PREMANDATORY – 1

Environment & Ecology		
12th Botany	Unit - 7	Ecosytem
9 th Std	Unit - 24	Environmental Science
12th std -Zoology	Unit - 12	Biodiversity and its conservation
12th Botany	Unit - 8	Environmental Issues
12th Geography	Unit - 7	Sustainable Development
Science & Technology		
12th Phy vol - 2	Unit - 10	Communication Systems
8th Std term - 3	Unit - 3	Universe and Space Science
9 th Std	Unit - 9	Universe

12th std –Botany
Unit – 7 – Ecosytem

- **Structure of ecosystem**

Ecosystem comprises of two major components. They are:

i. **Abiotic (non-living) components:** It includes climatic factors (air, water, sunlight, rainfall, temperature and humidity), edaphic factors (soil air, soil water and pH of soil),topography (latitude, altitude), organic components (carbohydrates, proteins, lipids and humic substances) and inorganic substances (C, H, O, N and P). Abiotic components play vital role in any ecosystem and hence the total inorganic substances present in any ecosystem at a given time is called standing quality (or) standing state.

ii. **Biotic (living) components:** It includes all living organisms like plants, animals, fungi and bacteria. They form the trophic structures of any ecosystem. On the basis of nutritional relationships, trophic levels of an ecosystem has two components.

(1) **Autotrophic components:** Autotrophs are organisms which can manufacture the organic compounds from simple inorganic components through a process called photosynthesis. In most of the ecosystems, green plants are the autotrophs and are also called producers.

(2) **Heterotrophic components**: Those organisms which consume the producers are called consumers and can be recognized into macro and micro consumers. Macroconsumers refer to herbivores, carnivores and omnivores (primary, secondary and tertiary consumers). Microconsumers are called decomposers. Decomposers are organisms that decompose the dead plants and animals to release organic and inorganic nutrients into the environment which are again reused by plants. Example: Bacteria, Actinomycetes and Fungi.

The amount of living materials present in a population at any given time is known as standing crop, which may be expressed in terms of number or biomass per unit area. Biomass can be measured as fresh weight or dry weight or carbon weight of organisms. Biotic components are essential to construct the food chain, food web and ecological pyramids.

- **Functions of ecosystem**

The function of ecosystem include to energy creation, sharing of energy and cycling of materials between the living and non-living component of an ecosystem.

1. Photosynthetically Active Radiation (PAR)

The amount of light available for photosynthesis of plants is called Photosynthetically Active Radiation (PAR) which is between the range of 400-700 nm wave length. It is essential for photosynthesis and plant growth. PAR is not always constant because of clouds, tree shades, air, dust particles, seasons, latitudes and length of the daylight availability.

Generally plants absorb more blue and red light for efficient photosynthesis.

Types of Carbon

Green carbon – carbon stored in the biosphere (by the process of photosynthesis).
Grey carbon – carbon stored in fossil fuel (coal, oil and biogas deposits in the lithosphere).

Blue carbon – carbon stored in the atmosphere and oceans.

Brown carbon – carbon stored in industrialized forests (wood used in making commercial articles)

Black carbon – carbon emitted from gas, diesel engine and coal fired power plants.

2. Productivity of an ecosystem

The rate of biomass production per unit area in a unit time is called productivity. It can be expressed in terms of gm /m2/year or Kcal/m2/ year. It is classified as given bellow.

1. Primary productivity
2. Secondary productivity
3. Community productivity

1. Primary productivity:

The chemical energy or organic matter generated by autotrophs during the process of photosynthesis and chemosynthesis is called primary productivity. It is the source of energy for all organisms, from bacteria to human.

a. Gross Primary Productivity (GPP)

The total amount of food energy or organic matter or biomass produced in an ecosystem by autotrophs through the process of photosynthesis is called gross primary productivity

b. Net Primary Productivity (NPP)
The proportion of energy which remains after respiration loss in the plant is called net primary productivity. It is also called as apparent photosynthesis. Thus the difference between GPP and respiration is known as NPP.

NPP = GPP – Respiration

NPP of whole biosphere is estimated to be about 170 billion tons (dry weight) per year. Out of which NPP of oceanic producers is only 55 billion tons per year in unit time.

2. Secondary productivity

The amount of energy stored in the tissues of heterotrophs or consumers is called secondary productivity.

a. Gross secondary productivity

It is equivalent to the total amount of plant material is ingested by the herbivores minus the materials lost as faeces.

b. Net secondary productivity

Storage of energy or biomass by consumers per unit area per unit time, after respiratory loss is called net secondary productivity.

3. Community productivity

The rate of net synthesis of organic matter (biomass) by a group of plants per unit area per unit time is known as community productivity.

Concept of trophic level in an ecosystem

(Greek word ' trophic' = to food or feeding)

A trophic level refers to the position of an organism in the food chain. The number of trophic levels is equal to the number of steps in the food chain. The green plants (producers) occupying the first trophic level (T_1) are called producers. The energy produced by the producers is utilized by the plant eaters (herbivores) they are called primary consumers and occupies the second trophic level (T_2).

Herbivores are eaten by carnivores, which occupy the third trophic level (T3). They are also called secondary consumers or primary carnivores. Carnivores are eaten by the other carnivores, which occupy the fourth trophic level (T4). They are called the tertiary consumers or secondarycarnivores. Some organisms which eat both plants and animals are called as omnivores (Crow). Such organisms may occupy more than one trophic level in the food chain.

Energy flow

The transfer of energy in an ecosystem between trophic levels can be termed as energy flow. It is the key function in an ecosystem. Part of the energy obtained from the sun by producer is transferred to consumers and decomposers through the each trophic level, while some amount of energy is dissipated in the form of heat. Energy flow is always unidirectional in an ecosystem.

4. Laws of thermodynamics

The storage and loss of energy in an ecosystem is based on two basic laws of thermo-dynamics.

i. First law of thermodynamics

It states that energy can be transmitted from one system to another in various forms. Energy cannot be destroyed or created. But it can be transformed from one form to another. As a result, the quantity of energy present in the universe is constant.

Example:

In photosynthesis, the product of starch (chemical energy) is formed by the combination of reactants (chlorophyll, H2O, CO2). The energy stored in starch is acquired from the external sources (light energy) and so there isno gain or loss in total energy. Here light energy is converted into chemical energy.

$$6\,CO_2 + 6\,H_20 \xrightarrow[\text{Chlorophyll}]{\text{light}} C_6H_{12}0_6 + 6\,O_2$$

Light energy ⟶ chemical energy

ii.Second law of thermodynamics

It states that energy transformation results in the reduction of the free energy of the system. Usually energy transformation cannot be 100% efficient. As energy is transferred from one organism to another in the form of food, a portion of it is stored as energy in living tissue, whereas a large part of energy is dissipated as heat through respiration. The transfer of energy is irreversible natural process. Example: Ten percent law

Ten percent law

This law was proposed by Lindeman (1942). It states that during transfer of food energy from one trophic level to other, only about 10% stored at every level and rest of them (90%) is lost in respiration, decomposition and in the form of heat. Hence, the law is called ten percent law.

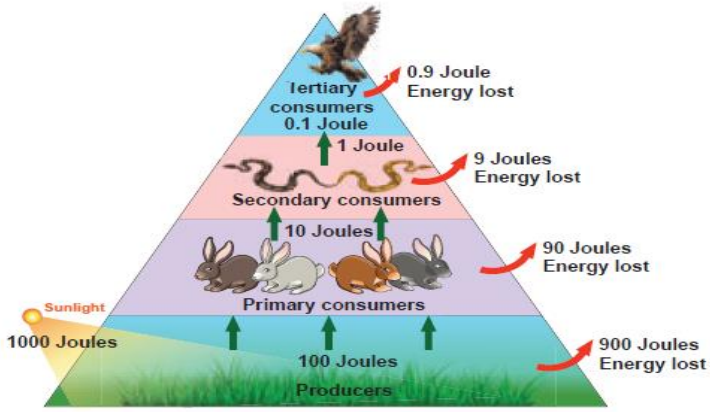

Figure 7.4: Ten percent law

Example: It is shown that of the 1000 Joules of Solar energy trapped by producers. 100 Joules of energystored chemical energy through photosynthesis. The remaining 900 Joules could be lost in the environment. In the next trophic level herbivores, which f ed on producers get only 10 Joules f energy and the remaining90 Joules is lost in the environment. Likewise, in the next trophic level, carnivores, which eatherbivores store only 1 Joule of energy and the remaining 9 Joules is dissipated. Finally, the carnivores are eaten by tertiary consumers which store only 0.1 Joule of energy and the remaining 0.9 Joule is lost in the environment. Thus, at the successive trophic level, only ten percent energy is stored.

- **Food chain**

The movement of energy from producers upto top carnivores is known as food chain, i.e., in any food chain, energy flows from producers to primary consumers, then from primary consumers to secondary consumers, and finally secondary consumers to tertiary consumers. Hence, it shows linear network links. Generally, there are two types of food chain, (1) Grazing food chain and (2) Detritus food chain.

1. Grazing food chain

Main source of energy for the grazing food chain is the Sun. It begins with the first link, producers (plants). The second link in the food chain is primary consumers (mouse) which get their food from producers. The third link in the food chain is secondary consumers (snake) which get their food from primary consumers. Fourth link in the food chain is tertiary consumers (eagle) which get their food from secondary consumers.

2. Detritus food chain:

This type of food chain begins with dead organic matter which is an important source of energy. A large amount of organic matter is derived from the dead plants, animals and their excreta. This type of food chain is present in all ecosystems.

The transfer of energy from the dead organic matter, is transferred through a series oforganisms called detritus consumers (detritivores)- small carnivores - large (top) carnivores with repeated eating and being eaten respectively. This is called the detritus food chain.

- **Food Web**

The inter-locking pattern of a number of food chain form a web like arrangement called food web. It is the basic unit of an ecosystem, to maintain its stability in nature. It is called homeostasis.

Example: In a grazing food chain of a grass land, in the absence of a rabbit, a mouse may also eat food grains. The mouse in turn may be eaten directly by a hawk or by a snake and the snake may be directly eaten by hawks.

Hence, this interlocking pattern of food chains is the food web and the species of an ecosystem may remain balanced to each other by some sort of natural check.

Significance of food web

- Food web is constructed to describe species interaction called direct interaction.
- It can be used to illustrate indirect interactions among different species.
- It can be used to study bottom-up or top- down control of community structure.
- It can be used to reveal different patterns of energy transfer in terrestrial and aquatic ecosystems.

- **Ecological pyramids**

Graphic representation of the trophic structure and function at successive trophic levels of an ecosystem is called ecological pyramids. The concept of ecological pyramids was introduced by Charles Elton (1927). Thus they are also called as Eltonian pyramids.

There are three types: (1) pyramid of number (2) pyramid of biomass (3) pyramid of energy.

1. Pyramid of number

A graphical representation of the number of organisms present at each successive trophic level in an ecosystem is called pyramids of number. There are three different shapes of pyramids upright, spindle and inverted.

There is a gradual decrease in the number of organisms in each trophic level from producers to primary consumers and then to secondary consumers, and finally to tertiary consumers. Therefore, pyramids of number in grassland and pond ecosystem are always upright.

In a forest ecosystem the pyramid of number is somewhat different in shape, it is because the base (T1) of the pyramid occupies large sized trees (Producer) which are lesser in number. Herbivores (T2) (Fruit eating birds, elephant, deer) occupying second trophic level, are more in number than the producers. In final trophic level (T4), tertiary consumers (lion) are lesser in number than the secondary consumer (T3) (fox and snake). Therefore, the pyramid of number in forest ecosystem looks spindle shaped.

The pyramid of number in a parasite ecosystem is always inverted, because itstarts with a single tree. Therefore there is gradual increase in the number of organisms in successive tropic levels from producer to tertiary consumers.

2. Pyramid of biomass

A graphical representation of the amount of organic material (biomass) present at each successive trophic level in an ecosystem is called pyramid of biomass. In grassland and forest ecosystems, there is a gradual decrease in biomass of organisms at successive trophic levels from producers to top carnivores (Tertiary consumer). Therefore, these two ecosystems show pyramids as upright pyramids of biomass. However, in pond ecosystem, the bottom of the pyramid is occupied by the producers, which comprise very small organisms possessing the least biomass and so, the value gradually increases towards the tip of the pyramid. Therefore, the pyramid of biomass is always inverted in shape.

3. Pyramid of energy

A graphical representation of energy flow at each successive trophic level in an ecosystem is called pyramids of energy. The bottom of the pyramid of energy is occupied by the producers. There is a gradual decrease in energy transfer at successive tropic levels from producers to the upper levels. Therefore, the pyramid of energy is always upright.

- **Decomposition:**

Decomposition is a process in which the detritus (dead plants, animals and their excreta) are breakdown in to simple organic matter by the decomposers. It is an essential process for recycling and balancing the nutrient pool in an ecosystem.

1. Nature of decomposition

The process of decomposition varies based on the nature of the organic compounds, i.e., some of the compounds like carbohydrate, fatand protein are decomposed rapidly than the cellulose, lignin, chitin, hair and bone.

2. Mechanism of decomposition

Decomposition is a step wise process of degradation mediated by enzymatic reactions. Detritus acts as a raw material for decomposition. It occurs in the following steps.

a. Fragmentation - The breaking down of detritus into smaller particles by detritivores like bacteria, fungi and earth worm is known as fragmentation. These detritivores secrete certain substances to enhance the fragmentation process and increase the surface area of detritus particles.
b. Catabolism - The decomposers produce some extracellular enzymes in their surroundings to break down complex organic and inorganic compounds in to simpler ones. This is called catabolism
c. Leaching or Eluviation - The movement of decomposed, water soluble organic and inorganic compounds from the surface to the lower layer of soil or the carrying awayof the same by water is called leaching or eluviation.
d. Humification - It is a process by which simplified detritus is changed into dark coloured amorphous substance called humus. It is highly resistant to microbial action, therefore decomposition is very slow. It is the reservoir of nutrients.
e. Mineralisation - Some microbes are involved in the release of inorganic nutrients from the humus of the soil, such process is called mineralisation.

3. Factors affecting decomposition

Decomposition is affected by climatic factors like temperature, soil moisture, soil pH,oxygen and also the chemical quality of detritus.

