ENTRI

Module II: Physical Geography

4.Ecosystems and their functioning

- The term ecosystem was coined by **Sir Arthur Tansley in 1935.**
- The ecosystems are parts of nature where **living organisms interact amongst themselves and with their physical environment.**
- An ecosystem is composed of a biotic community, integrated with its physical environment through the exchange of energy and recycling of the nutrients.
- An ecosystem has two basic components:
- **ABIOTIC COMPONENTS:**
  - ❖ Abiotic components **(or inorganic components)** are the physical/chemical factors that act on the living organisms at some or the other part of their life.
  - ❖ **They are also known as ecological factors**.
  - ❖ A**ir, light, soil, nutrients, temperature and rainfall** form the abiotic components of an ecosystem.
  - ❖ **Abiotic factors vary from ecosystem to ecosystem**.
  - ❖ In an aquatic ecosystem, the abiotic factors may include water pH, sunlight, turbidity, water depth, salinity, available nutrients and dissolved oxygen. Similarly, **abiotic factors in terrestrial ecosystems can include soil, soil types, temperature, rain, altitude, wind, nutrients, sunlight etc.**
  - ❖ **Various important abiotic factors**
    - ➢ **Climatic factors:** These include light, temperature, precipitation, atmospheric humidity and wind.
    - ➢ **Topographic factors:** These include altitude, surface slope and exposure, etc.
    - ➢ **Edaphic factors**: These include soil and substratum.

- **Air**: Air is the invisible mixture of gasses that surrounds the Earth.
- Air contains important substances, such as oxygen and nitrogen that most species need to survive.
- Nitrogen and oxygen make up about 99 percent of Earth's air. People and other animals need oxygen to live.
- Carbon dioxide, a gas that plants depend on, makes up less than .04 percent.
- **Humidity**: Humidity is the amount of water vapor in the air. If there is a lot of water vapor in the air, the humidity will be high. The higher the humidity, the wetter it feels outside.
- **Relative humidity:** It is the amount of water vapor actually in the air, expressed as a percentage of the maximum amount of water vapor the air can hold at the same temperature.
- **Weather and Climate**: The term "weather" refers to the temporary conditions of the atmosphere, the layer of air that surrounds the Earth.
- Weather doesn't just stay in one place. It moves, and changes from hour to hour or day to day.
- Over many years, certain conditions become familiar weather in an area.
- The average weather in a specific region, as well as its variations and extremes over many years, is called climate.
- **Temperature:** Temperature is the degree of hotness or coldness of an
- **Precipitation:** Precipitation is any type of water that forms in the Earth's atmosphere and then drops onto the surface of the Earth.
- Water vapor, droplets of water suspended in the air, builds up in the Earth's atmosphere. Water vapor in the atmosphere is visible as clouds and fog.

- ➢ Water vapor collects with other materials, such as dust, in clouds.
- ➢ Precipitation condenses, or forms, around these tiny pieces of material, called **cloud condensation nuclei (CCN).**
- ➢ Clouds eventually get too full of water vapor, and the precipitation turns into a liquid (rain) or a solid (snow).
- ➢ **Altitude:** Altitude, like elevation, is the distance above sea level. As altitude rises, air pressure drops.

- **BIOTIC COMPONENTS:**
  - ❖ The living components (or **Organic Components**) of an ecosystem are called the biotic components.
  - ❖ The biotic components of the ecosystem both live on and interact with the abiotic components. Some of the biotic factors include **plants, animals, fungi and bacteria.**
  - ❖ The biotic components can be further classified into **three broad categories,** based on the energy requirement source.
  - ❖ **Producers (Autotrophs)**
    - ➢ They are the producers of food for all other organisms of the ecosystem.
    - ➢ In the terrestrial ecosystem, producers are basically green plants, while in aquatic ecosystems, producers are microscopic algae.
    - ➢ The total rate at which the radiant energy is stored by the process of photosynthesis in the green plants is called **Gross Primary Production (GPP).**
    - ➢ This is also known as total photosynthesis or total assimilation. From the gross primary productivity a part is utilized by the plants for its own metabolism.
    - ➢ The remaining amount is stored by the plant as **Net Primary Production (NPP)** which is available to consumers
    - ➢ There are two major types of producers

1. **phototrophs:** They use the energy from the sun to convert carbon dioxide into carbohydrates.
2. **Chemotrophs:** They obtain energy mainly from carbon dioxide and from other inorganic chemicals through a process called chemosynthesis.

❖ **Consumers (Heterotrophs)**

➢ They are **not capable of producing their own food.**

➢ They are **directly or indirectly dependent on producers for their food**. Consumers are further categorized as herbivores, carnivores, and omnivores.

➢ The herbivores are the living organisms that feed on plants.

➢ Carnivores eat other living organisms.

➢ Omnivores are animals that can eat both plant and animal tissue.

❖ **Decomposers (Saprotrophs/Micro Consumers)**

➢ **Decomposers are the living component of the ecosystem that breaks down waste material and dead organisms.**

➢ Examples of decomposers include **earthworms, dung beetles and many species of fungi and bacteria.**

➢ They feed on the decaying organic matter and convert this matter into nitrogen and carbon dioxide.

➢ The saprophytes play a vital role in recycling the nutrients so that the producers i.e. plants can use them once again.

- Functions of an Ecosystem

❖ Energy Flow

➢ Energy moves life. The cycle of energy is based on the flow of energy through different trophic levels in an ecosystem. Our ecosystem is maintained by cycling energy and nutrients obtained from different external sources.

➢ At the first trophic level, primary producers use solar energy to produce organic material through photosynthesis.

- The herbivores at the second trophic level, use the plants as food which gives them energy. A large part of this energy is used up for the metabolic functions of these animals such as breathing, digesting food, supporting growth of tissues, maintaining blood circulation and body temperature.
- The carnivores at the third trophic level, feed on the herbivores and derive energy for their sustenance and growth. If large predators are present, they represent a still higher trophic level and they feed on carnivores to get energy. Thus, the different plants and animal species are linked to one another through food chains.
- Decomposers which include bacteria, fungi, molds, worms, and insects break down wastes and dead organisms, and return the nutrients to the soil, which is then taken up by the producers. Energy is not recycled during decomposition, but it is released.
- The trophic level interaction involves **three concepts namely:**
- **Food chain**
  - The sun is the ultimate source of energy on earth. A food chain is an energy transfer link between living organisms.
  - Food chain starts with the producers, then moves to the consumers and finishes with the decomposers. Each step in the food chain is called trophic level.
  - Organisms in the ecosystem are related to each other through feeding mechanisms or trophic levels. Small insects feed on green plants **(Producers**), and bigger animals feed on smaller ones and so on. This feeding relationship in an ecosystem is called a food chain.
  - During this process of transfer of energy some energy is lost into the system as heat energy and is not available to the next trophic level. Therefore, the number of steps are limited in a chain to **4 or 5.**

- ➔ Example: **Grasses → Grasshopper → Frog → Snake → Eagle (on land);**

➢ **Food web**

- ➔ The word **'web' means network**. Food web can be defined as 'a network of interconnected food chains so as to form a number of feeding relationships amongst different organisms of a biotic community.'
- ➔ The same food resource may be a part of more than one chain. This is possible when the resource is at the lower trophic level. A food web comprises all the food chains in a single ecosystem.
- ➔ If any of the intermediate food chain is removed, the succeeding links of the chain will be affected largely.
- ➔ The food web provides more than one alternative for food to most of the organisms in an ecosystem and therefore **increases their chance of survival.**

➢ **Ecological Pyramids**

- ➔ An ecological pyramid is a graphical representation of the relationship between different organisms in an ecosystem.
- ➔ The concept was first introduced by Charles Elton, the pioneer British Ecologist.
- ➔ The basis of an ecological pyramid is biomass, energy, and number. Just as the name suggests, ecological pyramids are in the shape of a pyramid.
- ➔ The ecological pyramid consists of a number of horizontal bars representing specific trophic levels which are arranged sequentially from producer to top level consumers.
- ➔ The length of each horizontal bar depicts the total number of individuals at each trophic level in an ecosystem.
- ➔ The bottom of an ecological pyramid is the broadest and is occupied by the producers. They form the first trophic level.

Just as in a food chain, in the ecological pyramid also, primary consumers occupy the next level. This is because primary consumers consume producers. Similarly, secondary consumers occupy the third level. And then the tertiary consumers that occupy the next level and so on.

➔ The ecological pyramids are of **three types:**

1. **Pyramid of numbers**
   - ★ A pyramid of numbers shows the relative number of organisms at each stage of a food chain.
   - ★ Pyramids of numbers can be either upright or inverted, depending on the ecosystem.
   - ★ This type of pyramid can be convenient, as counting is often a simple task and can be done over the years to observe the changes in a particular ecosystem.
   - ★ However, some types of organisms are difficult to count, especially when it comes to some juvenile forms.
   - ★ Pyramid of Numbers (Upright) & Pyramid of Numbers (Inverted)
2. **Pyramid of biomass**
   - ★ The pyramid of biomass indicates the total mass of organisms at each trophic level. Usually, this type of pyramid is larger at the bottom and gets smaller going up, but exceptions do exist.
   - ★ The biomass of one trophic level is calculated by multiplying the number of individuals in the trophic level by the average mass of one individual in a particular area.
   - ★ This type of ecological pyramid solves some problems of the pyramid of numbers, as it shows a more accurate representation of the amount of energy

contained in each trophic level, but it has its own limitations.

