption of a nation is usually considered as an index of its development.*

The energy resources can be classified in many ways

***Commercial resources*:** These include coal, lignite, petroleum products, natural gas and electricity.
Non-commercial resources: these include fuel wood, cow dung, agricultural wastes etc.

***Primary energy sources*:** Primary energy resources are those which are mined or otherwise obtained from the environment. These include fossil fuels (coal, lignite, crude oil and natural gas), nuclear fuels, hydro energy, solar, wind and geothermal energy.
Secondary energy resources: Secondary energy resources are those which don't occur in nature instead they are derived from primary energy resources. These include petrol, diesel, electrical energy (from coal, diesel and gas) etc.

***Conventional energy resources*:** These include fossil fuels (coal, lignite, crude oil and natural gas), nuclear fuels and hydro energy.
***Non-conventional*:** These include solar, wind, geothermal, ocean (thermal, tidal and wave), biomass and hydrogen energy.

RENEWABLE ENERGY RESOURCES

Renewable energy resources are those energy resources which are inexhaustible and can be used to produce energy again and again. These are available in unlimited amount in nature and develop in a relatively short period of time. Following are the examples of some of the renewable energy resources: Solar energy, Wind energy, Hydel energy, geothermal energy, Biomass energy. At present total potential of 1,26,000 MW assessed by different non-conventional energy sources. At present, most important non-conventional energy source is wind energy for which a capacity of 1800 MW has been set up in the country. There is also large potential for trapping of ocean energy, geothermal energy and tidal energy, but the techno-economic viability for power generation from these sources has still to be established.

Solar energy

Of all the renewable energy sources, solar energy holds key to an inexhaustible, non-polluting energy supply, because heat and light from the sun is the most abundant form of energy. The solar energy received by the near earth space is approximately 1.4 kilojoules/second/m^2 known as *solar constant*. One important factor about solar energy is the fact that the sun's radiation is free of cost to everyone and is available during all clear day. The solar energy received in the form of radiations can be converted directly or indirectly into other forms of energy like heat and electricity.

The various applications of solar energy are:

- heating and cooling of residential buildings
- solar water heating
- solar drying of the agricultural and animal products
- solar cookers
- solar photovoltaic cells
- solar engines for water pumping

Wind Energy

Wind energy can be used to rotate wind turbines and convert kinetic energy in into electricity. This is one of the simplest natural resource on earth. People have used wind to move boats across oceans, to scatter grains, to pump water, and more recently to supply electricity for small towns. Wind is also a clean source of energy because wind turbines emit no air pollutants, or hazardous waste.

Wind energy can be used for the following purposes:

- The energy of the wind is used to propel the sailing boats in rivers and seas for the purpose of transportation
- The energy of the wind is used through the wind mills to run the pumps to draw the water from the ground
- The energy of the wind is used to run flour mills to grind the grains such as wheat and corn into floor
- Wind energy is also used to generate electricity by the rotation of the wind mill blades which in turn, turns the coil of the electric generator.

The minimum wind speed required for satisfactory working of a wind generator is 15 km/hr. The wind power potential of our country is estimated to be about 20,000 MW while at present we are generating about 1020 MW. The largest wind farm of our country is near Kanyakumari in Tamil Nadu generating 380 MW electricity. Since 1990, wind energy is growing as the 2nd fastest growing source of energy and soon it is going to be the cheapest way to produce electricity. It is believed that by the middle of the century wind power would supply more than 10% of the world electricity.

Although wind power is economical and safe means to generate electricity, this source is not used extensively for three main reasons:

- The first reason is because the wind generation plants are extremely loud
- The second reason is that wind energy is not available continuously.

- The wind power plant is not reliable for the modern lives. If there are a few calm days, an entire city could go dark.

Hydel energy

This uses water flowing down a natural gradient to turn turbines to generate electricity known as 'hydroelectric power' by constructing dams across rivers. Mini and micro hydel power plants on a small scale also can be constructed but the minimum height of the waterfall should be 10 meters. The hydropower potential of India is estimated to be bout 4×10^{11} KW-hours. Till now we have utilized only a little more than 11% of this potential. Between 1950 and 1970, Hydropower generation worldwide increased 7 times. Advantages of Hydel power are:

- Long life of hydropower plants
- Renewable energy source
- Low operating and maintenance costs
- Absence of pollutants as in fossil fuels.