Biogeochemical cycle (Nutrient cycle)

Exchange of nutrients between organisms and their environment is one of the essential aspects of an ecosystem. All organisms require nutrients for their growth, development, maintenance and reproduction. Circulation of nutrients within the ecosystem or biosphere is known as biogeochemical cycles and also called as 'cycling of materials.' There are two basic types,

1. Gaseous cycle – It includes atmospheric Oxygen, Carbon and Nitrogen cycles.
2. Sedimentary cycle – It includes the cycles of Phosphorus, Sulphur and Calcium – Which are present as sediments of earth.

Many of the cycles mentioned above are studied by you in previous classes. Therefore, in this chapter, only the carbon and phosphorous cycles are explained.

Carbon cycle

The circulation of carbon between organisms and environment is known as the carbon cycle. Carbon is an inevitable part of all biomolecules and is substantially impacted by the change in global climate. Cycling of carbon between organisms and atmosphere is a consequence of two reciprocal processes of photosynthesis and respiration. The releasing of carbon in the atmosphere increases due to burning of fossil fuels, deforestation, forest fire, volcanic eruption and decomposition of dead organic matters.

Phosphorus cycle

It is a type of sedimentary cycle. Already we know that phosphorus is found in the biomolecules like DNA, RNA, ATP, NADP and phospholipid molecules of living organisms. Phosphorus is not abundant in the biosphere, whereas a bulk quantity of phosphorus is present in rock deposits, marine sediments and guano. It is released from these deposits by weatheringprocess. After that, it circulates in lithosphere as well as hydrosphere. The producers absorb phosphorus in the form of phosphate ions, and then it is transferred to each trophic level of food chain through food. Again death of the organisms and degradation by the action of decomposers, the phosphorus is released back into the lithosphere and hydrosphere to maintain phosphorus cycle.

- **Types of ecosystem**

Biosphere consists of different types of ecosystems, which are as follows:

Stratification of pond ecosystem

Based on the factors like distance from the shore, penetration of light, depth of water, types of plants and animals, there may be three zones, littoral, limnetic and profundal. The littoral zone, which is closest to the shore with shallow water region, allows easy penetration of light. It is warm and occupied by rooted plantspecies. The limnetic zone refers the open water of the pond with an effective penetration of light and domination of planktons. The deeper region of a pond below the limnetic zone is called profundal zone with no effective light penetration and predominance of heterotrophs. The bottom zone of a pond is termed benthic and is occupied by a community of organisms called benthos (usually decomposers).The primary

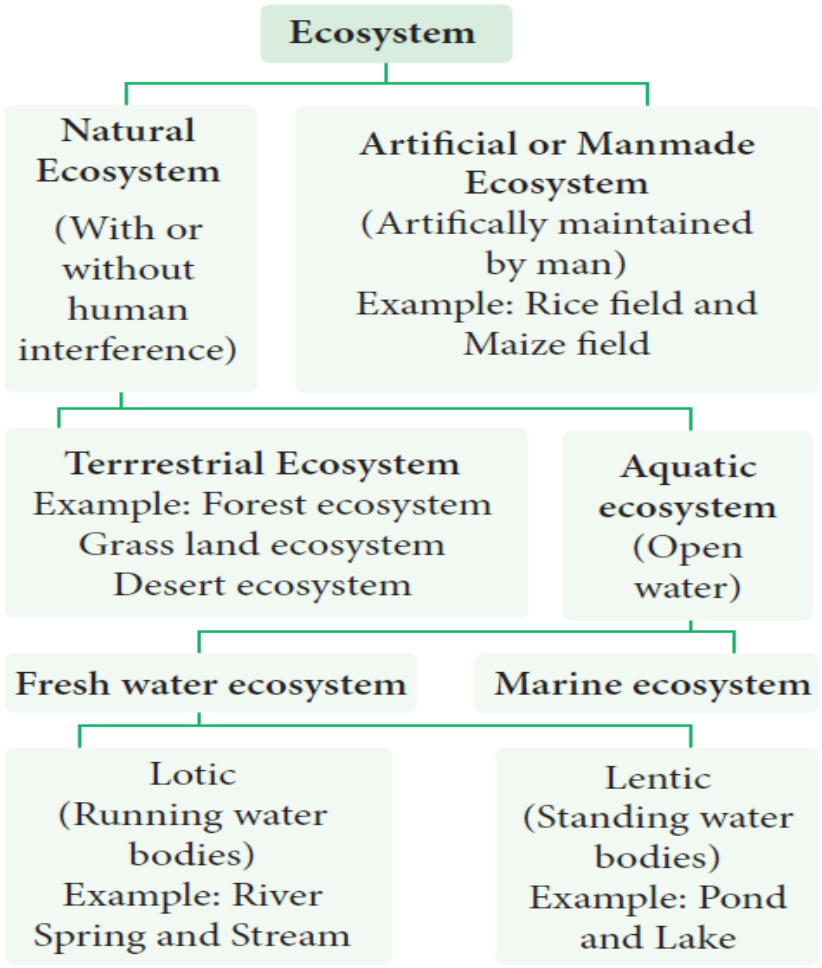

Figure 7.14: Types of Ecosystem

productivity through photosynthesis of littoral and limnetic zone is more due to greater penetration of light than the profundal zone.

- **Ecosystem services (Benefits)**

Ecosystem services are defined as the benefits that people derive from nature. Robert Constanza et al (1927) stated "Ecosystem services are the benefits provided to human, through the transformation of resources (or Environmental assets including land, water, vegetation and atmosphere) into a flow of essential goods and services".

Study on ecosystem services acts as an effective tool for gaining knowledge on ecosystem benefits and their sustained use. Without such knowledge gain, the fate of any ecosystem will be at stake and the benefits they provide to us in future will become bleak.

Robert Constanza and his colleagues estimated the value of global ecosystem services based on various parameters. According to them in 1997, the average global value of ecosystems services estimated was US $ 33 trillion a year. The updated estimate for the total global ecosystem services in 2011 is US $ 125 trillion / year, indicating a four-fold increase in ecosystem services from 1997 to 2011.

- **Mangrove ecosystem services**
  - ❖ Offers habitat and act as nursery for aquatic plants and animals
  - ❖ Provides medicine, fuel wood and timber.
  - ❖ Act as bridge between sea and rivers by balancing sedimentation and soil erosion.
  - ❖ Help to reduce water force during cyclones, tsunamis and high tide periods.
  - ❖ Help in wind break, O2 production, carbon sequestration and prevents salt spray from waves.

The varieties of benefits obtained from the ecosystem are generally categorized into the following four types

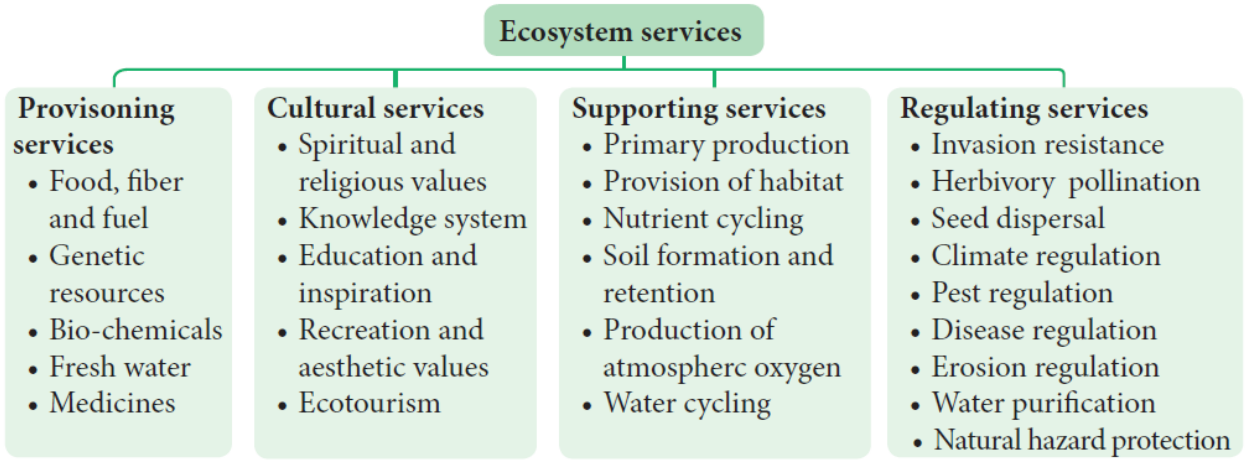

Figure 7.17: Types of Ecosystem services

How do anthropogenic activities affect ecosystem services?

Now, we all exploit the ecosystem more than that of our needs. The Millennium Ecosystem Assessment (2005) found that "over the past 50 years, humans have changed the ecosystem more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, medicine, timber, fiber and fuel."

Generally the following human activities disturb or re-engineer an ecosystem every day.

- ❖ Habitat destruction
- ❖ Deforestation and over grazing
- ❖ Erosion of soils
- ❖ Introduction of non-native species
- ❖ Over harvesting of plant material
- ❖ Pollution of land, water and air
- ❖ Run off pesticides, fertilizers and animal wastes

Ecosystem resilience

Ecosystem is damaged by disturbances from fire, flood, predation, infection, drought, etc., removing a great amount of biomasss. However, ecosystem is endowed with the ability to resist the damage and recover quickly. This ability of ecosystem is called ecosystem resilience or ecosystem robustness.

How to protect the ecosystem?

It is a practice of protecting ecosystem at individual, organisational and governmental levels for the benefits of both nature and humans. Threats to ecosystems are many, like adverse human activities, global warming, pollution, etc. Hence, if we change our everyday life style, we can help to protect the planet and its ecosystem.

"If we fail to protect environment, we will fail to save posterity".

Therefore, we have to practice the following in our day today life:

- Buy and use only ecofriendly products and recycle them.
- Grow more trees
- Choose sustained farm products (vegetables, fruits, greens, etc.)
- Reduce the use of natural resources.
- Recycle the waste and reduce the amount of waste you produce.
- Reduce consumption of water and electricity.
- Reduce or eliminate the use of house-hold chemicals and pesticides.
- Maintain your cars and vehicles properly. (In order to reduce carbon emission)
- Create awareness and educate about ecosystem protection among your friends and family members and ask them to find out solution to minimise this problem.

Ecosystem Management

It is a process that integrates ecological, socio economic and institutional factors into a comprehensive strategy in order to sustain and enhance the quality of the ecosystem to meet current and future needs.

Ecosystem management emphasis on human role in judicious use of ecosystem and for sustained benefits through minimal human impacts on ecosystems. Environmental degradation and biodiversity loss will result in depletion of natural resources, ultimately affecting the existence of human

"By 2025, at least 3.5 billion people, nearly 50% of the world's population are projected to face water scarcity." – IUCN.
"Forests house approximately 50% of global bio-diversity and at least 300 million people are dependent on forest's goods and services to sustain their livelihood." – IUCN

Strategy of ecosystem management

- It is used to maintain biodiversity of ecosystems.
- It helps in indicating the damaged ecosystem (Some species indicate the health of the ecosystem: such species are called a flagship species).
- It is used to recognize the inevitability of ecosystem change and plan accordingly.
- It is one of the tools used for achieving sustainability of ecosystem through sustainable development programme (or projects).
- It is also helpful in identifying ecosystems which are in need of rehabilitation.
- It involves collaborative management with government agencies, local population, communities and NGO's.

- It is used to build the capacity of local institutions and community groups to assume responsibility for long term implementation of ecosystem management activities even after the completion of the project.

Urban ecosystem restoration model

AdayarPoonga is located in Chennai and covers an area around a total of 358 acres of Adayar creek and estuary, of which 58 acres were taken up for eco restoration under the auspices of Government of Tamil Nadu. It is maintained by Chennai Rivers Restoration Trust (CRRT).This was a dumping site previously.

Presently it has 6 species of mangroves, about 170 species of littoral and tropical dry evergreen forests (TDF) which have successfully established as a sustainable ecosystem. Restoration of plants species has brought other associated fauna such as butterflies, birds, reptiles, amphibians and other mammals of the ecosystem.

Currently AdayarPoonga functions as an environmental education Centre for school and college students and the public. The entire area stands as one of the best examples for urban eco restoration in the state of Tamil Nadu.

- **Plant Succession**

Successive replacement of one type of plant community by the other of the same area/ place is known as plant succession. The first invaded plants in a barren area are called **pioneers**. On the other hand, a series of transitional developments of plant communities one after another in a given area are called **seral communities**. At the end a final stage and a final plant community gets established which are called as climax and **climax community** respectively.

1. Causes of Succession

Ever since the onset of origin of life, organic evolution and ecological succession are taking place parallelly. Ecological succession is a complex process. There are three types of causes for any ecological succession. They are

a. Initiating causes - Activity of abiotic (light, temperature, water, fire, soil erosion and wind) and biotic factors (competition among organisms) leads to formation of a barren area or destruction of the existing community of an area, initiating primary or secondary succession respectively.
b. Continuing causes - The processes of migration, aggregation, competition, reaction etc, are the continuing causes which lead to change the plant communities and nature of the soil in an area.
c. Stabilizing causes - The stabilization of the plant community in an area is primarly controlled by climatic factors rather than other factors.

2. Characteristics of ecological succession

- It is a systematic process which causes changes in specific structure of plant community.
- It is resultant of changes of abiotic and biotic factors.

- ❖ It transforms unstable community into a stable community.
- ❖ Gradual progression in species diversity, total biomass, niche specialisation, and humus content of soil takes place.
- ❖ It progresses from simple food chain to complex food web.
- ❖ It modifies the lower and simple life form to the higher life forms.
- ❖ It creates inter-dependence of plants and animals.

3. Types of succession

The various types of succession have been classified in different ways on the basis of different aspects. These are as follows:

1. Primary succession - The development of plant community in a barren area where no community existed before is called primary succession. The plants which colonize first in a barren area is called pioneer species or primary community or primary colonies. Generally, Primary succession takes a very long time for the occurrence in any region.
   Example: Microbes, Lichen, Mosses.

2. Secondary succession - The development of a plant community in an area where an already developed community has been destroyed by some natural disturbance (Fire, flood, human activity) is known as secondary succession. Generally, This succession takes less time than the time taken for primary succession.
   Example: The forest destroyed by fire and excessive lumbering may be re-occupied by herbs over period of times.

	Primary succession	**Secondary Succession**
1	Developing in an barren area	Developing in disturbed area
2.	Initiated due to a biological or any other external factors	Starts due to external factors only
3.	No Soil, while primary succession starts	It starts where soil covers already present
4.	Pioneer species come from outside environment	Pioneer species develop from existing environment
5.	It takes more time to complete	It takes comparatively less time to complete.