★ Pyramid of biomass (Upright) & Pyramid of biomass(Inverted)

3. Pyramid of energy.

★ **A pyramid of energy shows the amount of energy trapped per area in a given time period at each stage of a food chain**. **These pyramids are always upright in shape**, as energy is lost along food chains (either used in respiration or lost as heat).

★ Each level in the pyramid will be roughly one tenth the size of the preceding level as energy transformations are **~10% efficient.**

★ An energy pyramid reflects the **"Law of Thermodynamics"**, with conversion of solar energy to chemical energy and heat energy at each trophic level and with loss of energy being depicted at each transfer to another trophic level.

➢ POLLUTANTS AND TROPHIC LEVEL

➔ Pollutants, especially non-degradable ones, move through the various trophic levels in an ecosystem.

➔ Non-degradable pollutants mean materials, which cannot be metabolized by the living organisms. Example: **Chlorinated Hydrocarbons.**

➔ Movement of these non-degradable pollutants involves two main processes

➔ **<u>Bioaccumulation and Biomagnification</u>**

★ **Bioaccumulation** is the process by which **toxins enter the food web by building up in individual organisms, while biomagnification is the process by which toxins are**

passed from one trophic level to the next (and thereby increase in concentration) within a food web.

★ **Biomagnification, there is an increase in concentration of a pollutant from one link in a food chain to another.**

❖ Nutrient Cycling

➢ All elements in the earth are recycled time and again. The major elements such as **oxygen, carbon, nitrogen, phosphorus, and sulfur** are essential ingredients that make up organisms.

➢ **("Bio" – living, "Geo" – rock, "Chemical" – element).** The cycling of the nutrients in the biosphere is called biogeochemical or nutrient cycle. It involves movement of nutrient elements through the various components of an ecosystem.

➢ As an element moves through this cycle, it often forms compounds with other elements as a result of metabolic processes in living tissues and of natural reactions in the atmosphere, hydrosphere, or lithosphere.

➢ Such cyclic exchange of material between the living organisms and their nonliving environment is called the Biogeochemical Cycle. **Thus the nutrients are never lost from the ecosystems.**

➢ Following are some important biogeochemical cycles:

1. **Carbon Cycle:**

➔ **Carbon is the second most abundant element in organisms, by mass. Carbon enters into the living world in the form of carbon dioxide through the process of photosynthesis as carbohydrates**.

➔ During photosynthesis, the **carbon is converted into organic compounds such as glucose, which are stored within the bodies of these organisms**. This carbon can be stored for many hundreds of years within the bodies of plants in areas such as tropical rainforests.

- ➔ When the organic compounds are consumed by heterotrophs, they are passed through the food web, where they are broken down into useful substances using cellular respiration. Cellular respiration produces **CO2,** which is released back into the atmosphere.
- ➔ The carbon is finally returned to the surrounding medium by the process of respiration or decomposition of plants and animals by the decomposers. Carbon is also recycled during the burning of fossil fuels.
- ➔ **The ocean is the second largest carbon sink.** As well as dissolved inorganic carbon which is stored at depth, the surface layer holds large amounts of dissolved carbon that is rapidly exchanged with the atmosphere.
- ➔ **Carbon dioxide is a greenhouse gas and traps heat in the atmosphere. Without it and other greenhouse gasses, Earth would be a frozen world.**
- ➔ **The recent increase in amounts of greenhouse gasses such as carbon dioxide is having a significant impact on the warming of our planet.**

2. Water Cycle:

- ➔ The biogeochemical cycle of water, or the hydrological cycle describes the way that water **(Hydrogen Dioxide or H2O**) is circulated and recycled throughout Earth's systems.
- ➔ **The hydrologic cycle is the continuous circulation of water in the earth-atmosphere system which is driven by solar energy.**
- ➔ All living organisms, without exception, need water to survive and grow, making it one of the most important substances on Earth.

- ➔ On a geographical level, **the biogeochemical cycle of water is responsible for weather patterns.**
- ➔ As **water in its various forms (vapor, liquid and ice)** interacts with its surroundings and it alters the temperature and pressure of the atmosphere, creating wind, rain and currents, and is responsible for changing the structure of earth and rock through weathering.
- ➔ Although there is no real beginning to the **water cycle, 97% of the world's water is stored within the oceans.**
- ➔ Of the ocean water, a very small proportion becomes frozen as it reaches the poles, and is stored as ice within glaciers.
- ➔ Some of the surface water is heated by the sun, and evaporation takes place. In this process, the liquid water is converted into water vapor and is taken up into the atmosphere. As the water rises, it cools and condensation occurs. This results in the water being stored within the atmosphere in the form of clouds.
- ➔ As the clouds are moved around the earth's atmosphere they collide and grow. Eventually the water droplets grow large enough so that they are heavy enough to fall as precipitation (rain) or as snow, depending on the environmental conditions.
- ➔ Most of the snow that falls is either stored as ice caps, or melts to form streams and rivers.
- ➔ Some of the water that makes it to the ground is affected by gravity and flows back into the ocean via surface runoff.

3. Nitrogen Cycle:

- ➔ Most of the nitrogen on Earth is in the atmosphere. Nitrogen is present in the atmosphere in an elemental form so, it cannot be utilized by living organisms.
- ➔ Approximately **80%** of the molecules in Earth's atmosphere are made of two nitrogen atoms bonded together **(N2).** All plants and animals need nitrogen to make amino acids, proteins and **DNA**, but the nitrogen in the atmosphere is not in a form that they can use.
- ➔ Nitrogen needs to be 'fixed', that is, converted to ammonia, nitrites or nitrates, before it can be taken up by plants.
- ➔ **Nitrogen fixation on earth is made in three different ways:**
  1) **By microorganisms (bacteria and blue-green algae)**
  2) **By industrial processes (fertilizer factories)**
  3) **By atmospheric phenomenon (thunder and lightning).**
- ➔ Plants get the nitrogen they need from the soils or water in which they live mostly in the form of inorganic **nitrate (NO3-).** Nitrogen is a limiting factor for plant growth.
- ➔ Animals get the nitrogen they need by consuming plants or other animals that contain organic molecules composed partially of nitrogen.
- ➔ **Cyanobacteria, Rhizobium and Azotobacter** are some examples. **Cyanobacteria play a role in nitrogen fixation in aquatic ecosystems. The other two fix nitrogen in a terrestrial ecosystem.**
- ➔ When organisms die, their bodies decompose bringing the nitrogen into soil on land or into the oceans. As dead plants and animals decompose, nitrogen is converted

into inorganic forms such as ammonium salts **(NH4+)** by a process called mineralization.

➔ The ammonium salts are absorbed onto clay in the soil and then chemically altered by bacteria into nitrite **(NO2-) and then nitrate (NO3-).**

➔ Nitrate is the form commonly used by plants. It is easily dissolved in water and leached from the soil system. Dissolved nitrate can be returned to the atmosphere by certain bacteria through a process called de-nitrification.

4. Phosphorus Cycle:

➔ **Phosphorus is an essential nutrient for living processes**. It is a major component of nucleic acids and phospholipids, and, as calcium phosphate, it makes up the supportive components of our Phosphorus is often the limiting nutrient (necessary for growth) in aquatic, particularly freshwater, ecosystems.

➔ Phosphorus occurs in nature as the **phosphate ion (PO43-)** and enters the **cycle from erosion and mining activities.**

➔ **The phosphate rock has its origins in the ocean.** Phosphate-containing ocean sediments form primarily from the bodies of ocean organisms and from their excretions.

➔ However, **volcanic ash, aerosols, and mineral dust may also be significant phosphate sources.** This sediment then is moved to land over geologic time by the uplifting of Earth's surface.

➔ **Excess phosphorus and nitrogen that enter the ecosystems from fertilizer runoff and from sewage cause excessive growth of algae.** The subsequent death and decay of these organisms depletes dissolved

oxygen, which leads to the death of aquatic organisms such as shellfish and fish. T**his process is responsible for dead zones in lakes.**

➔ **A dead zone is an area in lakes and oceans near the mouths of rivers where large areas are periodically depleted of their normal flora and fauna**.

➔ These zones are caused by eutrophication coupled with other factors including oil spills, dumping toxic chemicals, and other human activities.

5. **Sulfur Cycle:**

➔ **Sulfur is one of the components that make up proteins and vitamin**s. Proteins consist of amino acids that contain sulfur atoms.

➔ Sulfur is important for the functioning of proteins and enzymes in plants, and in animals that depend upon plants for sulfur.

➔ Plants absorb sulfur when it is dissolved in water. Animals consume these plants, so that they take up enough sulfur to maintain their health.