Ocean Thermal Energy (OTE)

The energy available due to the difference in temperature of water at the surface of the tropical oceans and at deeper levels is called Ocean Thermal Energy. A difference of 20^{o}C or more is required between surface water and deeper water of ocean for operating OTEC (Ocean Thermal Energy Conversion) power plants. The warm surface water of ocean is used to boil a liquid like ammonia. The high pressure vapours of the liquid formed by boiling are then used to turn the turbine of generator and produce electricity. The colder water from deeper oceans is pumped to cool and condense the vapours into liquid. Thus the process keeps on going continuously for 24 hours a day.

Geothermal energy

'Geo' means earth, and 'thermal' means heat, so geothermal means earth – heat. Geothermal energy is the heat from the earth which is clean and sustainable. The energy harnessed from the hot rocks present inside the earth is called geothermal energy. This heat comes from the fission of radioactive material naturally present in the rocks. In some places, the steam or the hot water comes out of the ground naturally through cracks – *natural geysers* e.g., Manikaran (Kullu) and Sohana (Haryana). Sometimes artificially a hole is drilled in the earth to make the steam or hot water gush out through the pipe at high pressure which turns the turbine of generator to produce electricity. The energy harnessed from the geothermal sources can either be used directly for space heating in houses and buildings or indirectly to generate electricity by the flashed steam method. In USA and New Zealand, there are several geothermal plants working successfully. The advantages of geothermal energy are

- ✓ It is renewable source of energy
- ✓ It is non-polluting and environment friendly
- ✓ Maintenance cost of geothermal power plants is very less
- ✓ Geothermal power plants don't occupy too much space and thus help in protecting natural environment.
- ✓ Unlike solar energy, it is not dependent on the weather conditions

Biomass energy

Biomass is the organic matter produced by the plants or animals. It is basically the waste material of the living things and includes forest crops, residues, wood, cattle dung, manure, sewage, agricultural wastes etc especially for their energy content. Biomass is considered as the renewable energy source because plant and animal life renews and adds itself every year unlike the fossil fuels which takes millions of years to form. Biomass resource can be converted into useful form of energy and it comes under three categories:

1) ***Solid traditional biomass***: In this, biomass is burnt directly to get the heat energy

2) ***Non-traditional form of the biomass***: Here biomass is converted into ethanol and methanol and used as the liquid fuels

3) ***Anaerobic fermentation***: Here biomass is fermented to obtain the gaseous fuels like the biogas.

Biogas

Biogas is a mixture of methane, carbon-di-oxide, hydrogen and hydrogen sulphide. Methane is the major constituent. Biogas is produced by anaerobic degradation of animal/plant wastes in the presence of water. Anaerobic degradation means breakdown of organic matter by bacteria in the absence of oxygen. Biogas is non-polluting, clean and low cost fuel and, more importantly the sludge leftover can be used as fertilizer. India has the largest cattle population in the world (240 million). From cattle dung alone we can produce biogas of a magnitude of 22,500 Mm^3 annually.

Biofuels

Biomass can be fermented to alcohols like ethanol and methanol which can be used as fuels. **Ethanol** can be easily produced from carbohydrate rich substances like sugarcane, corn and sorghum (Jowar). However as compared to petrol its calorific value is less and therefore produces much less heat than petrol. It is also considered to be an excellent substitute for kerosene and its combustion is as clean as LPG. **Gasohol** – a mixture of ethanol and gasoline – is a common fuel used in Brazil and Zimbabwe fir running cars and buses. **Methanol** is very useful since it burns at lower temperature than gasoline or diesel. Methanol can be easily obtained from woody plants and ethanol from grain-based or sugar-containing plants.