3. Autogenic succession

Autogenic succession occurs as a result of biotic factors. The vegetation reacts with its environment and modifies its own environment causing its own replacement by new communities. This is known as autogenic succession.

Example: In forest ecosystem, the larger trees produce broader leaves providing shade to theforest floor area. It affects the shrubs and herbs which require more light (heliophytes) but supports the shade tolerant species (sciophytes) to grow well.

4. Allogenic succession

Allogeneic succession occurs as a result of abiotic factors. The replacement of existing community is caused by other external factors (soil erosion, leaching, etc.,) and not by existing organisms.

Example: In a forest ecosystem soil erosion and leaching alter the nutrient value of the soil leading to the change of vegetation in that area.

5. Autotrophic succession

If the autotrophic organisms like green plants are dominant during the early stages of succession it is called autotrophic succession, this occurs in the habitat which is rich in inorganic substances. Since, green plants dominate in the beginning of this succession, there is a gradual increase in organic matter and subsequently the energy flow in the ecosystem.

6. Heterotrophic succession

If heterotrophic organisms like bacteria, fungi, actinomycetes, and animals are dominant during the early stages of succession it is called heterotrophic succession. Such a succession takes place in organic habitats. Since heterotrophs dominate in the beginning of such succession, there will be a gradual decrease in the energy content.

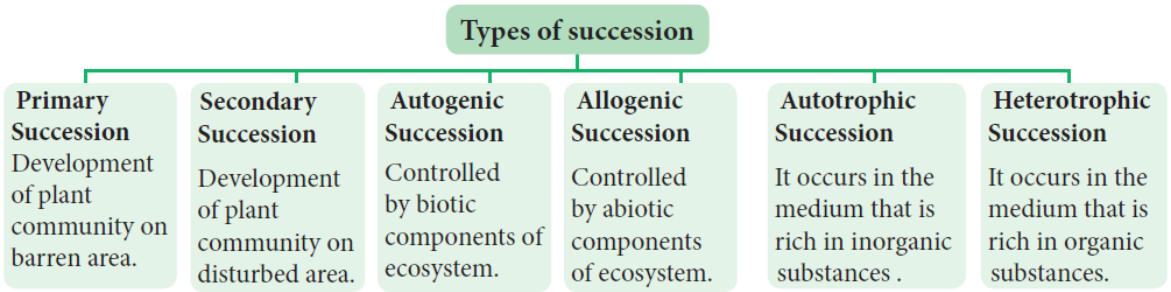

Figure 7.19: Types of succession

4. Process of succession

There are a number of sequential processes in primary autotrophic succession. They are (1) Nudation, (2) Invasion (migration) (3) Ecesis, (4) Aggregation, (5) Competition, (6) Reaction (7) Stabilization (climax).

1. Nudation - This is the development of a barren area without any form of life. The barren area may be developed due to topographic (soil erosion, wind action), climatic (hails, storm, fire), and biotic (human activities, epidemics, etc.,) factors.
2. Invasion - If species invade or reach a barren area from any other area it is called invasion. When the seeds, spores or other propagules of plant species reach the barren area, by air, water and various other agent, it is known as migration.
3. Ecesis (Establishment) - After reaching a new area (invasion), the successful establishment of the species, as a result of adjustment with the conditions prevailing in the area, is known as ecesis. If the establishment is complete, the plant will be able to reproduce sexually in that particular area.
4. Aggregation - The successful establishment of species, as a result of reproduction and increase in population of the species than the earlier stage is called aggregation.
5. Competition - It refers to the aggregation of a particular species in an area which leads to inter specific and intraspecific competition among the individuals for water, nutrient, radiant energy, CO2, O2 and space, etc.

6. Reaction - The species occupying a habitat gradually modify the environmental condition, where the existing species community is displaced or replaced by another. This is called reaction. The community which is replaced by another community is called seral community.

7. Stabilization (Climax stage) - The final establishment of plant community is called stabilization. This establishment of a plant community which maintains itself in equilibrium with climax of the area and not replaced by others is known as climax community and the stage is climax stage.

5. Classification of Plant succession

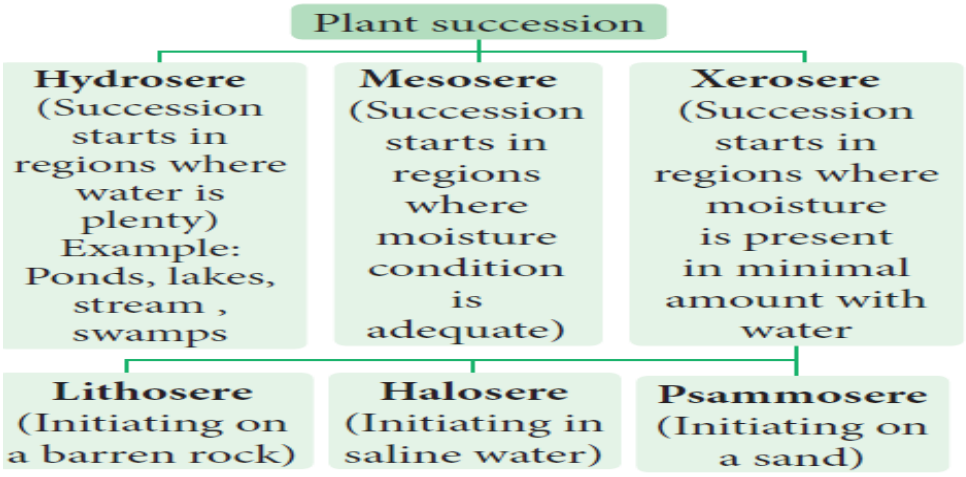

Figure 7.20: Classification of plant succession

6. Significance of Plant Succession

- Succession is a dynamic process. Hence an ecologist can access and study the seral stages of a plant community found in a particular area.
- The knowledge of ecological succession helps to understand the controlled growth of one or more species in a forest.
- Utilizing the knowledge of succession, even dams can be protected by preventing siltation.
- It gives information about the techniques to be used during reforestation and afforestation.
- It helps in the maintenance of pastures.
- Plant succession helps to maintain species diversity in an ecosystem.
- Patterns of diversity during succession are influenced by resource availability and disturbance by various factors.
- Primary succession involves the colonization of habitat of an area devoid of life.
- Secondary succession involves the reestablishment of a plant community in disturbed area or habitat.
- Forests and vegetation that we come across all over the world are the result of plant succession.

9 th book
Unit- 24 – Environmental Science

- **Nitrogen Cycle**

Nitrogen is the important nutrient needed for the survival of all living organisms. It is an essential component of proteins, DNA and chlorophyll. Atmosphere is a rich source of nitrogen and contains about 78% nitrogen. Plants and animals cannot utilize atmospheric nitrogen. They can use it only if it is in the form of ammonia, amino acids or nitrates.

Processes involved in nitrogen cycle are explained below.
Nitrogen fixation : Nitrogen fixation is the conversion of atmospheric nitrogen, which is in inert form, to reactive compounds available to living organisms. This conversion is done by a number of bacteria and **blue green algae** (Cyanobacteria).

Leguminous plants like pea and beans have a symbiotic relationship with nitrogen fixing bacteria *Rhizobium*. Rhizobium occur in the root nodules of leguminous plants and fixes nitrogenous compounds.

Nitrogen assimilation: Plants absorb nitrate ions and use them for making organic matter like proteins and nucleic acids. Herbivorous animals convert plant proteins into animal proteins. Carnivorous animals synthesize proteins from their food.

Ammonification: The process of decomposition of nitrogenous waste by putrefying bacteria and fungi into ammonium compounds is called ammonification. Animal proteins are excreted in the form of urea, uric acid or ammonia. The putrefying bacteria and fungi decompose these animal proteins, dead animals and plants into ammonium compounds.

Nitrification:The ammonium compounds formed by ammonification process are oxidised to soluble nitrates. This process of nitrate formation is known as nitrification. The bacteria responsible for nitrification are called as nitrifying bacteria.
Microorganisms involved in nitrogen cycle

Role played in nitrogen cycle	**Name of the Microorganisms**
Nitrogen fixation	Azotobacter (in soil) Rhizobium (in root nodules) Blue green algae- Nostoc
Ammonification	Putrefying bacteria, Fungi
Nitrification	Nitrifying bacteria i. Nitrosomonas ii. Nitrobacter
Denitrification	Denitrifying bacteria Pseudomonas

animals release carbon into atmosphere in the form of carbon dioxide. Carbon dioxide is also returned to the atmosphere through decomposition of dead organic matter, burning fossil fuels and volcanic activities.

Human impacts on carbon cycle

Burning fossil fuels, application of nitrogenbased fertilizers and other activities can increase the amount of biologically available nitrogen in an ecosystem. Nitrogen applied to

agricultural fields enters rivers and marine systems. It alters the biodiversity, changes the food web structure and destroys the general habitat. 24.1.3

- **Carbon Cycle**

Carbon occurs in various forms on earth. Charcoal, diamond and graphite are elemental forms of carbon. Combined forms of carbon include carbon monoxide, carbon dioxide and carbonate salts. All living organisms are made up of carbon containing molecules like proteins and nucleic acids. The atmospheric carbon dioxide enters into the plants through the process of photosynthesis to form carbohydrates. From plants, it is passed on to herbivores and carnivores. During respiration, plants and animals release carbon into atmosphere in the form of carbon dioxide. Carbon dioxide is also returned to the atmosphere through decomposition of dead organic matter, burning fossil fuels and volcanic activities.

Human impacts on carbon cycle

More carbon moves into the atmosphere due to burning of fossil fuels and deforestation. Most of the carbon in atmosphere is in the form of carbon dioxide. Carbon dioxide is a greenhouse gas. By increasing the amount of carbon dioxide, earth becomes warmer. This leads to greenhouse effect and global warming.

12th zoology
Unit - 12 Biodiversity and its conservation

Biodiversity

The 1992 UN Earth Summit defined Biodiversity as the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part. This includes diversity within species, between species and ecosystems of a region. It reflects the number of different organisms and their relative frequencies in an ecological system and constitutes the most important functional component of a natural ecosystem.It helps to maintain ecological processes, create soil, recycle nutrients, influence climate, degrade waste and control diseases. It provides an index of health of an ecosystem.The survival of human race depends on the existence and wellbeing of all life forms (plants and animals) in the biosphere.

Concept of biodiversity

The term biodiversity was introduced by Walter Rosen (1986). Biodiversity is the assemblage of different life forms. Each species is adapted to live in its specific environments.The changes in climatic conditions are reflected in the distribution and pattern of biodiversity on our planet. The number of species per unit area declines as we move from tropics towards the poles. The Tundra and Taiga of northern Canada, Alaska, northern Europe and Russia possess less than 12 species of trees. The temperate forests of the United states have 20-35 species of trees,while the tropical forests of Panama have over 110 species of trees in a relatively small area.

Levels of biodiversity

Edward Wilson popularized the term 'Biodiversity' to describe diversity at all levels of biological organization from populations to biomes. There are three levels of biodiversity - Genetic diversity, Species diversity and Community/Ecosystem diversity (Fig. 12.1).

Genetic diversity refers to the differences in genetic make-up (number and types of genes) between distinct species and to the genetic variation within a single species; also covers genetic variation between distinct populations of the same species. Genetic diversity can be measured using a variety of molecular techniques. India has more than 50,000 genetic variants of Paddy and 1000 variants of Mango. Variation of genes of a species increases with diversity in size and habitat. It results in theformation of different races, varieties and subspecies. Rouwolfavomitaria, a medicinal plant growing in different ranges of the Himalayas shows differences in the potency and concentration of the active ingredient reserpine due to genetic diversity. Genetic diversity helps in developing adaptations to changing environmental conditions.

Species diversity refers to the variety in number and richness of the species in any habitat. The number of species per unit area at a specific time is called species richness, which denotes the measure of species diversity. The Western Ghats have greater amphibian species diversity than the Eastern Ghats. The more the number of species in an area the more is the species richness (Fig. 12.1a). The three indices of diversity are - Alpha, Beta and Gamma diversity.

i. Alpha diversity: It is measured by counting the number of taxa (usually species) within a particular area, community or ecosystem.

ii. Beta diversity: It is species diversity between two adjacent ecosystems and is obtaining by comparing the number of species unique to each of the ecosystem.
iii. Gamma diversity refers to the diversity of the habitats over the total landscape or geographical area.

Community/Ecosystem diversity is the variety of habitats, biotic communities, and ecological processes in the biosphere. It is the diversity at ecosystem level due to diversity of niches, trophic levels and ecological processes like nutrient cycles, food webs, energy flow and several biotic interactions. India with its alpine meadows, rain forests, mangroves, coral reefs, grass lands and deserts has one of the greatest ecosystem diversity on earth.

Magnitude of biodiversity

Biodiversity is often quantified as the number of species in a region at a given time. The current estimate of different species on earth is around 8-9 million. However, we really don't know the exact magnitude of our natural wealth. This is called the 'The Taxonomic impediment'. So far about 1.5 million species of microorganisms, animals and plants have beendescribed. Each year about 10-15 thousand new species are identified and published worldwide, of which 75% are invertebrates. The number of undescribed species is undoubtedly much higher.

India is very rich in terms of biological diversity due to its unique bio-geographical location, diversified climatic conditions and enormous eco-diversity and geo-diversity According to world biogeographic classification, India represents two of the major realms (The Palearctic and Indo-Malayan) and three biomes (Tropical humid forests, Tropical Dry/ Deciduous forests and Warm Deserts/Semi deserts). With only about 2.4% of the world's total land surface, India is known to have over 8 % of the species of animals that the world holds and this percentage accounts for about 92,000 known species.India is the seventh largest country in the world in terms of area. India has a variety of ecosystems, biomes with its varied habitats like, hills, valleys, plateaus, sea shores, mangroves, estuaries, glaciers, grasslands and river basins. It also reflects different kinds of climates, precipitation, temperature distribution, river flow and soil. India is one of the 17 mega biodiversity countries of the world and has ten biogeographic zones with characteristic habitat and biota.

"The world is currently undergoing a very rapid loss of biodiversity comparable with the great mass extinction events that have previously occurred only five or six times in the earth's history."

- World Wildlife Fund

Patterns of biodiversity distribution

The distribution of plants and animals is not uniform around the world. Organisms require different sets of conditions for theiroptimum metabolism and growth. Within this optimal range (habitat) a large number and type of organisms are likely to occur, grow and multiply. The habitat conditions are determined by their latitudes and altitudes.