➔ **Most of the earth's sulfur is tied up in rocks and salts or buried deep in the ocean in oceanic sediments.**

➔ **Sulfur can also be found in the atmosphere.** It enters the atmosphere through both natural and human sources. Atmospheric sulfur is found in the form of **sulfur dioxide (SO2)**, which enters the atmosphere in three ways: **first, from the decomposition of organic molecules; second, from volcanic activity and geothermal vents; and, third, from the burning of fossil fuels by humans.**

- ➔ On land, sulfur is deposited in four major ways: precipitation, direct fallout from the atmosphere, rock weathering, and geothermal vents.

❖ Ecological Succession.

- ➢ **Succession is a series of progressive changes in the composition of an ecological community over time**. **Ecological succession is the process by which the structure of a biological community evolves over time.**
- ➢ The species living in a particular area gradually change over time as does the physical and chemical environment within that area.
- ➢ Succession takes place because organisms interact with and affect the environment within an area, through the processes of living, growing and reproducing, gradually changing it.
- ➢ Each species is adapted to thrive and compete best against other species under a very specific set of environmental conditions. If these conditions change, then the existing species will be outcompeted by a different set of species which are better adapted to the new conditions.
- ➢ Change in the plant species present in an area is one of the driving forces behind changes in animal species. This is because each plant species will have associated animal species which feed on it. The presence of these herbivore species will then dictate which particular carnivores are present.
- ➢ The structure or ‘architecture’ of the plant communities will also influence the animal species which can live in the microhabitats provided by the plants.
- ➢ Changes in plant species also alter the fungal species present because many fungi are associated with particular plants.
- ➢ Succession is directional. Different stages in a particular habitat succession can usually be accurately predicted. These stages,

characterized by the presence of different communities, are known as ‘seres’.

- ➢ Communities change gradually from one server to another. The series are not totally distinct from each other and one will tend to merge gradually into another, finally ending up with a ‘climax’ community.
- ➢ **Succession will not go any further than the climax community. This is the final stage.**
- ➢ This does not however, imply that there will be no further change. When large organisms in the climax community, such as trees, die and fall down, then new openings are created in which secondary succession will occur.
- ➢ Many thousands of different species might be involved in the community changes taking place over the course of a succession. For example, in the succession from freshwater to climax woodland.
- ➢ The actual species involved in a succession in a particular area are controlled by such factors as the geology and history of the area, the climate, microclimate, weather, soil type and other environmental factors.
- ➢ Succession occurs on many different timescales, ranging from a few days to hundreds of years.
- ➢ It may take hundreds of years for a climax woodland to develop, while the succession of invertebrates and fungi within a single cow pat **(cow dung),** may be over within as little as 3 months.
- ➢ By this time, the dung has been transformed into humus and nutrients and has been recycled back into the soil. The holes clearly visible in the cow pat (right) have been made by the animals which have colonized it.
- ➢ **Two different types of succession**

1. **Primary Succession**

- ➔ Primary succession is the series of community changes which occur on an entirely new habitat which has never been colonized before.
- ➔ Examples of such habitats would include newly exposed or deposited surfaces, such as landslides, volcanic lava and debris, elevated sand banks and dunes, quarried rock faces.
- ➔ A number of seral stages will take place in which an initial or **'pioneer'** community will gradually develop through a number of different communities into a 'climax' community, which is the final stage.
- ➔ If this primary ecosystem is disturbed and wiped out, secondary succession can take place.

2. Secondary Succession

- ➔ Secondary succession is the series of community changes which take place on a previously colonized, but disturbed or damaged habitat. **Examples include areas which have been cleared of existing vegetation (such as after tree-felling in a woodland) and destructive events such as fires (For example: Australian fires most recently).**

- Concept Biome
  - ❖ A biome is defined by a **broad-scale collection of flora and fauna that although different in detail from ecosystem to ecosystem share some commonalities.**
  - ❖ Ecosystems within a biome are often similar in nutrients and energy available to plants and animals.
  - ❖ This leads to similar types of flora and fauna across the biome, even though individual ecosystems within the biome differ in scale, structure, and function.

- The contraction or expansion of biome pattern and distribution is not solely a function of changing temperatures; it also displays changes in atmospheric pressure, humidity, and amount of precipitation, wind directions, and other atmospheric factors.
- **Biomes are also strongly controlled by the type of soil and other aspects related to the lithosphere, hydrosphere, and cryosphere.**
- Ecosystems fall into two major groups,
    1. Terrestrial ecosystems
        - ➢ We divide terrestrial ecosystems into biomes. There are four principal biomes:
        - ➢ **Forests**
            1. **Tropical rain forests**
                - ➔ The tropical rain-forest occupies low-altitude areas near the equator in **South America, Central and West Africa, and in the Indo-Malay peninsula and New Guinea regions.** Although these areas are physically isolated, the forest growing in them shows great similarity of structure and function.
                - ➔ These are found in the high rainfall areas on either side of the equator, having high temperature and high humidity and receive above **200 cm of rainfall per year. Soil is rich in humus.**
                - ➔ It is a **broad-leaved evergreen forest of dense**, prolific growth and an extremely diverse fauna and flora.
                - ➔ The hot, wet tropical climate is highly conducive to plant growth and there is very little seasonality which means that the growing period extends throughout the year.
                - ➔ All green plants strive to reach the light so that they either become very tall, or adopt a climbing habit or live as epiphytes (plants living on other plants but not deriving food from them).

- ➔ **The dominant trees are extremely varied in species but have similar appearances, typically characterized by buttress roots, dark leaves and a thin bark**.
- ➔ The leaves possess thick cuticles for protection against the strong sunlight, and drip tips whose probable function is to shed water rapidly, thereby aiding transpiration.
- ➔ These forests have a very rich biodiversity e.g. Brazilian tropical rain forests have more than 300 species of trees in an area of **200 square kilometer**. Trees are tall, growing up to 50 to 60 m.
- ➔ These forests also support **epiphytes, like vines, creepers, woody creepers and orchids etc**.
- ➔ These forests are rich in tree dwelling animals such as **monkeys, flying squirrels, snails, centipedes, millipedes, and many insect** species are common on the forest floor. **Many snakes and mammals are adapted** to live in the trees because this is where the bulk of the foliage exists.

2. **Temperate deciduous forests**
   - ➔ This type of forest, dominated by broad-leaved deciduous trees, had a great extent in the past when it covered most of the temperate areas of **Europe, eastern North America, eastern Asia, and small parts of South America and Australia.**
   - ➔ The temperate deciduous forest has probably been more modified by human activity than any other type of ecosystem.
   - ➔ Temperate deciduous forest consists largely of trees that drop their leaves during the cold season. It is

characteristic of the marine west coast and moist continental climates.

- ➔ There is a longer growing season, higher light intensity, and a moderate amount of precipitation of between 50 and **150 cm per annum.**
- ➔ The temperature regime is also characterized by a lack of extremes but there is still a marked cold season which plants and animals must endure.
- ➔ **The climatic zone it occupies is less extreme than that of the boreal forest.**
- ➔ Trees common to the deciduous forest of eastern **North America, southeastern Europe, and eastern Asia are oak, beech, birch, hickory, walnut, maple, elm, and ash.** Where the deciduous forests have been cleared by lumbering, pines readily develop as second-growth forest.
- ➔ In Western Europe, the mid-latitude deciduous forest is associated with the marine west coast climate.
- ➔ Here, the dominant trees are mostly oak and ash, with beech found in cooler and moisture areas.
- ➔ In Asia, the mid-latitude deciduous forest occurs as a belt between the boreal forest to the north and steppe lands to the south.
- ➔ A small area of deciduous forest is found in **Patagonia, near the southern tip of South America.**

3. **Boreal or north coniferous forests**

- ➔ Boreal forest is the cold-climate needle leaf forest of high latitudes .It occurs in two great continental belts, one in **North America and one in Eurasia.**

- ➔ These belts span their land masses from west to east in **latitudes 45° N to 75° N** and they closely correspond to the region of boreal forest climate.
- ➔ The area occupied by this formation has been subjected to severe glacial or periglacial activity and has much subdued relief and surface water.
- ➔ The conditions for life are harsh because of the adverse climate. **The growing season is only three or four months**' duration and even during this time; the energy input from solar radiation is small because of the high latitude.
- ➔ Temperatures are low throughout the year, although the average temperature of the warmest month of the year is higher than **10° C.** In the winter the temperatures fall too many degrees below freezing and permafrost frequently extends into the northern edge of the forest.
- ➔ Precipitation ranges from **40 to 70 cm per annum,** mostly falling as snow, the weight of which may cause mechanical damage to the trees.
- ➔ Despite the climate, coniferous trees form dense canopies which intercept a great amount of light and precipitation so that conditions beneath are dark and dry.
- ➔ Consequently there is little opportunity for undergrowth to develop and very few other plants are associated with the coniferous trees.
- ➔ The boreal forest of **North America, Europe, and western Siberia** is composed of such evergreen conifers as spruce and fir, while the boreal forest of north-central and eastern Siberia is dominated by larch.
- ➔ The larch tree sheds its needles in winter and is thus a deciduous needle leaf tree.