Hydrogen as a fuel

Hydrogen burns in air and releases 150 kilojoules of energy per gram. Due to its high, *rather the highest calorific value*, hydrogen can serve as an excellent fuel. Production of hydrogen is possible by: Thermal dissociation (3000^oK), Photolysis and Electrolysis. However hydrogen is highly inflammable and explosive in nature, hence, safe handling is required. Presently H_2 is used in the form of liquid hydrogen as a fuel in spaceships. H_2 can be used in fuel cell to generate electricity

NON-RENEWABLE ENERGY RESOURCES

These resources have accumulated in nature over a long span of time and cannot be quickly replenished when exhausted. E.g., coal, petroleum, natural gas and nuclear fuels. These were formed by the decomposition of the remains of plants and animals buried under the earth millions of years ago. The fuels are very precious because they have taken a long time for formation and if we exhaust their reserves at such a fast rate as we have been doing in past and present, then very soon we will lose these resources forever.

Coal

The ancient plants along the banks of rivers and swamps were buried after death into the soil and due to the heat and pressure gradually got concerted into peat and coal over millions of years of time. There are mainly 3 types of coal: Anthracite (hard coal), Bituminous (soft coal) and Lignite (brown coal). Anthracite has maximum carbon (90%) and calorific value (8700 kcal/kg). Bituminous, lignite and peat contain 80, 70 and 60% C respectively.

At the present rate of usage, the coal reserves are likely to last for about 200 years and if its use increase by 2% per year, then it will last for another 65 years India has 5% of world's coal but it is not very good in terms of heat capacity. The coal states of India are Jharkhand, Odisha, West Bengal, Madhya Pradesh, Andhra Pradesh and Maharashtra. Anthracite coal occurs only in J & K. When coal is burnt it produces CO2 which is a greenhouse gas responsible for causing enhanced global warming. Coal also contains impurities like sulphur and therefore it also releases toxic gases like oxides of S and N when burnt.

Petroleum

OPEC (Organization of Petroleum Exporting Countries) – 13 countries – have 67% of world petroleum reserves. About $1/4^{th}$ of oil reserves are in Saudi Arabia. At the present rate of usage, the world's crude oil reserves are estimated to get exhausted in another 40 years. Crude petroleum is a complex mixture of alkane hydrocarbons. Hence it has to be purified and refined by the process of fractional distillation, during which process different constituents like petroleum gas, kerosene, petrol, diesel, fuel oil, lubricating oil, paraffin wax, asphalt, plastic etc separate out at different temperatures.

Petroleum is a cleaner fuel as compared to coal. It is easier to transport and use and that is the reason why petroleum is preferred amongst all the fossil fuels. Liquefied Petroleum Gas (LPG): the main component of petroleum is butane, the other being propane and ethane. Under pressure the petroleum gas is converted into liquid form – LPG. LPG is odourless but *ethyl mercaptan* is added to it in domestic gas cylinders so that it gives foul smelling on leakage. Oil fields in India are located at Digboi (Assam), Gujarat Plains and Bombay High, offshore areas in deltaic coasts of Godavari, Krishna, Kaveri and Mahanadi.

Natural Gas

It is mainly composed of methane (95%) with small amounts of propane and ethane. Natural gas is usually found at oil deposits because it is also formed from decomposition of dead animal and plant remains. It is the cleanest fossil fuel as it burns without any smoke. It has high calorific value of about 50 KJ/G. Russia has maximum reserves (40%), followed by

Iran (14%) and USA (7%). Natural gas is used as a fuel in thermal power plants and source of hydrogen gas and carbon in fertilizer industry and tire industry respectively

- **Compressed Natural Gas (CNG)**: It is being used as an alternative to petrol and diesel for transport of vehicles. Delhi has totally switched over to CNG. CNG use has greatly reduced vehicular pollution in the city.
- **Synthetic Natural Gas (SNG)**: It is a connecting link between a fossil fuel and substituted natural gas. Low grade coal is initially transformed into synthetic gas by gasification followed by catalytic conversion to methane

Nuclear Energy

Nuclear power can be generated by:

- **Nuclear fission:** Nucleus of certain isotopes with large mass numbers split into lighter nuclei on bombardment with neutrons releasing a large amount of energy through a chain reaction. U-235 nucli are most commonly used in nuclear reactors.
- **Nuclear fusion:** Here two isotopes of a light element are forced together at extremely high temperatures until they fuse they from a heavier nucleus releasing enormous energy. It is difficult to initiate the process but it releases more energy than nuclear fission

Nuclear energy has tremendous potential but its leakage may cause devastating pollution. Disposal of the nuclear waste is also a big problem. There are four nuclear power station 1) Tarapur, Maharashtra 2) Rana Pratap Sagar, Rajasthan 3) Kalpakkam, TN and 4) Narora, UP which have a installed capacity of 2005 MW.