Latitudinal and altitudinal gradients:

Temperature, precipitation, distance from the equator (latitudinal gradient), altitude from sea level (altitudinal gradient) are some of the factors that determine biodiversity distribution patterns. The most important pattern of biodiversity is latitudinal gradient in

diversity. This means that there is an increasing diversity from the poles to equator. Diversity increases as one moves towards the temperate zones and reaches the maximum at the tropics. Thus, tropics harbour more biodiversity than temperate or polar regions, especially between the latitudes of 23.5ºN and 23.5ºS (Tropic of Cancer to the Tropic of Capricorn). Harsh conditions exist in temperate areas during the cold seasons while very harsh conditions prevail for most of the year in polar regions.

Columbia located near the equator (0º) has nearly 1400 species of birds while New York at 41ºN has 105 species and Greenland at 71ºN has 56 species. India, with much of its land area in the tropical latitudes, is home for more than 1200 species of birds. Thus it is evident that the latitude increases the species diversity.Decrease in species diversity occurs as one ascends a high mountain due to drop in temperature (temperature decreases @ 6.5º C per Km above mean sea level). The reasons for the richness of biodiversity in the Tropics are:

- Warm tropical regions between the tropic of Cancer and Capricorn on either side of equator possess congenial habitats for living organisms.
- Environmental conditions of the tropics are favourable not only for speciationbut also for supporting both variety and number of organisms.
- The temperatures vary between 25ºC to 35ºC, a range in which most metabolic activities of living organisms occur with ease and efficiency.
- The average rainfall is often more than 200 mm per year.
- Climate, seasons, temperature, humidity, photoperiods are more or less stable and encourage both variety and numbers.
- Rich resource and nutrient availability.

Importance of biodiversity – Global and India

Biodiversity is the variety of life on earth. That is, it is the number of different species of flora and fauna including microorganisms. These organisms can inhabit different ecosystems with varying conditions like the Rainforests, Coral reefs, Grasslands, Deserts, Tundra and the Polar ice caps. This variety (Biodiversity) is essential for the wellbeing of our planet and sustenance of life as a whole. The importance of biodiversity can be viewed and measured as

a) Ecosystem services b) Biological resources c) Social benefits of biodiversity

The organization and functioning of ecosystems world over is effected and dependent on biodiversity and its richness. The major functional attributes are:

- continuity of nutrient cycles or biogeochemical cycles (N2, C, H2O, P, S cycles)
- soil formation, conditioning or maintenance of soil health (fertility) by soil microbial diversity along with the different trophic members
- increases ecosystem productivity and provide food resources
- act as water traps, filters, water flow regulators and water purifiers (forest cover and vegetation)
- climate stability (forests are essential for rainfall, temperature regulation, CO2 absorption, which in turn regulate the density and type of vegetation)
- forest resource management and sustainable development
- maintaining balance between biotic components

- cleaning up of pollutants – microbes are the biggest degraders of molecules including many anthropogenic ones which are present in effluents, sewage, garbage and agro-chemicals
- ecological stability – the varieties and richness of species contribute to ecological stability and survival of species. Biodiverse regions are reservoirs of biological resources like food resources, gene pool, genetic resource, medicinal resources, bio-prospecting
- to provide unique aesthetic value and hot spots for Ecotourism. Along with forest resources and wildlife it has commercial significance
- an indicator of the health of the ecosystem. Endemism is a crucial indicator of richness.

Do you know?

The interrelationship and interdependence of all living components in a system can be seen from the example of the fruit bats of Guam (South East Asia). The fruit bats are a delicacy here, and hence their population has dwindled which is not surprising. What is surprising is that local fruit production has got affected as it was identified that the bats served as pollinators. Hence there is a need for conservation of diversity as that could avert such situations.

Biogeographical regions of India

As per the international 'biome' type of classification based upon climate, fauna and flora and the soil conditions, India can be divided into ten different biogeographic zones, (Fig. 12.3) namely:

1. **Trans Himalayan Region**: An extension of the Tibetan plateau, high-altitude cold desert in Ladakh (J&K) and LauhalaSpiti (H.P) comprising 5.7% of the country's landmass. The mountains of this region have the richest wild sheep and goat community in the world, renowned for its quality wool and wool products. Otherfauna include Chiru and Black-rocked Crane.

2. **Himalayas**: The entire mountain chain running from north-western to northeastern India, comprising a diverse range of biotic provinces and biomes and covers 7.2% of the country's landmass. The common fauna of the Himalayan ranges, are the wild sheep, mountain goats, shrew, snow leopard and panda, many of which are endangered.

3. **Indian Desert**: The extremely arid area west of the Aravalli hill range, comprising both the salty desert of Gujarat and the sand desert of Rajasthan. It comprises 6.9% of the country's land-mass. Wild ass is endemic to this region. It is also the habitat for the Indian Bustard, camel, foxes and snakes, many of which are endangered.

4. **Semi – Arid Zones**: This zone is between the desert and the Deccan plateau, including the Aravalli hill range covering 15.6% of the country's landmass. Fauna found here are nilghai, blackbuck, four horned antelopes, sambar, chital and spotted deer which are herbivores along with predators like Asiatic lion, tiger, leopard and jackal.

5. **Western Ghats**: Western Ghats, are mountain ranges along the west coast of India, extending over almost 1,500km from Sat Pena in south Gujarat to the southernmost tip of Kerala. The annual rainfall is about 2000 mm. This zone has large populations of Nilgiritahr (State animal of Tamil Nadu), Nilgirilangur, tiger, leopard, and Indian elephant.The grizzled squirrel and lion tailed macaque are endemic to this region.

6. **Deccan Peninsula**: This covers much of the southern and south-central plateau with predominantly deciduousvegetation and 4.3% of the country's landmass. It is known for deciduous forests, thorn forests and pockets of semi ever green forests. Fauna found here are Chital, Sambhar, Nilghai, elephant, sloth bear, black buck and barking deer. It is the catchment area of major Indian rivers like Godavari, Tapti, Narmada and Mahanadi.

7. **Gangetic Plains**: These plains are relatively homogenously defined by the Ganges river system and occupy about 11% of the country's landmass. This region is very fertile and extends up tothe Himalayan foothills. Fauna includes rhinoceros, elephant, buffalo, swamp deer, hog-deer.

8. **North-East India:** The plains and non-Himalayan hill ranges of north eastern India are home to a wide variety of vegetation. With 5.2% of the country's landmass, this region represents the transition zone between the Indian, Indo-Malayan and Indo-Chinese bio-geographical regions and is the meeting point of the Himalayan Mountains andpeninsular India. The North-East is thus the biogeographical 'Gateway' for much of India's fauna and flora and also biodiversity hotspot (Eastern Himalaya), which includes the Indian rhinoceros, leopard and golden langur.

9. **Coastal Region:** Coastal region of India with sandy beaches, mud flats, coral reefs, mangroves constitutes 2.5% of the total geographical area. The coastline from Gujarat to Sundarbans is estimated to be 5423km long. Apart from this a total of 25 islets constitute the Lakshadweep, which are of coral origin and have a typical reef lagoon system, rich in biodiversity. The fauna includes native crabs, turtles and tunas

10. **Andaman and Nicobar Islands**: The Andaman and Nicobar Islands in the Bay of Bengal have highly diverse set of biomes, constituting 0.3% of the total geographical area. They are centers of high endemism and contain some of India's finest evergreen forests and support a wide diversity of corals. Fauna includes Narcondam hornbills of the Andamans and the South Andaman Krait.

Threats to biodiversity

Even though India is one of the 17 identified mega diverse countries of the world, it faces lots of threats to its biodiversity.Apart from natural causes, human activities, both directly and indirectly are today's main reason for habitat loss and biodiversity loss. Fragmentation and degradation due to agricultural practices, extraction (mining, fishing, logging, harvesting) and development (settlements, industrial and associated infrastructures) leads to habitat loss and fragmentation leads to formation of isolated, small and scattered populations and as endangered species.

Some of the other threats include specialized diet, specialized habitat requirement, large size, small population size, limited geographic distribution and high economic or commercial value. Large mammals by virtue of their size require larger areas to obtain the

necessities of life - food, cover, mates than do smaller mammals. Individual home range of Lion can be about 100 square Km. Mammals have specialized dietary needs such as carnivores, frugivores and the need to forage over much larger areas than general dietary herbivores and omnivores. Mammals also have low reproductive output other than small rodents.

Causes of biodiversity loss

The major causes for biodiversity decline are:

- Habitat loss, fragmentation and destruction (affects about 73% of all species)
- Pollution and pollutants (smog, pesticides, herbicides, oil slicks, GHGs)
- Climate change
- Introduction of alien/exotic species
- Over exploitation of resources (poaching, indiscriminate cutting of trees, over fishing, hunting, mining)
- Intensive agriculture and aqua cultural practices
- Hybridization between native and non-native species and loss of native species
- Natural disasters (Tsunami, forest fire, earth quake, volcanoes)
- Industrialization, Urbanization, infrastructure development, Transport – Road and Shipping activity, communication towers, dam construction, unregulatedtourism and monoculture are common area of specific threats
- Co-extinction

Hotspots

Hotspots are areas characterized with high concentration of endemic species experiencing unusual rapid rate of habitat modification loss. Norman Myers defined hot spots as "regions that harbour a great diversity of endemic species and at the same time, have been significantly impacted and altered by human activities."A hotspot is a region that supports at least 1500 endemic vascular plant species (0.5% of the global total) has lost more than 70% of its original vegetation. There are 35 biodiversity hotspots in the world. India is home to four biodiversity hotspots (as per ENVIS). They are

a. Himalaya (the entire Indian Himalayan region)
b. Western Ghats
c. Indo-Burma: includes entire North-eastern India, except Assam and Andaman group ofIslands (and Myanmar, Tailand, Vietnam, Laos, Cambodia and Southern China)
d. Sundalands: includes Nicobar group of Islands (and Indonesia, Malaysia, Singapore, Brunei, Philippines)

IUCN

The International Union for Conservation of Nature (IUCN) is an organization working in the field of nature conservation and sustainable use of natural resources. It was established in 1948 and located at Gland VD, Switzerland. It is involved in data gathering and analysis research, field projects and education on conservation, sustainable development and biodiversity. IUCN's mission is to influence, encourage and assist societies throughout the world to conserve nature and to ensure that any use of natural resources is

equitable and ecologically sustainable. It influences governments and industries through partnerships by providing information and advice. The organization collects, compiles and publishes the IUCN red list of threatened species and their conservation status in the world. It plays a vital role in the implementation of several international conventions on nature conservation and biodiversity.

Red Data Book

Red Data book or Red list is a catalogue of taxa facing risk of extinction. IUCN – International Union of Conservation of Nature and Natural Resources, which is renamed as WCU – World Conservation Union (Morges Switzerland) maintains the Red Data book. The concept of Red list was mooted in 1963. The purpose of preparation of Red List are:

- To create awareness on the degree of threat to biodiversity
- Identification and documentation of species at high risk of extinction
- Provide global index on declining biodiversity
- Preparing conservation priorities and help in conservation of action
- Information on international agreements on conservation of biological diversity

Red list has eight categories of species Extinct ii) Extinct in wild iii) Critically Endangered iv) Endangered v) Vulnerable vi) Lower risk vii) Data deficiency viii) Not evaluated.

Biodiversity and its conservation

The natural resources of the Earth, including air, water, land, flora and fauna of natural ecosystems must be safeguarded for the benefit of the present and future generations through careful planning and management, as appropriate – Principle of the Stockholm Declaration, 1972.The large-scale loss of biodiversity and its global impact makes conservation the need of the hour. Conservation of biodiversity is protection and scientific management of biodiversity so as to maintain it at its optimum level and derive sustainable benefits for the present as well as future generations. It aims to protect species from extinction and their habitats and ecosystems from degradation.

General strategies in conservation

- identify and protect all threatened species
- identify and conserve in protected areas the wild relatives of all the economically important organisms
- identify and protect critical habitats for feeding, breeding, nursing, resting of each species
- resting, feeding and breeding places of the organisms should be identified and protected
- Air, water and soil should be conserved on priority basis
- Wildlife Protection Act should be implemented

There are two aspects of conservation strategies (Fig. 12.3)

i) In-situ conservation
ii)Ex-situ conservation

In-situ Conservation (Conservation in the natural habitat):

This is the conservation of genetic resources through their protection within a natural or manmade ecosystem in which they occur. It is conservation and protection of the whole ecosystem and its biodiversity at all levels in order to protect the threatened species. Maximum protection of biodiversity hotspots regions with very high levels of species richness. Although all the biodiversity hotspots together cover less than 2 percent of the earth land area, the number of species they harbour is extremely high and protection of these hotspots could reduce the ongoing mass.

Protected Areas:

These are biogeographical areas where biological diversity along with natural and cultural resources is protected, maintained and managed through legal measures. protected areas include national parks, wild life sanctuaries, community reserves and biosphere reserves. World Conservation monitoring centre has recognized 37,000 protected areas world-wide. India has about 771 protected areas covering 162099 km2 comprising of National Parks (104), Wild Life Sanctuaries (544), biosphere reserves (18) and several sacred groves.

National Parks (NP):

It is a natural habitat that is notified by the state government to be constituted as a National Park due to its ecological, faunal, floral, geomorphological, or zoological association of importance. No human activity is permitted inside the national park except the activities permitted by the Chief Wildlife Warden of the state under the conditions given in CHAPTER IV, of the Wildlife Protection Act (WPA) 1972 (Table 12.1).

Project Tiger:

The Government of India launched the 'Project Tiger' in 1973 to protect our national animal. From 9 tiger reserves since its inception, the Project Tiger coverage has increased to 50 at present. Project Tiger is an ongoing Centrally Sponsored Scheme of the Ministry of Environment and Forests, providing central assistance to the states for tiger conservation in designated tiger reserves. Project Tiger was launched in the Jim Corbett National Park, Uttarakhand in1973. The project ensures a viable population of Bengal tigers in their natural habitats, protecting them from extinction and preserving areas of biological importance as a natural heritage.

The National Tiger Conservation Authority (NTCA) is a statutory body of the Ministry, created under the Wildlife (Protection) Act, 1972. India holds over half the world's tiger population. According to the latest tiger census report released on 20th January 2015 by NTCA, the current tiger population is estimated at 2,212. There are 50 tiger reserves in the country.