4. **Monsoon forest**
   - ➔ **Monsoon forest, also called dry forest or tropical deciduous forest**. It is typically open, but grades into woodland, with open areas occupied by shrubs and grasses .
   - ➔ Monsoon forest of the tropical latitude zone differs from tropical rainforest in that it is deciduous; that is, most of the trees of the monsoon forest shed their leaves due to stress during the long dry season, which occurs at the time of low Sun and cool temperatures.
   - ➔ This forest develops in the wet-dry tropical climate, where a long rainy season alternates with a dry, rather cool season.
   - ➔ They are located in the monsoon climate beyond the equatorial region between **10◦ and 25** ◦ and **North and South of the equator.** The countries are along the coastal regions of southwest **India, Sri Lanka, Bangladesh, Myanmar, Thailand, and Cambodia, South western Africa, French Guiana, and northeast and southeastern Brazil.**

➢ **Grasslands**

- ➔ Grasslands are areas dominated by grasses.
- ➔ They occupy about **20% of the land on the earth's surface**.
- ➔ **Grasslands occur in both tropical and temperate regions** where rainfall is not enough to support the growth of trees.
- ➔ Grasslands are known by various names in different parts of the world.
- ➔ Grasslands are found in areas having well defined hot and dry, warm and rainy seasons

Place	Name of The GrassLand
North America	Prairies
Eurasia	Steppes
Africa	Savanna
South America	Pampas
India	GrassLand, Savanna

➔ Grassland ecosystems contrast with forest ecosystems in several ways.

➔ They have a much smaller biomass, of which a large percentage is made up of roots. **Grasses are probably not as effective at precipitation interception as trees, except for the period of maximum growth.**

➔ The grass form facilitates stem flow, and surface run-off is greater from grass-covered than from forested slopes.

➔ The annual primary productivity of a **grassland ecosystem is only about an eighth or ninth of an adjacent forest area**.

➔ The smaller standing crop also means that there are more limited nutrient reservoirs in grassland.

➔ Two main types of grassland are normally distinguished

➔ **Temperate Grasslands**

★ These include the prairies of **North America, the steppes of Eurasia, the pampas of South America, and the veldt of South Africa.**

★ Smaller tracts occur in Australia and New Zealand. Precipitation in these areas ranges from **25 to 100 Cm** per annum, and the grasslands extend over a wide range of soil conditions.

- ★ **Trees only occur on steep slopes or near water.** The geographical isolation of these areas from each other has led to some species differentiation, but most other features are similar.
- ★ **The animals of the grassland are distinctive, and feature many grazing mammals.**
- ★ The grassland ecosystem supports some rather unique adaptations to life .
- ★ Animals such as **jackrabbits and jumping mice have learned to jump or leap, to gain an unimpeded view of their surroundings.**
- ★ Tallgrass prairie is a ground cover of tall grasses along with some broad-leafed herbs, named forbes.
- ★ **Steppe,** or short-grass prairie, consists of sparse clumps of short grasses.
- ★ **Steppe grades into semi-desert in dry environments and into prairies where rainfall is higher.**
- ★ **Steppe grassland is concentrated largely in the mid-latitude areas of North America and Eurasia.**
- ★ Prairie grasslands are associated with the drier areas of moist continental climate, and steppe grasslands correspond well with the semiarid subtype of the dry continental climate.
- ★ **The Pampa region falls into the moist subtropical climate with mild winters and abundant precipitation.**
- ★ This grassland biome includes **tall-grass and short-grass prairie (steppe).**
- ★ **Tall-grass prairie provides rich agricultural land suited to cultivation and cropping.** Short-grass prairie

occupies vast regions of semi-desert and is suited to grazing.

➔ **Tropical grasslands (Savannas)**

★ Tropical grasslands are commonly called Savannas. They occur in eastern Africa, South America, Australia and India.

★ **Savannas form a complex ecosystem with scattered medium sized trees in grasslands.**

★ The savanna biome is usually associated with the tropical wet dry climate of Africa and South America. Its vegetation ranges from woodland to grassland.

★ In savanna woodland, the trees are spaced rather widely apart because there is not enough soil moisture during the dry season to support a full tree cover.

★ The woodland has an open, park-like appearance. Savanna woodland usually lies in a broad belt adjacent to equatorial rainforest.

★ Savanna biome vegetation is described as rain-green. Fires occur frequently in the savanna woodland during the dry season, but the tree species are particularly resistant to fire.

★ The much greater diversity of tropical as opposed to temperate grasslands is often a function of the added variety afforded by wooded plants. In some cases the tree cover may be as much as 50 per cent; in others it may be nil.

★ Marked contrasts exist in the appearance of the savanna during the year: the brown and withered short grasses of the dry season give way rapidly to tall lush growth with the arrival of the summer rains.

- ★ **The Ferralsolic soils of savanna areas frequently include near-surface lateritic crusts, creating an impermeable surface soil layer in which nutrients, especially phosphates and nitrates, are markedly lacking.**
- ★ As in the case of prairies, tropical grasslands tend to show little ecotone development, especially on margins adjacent to tropical rain-forest.
- ★ **Overall, savanna boundaries on all continents reveal only poor correlation with precipitation amounts or the duration of the rainy season.**
- ★ The **African savanna is widely known for the diversity of its large grazing mammals**.
- ★ With these grazers come a large variety of predators—lions, leopards, cheetahs, hyenas, and jackals.
- ★ **Elephants are the largest animals of the savanna and adjacent woodland regions.**

➢ **Deserts**

- ➔ The desert is a highly evolved ecosystem that supports a multitude of plants and animals.
- ➔ The desert biome includes semi desert and dry desert and occupies the **tropical, subtropical, and mid-latitude dry climates.**
- ➔ Desert plants vary widely in appearance and in adaptation to the dry environment.
- ➔ Deserts are hot and low rain areas suffering from water shortage and high wind velocity. Annual rainfall is very little. It may be less than **25 cm per annum**. At some places if it is high it is unevenly distributed. They show extremes of temperature.

- ➔ **Globally deserts occupy about 1/7thof the earth‘s surface.**
- ➔ The desert biome includes several formation classes that are transitional from grassland and savanna biomes into vegetation of the arid desert.
- ➔ Semi desert is a transitional formation class found in a wide latitude range, from the tropical zone to the mid-latitude zone.
- ➔ Semi desert consists primarily of sparse xerophytic shrubs. One example is the sagebrush vegetation of the middle and southern **Rocky Mountain region and Colorado Plateau.**
- ➔ Dry desert is a formation class of plants that are widely dispersed over the ground.
- ➔ **It consists of small, hard-leafed, or spiny shrubs, succulent plants (such as cactus), and/or hard grasses.**
- ➔ Many species of small annual plants appear only after rare and heavy downpours.
- ➔ **Desert plants around the world look very different from each other.**
- ➔ In the Mojave and Sonoran deserts of the southwestern **United States, for example, plants are often large, giving the appearance of woodland.**
- ➔ Desert animals are insects, reptiles, and burrowing rodents. **Desert shrew, fox, kangaroo, wood rat, rabbit; armadillo are common mammals in the desert.**
- ➔ **Camel is known as the ship of the desert as it can travel long distances without drinking water for several days.**

➢ **Tundra**

➔ The word tundra means a —barren landǁ since they are found in those regions of the world where environmental conditions are very severe.

➔ There are two types of

➔ **Arctic tundra**

★ Extends as a continuous belt below the polar ice cap and above the tree line on the northern hemisphere.

★ It occupies the northern fringe of **Canada Alaska, European Russia, and Siberia, and the island group of the Arctic Ocean.**

➔ **Alpine tundra**

★ Occurs at high mountain peaks above the treeline. Since mountains are found at all latitudes, therefore, alpine tundra show day and night temperature variations

★ Permanently frozen subsoil called permafrost is found in the arctic and Antarctic tundra.

★ The summer temperature may be around **15°C** and in winter it may be as low as **–57°C** in arctic tundra .A very low precipitation of less than **400 mm per year** .A short vegetation period of generally less than **50 days between spring and autumn frost. Productivity is low.**

2. Aquatic Biomes

➢ An aquatic ecosystem refers to plant and animal communities‘ occurring in water bodies.

➢ Aquatic ecosystems are classified on the basis of salinity into the following two types:

➢ **Freshwater**

➔ Water on land which is continuously cycling and has low salt content is known as fresh water and its study is **called limnology.**

➔ **Static or still water (Lentic) e.g. pond, lake, bogs, and swamps.**

➔ **Running water (Lotic) e.g. springs, mountain brooks, streams, and rivers.**

➔ Physical characteristics

★ Fresh waters have a low concentration of dissolved salts. The temperature shows diurnal and seasonal variations. In tropical lakes, surface temperature never goes below **400C**, in temperate fresh waters, never goes above or below **40 C** and in polar lakes never above **40C**.

★ In temperate regions, the surface layer of water freezes but the organisms survive below the frozen surface.

★ Light has a great influence on freshwater ecosystems. A large number of suspended materials obstruct penetration of light in water.

★ Certain animals float upto water surface to take up oxygen for respiration. Aquatic plants use carbon dioxide dissolved in water for photosynthesis.

★ Lakes and ponds are inland depressions containing standing water.

★ **The largest lake in the world is Lake Superior in North America**

★ **Lake Baikal in Siberia is the deepest. Chilka lake of Orissa is the largest lake in India.**

★ Three main zones can be differentiated in a lake

1. **Peripheral zone** (littoral zone) with shallow water.
2. **Open water** beyond the littoral zone where water is quite deep.
3. **Benthic zone** (bottom) or the floor of the lake.