GROWING ENERGY NEEDS

Energy has always been closely linked to man's economic growth and development. The fossil fuels like coal, oil and natural gas which at present are supplying 95% of the commercial energy of the world's resources are not going to last for many more years. Life style has changes from simple to luxurious. Developed countries like USA and Canada constitute about 5% of the world's population but consume 1/4th of global energy resources. An average person there consumes 300 GJ of energy per year in contrast to 1 GJ for an average man in a poor country like Bhutan, Nepal or Ethiopia. So a person in a rich country consumes almost as much energy in a single day as one person does in a whole year in a poor country

The energy needs of man for development has increased as can be understood by following points;

- Between 1950 and 1990, the world's energy needs increased four-fold.
- The world's demand for electricity has doubled over the last 22 years.
- For almost 200 years, coal was the primary energy source fuelling the industrial revolution in the 19th century. At the close of the 20th century, oil accounted for 39% of the world's commercial energy consumption, followed by coal (24%) and natural gas (24%), while nuclear (7%) and hydro/renewable (6%) accounted for the rest.
- Among the commercial energy sources used in India, coal is a predominant source accounting for 55% of energy consumption estimated in 2001, followed by oil (31%), natural gas (8%), hydro (5%) and nuclear (1%).

The energy needs have grown because of the increase in following sectors:

- Transportation
- Power plants
- Industrialization
- Domestic purposes
- Space technologies
- Military and defence use

ALTERNATE ENERGY SOURCES

- **Solar energy:** In 1 hour the sun pours as much energy onto the earth as we use in a whole year
    - Solar heating for homes: South facing glass windows
    - Solar water heating: About 80% of homes in Israel have solar water heaters
    - Solar cookers: India has the world's largest solar cooker programme and an estimated 2 lakh families that use solar cookers
- **Photovoltaic energy:** The alternate energy technology that has the greatest potential for use throughout the world is that of solar photovoltaic cells, which directly produce electricity from sunlight using photovoltaic energy – solar cells or solar panels.
- **Solar thermal electric power (STE):** Solar radiation can produce high temperatures, which can generate electricity. Areas with low cloud cover with little scattered radiation (desert) are considered the most suitable sites

LAND RESOURCES:

Land is a finite and valuable resource upon which we depend for our food, fibre and fuel wood. The various purposes for which land can be used include agriculture, horticulture, forestry, grazing, fishing and mining. It has many physical forms like mountains, hills, plains and valleys. It is characterized by climate from hot to cold and from humid to dry. The surface layer of the land is called soil. Latin word 'Solum' meaning upper crust of the earth. Soil is generally defined as upper layer of the earth differentiated into various horizons and capable of supporting life. It contains living as well as non-living matter and supports or is capable of supporting plants.

Soil is a dynamic layer of earth's crust which is constantly changing and developing. About 200-1000 years are needed for the formation of 1 inch or 2.5 cm soil. It takes place with the decomposition of rocks and minerals. The topography climate and biotic factors control the conditions of the soil. Its properties like soil texture, structure, permeability, soil water, porosity, soil pH, organic and inorganic content, cation-exchange capacity, microbial properties etc. play an important role in determining productivity. Soil is renewable natural resource. It plays a very vital role in the determination of the quality and composition of the biosphere. In fact the biosphere develops over the soil. It is not only the home for microbes but also gives nutrition for plants

Some of the important functions of the soil are as under.