National Parks in Tamil Nadu

National Parks in Tamil Nadu	Year of establishment	District(s)
Guindy NP	1976	Chennai

Gulf of Mannar Marine NP	1980	Ramanathapuram and Tuticorin
Indira Gandhi (Annamalai) NP	1989	Coimbatore
Mudumalai NP	1990	Nilgris
Mukurthi NP	1990	Nilgris

There are 104 existing national parks in India covering an area of 40,501 km2, which is 1.23% of the geographical area of the country (National Wildlife Database, Aug. 2018). National Park is an area which is strictly reserved for the betterment of wildlifeand biodiversity and where activities like development, forestry, poaching, hunting, grazing and cultivation are not permitted. They are large areas of scenic and national beauty maintained for scientific educational and recreational use. They are not used for commercial extraction of resources. KazirangaNational park is a protected area for the one Horned Rhinoceros in Assam.

Wild Life Sanctuaries (WLS):

Any area other than the area comprised with any reserve forest or the territorial waters can be notified by the State Government to constitute as a sanctuary if such area is of adequate ecological, faunal, floral, geomorphological, natural or zoological significance. This is for the purpose of protecting, endangered factual species. Some restricted human activities are allowed inside the Sanctuary area details of which are given in CHAPTER I V, of the Wildlife Protection Act (WPA) 1972. Ecotourism is permitted, as long as animal life is undisturbed.

There are 544 existing wildlife sanctuaries in India covering an area of 118,918 km2, which is 3.62 % of the geographical area of the country (National Wildlife Database, 2017).Sanctuaries are tracts of land where wild animals and fauna can take refuge without being hunted or poached. Other activities like collection of forest products, regulated harvesting of timber, private ownership of land are permitted. Periyar wild life sanctuary in Kerala is famous for the Indian Tiger and Asiatic Elephant.

Wild life sanctuaries in Tamil Nadu

Prominent WLS in Tamil Nadu	Year of establishment	Districts
Vedanthangal Lake Birds WLS	1936	Chengalpet
Mudumalai WLS	1942	Nilgiris
Point Calimere WLS	1967	Nagapattinam
Indira Gandhi (Annamalai) WLS	1976	Coimbatore
Mundanthurai WLS	1977	Tirunelveli

THE MADRAS CROCODILE BANK TRUST

The Madras Crocodile Bank Trust and Centre for Herpetology was the brain child of the legendary Romulus Whitaker and a handful of like-minded conservation visionaries, who began work on the facility in 1976. It aimed to save India's dwindling crocodilian population. The mission is to promote the conservation of reptiles and amphibians and their habitats through education, scientific research and capture breeding. The crocodile bank remains a world leader in the field of frontline conservation and the preservation of natural landscapes. The Crocodile Bank currently consists of a large reptile park near Chennai and

several field projects located throughout the subcontinent reaching as far as the Nicobar Islands. About half a million people visit the bank every year, making it one of the most popular tourist attractions along the East Coast Road.

Arignar Anna Zoological Park, Vandalur

Arignar Anna Zoological Park is spread over an area of 602 hectares. of Reserve Forest at Vandalur, Chennai. It is one of the largest zoo in South East Asia in terms of area. The Zoological Park exhibits different classes of animals - it has around 2500 wild animals of nearly 180 species which includes Mammals, Birds and Reptiles. 34 years since its establishment, the Zoological Park has emerged as a successful ex-situ conservation centre and a captive breeding centre for many endangered species like Royal Bengal Tiger, Lion Tailed Macaque, NilgiriLangur, Gray Wolf, etc.,

The Zoo has many attractive features like Butterfly Park, Children's Park, Walk Through Aviary, Lion & Deer Safari, Forest Museum, Interpretation centre, etc., which attractsof installing CCTV Cameras for both visitors and animal management under the name of Zoo e-Eye. 24 x 7 Animal Live Streaming was introduced for the benefit of the visitors for the first time in the world. Vandalur Zoo Mobile Application was introduced to provide services to the visitors like facility to book tickets, Zoo navigation, Animal information in text and audio format. Digital payments at ticket counters are also available.

The Zoo school has been involved in education and outreach programmes. One such successful programme is 'Zoo Ambassador' which is been conducted for school children. In the year 2018, more than 400 students were trained and titled as Zoo Ambassadors. The Zoo also has a Rescue Centre which accommodates rescued wild animals and treats them to come out of stress.

Source: Director, Arignar Anna Zoological Park, Vandalur, Chennai

Biosphere Reserve (BR):

Biosphere Reserve (BR) is an international designation by UNESCO for representative parts of natural and cultural landscapes extending over large area of terrestrial or coastal/ marine ecosystems or a combination thereof. BRs are designated to deal with the conservation of biodiversity, economic and social development and maintenance of associated cultural values. Biosphere Reserves are thus special environments for both people and nature and are living examples of how human beings and nature can co-exist while respecting each other's needs. The Biosphere Reserve Programme is guided by UNESCO's Man and Biosphere (MAB) programme, as India is a signatory to the landscape approach supported by MAB programme. The scheme called Biosphere Reserve was implemented by the Government of India in 1986. There are 18 Biosphere Reserves in the country. Agasthyamalai (Karnataka - Tamil Nadu -Kerala), Nilgiri (Tamil Nadu - Kerala), Gulf of Mannar (Tamil Nadu) are the BRs notifed in Tamil Nadu.

Sacred Groves

A sacred grove or sacred woods are any grove of trees that are of special religious importance to a particular culture. Sacred groves feature in various cultures throughout the world.

Ex-Situ Conservation

It is conservation of selected rare plants/ animals in places outside their natural homes. It includes offsite collections and gene banks.

Offsite Collections:

They are live collections of wild and domesticated species in Botanical gardens, Zoological parks, Wildlife safari parks, Arborata (gardens with trees and shrubs). The organisms are well maintained for captive breeding programmes. As a result, many animals which have become extinct in the world continue to be maintained in Zoological Parks. As the number increases in captive breeding, the individuals are selectively released in the wild. In this way the Indian crocodile and Gangetic dolphin have been saved from extinction.

Gene Banks:

Gene banks are a type of biorepository which preserve genetic materials. Seeds of different genetic strains of commercially important plants can be stored in long periods in seed banks, gametes of threatened species can be preserved in viable and fertile condition for long periods using cryopreservation techniques.However, it is not economically feasible to conserve all biological wealth and all the ecosystems. The number of species required to be saved from extinction far exceeds the conservation efforts.

Different between Insitu and Exsitu Conservation

Insitu Conservation	Existu Conservation
It is the on-site conservation or the conservation of genetic resources in natural populations of plant or animal species.	This is a conservation strategy which involves placing of threatened animals and plants in special care locations for their protection.
It is the process of protecting an endangered plant or animal species in its natural habitat, either by protecting or restoring the habitat itself, or by defending the species from predators.	It helps in recovering populations or preventing their extinction under simulated conditions that closely resemble their natural habitats.
National Parks, Biosphere Reserve, Wild Life Sanctuaries form insitu conservation strategies	Zoological parks and Botanical gardens are common exsitu conservation programs.

Role of WWF and CITES

World Wild Fund for Nature (WWF) is an international non-governmental charitable trust founded in 1961, with headquarters at Gland, Vaud, Switzerland. It aims at wildness preservation and the reduction of human impact on the environment. It was formerly named the World Wildlife Fund. The living planet report is being published every two years by WWF since 1998.The vision of WWF is to conserve nature and reduce the most pressing threats to the diversity of life on Earth by conserving the world's most ecologically important regions, protect and restore species and their habitats, strengthen local communities' ability to conserve the natural resources they depend upon and to ensure that

the value of nature is reflected in decision made by individuals, communities, governments and businesses.

CITES:

The Convention on International Trade in Endangered Species (CITES) of wild faunaand flora, also known as the Washington Convention, is a multilateral treaty to protect endangered plants and animals. It was drafted from a resolution adopted from a meeting of members of the IUCN in 1963 and opened for signature in 1973. It came into force during July 1975.It aims to ensure that international trade in specimens of wild animals and plants should not be a threat to the survival of the species in the wild. It accords varying degrees of protection to more than 35,0000 species of animals and plants.

ZOOLOGICAL SURVEY OF INDIA

The Zoological Survey of India (ZSI) was established in 1916 to promote survey, exploration and research leading to the advancement in our knowledge of various aspects of biodiversity of our country.

The objectives of ZSI are:

- Exploration, Survey, Inventorying and Monitoring of faunal diversity in various states, ecosystems and protected areas of India.
- Periodic review of the status of threatened and endemic species.
- Preparation of Red Data Book and Fauna of India.
- Biological studies on selected important species.
- Maintenance and Development of National Zoological Collections.

Restoration of Degraded Habitat

Biodiversity conservation through eco development - an Indian case study

The Forestry Research Education and Extension Project FREEP (A World Bank Initiative) in India is employing a strategy called 'eco development' which enlists local commodities in the preservation of biodiversity. The strategy involves developing alternate resources and sources of income for those who depend on the protected natural habitat (forest) for their livelihood.

FREEP is conducting pilot eco-development programmes in the Kalakad-Mundanthurai Tiger Reserve (KMTR) in Tamil Nadu. The reserve contains a unique and varied array of flora ranging from thorn and dry teak to tropical evergreen, and supports a rich variety of birds and mammals, including tigers, leopards and elephants.Te last tiger refuge in Tamil Nadu, the KMTR is one of 50 sites covered under the Indian Government's Project Tiger, a programme receiving international assistance to enhance tiger habitat.

Over 100 villages are now participating in the KMTR project. Communities and individual farmers have planted fuelwood and fodder plantations. Some villagers have installed cow dung-based gas plants for home fuel needs and are using fuel-saving pressure cookers and more efficient wood-burning stoves (smokeless chulas). Loans for a wide array of alternative income-generating activities such as dairy and poultry farming, tailoring, coconut leaf weaving, and setting up tea and dry goods shops are made available.

Thus, the eco-development programme at the KMTR is rapidly coming to be seen as a model for conserving biodiversity through local participation.

Biodiversity Act (BDA) 2002

The Convention on Biological Diversity (CBD) is a United Nations initiative to protect Biodiversity and encourage the sustainable use of natural resources. The convention was held in 1992 at the 'Earth Summit' in Brazil. India is a signatory of the CBD. The Biological Diversity Act, 2002 is an Act of the Parliament of India for preservation of biological diversity in India, and provides mechanism for equitable sharing of benefits arising out of the use of traditional biological resources and knowledge. The Act was enacted to meet the obligations under Convention on Biological Diversity (CBD), to which India is a party.

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

- **International Union for Conservation of Nature (IUCN)**

Founded in 1948, the International Union for Conservation of Nature (IUCN) is the world's oldest environmental organisation with its headquarters at Gland, Switzerland. It is a neutral forum for Governments, NGO's, Scientists, business and local communities with the aim of developing solution and implementing policies related to the conservation of environment and sustainable development.

- **IUCN Red List**

IUCN Red List categories help us to evaluate the degree of threat and conservation priorities to the flora and fauna It is also a powerful tool forpersuading governments to protect threatened species and for most of the plant and animal species world-wide. IUCN has developed protected areas and developed criteria for threatened species.
The criteria are as follows.

A - Population reduction
B - Geographic range
C - Small population size and decline
D - Very small or restricted population
E - Quantitative analysis

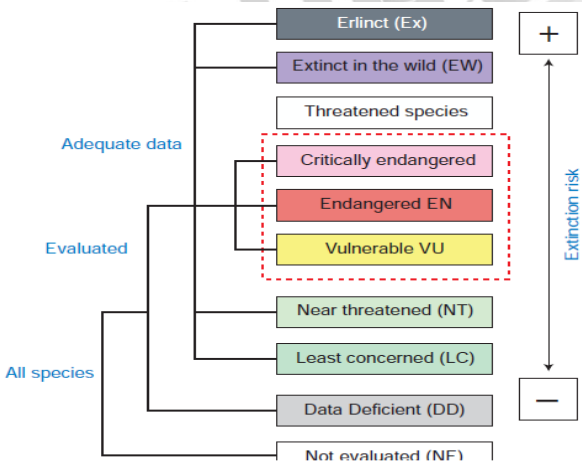

Figure 8.10: IUCN Red List categories

- **IUCN Red List categories**

Extint (EX)

A taxon is Extinct when there is no reasonable doubt on the death of the last individual. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Example: Neuracanthusneesianus

Extinct in the wild (EW)

A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalised population (or populations) well outside the past range. Example: Ginkgo biloba

Critically endangered (CR)

A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered, and it is therefore considered to be facing an extremely high risk of extinctions in the wild. Example: Euphorbia santapaui, Piper barberi, Syzygiumgambelianum.

Endangered (EN)

A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered, and it is therefore considered to be facing a very high risk of extinction in the wild. Example: Elaeocarpus venustus, Pogostemonnilagricus, Eugenia singampattiana.

Vulnerable (VU)

A taxon is Vulnerable when the best available evidence indicates that it meets any other criteria A to E for Vulnerable, and it is therefore considered to be facing a high risk of extinction in the wild. Example: Dalbergialatifolia, Santalum album, Chloroxylonsweitenia

Near threatened (NT)

A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for threatened category in the near future.

Least concerned (LC)

A taxon is Least Concerned when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened, Widespread and abundant taxa are included in this category.

Data deficient (DD)

A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of the risk of extinction based on its distribution and/or population status.

Conservation movement

A community level participation can help in preservation and conservation of our environment. Our environment is a common treasure for all the living organisms on earth. Every individual should be aware of this and participate actively in the programs meant for the conservation of the local environment. Indian history has witnessed many people movements for the protection of environment.

Chipko Movement

The tribal women of Himalayas protested against the exploitation of forests in 1972. Later on it transformed into Chipko Movement by Sundarlal Bahuguna in Mandal village of Chamoli district in 1974. People protested by hugging trees together which were felled by a sports goods company. Main features of Chipko movement were,

- This movement remained non political
- It was a voluntary movement based onGandhian thought.
- It was concerned with the ecological balance of nature
- Main aim of Chipko movement was to give a slogan of five F's – Food, Fodder, Fuel, Fibreand Fertilizer, to make the communities selfsufficient in all their basic needs.