- ★ Aquatic organisms can be floating in the water or free-swimming or sedentary (fixed), depending on their size and habit.
- ★ Microscopic floating organisms such as algae, diatoms, protozoans, and larval forms are called plankton. **Rooted aquatic plants, fish, mollusks, and echinoderms are bottom dwellers.**
- ★ Wetlands are areas that periodically get inundated with water and support a flourishing community of aquatic organisms including frogs and other amphibians.
- ★ Wetlands are between aquatic and terrestrial ecosystems. They show an edge effect and form an ecotone.
- ★ **Ecotone** is a transitional zone between two ecosystems. **Swamps, marshes, and mangroves are examples of wetlands**.

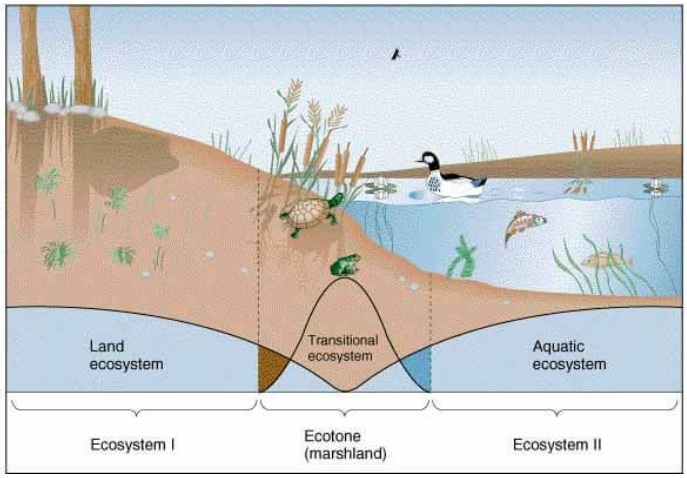
➢ **Marine**

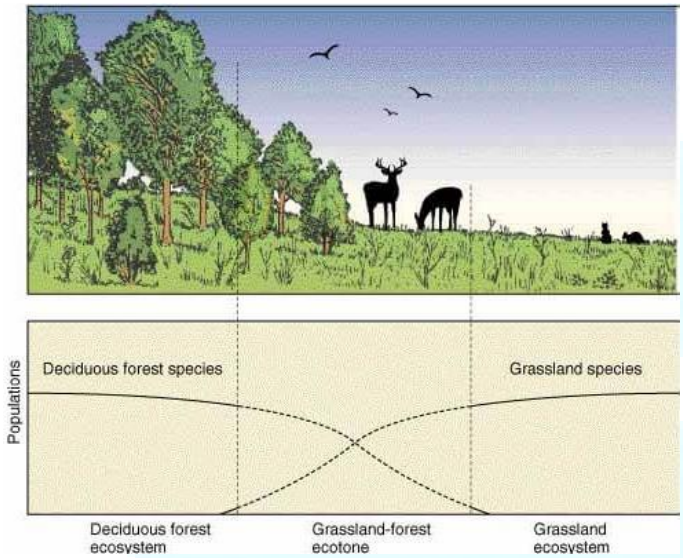
- ➔ Oceans cover **70 percent** of the **surface area of the world,** they are habitable throughout and support total biomass probably as much as ten times that on land.
- ➔ In many ways, the marine environment is much more favorable to life than land areas; it is more equitable, and the two most essential gasses for life, oxygen and carbon dioxide, are readily available in water, provided it is not polluted.
- ➔ In addition, many of the nutrient minerals found in the Earth's crust are dissolved in the sea in varying amounts.
- ➔ The main environmental gradients in the sea are related to **temperature, salinity, and light intensity.**

- ➔ The most saline conditions occur where temperatures, and hence evaporation, are highest.
- ➔ Many marine organisms have very narrow tolerance ranges to particular salinity concentrations, which may therefore localize them considerably in terms of depth or area.
- ➔ In the open water of the major oceans, the range is much less, from **37%o in the tropics to 33%0 in polar seas.**
- ➔ Temperature variations in the sea are much less than those on land. The difference between the surface temperature of the warmest seas **(32°C)** and the coldest **(-2°C)** gives a range far less than that of land **(about 90°C).**
- ➔ Both vertical and horizontal ocean currents play a major role in equalizing variations of temperature, salinity, and dissolved gasses in the oceans, as well as being important factors in the global energy budget.
- ➔ Marine plants are confined to the **euphotic zone** by the light factor.
- ➔ They are far less diverse than land plants, being dominated by algae, with only a few angiosperms present, most of which are found in the nearshore zone.
- ➔ The most obvious and visible types of marine algae are seaweeds, but about **99 per cent** of marine vegetation is made up of microscopic floating algae (phytoplankton).
- ➔ **These are one-celled organisms containing chlorophyll and include diatoms and dinoflagellates.**
- ➔ **Near-shore areas additionally receive nutrients from rivers.**
- ➔ Coastal and estuarine areas therefore have a high productivity and great diversity of plant life, making them among the most fertile parts of the marine ecosystem.

- ➔ **The biodiversity of marine ecosystems is very high as compared to terrestrial ecosystems.**
- ➔ Almost every major group of animals occurs in the sea. Insects and vascular plants are completely absent in the marine ecosystem.
- ➔ The maximum diversity of marine organisms is found in the tidal zone that is near the shore. **Diatoms, algae, dinoflagellates, and jellyfishes are some of the free-floating life forms in oceans.**
- ➔ Large crustaceans, molluscs, turtles, and mammals like seals, porpoises, dolphins, and whales are free-swimming animals that can navigate. Bottom dwellers are generally **sessile (fixed) organisms like sponges, corals, crabs, and starfish.**

- Ecotone
  - ❖ **An ecotone is a zone of junction or a transition area between two biomes (diverse ecosystems).**
  - ❖ Ecotone is the zone where **two communities meet and integrate**.
  - ❖ For e.g. the **mangrove forests** represent an ecotone between marine and terrestrial ecosystems.
  - ❖ **grassland (between forest and desert), estuary (between freshwater and saltwater) and riverbank or marshland (between dry and wet).**





❖ **Characteristics of Ecotone**

- ➢ It may be **narrow (between grassland and forest) or wide (between forest and desert).**
- ➢ It has conditions intermediate to the adjacent ecosystems. Hence it is a **zone of tension**.
- ➢ Usually, the number and the population density of the species of an outgoing community decreases as we move away from the community or ecosystem.
- ➢ A well-developed ecotone contains some organisms which are entirely different from that of the adjoining communities.

❖ Ecocline

- ➢ Ecocline is a zone of gradual but continuous change from one ecosystem to another when there is no sharp boundary between the two in terms of species composition.
- ➢ Ecocline occurs across the environmental **gradient (gradual change in abiotic factors such as altitude, temperature (thermocline), salinity (halocline), depth, etc.).**

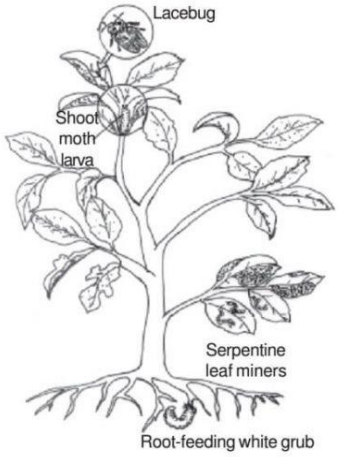
❖ Edge Effect – Edge Species

- ➢ Edge effect refers to the changes in population or community structures that occur at the boundary of two habitats (ecotone).
- ➢ **Sometimes the number of species and the population density of some of the species in the ecotone is much greater than either community. This is called the edge effect.**
- ➢ The organisms which occur primarily or most abundantly in this zone are known as edge species.
- ➢ In **terrestrial ecosystems** the edge effect is especially applicable to birds.
- ➢ **For example, the density of birds is greater in the ecotone between the forest and the desert.**

❖ Ecological Niche

- ➢ **Niche refers to the unique functional role and position of a species in its habitat or ecosystem.**
- ➢ The functional characteristics of a species in its habitat is referred to as **“niche” in that common habitat.**
- ➢ In nature, many species occupy the same habitat, but they perform different functions:
- ➢ **habitat niche – where it lives, food niche – what it eats or decomposes & what species it competes with, reproductive niche – how and when it reproduces, physical & chemical niche – temperature, land shape, land slope, humidity & another requirement.**

➢ **Niche plays an important role in the conservation of organisms.**



Different species of insects feeding on different parts of the same plant

- Community
  - ❖ Communities in most instances are named after the dominant plant form.
  - ❖ For example, **a grassland community is dominated by grasses, though it may contain herbs, trees, etc.**
  - ❖ Major Communities
    - ➢ **These are large sized and relatively independent.**
    - ➢ They depend only on the sun's energy from outside. E.g. **Tropical evergreen forests.**
  - ❖ Minor Communities
    - ➢ These are dependent on neighboring communities and are often called **societies.**
    - ➢ They are secondary aggregations within a major community. E.g. **A mat of lichen on a cow dung pad.**
- Biodiversity
  - ❖ Biodiversity is the term popularized by sociobiologist **Edward Wilson to describe the combined diversity at all the levels of biological organization.**