1. It provides mechanical support to the flora.
2. Due to its porosity and water holding capacity the soil serves as a reservoir of water and supplies water to the plants (even when the land surface is dry).
3. The ion exchange capacity of soil ensures the availability and supply of micro and macro nutrients for the growth of plants, microbes and animals.
4. Soil also helps in preventing excessive leaching of nutrient ions, while maintaining proper pH.
5. Soil contains a wide variety of bacteria like nitrifying nitrogen fixing bacteria), fungi, protozoans and many other microbes which help in the decomposition and mineralization of organic matter and regeneration of nutrients.

With increasing population growth the demands for arable land for producing food, fibre and fuel wood is also increasing. Hence there is more and more pressure on the limited land resources which are getting degraded due to over-exploitation. Soil degradation is a real cause of alarm because soil formation is an extremely slow process. The average annual erosion rate is 20-100 times more than the renewal rate. Soil erosion, water-logging, salinization and contamination of the soil with industrial wastes like fly-ash, press-mud or heavy metals all cause degradation of land.

Global land use patterns

Land can be used by humans for many purposes. The ways in which the human beings make use of the land resource is termed as Land Use. Human population can use the land for agricultural expansion, resource extraction, urbanization, developmental projects etc. Land use changes have greatly changed the global environment. Humans have altered terrestrial ecosystems since pre-historic times, for use of fire, domestication of plants and animals etc. Increasing the agricultural land use occurred at the expense of forests, grass lands and wetlands. A country which depends more on the agricultural would be having most of the land under agriculture. Similarly a country where most of the people depend on the development and industries would be having most of the land urban cover and industrial areas

GLOBAL LAND USE PATTERNS

Land use pattern	%
Agricultural land	11
Pasture and Meadows	24
Forest land	31
Other land	34

INDIA LAND USE PATTERNS

Land use pattern	%
Agricultural land	51
Pasture and Meadows	6.40
Forest land	23.80
Other land	18.80

As far as India is concerned it is very interesting to note that it has only 2.4% of the world's total land area but holds almost 16% of the world's total population.

Soil erosion

The literal meaning of soil erosion is *wearing away of soil.* Soil erosion refers to the loss or removal of the top layer of the soil by the action of wind, water or human actions. The factors that influence the extent to which soil erosion will occur include:

- ✓ Distribution intensity and amount of rainfall

- ✓ Slope of the ground
- ✓ Soil type
- ✓ Vegetation cover
- ✓ Soil Management

Soil erosion results in loss of fertility. World situation – 1/3rd of world's cropland is getting eroded and 2/3rd of the seriously degraded lands lie in Asia and Africa.

Based upon the cause soil erosion is basically of two types:

- **Normal soil erosion or geologic soil erosion**: caused by natural processes which bring an equilibrium between physical, biological and hydrological activities and maintain a natural balance between erosion and renewal
- **Accelerated soil erosion**: caused by anthropogenic (man-made) activities and the rate of erosion is much faster than the rate of formation of soil. Overgrazing, deforestation and mining are some important activities causing accelerated erosion

There are two types of agents which cause soil erosion:

- **Climatic agents**: Water and wind are the climatic agents of soil erosion. Water affects soil erosion in the form of torrential rains, rapid flow of water along slopes, runoff, wave action and melting and movement of snow
- **Biotic agents**: excessive grazing, mining and deforestation are the major biotic agents responsible for soil erosion. The top soil is disturbed and exposed directly to various physical forces. Overgrazing accounts for 35% of worlds soil erosion while deforestation is responsible for 30% of the earth's seriously eroded lands. Unsustainable methods of farming cause 28% of soil erosion

Water induced soil erosion is of the following types:

- **Sheet erosion:** Uniform removal of thin layer of soil from a large surface area
- **Rill erosion:** When rapidly sunning water produces finger shaped grooves
- **Gully erosion:** When rainfall is very heavy, U or V shaped deeper cavities or gullies are formed
- **Slip erosion:** Erosion that occurs on slopes of hills and mountains
- **Stream bank erosion:** During rainy seasons when fast running streams cut the soil along stream banks

Wind erosion is responsible for the following three types of soil movements:

- **Saltation:** This occurs under the influence of direct pressure of stormy wind sand the soil particles of 1-1.5 mm diameter move up in vertical direction
- **Suspension:** Here fine soil particles (less than 1mm diameter) are suspended in air and taken away to different places
- **Surface creep:** Here larger particles (5-10 mm diameter) creep over the soil surface along with wind