Appiko Movement

The famous Chipko Andolen of Uttarakhand in the Himalayas inspired the villagers of Uttar Karnataka to launch a similar movement to save their forests. This movement started in Gubbi Gadde a small village near Sirsi in Karnataka by Panduranga Hegde. This movement started to protest against felling of trees, monoculture, forest policy and deforestation.

Not evaluated (NE)

A taxon is Not Evaluated when it has not yet been evaluated against the criteria.

7. Sustainable Development

United Nations and Sustainable Development

Sustainability was first featured in the principles adopted by the United Nations Conference on the Human Environment held at Stockholm on 16 June 1972. It was now realized that development needed to be sustainable – it should not only focus on economic and social matters, but also on matters related to the use of natural resources. The United Nations commissioned a group of 22 people from both developed and developing countries to identify long-term environmental strategies for the international community. This World Commission on Environment and Development (WCED), was headed by Gro Harlem Brundtland, then the Prime Minister of Norway. This commission came to be known as the Brundtland Commission, which submitted its report, entitled our common future, to the UN in 1987.

The Brundtland Report focused on the needs and interests of humans. It was concerned with securing a global equity for future generations by redistributing resources towards poorer nations to encourage their economic growth in order to enable all human beings to achieve their basic needs. The report highlighted the three fundamental components of sustainable development, the environment, the economy, and society, which later became known as the triple bottom line.

The 1992 and 2002 Earth Summits held at Rio de Janeiro and Johannesburg were the United Nations Conference on Environment and Development (UNCED), a direct result of the Brundtland Commission. An important achievement of the Rio summit was an agreement on the Climate Change Convention which led to the Kyoto Protocol which you have learned about earlier. The United Nations Conference on Sustainable Development (UNCSD), also known as Rio 2012, Rio+20 or Earth Summit 2012 was the third and recent International conference on sustainable development. It was hosted by Brazil in Rio de Janeiro from 13 to 22 June 2012.

Concept and Goals of Sustainable Development

In 1980 the International Union for the Conservation of Nature introduced the term "sustainable development". Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

A primary goal of sustainable development is to achieve a reasonable and equitably distributed level of economic wellbeing that can be continued for many human generations.

Sustainable Development Goals (SDGs)

In 1992, the UN Conference on Environment and Development published the Earth Charter, which outlined the building of a just, sustainable, and peaceful global society in the 21st century. The action plan was known as 'Agenda 21' for sustainable development.

In September 2015, the United Nations General Assembly formally adopted the "Universal, integrated and transformative" 2030 Agenda for Sustainable Development, a set of 17 Sustainable Development Goals (SDGs). The goals are to be implemented and achieved in every country from the year 2016 to 2030.

Countries adopted a set of goals to end poverty, protect the planet and ensure prosperity for all as part of a new sustainable development agenda. Each goal has specific targets to be achieved over the next 15 years.

For the goals to be reached, everyone needs to do their part: governments, the private sector, civil society and people.

Goal 1: End poverty in all its forms everywhere
One in five people in developing countries still live on less than $1.90 a day, many people risk slipping back into poverty. Economic growth must be inclusive to provide sustainable jobs and promote equality.

Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Agriculture, forestry and fisheries can provide nutritious food for all and generate decent incomes, while supporting people-centered rural development and protecting the environment. A profound change of the global food and agriculture system is needed if we are to nourish today's 815 million hungry and the additional 2 billion people expected by 2050.

Goal 3: Ensure healthy lives and promote well-being for all at all ages
Significant strides have been made in increasing life expectancy and reducing some of the common killers associated with child and maternal mortality. Major progress has been made on increasing access to clean water and sanitation, reducing malaria, tuberculosis, polio and the spread of HIV/AIDS.

Goal 4: Ensure inclusive and quality education for all and promote lifelong learning
Major progress has been made towards increasing access to education at all levels and increasing enrolment rates in schools particularly for women and girls. For example, the world has achieved equality in primary education between girls and boys, but few countries have achieved that target at all levels of education.

Goal 5: Achieve gender equality and empower all women and girls
Gender equality is not only a fundamental human right, but a necessary foundation for a peaceful, prosperous and sustainable world.

Goal 6: Ensure access to water and sanitation for all
Clean, accessible water for all is an essential part of the world we want to live in. There is sufficient fresh water on the planet to achieve this. But due to bad economics or poor infrastructure, every year millions of people, most of them children, die from diseases associated with inadequate water supply, sanitation and hygiene. By 2050, at least one in four people is likely to live in a country affected by chronic or recurring shortages of fresh water.

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all
Energy is central to nearly every major challenge and opportunity the world faces today. Sustainable energy is opportunity – it transforms lives, economies and the planet.

Goal 8: Promote inclusive and sustainable economic growth, employment and decent work for all

Sustainable economic growth will require societies to create the conditions that allow people to have quality jobs that stimulate the economy while not harming the environment. Job opportunities and decent working conditions are also required for the whole working age population.

Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation
Inclusive and sustainable industrial development is the primary source of income generation, allows for rapid and sustained increases in living standards for all people, and provides the technological solutions to environmentally sound industrialization.

Goal 10: Reduce inequality within and among countries
To reduce inequality, policies should be universal in principle paying attention to the needs of disadvantaged and marginalized populations.

Goal 11: Make cities inclusive, safe, resilient and sustainable
Cities are hubs for ideas, commerce, culture, science, productivity, social development and much more. At their best, cities have enabled people to advance socially and economically Common urban challenges include congestion, lack of funds to provide basic services, a shortage of adequate housing and declining infrastructure.

Goal 12: Ensure sustainable consumption and production patterns
Sustainable consumption and production is about promoting resource and energy efficiency, sustainable infrastructure, and providing access to basic services, green and decent jobs and a better quality of life for all. Its implementation helps to achieve overall development plans, reduce future economic, environmental and social costs, strengthen economic competitiveness and reduce poverty.

Goal 13: Take urgent action to combat climate change and its impacts
Climate change is now affecting every country on every continent. It is disrupting national economies and affecting lives, costing people, communities and countries dearly today and may be even more tomorrow.

Goal 14: Conserve and sustainably use the oceans, seas and marine resources
The world's oceans – their temperature, currents and life – drive global systems that make the earth habitable for humankind. Careful management of this essential global resource is a key feature of a sustainable future.

Goal 15: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss
Forests cover 30 per cent of the Earth's surface and in addition to providing food security and shelter, forests are key to combating climate change, protecting biodiversity and the homes of the indigenous population. Thirteen million hectares of forests are being lost every year while the persistent degradation of dry lands has led to the desertification of 3.6 billion hectares.

Goal 16: Promote just, peaceful and inclusive societies
This Goal is dedicated to the promotion of peaceful and inclusive societies for sustainable development, the provision of access to justice for all, and building effective, accountable institutions at all levels.

Goal 17: Revitalize the global partnership for sustainable development
A successful sustainable development agenda requires partnerships between governments, the private sector and civil society. These inclusive partnerships built upon principles and values, a shared vision, and shared goals that place people and the planet at the center, are needed at the global, regional, national and local level.

Paris Agreement
To address climate change, countries adopted the Paris Agreement at the COP21 in Paris on 12 December 2015. The Agreement entered into force shortly thereafter, on 4 November 2016. In the agreement, all countries agreed to work to limit global temperature rise to well below 2°C, and given the grave risks, to strive for 1.5°C.

Climate Change and Sustainability

The Earth's climate has changed throughout history. In the last 650,000 years there have been several cycles of glacial and warm periods each lasting thousands or millions of years. Most of these climate changes are attributed to very small variations in earth's orbit that changes the amount of solar energy our planet receives. It is understood that at present the Earth's climate is getting warmer which is referred to as 'Global Warming'. Earth's temperature has gone up about one degree Fahrenheit in the last 100 years. This is a very small change but small changes in earth's temperature can have big effects. Some effects are already happening such as melting of glaciers, rise in the level of oceans, prolonged droughts, excessive rain and floods, etc.

Reasons for Climate change

Burning fossil fuels emits gases into the atmosphere. Burning fossil fuel to provide energy, coupled with the effects of major transportation and deforestation causes a rapid increase in global temperatures. This can change the climate of a place.

Effects of climate change – Scientists had predicted in the past that the result from global climate change are now occurring, loss of sea ice, accelerated sea level rise and longer, more intense heat waves.

Temperatures will continue to rise - Experts agree that greenhouse gases which trap heat and prevent it from leaving the earth's atmosphere are mostly responsible for the temperature spike.

Frost- free season (and growing season) will lengthen - it could actually have detrimental effects on the crops we grow. Warmer weather helps pests survive longer which can destroy crops. Rising temperatures are also expected to contribute to a shift in areas which are agriculturally most productive and the crops that grow there.

Changes in precipitation patterns - The contrast between wet and dry areas will increase globally. In other words, the wet areas will get wetter and the dry areas will get drier.

More droughts and heat waves - With rising temperatures and shifting rainfall patterns, heat waves and droughts are increasing in frequency and intensity.

Sea level rise - Scientists have determined that global sea level has been steadily rising since 1900 at a rate of at least 0.1 to 0.25 centimeter per year. Sea level can rise by two different mechanisms with respect to climate change.

Arctic likely to become ice-free - The Arctic Ocean is expected to become essentially ice free in summer before mid-century.

Response to Climate Change
There are two main responses to climate change.

Mitigation -Which addresses the root causes of climate change, by reducing greenhouse gas emissions.

Adaptation - seeks to lower the risks posed by the consequences of climatic changes. Both approaches will be necessary to deal with the global changes that have already been set in motion.

Mitigation measures:
It is important that we learn how to reduce climate change, and put them into practice now, before it is too late.

Cleaner alternative energy sources: One important way to fight climate change is to reduce our reliance on and usage of fossil fuels, and depend on alternative renewable and greener sources of energy such as wind energy, solar energy, water or hydropower, biomass, and geothermal energy.

Energy saving tips - we can adopt energy saving tips by investing in more expensive energy-saving appliances like the compact fluorescent light (CFL) bulbs, Air-conditioners, refrigerators etc. Switching off our electrical appliances when not in use.

Green driving tips - The best strategy to reduce toxic gas emissions is definitely to reduce the use of automobiles. Use public transport, carpooling, use of electricity powered cars or two wheelers can be an alternative.

Reduce - Reuse - Recycle practices - Reducing, reusing and recycling helps us conserve resources and energy, and reduce pollution and greenhouse gas emissions produced thereby.

Re-forestation - The cleanest and most efficient remover of carbon dioxide from our atmosphere actually is nothing but green plants and trees. The rate at which we are cutting down our trees and forests to make way for human developments has greatly reduced the earth's ability to remove carbon dioxide from the atmosphere.

Organic farming - Soils are an important sink for atmospheric carbon dioxide. Nevertheless, deforestation making way for conventional agriculture is increasingly depleting this sink. Sustainable and organic agriculture helps to counteract climate change by restoring soil organic matter content as well as reduce soil erosion and improve soil physical structure. Organic farming uses natural fertilizers and helps maintain crop yields.

Watershed management and its importance

Watershed is a geographical area drained by a stream or a system connecting stream in which water from all over an area flow under gravity to a common drainage channel. A watershed system delivers water through rills, gullies and streams to a larger body of water.

Watershed management is proper utilization of land and water resource for optimum production with minimum hazards to natural resources. It relates to soil and water conservation proper land uses, promote afforestation and sustainable farming practices, conserve farmland and pastureland, maintaining soil fertility, proper management of local water for farming, drainage, construct small dams for flood protection, improving individuals standard of living and thereby promote ecological balance.

Key steps in watershed management

Watershed plans should first identify the characteristics of the watershed and inventory the watershed's natural resources. The first steps in watershed management planning are to:

i. Delineate and map the watershed's boundaries and the smaller drainage basins within the watershed.

ii. Map and prepare an Inventory of resources in the watershed.

iii. Prepare an Inventory and map the natural and manmade drainage systems in the watershed.

iv. Prepare an Inventory and map land use and land cover.

v. Prepare a soil map of the watershed.

vi. Identify areas of erosion, including stream banks and construction sites.
vii. Identify the quality of water resources in the watershed as a baseline; and

viii. Prepare a map and Inventory of pollution sources, both point sources (such as industrial discharge pipes) and nonpoint sources (such as municipal storm water systems, failing septic systems, illicit discharges).

Watershed Management in India:

Watershed development project in the country has been sponsored and implemented by Government of India from early 1970s onwards. Various watershed development programs like Drought Prone Area Program (DPAP), Desert Development Program (DDP), and river Valley Project (RVP), National Watershed Development Project for Rain-fed Areas (NWDPRA) and Integrated Wasteland Development Program (IWDP) were launched subsequently in various hydro-ecological regions. Entire watershed development programs primarily focused on soil conservation and rainwater harvesting during 1980s and before.

Rain Water Harvesting (RWH)

Millions of people throughout the world do not have access to clean water for domestic purposes. In many parts of the world conventional piped water is either absent, unreliable

or too expensive. One of the biggest challenges of the 21st century is to overcome the growing water shortage. Rain Water Harvesting (RWH) has thus regained its importance as a valuable alternative or supplementary water resource, along with more conventional water supply technologies. Water shortages can be relieved if rain water harvesting is practiced more widely.

Need for Rain Water Harvesting

To overcome the situation of inadequacy of water supply. The most economical way to increase the ground water table. To replenish the sub soil of the urban area covered with pavements. To recharge the underground water table at places where the availability of rain water is higher or to overcome the situation of water logging.
Rain water harvesting also improves the quality of underground water through a process called dilution. To get water for irrigation of greenbelts, farms, gardens, etc.

Rain Water Harvesting Techniques
There are two main techniques of rain water harvestings:

1) Storage of rain water on surface for future use.

2) Recharge to ground water.
The storage of rain water on surface is a traditional technique and structures used were underground tanks, ponds, check dams, weirs, etc. Recharge of ground water is a new concept of rain water harvesting and the structures generally used are: Recharge pits filled with boulders, gravels, and coarse-sand, Wells, Trenches etc.

Environmental Impact Assessment

Every country strives to progress ahead. One aspect of progress is economic development through manufacturing and trading. Every country builds industries which provide employment, serve the consumers' needs and help to generate revenue. The dominant pattern of development that humankind has followed in recent decades has brought about large scale changes in the earth systems. We are already feeling the impact of these changes upon our health, livelihoods and safety. On the other hand, the fruits of development are not equally distributed. Some countries and some communities have a high standard of living, while others are not able to meet their basic needs.