- Biodiversity is defined 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 of ecosystems’
- The most important of them are
- **Genetic diversity:**
  - A single species might show high diversity at the genetic level over its distributional range. **India has more than 50,000 genetically different strains of rice and 1,000 varieties of mango.**
- **Species diversity:**
  - The diversity at the species level. For example, **the Western Ghats have greater amphibian species diversity than the Eastern Ghats.**
- **Ecological diversity:**
  - At the ecosystem level, India, for instance, with its deserts, rain forests, mangroves, coral reefs, wetlands, estuaries, and alpine meadows has greater ecosystem diversity than a Scandinavian country like Norway.
- Loss of Biodiversity
  - The biological wealth of our planet has been declining rapidly and the accusing finger is clearly pointing to human activities. The last twenty years alone have witnessed the disappearance of **27 species**.
  - Presently, **12 percent of all bird species, 23 percent of all mammal species, 32 percent of all amphibian species, and 31per percent of all gymnosperm species in the world face the threat of extinction.**
- Causes of biodiversity losses
  1. Habitat loss and fragmentation
  2. Over-exploitation

3. Alien species invasions
4. Co-extinctions

❖ Biodiversity Conservation:

➢ Earth‘s rich biodiversity is vital for the very survival of mankind. Besides the direct benefits **(food, fiber, firewood, pharmaceuticals, etc.),** there are many indirect benefits we receive through ecosystem services such as **pollination, pest control, climate moderation, and flood control.**

➢ the conservation efforts can be grouped into the following two categories:

➢ **In-situ (on-site) Conservation**

➔ **In-Situ conservation includes the protection of plants and animals within their natural habitats or in protected areas.** Protected areas are land or sea dedicated to protect and maintain biodiversity.

➔ **The in-situ strategy emphasizes the protection of total ecosystems for the conservation of overall biodiversity of genes, populations, species, communities, and ecological processes.**

➔ The in-situ approach includes the protection of a group of typical ecosystems through a network of protected areas as recognized by the **UNEP and the World Conservation Union (IUCN).**

➔ In situ conservation of biodiversity is advantageous in that it is a cheap and convenient method that requires people's supportive role.

➔ It maintains all organisms at different trophic levels from producers to top consumers such as carnivores. In the natural environment, organisms not only live and multiply but also evolve and continue to maintain their ability to resist various environmental stresses such as drought

storms, snow, temperature fluctuations, excessive rains, flood, fires, pathogens, etc.

➔ In situ conservation requires only the elimination of factors detrimental to the existence of the species and allows the larger number of species to grow simultaneously and flourish in their natural environment in which they were growing for a long time.

➔ **The only disadvantage of in situ conservation is that it requires larger areas and minimizes the space for inhibiting the human population which is increasing tremendously.**

➔ The following areas may be set aside for in situ conservation:

1. **National Parks and Wildlife Sanctuaries (terrestrial protected areas):**
   - ★ The earliest national parks, the Yellowstone in the **USA (established in 1872)** and the Royal near Sydney, Australia, were chosen because of their scenic beauty and recreational values.
   - ★ Many similar areas throughout the world now protect rare species or wilderness areas.
   - ★ The United Nations has recognized **102102** protected areas covering more than **18.8 million km2** covering 11.5 percent of the earth‘s land surface and **12.65** percent including the marine areas during 2003.
   - ★ There are **41997** protected areas around the world that fulfill the norms of **IUCN categories.**
2. **Marine Protected Area:**
   - ★ Since **1986 the IUCN** has been promoting the establishment of a global system of marine protected areas.

- ★ These are the areas of the intertidal and subtidal region taken together with their overlying water and associated flora and fauna which have been reserved by law or other effective means to protect it.
- ★ The main objectives of marine protected areas are protection and restoration of the depleted population of marine organisms, protection of endangered species and critical habitats, conserving and restoring marine ecosystem health for effective fishing management, to maintain biodiversity and ecological processes of marine and coastal ecosystems to use marine resources in a sustainable and equitable way.
- ★ According to the **World Database on Protected Areas records, 4116** protected areas in the **UN** list contain marine and coastal elements, covering **4.3 million km2.**

3. **Biosphere Reserves:**
   - ★ biosphere reserves are a special category of protected areas of land or coastal environments where people are an integral component of the system.
   - ★ **These are representative examples of natural biomes and contain unique biological communities.**
   - ★ The concept of biosphere reserve was launched in **1975 as a part of the UNESCO‘**s man and **Biosphere Programme** dealing with the conservation of ecosystems and the genetic resources contained therein.

➢ **Ex-situ (off-site) Conservation**

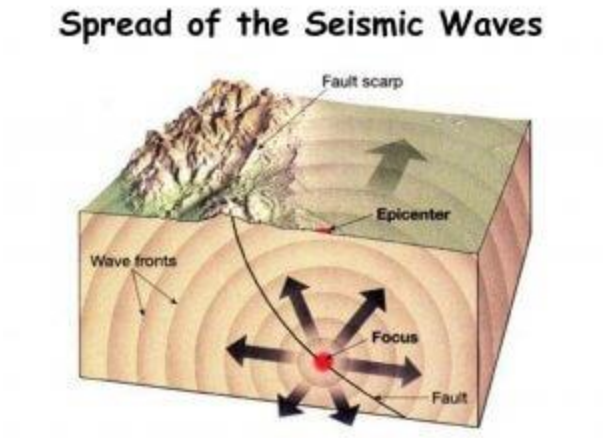
➔ conservation of plants and animals outside their natural habitats.

➔ These include botanical gardens, zoo, and gene banks; seed bank, tissue culture and cryopreservation.

1. **Seed Gene Bank:**
   - ★ The crop species diversity has declined with the onset of modern agricultural techniques, which will have severe implications on food security of the planet given environmental degradation, pests, epidemics and climate change.
   - ★ Seed gene banks are the easiest way to store germplasm of wild and cultivated plants at low temperature in cold rooms.
   - ★ Preservation of genetic resources is carried out in the field gene banks under normal growing conditions in the case of plants which do not produce seeds for example banana and plantains.
2. **In-vitro Gene Bank:**
   - ★ These are short and medium term storage for a range of crops, woody species, fruit trees and horticultural species using tissue culture techniques.
   - ★ Tissue culture systems allow the propagation of plants with high multiplication rates in an aseptic environment.
   - ★ The cells are grown on a gel and fed with suitable nutrients and hormones to give rise to entire plants.
3. **DNA Bank Network:**
   - ★ **This is a worldwide unique concept.**
   - ★ **DNA** band databases of all partners are linked and are accessible via a central web portal, providing **DNA** samples of complementary collections

(microorganisms, protists, plants, algae, fungi and animals).

- Natural hazards
  - ❖ Natural hazards are defined as environmental phenomena that have the potential to impact societies and the human environment.
  - ❖ Hazards namely **earthquake, tsunami, landslide, flood, cyclone and drought**
  - ❖ **Earthquake**
    - ➢ An earthquake is the shaking of the surface of the Earth, resulting from the sudden release of energy in the Earth‘s lithosphere that creates **seismic waves.**
    - ➢ **Earthquake is the form of energy of wave motion transmitted through the surface layer of the earth**.
    - ➢ It may be due to faulting , folding, plate movement, volcanic eruptions and anthropogenic factors like dams and reservoirs.
    - ➢ Earthquakes are by far the most unpredictable and highly destructive of all the natural disasters.
    - ➢ Minor earth tremors caused by gentle waves of vibration within the earth’s crust occur every few minutes while Major earthquakes usually caused by movement along faults, can be very disastrous particularly in densely populated areas.
    - ➢ **Focus and Epicenter**
      - ➔ **The point within Earth where faulting begins is the focus, or hypocenter.**
      - ➔ The point directly above the **focus on the surface is the epicenter.**
      - ➔ The intensity of the earthquake is highest at the epicenter and decreases with distance from the epicenter.



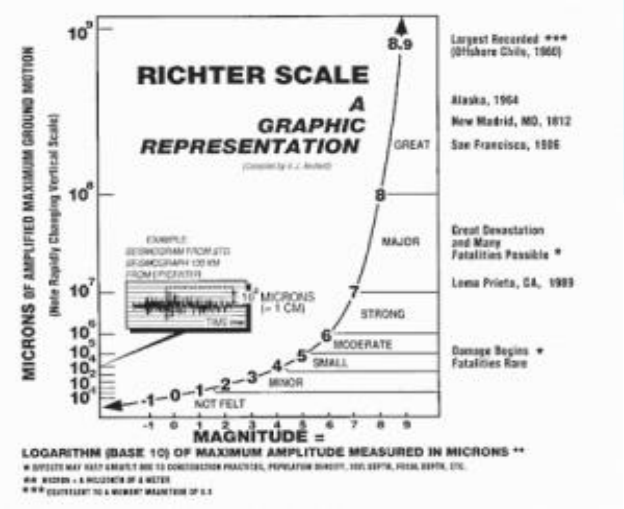
➢ **Richter scale**

➔ Richter **magnitude scale** is the scale to measure the magnitude of energy released by an earthquake.

➔ This scale was devised by **Charles. F. Richter in 1935**.