Prevention of soil erosion

- Conservational till farming: no till farming
- Contour farming: crops are grown in rows across rather than up and down on gentle slopes. Each row planted horizontally along the slope of the land acts as small dam
- Terracing: still steeper slopes are converted into a series of broad terraces which run across the contour. In high rainfall areas, ditches are also provided behind the terrace to permit adequate drainage
- Strip cropping: strips of cops are alternated with strips of cover crops like grasses or grass-legume mixture
- Alley cropping: it is the form of intercropping in which crops are planted between rows of trees or shrubs. This is also called as *Agroforestry*
- Wind breaks or shelter belts: They help in reducing erosion caused by strong winds. The trees are planted in long rows along the cultivated land boundary so that wind is blocked

Desertification

Desertification is a slow process of land degradation that leads to desert formation. It is a process whereby the productive potential of arid or semi-arid land falls by 10% or more.

- Moderate desertification: 10-25% drop in productivity
- Severe desertification: 25-50% drop in productivity
- Very severe desertification: more than 50% drop in productivity

Desertification is characterized by de-vegetation and loss of vegetal cover, depletion of groundwater, salinization and severe soil erosion. It may result either due to a natural phenomenon linked to climatic change or due to abusive use of land. For example, the Thar Desert (in India) was formed by the degradation of thousands of hectares of productive land. Increasing human population has put a great pressure on the land. Vast areas of land have been cleared for agriculture, industrial, and other purposes. Over cultivation, overgrazing, deforestation, poor irrigation practices, all contribute towards desertification. These activities bring about changes in rainfall, temperature, wind velocity, etc. and lead to soil erosion. Such changes then lead to desertification of the productive lands. The topsoil, which takes centuries to build up, can be lost in just a few years through such practices.

Causes of desertification: Desertification can occur by a number of factors, some of which are mentioned below:

- Climate change
- Population explosion
- Deforestation
- Overgrazing
- Industrialization
- Urbanization
- Dam construction
- Mining

Control of desertification: Following measures can be taken to control desertification

- Control of soil erosion
- Afforestation and reforestation
- Improvement in irrigation practices
- Control of human population
- Sustainable development practices
- Avoiding overgrazing

Wasteland reclamation

Wastelands are lands which are unproductive, unfit for cultivation, grazing and other economic uses due to rough terrain and eroded soils. The lands which are waterlogged and saline are also termed as wastelands. The National Wasteland Reclamation Board (NWRB) has defined wasteland as "degraded land which can be brought under vegetative cover with reasonable effort and which is currently under-utilized and land which is deteriorating for lack of appropriate water and soil management or on account of natural resources". The loss of fertility followed by erosion also leads to the conversion of marginal forest lands into wastelands. From the total land area of 328 million hectare about 51% is agricultural land, 4% is pasture land, 21% is forest land and 24% is wasteland.

Classification of wastelands

- **Barren and uncultivable wastelands**: These lands cannot be brought under cultivation or economic use except at a very high cost, whether they exist as isolated pockets or within cultivated holdings. Such lands are sandy deserts, stony or leached land, lands on hilly slopes rocky exposures etc

- **Cultivable wastelands**: These lands are not cultivated for 5 years or more. These are lands available for cultivation but not used for cultivation. These lands can be reclaimed through conservational methods, grazing or Agroforestry.

In our country maximum wastelands lie in Rajasthan. Anthropogenic activities leading to wasteland formation are deforestation, overgrazing, mining and intensive agricultural practices

Effects of land degradation:

- Surface runoff and floods
- Soil erosion and desertification
- Loss of nutrients and land productivity
- Soil acidification/alkalinisation
- Soil salinity
- Loss of biodiversity

- Long term socio economic impact on humans like migration

Reclamation of wasteland:

- These lands can be brought under cultivation by using excessive water and fertilizers
- Afforestation and agronomical methods are used to conserve the soil
- Construction of contour bunds
- These lands can be used for settling the landless agricultural labourers