Development projects in the past were undertaken without any consideration about their environmental consequences. As a result rivers and lakes have been polluted, air pollution has reached threatening levels and pilling of domestic and industrial wastes has resulted in land degradation. Industrialization and economic growth provided material comforts but at the same time deteriorated the quality of life.

The Objective of EIA
(i) To identify, predict and evaluate the economic, environmental and social impact of development activities
(ii) To provide information on the environmental consequences for decision making and
(iii) To promote environmentally sound and sustainable development through the identification of appropriate alternatives and mitigation measures.

Steps in the EIA Process
The eight steps of the EIA process:

Screening: First Stage of EIA, which determines whether the proposed project, requires an EIA and if it does, then the level of assessment required.

Scoping: This stage identifies the key impacts that should be investigated. This stage also defines the time limit of the study.

Impact analysis: This stage of EIA identifies and predicts the likely environmental and social impact of the proposed project and evaluates the significance.

Mitigation: This step in EIA recommends the actions to reduce and avoid the potential adverse environmental consequences of development activities.

Reporting: This stage presents the result of EIA in a form of a report to the decision-making body and other interested parties.

Review of EIA: It examines the adequacy and effectiveness of the EIA report and provides the information necessary for decision –making.

Decision-making: It decides whether the project is rejected, approved or needs further change.

Post monitoring: This stage comes into play once the project is commissioned. It checks to ensure that the impacts of the project do not exceed the legal standards and implementation of the mitigation measures are in the manner as described in the EIA report.

Environmental Impact Assessment in India

EIA was introduced in India in 1978, with respect to river valley projects. On 27 January 1994, the Union Ministry of Environment and Forests (MEF), Government of India, under the Environmental (Protection) Act 1986, made Environmental Clearance (EC) mandatory for expansion or modernisation or for setting up new projects listed in Schedule 1 of the notification. Since then there have been 12 amendments made in the EIA notification of 1994. Both central and state authorities share the responsibility of EIA's development and management. EIA is now mandatory for 30 categories of projects, and these projects get Environmental Clearance (EC) only after the EIA requirements are fulfilled.
The MoEF recently notified new EIA legislation in September 2006. The notification makes it mandatory for all projects to get environment clearance from the central government under the following categories:

Industries
Mining
Thermal power plants
River valley projects
Infrastructure and CRZ (Coastal Regulation Zone)

Nuclear power projects.

However, the new legislation has entrusted the decision of clearing projects on the state government depending on the size/ capacity of the project. EIA appraises the environmental health and social implications of planned developmental projects. It thus links environment with development. The goal of EIA is to ensure environmentally safe and sustainable development.

Measures for Promotion of Sustainable Development

As discussed earlier, the United Nations 17 Sustainable Development Goals and 169 targets are part of the 2030 Agenda for Sustainable Development adopted by 193 Member States at the UN General Assembly Summit in September 2015, and which came into effect on 1 January 2016. These goals are the result of international consultations that brought national governments and millions of citizens from across the globe together to negotiate and adopt the global path to sustainable development for the next 15 year.

The SDGs and targets will stimulate action in the following critically important areas: poverty, hunger, education, health and well-being, education, gender equality, water and sanitation, energy, economic growth and decent work, infrastructure, industry and innovation, reducing inequalities, sustainable cities, consumption and production, climate action, ecosystems, peace and justice, and partnership. This agenda recognises that it is not enough to focus on economic growth alone but in creating more equal societies, and a safer and more prosperous planet.

Which countries are achieving the UN Sustainable Development Goals fastest?
The ultimate aim of the Sustainable Development Goals is to end poverty, protect the planet and ensure prosperity for everyone. Each goal has specific targets that need to be met by 2030.

So how close are countries to meeting them? To find out, non-profit organization Bertelsmann Stiftung and the UN Sustainable Development Solutions Network have created a prototype index that measures their performance. Sweden leads the list, followed by Denmark and Finland. Among the G7 countries, only Germany and France can be found among the top ten performers. The United States ranks 42nd on the Index, while Russia and China rank 62nd and 71st respectively. Also in the top 20 were Canada (13th), the Czech Republic (15th) and Slovenia (17th). Asia-Pacific's top performers Japan, Singapore and Australia rounded off the list at 18th, 19th and 20th, respectively. The SDG Index underlines that despite achieving high percentages, all countries still have their work cut out to close the remaining gap. India ranks 116 out of 157 nations on a global index that assesses the performance of countries towards achieving the ambitious sustainable development goals (SDGs).

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Unit – 10 COMMUNICATION SYSTEMS

IMPORTANT COMMUNICATION SYSTEMS
SATELLITE COMMUNICATION

The satellite communication is a mode of communication of signal between transmitter and receiver via satellite. The message signal from the Earth station is transmitted to the satellite on board via an uplink (frequency band 6 GHz), amplified by a transponder and then retransmitted to another Earth station via a downlink (frequency band 4 GHz) (Figure 10.7).

The high-frequency radio wave signals travel in a straight line (line of sight) may come across tall buildings or mountains or even encounter the curvature of the earth. A communication satellite relays and amplifies such radio signals via transponder to reach distant and far off places using uplinks and downlinks. It is also called as a radio repeater in sky. The applications are found to be in all fields and are discussed below.

Applications

Satellites are classified into different types based on their applications. Some satellites are discussed below.

i) **Weather Satellites:** They are used to monitor the weather and climate of Earth. By measuring cloud mass, these satellites enable us to predict rain and dangerous storms like hurricanes, cyclones etc.

ii) **Communication satellites:** They are used to transmit television, radio, internet signals etc. Multiple satellites are used for long distances.

iii) **Navigation satellites:** These are employed to determine the geographic location of ships, aircrafts or any other object.

FIBRE OPTIC COMMUNICATION

The method of transmitting information from one place to another in terms of light pulses through an optical fiber is called fiber optic communication. It works under the principle of total internal reflection.Light has very high frequency (400 THz – 790 THz) than microwave radio systems. The fibers are made up of silica glass or silicon dioxide which is highly abundant on Earth.

Now it has been replaced with materials such as chalcogenide glasses, fluoroaluminate crystalline materials because they provide larger infrared wavelength and better transmission capability.
As fibers are not electrically conductive, it is preferred in places where multiple channels are to be laid and isolation is required from electrical and electromagnetic interference.

Applications

Optical fiber system has a number of applications namely, international communication, inter-city communication, data links, plant and traffic control and defense applications.

Merits

i) Fiber cables are very thin and weigh lesser than copper cables.
ii) This system has much larger band width. This means that its information carrying capacity is larger.
iii) Fiber optic system is immune to electrical interferences.
iv) Fiber optic cables are cheaper than copper cables.

Demerits

i) Fiber optic cables are more fragile when compared to copper wires.
ii) It is an expensive technology.

Fiber optic cables provide the fastest transmission rate compared to any other form of transmission. It can provide data speed of 1 Gbps for homes and business. Multimode fibers operate at the speed of 10 Mbps. Recent developments in optical communication provide the data speed at the rate of 25 Gbps

Most transatlantic telecommunication cables between the United States of America and Europe are fiber optic.

RADAR AND APPLICATIONS

Radar basically stands for Radio Detection and Ranging System. It is one of the important applications of communication systems and is mainly used to sense, detect, and locate distant objects like aircraft, ships, spacecraft, etc. The angle, range or velocity of the objects that are invisible to the human eye can be determined.

Radar uses electromagnetic waves for communication. The electromagnetic signal is initially radiated into space by an antenna in all directions. When this signal strikes the targeted object, it gets reflected or reradiated in many directions. This reflected (echo) signal is received by the radar antenna which in turn is delivered to the receiver. Then, it is processed and amplified to determine the geographical statistics of the object. The range is determined by calculating the time taken by the signal to travel from RADAR to the target and back.

Applications

Radars find extensive applications in almost all fields. A few are mentioned below.

i) In military, it is used for locating and detecting the targets.
ii) It is used in navigation systems such as ship borne surface search, air search and missile guidance systems.

iii) To measure precipitation rate and wind speed in meteorological observations, Radars are used.

iv) It is employed to locate and rescue people in emergency situations.

MOBILE COMMUNICATION

Mobile communication is used to communicate with others in different locations without the use of any physical connection like wires or cables. It allows the transmission over a wide range of area without the use of the physical link. It enables the people to communicate with each other regardless of a particular location like office, house etc. It also provides communication access to remote areas.

It provides the facility of roaming – that is, the user may move from one place to another without the need of compromising on the communication. The maintenance and cost of installation of this communication network are also cheap.

Applications

i) It is used for personal communication and cellular phones offer voice and data connectivity with high speed.
ii) Transmission of news across the globe is done within a few seconds.
iii) Using Internet of Things (IoT), it is made possible to control various devices from a single device. Example: home automation using a mobile phone.
iv) It enables smart classrooms, online availability of notes, monitoring student activities etc. in the field of education.

Recently, the mobile communication technology has evolved through various stages like 2G, 3G, 4G, 5G, WiMAX, Wibro, EDGE, GPRS and many others. This helps to increase the speed of communication and the range of coverage. The connectivity issues have decreased with reliable and secure connections. The GPS (Global Positioning System) and GSM (Global System for Mobile communication) technology play an important role in mobile communication. This increases the utilization of bandwidth of the network, sharing of the networks, error detections, etc. Many methods like digital switching, TDMA, CDMA have been used to ease the communication process.

INTERNET

Internet is a fast growing technology in the field of communication system with multifaceted tools. It provides new ways and means to interact and connect with people. Internet is the largest computer network recognized globally that connects millions of people through computers. It finds extensive applications in all walks of life.

To store all the information available on the internet, you would need over 1 billion DVDs or 200 million Blu-ray discs.

Applications:

i) **Search engine:** The search engine is basically a web-based service tool used to search for information on World Wide Web.
ii) **Communication:** It helps millions of people to connect with the use of social networking: emails, instant messaging services and social networking tools.
iii) **E-Commerce:** Buying and selling of goods and services, transfer of funds are done over an electronic network.

8th- term -3

Unit -3 UNIVERSE AND SPACE SCIENCE

Rockets

The universe is a great mystery to all of us. Our minds always try to know about the space around us. Understanding the space will be helpful to us in many ways. Space research provides information to understand the environment of the Earth and the changing climate and weather on Earth. Exploring the space will help us to answer many of the challenges we are facing these days

Discovery of rockets has opened a small portion of the universe to us. Rockets help us to launch space probes to explore the planets in the solar system. They also help us to launch space-based telescopes to explore the universe.

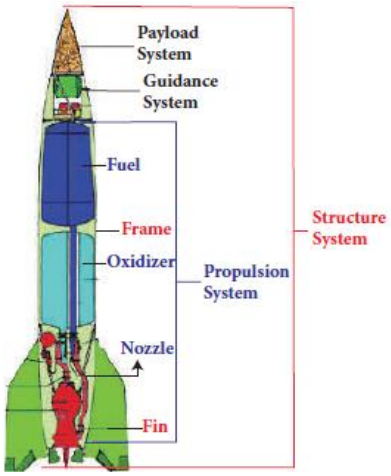
Rockets were invented in China, more than 800 years ago. The first rockets were a cardboard tube packed with gunpowder. They were called fire arrows. In 1232 AD, the Chinese used these 'fire arrows' to defeat the invading Mongol army. The knowledge of making rockets soon spread to the Middle East and Europe, where they were used as weapons.

More than all rockets enable us to put satellites, which are useful to us in a number of ways. Our country has effective rocket technology and has applied it successfully to provide so many space services globally.

Parts of Rockets

A rocket is a space vehicle with a very powerful engine designed to carry people or equipment beyond Earth and out into space. There are four major parts or systems in a rocket. They are:

- Structural system
- Payload system
- Guidance system
- Propulsion system



Parts of a Rocket

Structural system (Frame)

The structural system is the frame that covers the rocket. It is made up of very strong but light weight materials like titanium or aluminum. Fins are attached to some rockets at the bottom of the frame to provide stability during the flight.

Payload system

Payload is the object that the satellite is carrying into the orbit. Payload depends on the rocket's mission. The rockets are modified to launch satellites with a wide range of missions like communications, weather monitoring, spying, planetary exploration, and as observatories. Special rockets are also developed to launch people into the Earth's orbit and onto the surface of the Moon.

Guidance system

Guidance system guides the rocket in its path. It may include sensors, on-board computers, radars, and communication equipments.

Propulsion system

It takes up most of the space in a rocket. It consists of fuel (propellant) tanks, pumps and a combustion chamber. There are two main types of propulsion systems. They are: liquid propulsion system and solid propulsion system.

Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV) rockets are India's popular rockets.

Types of Propellants

A propellant is a chemical substance that can undergo combustion to produce pressurized gases whose energy is utilized to move a rocket against the gravitational force of attraction. It is a mixture, which contains a fuel that burns and an oxidizer, which supplies the oxygen necessary for the burning (combustion) of the fuel. The propellants may be in the form of a solid or liquid.

a. Liquid propellants

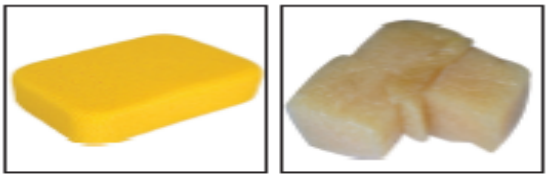
In liquid propellants fuel and oxidisers are combined in a combustion chamber where they burn and come out from the base of the rocket with a great force. Liquid hydrogen, hydrazine and ethyl alcohol are the liquid fuels. Some of the oxidizers are oxygen, ozone, hydrogen peroxide and fuming nitric acid.

Liquid Hydrogen

Fuming Nitric Acid

b. Solid propellants

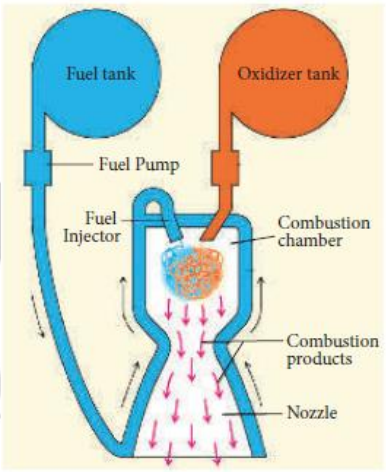
In solid rocket propellants fuel and oxidiser compounds are already combined. When they are ignited they burn and produce heat energy. Combustion of solid propellants cannot be stopped once it is ignited. Solid fuels used in rockets are polyurethanes and poly butadienes. Nitrate and chlorate salts are used as oxidizers



Polyurethanes Poly butadienes

c. Cryogenic propellants

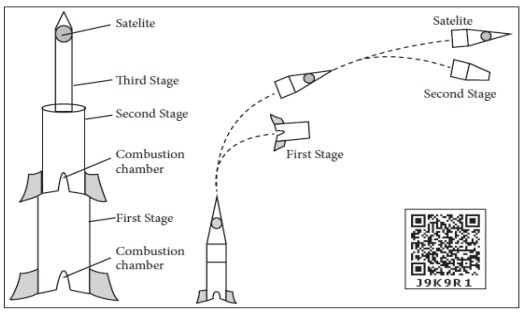
In this type of fuel, the fuel or oxidizer or both are liquefied gases and they are stored at a very low temperature. These fuels do not need any ignition system. They react on mixing and start their own flame.