➔ The number indicating magnitude **ranges between 0 to 9**

➔ An earthquake that registers **5.0 on the Richter scale has a shaking amplitude 10 times that of an earthquake** that registered **4.0, and thus corresponds to a release of energy 31.6 times that released by the lesser earthquake.**



➢ **Mercalli scale**

➔ The Mercalli intensity scale is a seismic scale used for measuring the intensity of an earthquake.

➔ **It measures the effects of an earthquake**

➔ The number indicating intensity ranges between **1 to 12**

➢ **Seismic Waves**

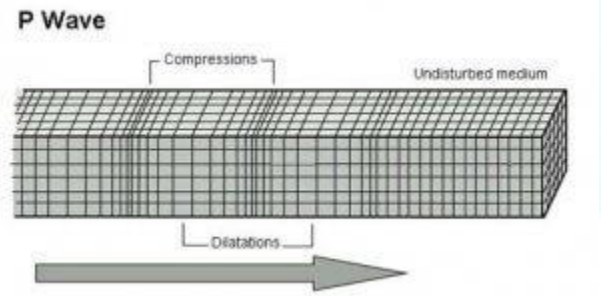
➔ Seismic waves are the waves of energy caused by the sudden breaking of rock within the earth.

➔ They are the energy that travels through the earth and is recorded on seismographs.

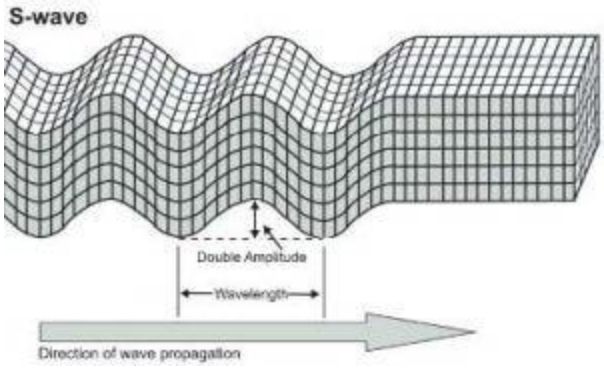
➔ The two main types of waves are **body waves and surface waves.**

➔ **Body waves**

1. **Primary waves (P-waves)**
   - ★ The first kind of body wave is the **P wave or primary wave.**
   - ★ This is the **fastest kind of seismic wave.**
   - ★ The P wave can move through **gaseous, solid rock and fluids, like water or the liquid layers of the earth.**
   - ★ It pushes and pulls the rock, it moves through just like sound waves push and pull the air.

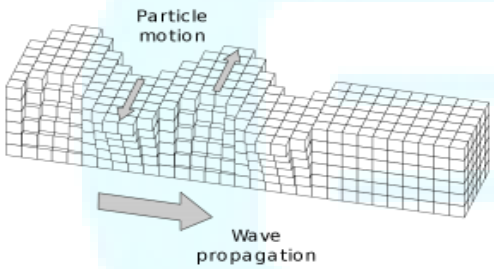


2. **Secondary waves (S-waves)**
   - ★ The second type of body wave is the **S wave or secondary wave.**
   - ★ An **S wave is slower than a P wave** and can only move through solid rock.
   - ★ This wave moves rock up and down, or side-to-side.
   - ★ **S-waves arrive at the surface with some time Lag.**

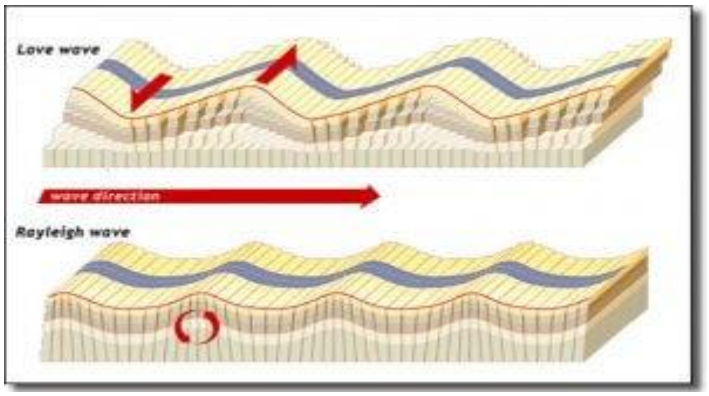


➔ **Surface waves**

1. **Love Waves (L-waves)**
   - ★ The first kind of surface wave is called a **Love wave, named after A.E.H. Love,** a British mathematician.
   - ★ It's the **fastest surface wave and moves the ground from side-to-side.**



2. **Rayleigh waves**
   - ★ The other kind of surface wave is the Rayleigh wave, named after Lord Rayleigh.
   - ★ A **Rayleigh wave rolls along the ground just like a wave rolls across a lake or an ocean.**
   - ★ Because it rolls, it moves the ground up and down, and side-to-side in the same direction that the wave is moving.
   - ★ Most of the shaking felt from an earthquake is due to the **Rayleigh wave, which can be much larger than the other waves.**



➢ Classification of earthquake

1. On basis of causative factors

➔ Volcanic

➔ Tectonic

➔ Isostatic

➔ Plutonic

➔ Artificial

2. On basis of depth of focus

➔ Moderate(0-50km)

➔ Intermediate(50-250km)

➔ Deep focus(250-700km)

3. On basis of human casualties

➔ Moderate (deaths<50,oo)

➔ Highly hazardous(51,000-1,00,00)

➔ Most hazardous(>1,00,00)

➢ Earthquake Causes

➔ **Natural Reasons**

★ Volcanic eruption

★ Faulting and folding

★ Upwarping and downwarping

★ Gaseous expansion and contraction inside the earth.

★ Plate Movement

★ Landslides

➔ **Man-made/Anthropogenic Reasons**

★ Deep underground mining
★ Blasting of rock by dynamites for construction purposes.
★ Deep underground tunnel
★ Nuclear explosion
★ Reservoir Induced Seismicity (RIS) (**E.g. Koyna Reservoir witnessed Earthquake in 1967 due to RIS**)
★ Hydrostatic pressure of man-made water bodies like reservoirs and lakes.

➢ World Distribution of Earthquakes

➔ The world's distribution of earthquakes coincides very closely with that of volcanoes.
➔ Regions of greatest seismicity are Circum-Pacific areas, with the epicenters and the most frequent occurrences along the **'Pacific Ring of Fire'.**
➔ It is said that as many as **70%** of earthquakes occur in the Circum-Pacific belt.
➔ Another **20%** of earthquakes take place in the **Mediterranean-Himalayan belt including Asia Minor, the Himalayas, and parts of north-west China.**
➔ The remaining occur in the interiors of plates and on spreading ridge centers.

❖ **Tsunami**

➢ **'Tsunami' is a Japanese term** represented by two characters: **"tsu" and "nami".**
➢ The character **"tsu"** means **harbor**, while the character **"nami"** means **wave**. which has been universally adopted to describe a large seismically generated sea wave.

- These waves are responsible for causing considerable destruction in certain coastal areas where submarine **earthquakes occur.**
- It is a series of waves of extremely long wavelengths and long periods generated in a body of water by an impulsive disturbance that displaces water.
- **Process of Generation of Tsunami**
  - When a tsunami is generated, its **steepness i.e. height to length ratio is very less.**
  - This enables it to pass unnoticed beneath the ships in the sea. As the wave approaches the shore, the **height of the wave rapidly increases because of the rebound from the shallow surface.**
  - The period of the wave remains constant, velocity drops, and the height increases. In confined coastal waters relatively close to their point of origin, tsunamis can reach a height of more than **30m.** Tsunamis travel at the speed of **100 -150 km/h which may pick up 650-900 km/h.**
  - When the tsunami enters the shoaling water of coastlines in its path, the velocity of its waves diminishes, and the wave height increases.
  - As a tsunami leaves the deep water of the open sea and propagates into the more shallow waters near the coast, it undergoes a transformation.
  - Since the speed of the tsunami is related to the water depth, as the depth of the water decreases, the speed of the tsunami diminishes.
  - The change in the total energy of the tsunami remains constant. Therefore, the speed of the tsunami decreases as it enters shallower water, and the height of the wave grows.

- ➔ Because of this **"shoaling"** effect, a tsunami that was imperceptible in deep water may grow to be several feet or more in height.
- ➔ It may travel a considerable distance. The frequency of tsunamis is highest in the Pacific Ocean.
- ➔ Since **1948, an International Tsunami Warning Network has been in operation around the Pacific Ocean to alert coastal residents to possible danger.**

➢ Causes of Tsunami

- ➔ **EARTHQUAKE**
- ➔ **LANDSLIDES**
- ➔ **UNDERSEA VOLCANOES**
- ➔ **METEORS, ASTEROIDS**
- ➔ **ANTHROPOGENIC FACTORS LIKE NUCLEAR EXPLOSIONS**

❖ Cyclones

➢ Cyclones are caused by atmospheric disturbances around a low-pressure area distinguished by swift and often destructive air circulation.