Cryogenic Fuels

Launching of Satellite

Before being launched into the space, rockets will be held down by the clamps on the launching pad initially. Manned or unmanned satellites will be placed at the top of the rocket. When the fuel in the rocket is burnt, it will produce an upward thrust. There will be a point at which the upward thrust will be greater than the weight of the satellite. At that point the clamp will be removed by remote control and the rocket will move upwards. According to Newton's third law, for every action there is an equal and opposite reaction. As the gas is released downward, the rocket will move upward.



Launching of Rocket

To place a satellite in a particular orbit, a satellite must be raised to the desired height and given the correct speed and direction by the launching rocket. If this high velocity is given to the rocket at the surface of the Earth, the rocket will be burnt due to air friction. Moreover, such high velocities cannot be developed by a single rocket. So, multistage rockets are used. To penetrate the dense lower part of the atmosphere, initially the rocket rises vertically and then it is tilted by a guidance system.

India's Space Programmes

Within few years after the independence, India initiated space research activities. In 1969, Indian Space Research Organisation (ISRO) was formed with the objective of developing space technology and its application for different needs of the nation. India is focusing on satellites for communication and remote sensing, space transportation systems and application programmes. The first ever satellite Aryabhata was launched in 1975. Since then India has achieved a lot in space programmes equal to that of the developed nations.

Rakesh Sharma, an Indian pilot from Punjab was selected as a 'Cosmonaut' in a joint space program between India and Soviet Russia and become the first Indian to enter into the space on 2nd April, 1984.

Chandrayaan – 1

Our country launched a satellite Chandrayaan-1 (meaning Moon vehicle) on 22nd October 2008 to study about the Moon. It was launched from Sathish Dhawan Space Center in Sriharikota, Andhra Pradesh with the help of PSLV (Polar Satellite Launch Vehicle) rocket. It was put into the lunar orbit on 8th November 2008.

The spacecraft was orbiting around the Moon at a height of 100 km from the lunar surface. It collected the chemical, the mineralogical and the geological information about the Moon. This mission was a major boost for the Indian space programs and helped to develop its own technology to explore the Moon. Chandrayaan-1 was operated for 312 days and achieved 95% of its objectives. The scientists lost their communication with the space craft on 28th August 2009. On the successful completion of all the major objectives, the mission was concluded.

Chandrayaan - 1

a. Objectives of Chandrayaan-1

The following were the objectives of Chandrayaan – 1 mission.

- To find the possibility of water on the Moon.
- To find the elements of matter on the Moon.
- To search for the existence of Helium-3.
- To make a 3-dimensional atlas of the Moon.
- To study about the evolution of the solar system.

Kalam Sat is the world's smallest satellite weighing only 64 gram. It was built by a team of high school students, led by RifathSharook, an 18 year old school student from 'Pallapatti' near Karur, Tamil Nadu. It was launched into the space on 22nd June 2017 by NASA.

b. Achievements of Chandrayaan-1

The following are the achievements of Chandrayaan-1 mission.

- The discovery of presence of water molecules in the lunar soil.
- Chandrayaan-1 confirmed that the Moon was completely molten once.
- Chandrayaan-1 has recorded images of the landing site of the US space-craft Apollo-15 and Apollo-11.

Know your Scientist

Dr.MylsamyAnnadurai was born on 2nd July 1958, at Kodhavadi, a small village near Pollachi in Coimbatore district. He pursued his B.E. degree course at Government College of Technology, Coimbatore. In 1982, he pursued his higher education and acquired an M.E. degree at PSG College of Technology, Coimbatore. In the same year he joined the ISRO as a scientist. And later, he got his doctorate degree from Anna University of Technology, Coimbatore. Annadurai is a leading technologist in the field of satellite system. He has served as the Project Director of Chandrayaan-1, Chandrayaan-2 and Mangalyaan. He has also made significant contributions to the cost effective design of Chandrayaan.

6. **It has provided high-resolution spectral data on the mineralogy of the Moon.**
7. **The existence of aluminium, magnesium and silicon were picked up by the X-ray camera.**

8. **More than 40,000 images have been transmitted by the Chandrayaan-1 camera in 75 days.**
9. **The acquired images of peaks and craters show that the Moon mostly consists of craters.**
10. **Chandrayaan-1 beamed back its first images of the Earth in its entirety.**
11. **Chandrayaan-1 has discovered large caves on the lunar surface that can act as human shelter on the Moon.**

Mangalyaan (Mars vehicle)

After the successful launch of Chandrayaan-1, ISRO planned an unmanned mission to Mars (Mars Orbiter Mission) and launched a space probe (space vehicle) on 5th November 2013 to orbit Mars orbit. This probe was launched by the PSLV Rocket from Sriharikota, Andrapradesh. Mars Orbiter Mission is India's first interplanetary mission. By launching Mangalyaan, ISRO became the fourth space agency to reach Mars.

Mangalyaan probe traveled for about a month in Earth's orbit, and then it was moved to the orbit of Mars by a series of projections. It was successfully placed in the Mars-orbit on 24th September 2014.

Mars Orbiter Mission successfully completed a period of 3 years in the Martian orbit and continues to work as expected. ISRO has released the scientific data received from the MOM in the past two years (up to September 2016).

More to know

Mars is the fourth planet from the Sun. It is the second smallest planet in the solar system. Mars is called as the Red Planet because of its reddish colour. Iron Oxide present in its surface and also in its dusty atmosphere gives the reddish colour to that planet. Mars rotates about its own axis once in 24 hours 37 minutes. Mars revolves around the Sun once in 687 days. The rotational period and seasonal cycles of Mars are similar to that of the Earth. Astronomers are more curious in the exploration of Mars. So, they have sent many unmanned spacecrafts to study the planet's surface, climate, and geology.

a. Objectives of Mangalyaan

The following are the objectives of Chandrayaan – 2 mission.

- **To develop the technology required for interplanetary mission.**
- **To explore the surface of Mars.**
- **To study the constituents of the Martian atmosphere.**
- **To provide information about the future possibility of life and past existence of life on the planet**.

India became the first Asian country to reach Mars and the first nation in the world to achieve this in the first attempt. Soviet Space Program, NASA, and European Space Agency are the three other agencies that reached Mars before ISRO.

Chandrayaan - 2

ISRO has currently launched a follow on mission to Chandrayaan-1 named as Chandrayaan-2, on 22nd July 2019. Chandrayaan 2 mission is highly complex mission compared to previous missions of ISRO. It brought together an Orbiter, Lander and Rover. It aims to explore South Pole of the Moon because the surface area of the South Pole remines in shadow much larger than that of North Pole.

Orbiter

It revolves around the moon and it is capable of communicating with Indian Deep Space Network (IDSN) at Bylalu as well as Vikram Lander.

Lander

It is named as Vikram in the memory of Dr.Vikram A. Sarabhai, the father of Indian space program.

Rover

It is a 6 wheeled robotic vehicle named as 'Pragyan' (Sanskrit word) that means wisdom. Chandrayaan-2 was successfully inserted into the lunar orbit on 20th August 2019. In the final stage of the mission, just 2.1 km above the lunar surface, Lander 'Vikram' lost its communication with the ground station on 7th September 2019. But the Orbiter continues its work successfully.

Vikram Lander

Know your Scientist

Dr.Kailasavadivoo Sivan is the chairperson of the Indian Space Research Organization (ISRO). He was born in Sarakkalvilai, in Kanyakumari district of Tamil Nadu. Sivan graduated with a bachelor's degree in Aeronautical Engineering from Madras Institute of Technology in 1980. Then he got his master's degree in Aerospace Engineering from Indian Institute of Science, Bangalore in 1982, and started working in ISRO. He completed his doctoral degree in Aerospace Engineering from Indian Institute of Technology, Bombay in 2006. He was appointed as Chairman of ISRO from 10th January 2018. Sivan is popularly known as the 'Rocket Man' for his significant contribution to the development of cryogenic engines for India's space programs. The ability of 'ISRO' to send 104 satellites in a single mission is a great example of his expertise.

More to know

The Moon is the only natural satellite of the Earth. It is at a mean distance of about 3,84,400 km from the Earth. Its diameter is 3,474 km. It has no atmosphere of its own. It doesn't have its own light, but it reflects the sunlight. The time period of rotation of the Moon about its own axis is equal to the time period of revolution around the Earth. That's why we are always seeing its one side alone.

NASA (National Aeronautics and Space Administration)

NASA is the most popular space agency whose headquarters is located at Washington, USA. It was established on 1st October 1958. It has 10 field centers, which provide a major role in the execution of NASA's work. NASA is supporting International Space Station which is an international collaborative work on space research. It has landed rovers on Mars, analysed the atmosphere of Jupiter, explored Saturn and Mercury.

The Mercury, Gemini and Apollo programs helped NASA learn about flying in space. NASA's robotic space probes have visited every planet in the solar system. Satellites launched by NASA have revealed a wealth of data about Earth, resulting in valuable information such as a better understanding of weather patterns. NASA technology has contributed to make many items used in everyday life, from smoke detectors to medical tests.

Apollo Mission

Apollo Missions are the most popular missions of NASA. These missions made American Astronauts to land on the Moon. It consists of totally 17 missions. Among them Apollo -8 and Apollo-11 are more remarkable. Apollo-8 was the first manned mission to go to the Moon. It orbited around the Moon and came back to the Earth.Apollo-11 was the first 'Man Landing Mission' to the moon. It landed on the Moon on 20th July 1969. Neil Armstrong was the first man to walk on the surface of the Moon.

The members present in the crew during the Man Landing Mission were Neil Armstrong, Buzz Aldrin and Michael Collins.

- **NASA's work with ISRO**

NASA made an agreement to work with ISRO to launch the NISAR Satellite (NASA-ISRO Synthetic Aperture Radar) and Mars Exploration Missions.

Work of Indians at NASA

People of Indian origin in America are working in NASA and they have made remarkable contribution to NASA.

- **KalpanaChawla**

KalpanaChawla was born on 17th March 1962 in Karnal, Punjab. In 1988, she joined the NASA. She was selected to take part in the Colombia Shuttle Mission in 1997 and she became the first Indian women astronaut to go to space. On her second mission on the

Colombia Shuttle, she lost her life, when the shuttle broke down. KalpanaChawla travelled over 10.4 million miles in 252 orbits of the earth, logging more than 372 hours in space.

Sunitha Williams

Sunitha Williams was born on 19th September 1965 in USA. She started her career as an astronaut in August 1998. She made two trips to the International Space Station. She set a record of the longest space walking time by a female astronaut in 2012, with a total space walk of 50 hour and 40 minute (7 space walks). She is one of the crew of NASA's Manned Mars Mission.

9th book
Unit – 9 – Universe

- **Building block of the Universe**

The basic constituent of the universe is luminous matter i.e., galaxies which are really the collection of billionsof stars. The universe contains everything that exists including the Earth, planets, stars, space, and galaxies. This includes all matter, energy and even time. No one knows how big the universe is. It could be infinitely large. Scientists, however, measure the size of the universe by what they can see. This is called the 'observable universe'. The observable universe is around 93 billion light years (1 light year = the distance that light travels in one year, which is 9.4607 × 1012 km) across.

One of the interesting things about the universe is that it is currently expanding. It is growing larger and larger all the time. Not only is it growing larger, but the edge of the universe is expanding at a faster and faster rate. However, most of the universe what we think of is empty space. All the atoms together only make up around four percent of the universe. The majority of the universe consists of something scientists call dark matter and dark energy.

- **International Space Station**

ISS is a large spacecraft which can house astronauts. It goes around in low Earth orbit at approximately 400 km distance. It is also a science laboratory. Its very first part was placed in orbit in 1998 and its core construction was completed by 2011. It is the largest man-made object in space which can also be seen from the Earth through the naked eye. The first human crew went to the ISS in 2000. Ever since that, it has never been unoccupied by humans. At any given instant, at least six humans will be presentin the ISS. According to the current plan, ISS will be operated until 2024, with a possible extension until 2028. After that, it could be deorbited, or recycled for future space stations.

Benefits of ISS

According to NASA, the following are some of the ways in which the ISS is already benefitting us or will benefit us in the future.

Supporting water-purification efforts

Using the technology developed for the ISS, areas having water scarcity can gain access to advanced water filtration and purification systems. The water recovery system (WRS) and the oxygen generation system (OGS) developed for the ISS have already saved a village in Iraq from being deserted due to lack of clean water.

Eye tracking technology

The Eye Tracking Device, built for a microgravity experiment, has proved ideal to be used in many laser surgeries. Also, eye tracking technology is helping disabled people with limited movement and speech. For example, a kid who has severe disability in body movements can use his eye-movements alone and do routine tasks and lead an independent life.

Robotic arms and surgeries

Robotic arms developed for research in the ISS are providing significant help to the surgeons in removing inoperable tumours (e.g., brain tumours) and taking biopsies with great accuracies. Its inventors say that the robot could take biopsies with remarkable precision and consistency.

Apart from the above-mentioned applications, there are many other ways in which the researches that take place in the ISS are helpful. They are: development of improved vaccines, breast cancer detection and treatment, ultrasound machines for remote regions etc,.

ISS and International Cooperation

As great as the ISS' scientific achievements are, no less in accomplishment is the international co-operation which resulted in the construction of the ISS. An international collaboration of five different space agencies of 16 countries provides, maintains and operates the ISS. They are: NASA (USA), Roskosmos (Russia), ESA (Europe), JAXA (Japan) and CSA (Cananda). Belgium, Brazil, Denmark, France, Germany, Italy, Holland, Norway, Spain, Sweden, Switzerland and the UK are also part of the consortium.