➢ Cyclones are usually accompanied by violent storms and bad weather

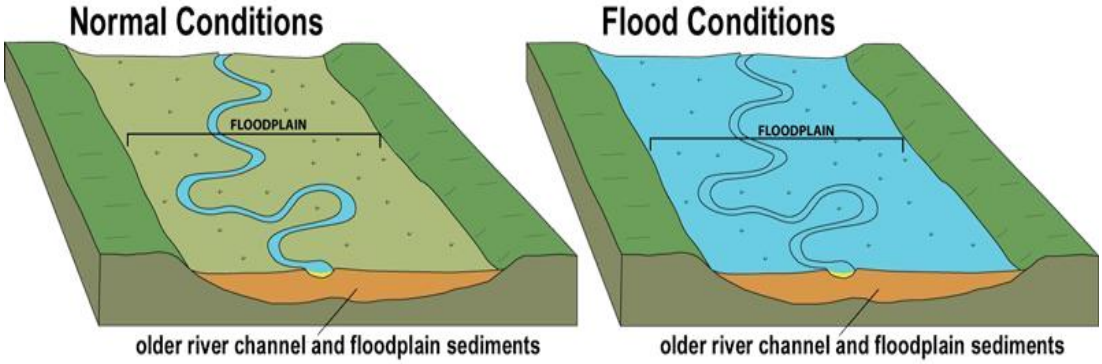
➢ The air circulates inward in an anticlockwise direction in the Northern hemisphere and clockwise in the Southern hemisphere.

➢ Cyclones are classified as: (i) **extra tropical cyclones (also called temperate cyclones); and (ii) tropical cyclones.**

❖ Floods

➢ **A high water level that overflows the natural banks along any portion of a stream is called a flood.** Thus, Floods are commonly associated with a stream or river.

- A stream floods when its discharge is greater than the capacity of its river channel.
- Excess water flows over the river banks and submerges the adjacent land which is usually dry. When it happens, the channel and the flood plain together allow passage of water.
- **Floods and Droughts on one hand are cumulative hazards.**
- On the other hand, due to the peculiar nature of the Indian monsoon floods and droughts may affect different pockets of the country at the same time of a year.
- Thus, floods can be seasonal, and sometimes flash floods also occur.



- Causes of Floods

1. Natural Causes

- ➔ Heavy rainfall and cloud bursts – Heavy concentrated rainfall reduces the capacity of rivers to accept any more surface run–offs due to rainfall and as result water spills over to adjoining areas. Cloud bursts are basically thunderstorms which yield very heavy rains (>50 – 100 cm within a few hours). All of these can cause extensive damage within a short span of time.
- ➔ Heavy melting of ice and snow,
- ➔ Changes in river systems and large catchment areas,

- ➔ Sediment deposition/Silting of river beds,
- ➔ The collapse of dams,
- ➔ Transgression of sea at the occasion of tropical cyclone, and
- ➔ Tsunami in coastal areas and landslides in course of rivers

2. **Man-made/Anthropogenic causes**
   - ➔ Deforestation
   - ➔ Unscientific use of land utilization and bad farming practices
   - ➔ Increased Urbanization

➢ Consequences of Floods

- ➔ Floods are taking thousands of lives and loss of property every year.
- ➔ The crops get adversely affected by the temporary loss of the agricultural season and fertile soil cover.
- ➔ It leads to changes in habitats, destruction of habitats, and loss of animals due to drowning.
- ➔ Disruption of the lines of rail, road communication, and essential services creating great problems for the movements of people and goods.
- ➔ **Spread of water**-borne and infectious diseases like cholera, gastro-enteritis, etc. immediately after floods.
- ➔ **Positive consequences** – Floods also make a few positive contributions. Every year floods deposit fertile silt over agricultural fields which are good for the crops. It also recharges the groundwater table.

❖ Droughts

- ➢ **Drought is a temporary reduction in water or moisture availability below the normal or expected amount for a specific period.**
- ➢ The occurrence of substantially lower than average precipitation in a season that normally has ample precipitation in a season for the support of cereal and non-cereal crops is known as Drought.
- ➢ The amount, time, and distribution of rainfall matters.
- ➢ In India, the erratic nature of the summer monsoon with long dry spells and high temperature are responsible for the drought

conditions. On average, one in every 5 years is a drought year. In Rajasthan, one in every 3 years is a drought year.

➢ Drought is a relative phenomenon as the inadequacy is with reference to prevailing agro-climatic conditions. Aridity is a permanent condition whereas drought is a temporary situation. Arid and semi-arid regions are more prone to drought.

➢ Types & Causes of Drought

1. Meteorological Drought

➔ It is a situation where there is a reduction in rainfall for a specific period below a specific amount i.e. the actual rainfall in an area is significantly less than the climatologically mean of that area.

➔ According to the Indian Meteorological Department (IMD), a drought exists when the average annual rainfall is less than **75% of the normal.**

➔ IMD also mentioned that rather than the total amount of rainfall, its evenness matters more.

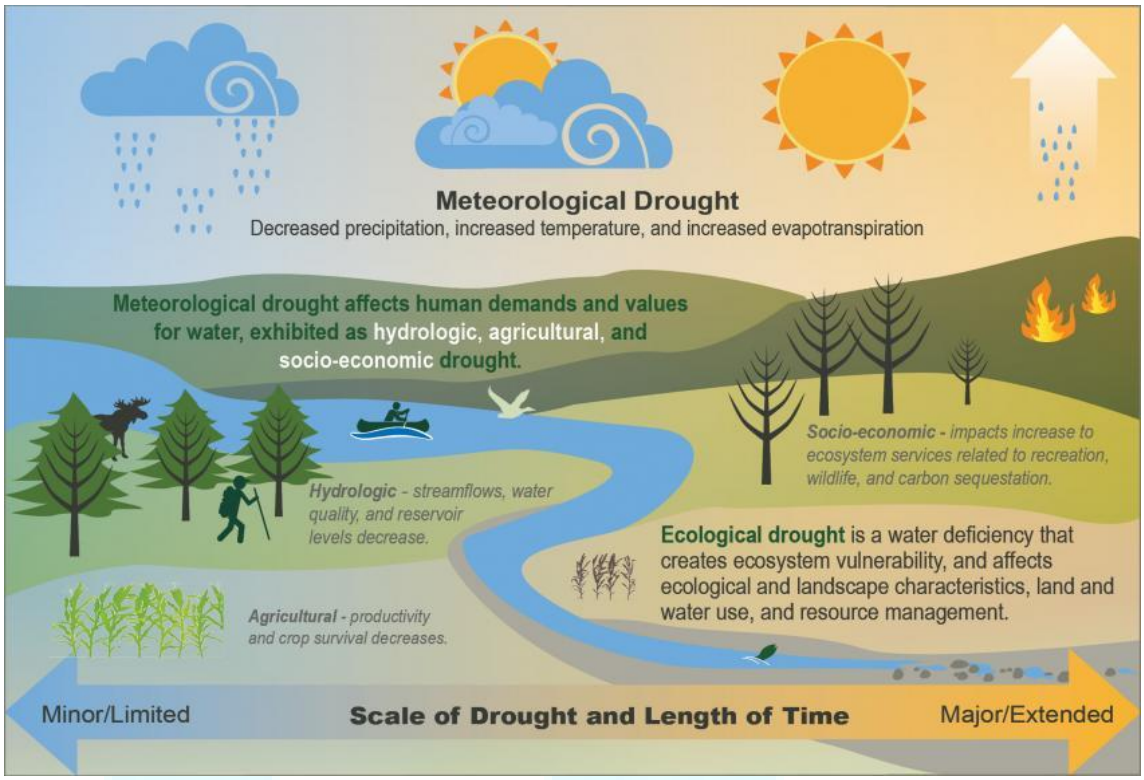
➔ We can observe that even though India gets an average annual rainfall of **110 cm**, the evenness of rainfall, due to the erratic and concentrated nature of rainfall, there are frequent droughts

➔ **Causes of Meteorological droughts**

★ Lean monsoon and below-average rainfall.

★ Late-onset or early withdrawal of monsoons.

★ Prolonged breaks in Monsoon.



2. Hydrological Drought

➔ It is associated with the reduction of water levels. There are 2 types of Hydrological Droughts

➔ **Surface water Drought** – It is concerned with the drying up of surface water resources such as rivers, streams, lakes, ponds, tanks, reservoirs, etc.

➔ **Groundwater Drought** – It is associated with the fall in the groundwater level.

★ Large scale deforestation.

★ Ecologically hazardous mining.

★ Excessive pumping of groundwater

3. Agricultural Drought

➔ It occurs when soil moisture goes below the level needed to sustain plant growth.

➔ It is also called the **Soil Moisture Drought.**

➔ The erratic rainfall conditions and inadequate soil moisture result in crop failures.

➔ Causes of Agricultural Droughts

★ Excessive use of High Yielding Seeds (HYV)

★ Change in cropping pattern

4. Socio-Economic Drought

➔ It reflects reduced availability of food and income loss due to crop failure.

5. Ecological Drought

➔ It occurs when the productivity of the natural ecosystem fails due to a shortage of water and causes environmental damages like the deaths of cattle, wildlife, and trees in the forest.

➢ Consequences of Droughts

➔ Economic losses

➔ Environmental Impact

➔ Impact on society

❖ Landslide

➢ L**andslide is a rapid movement of rock, soil, and vegetation down the slope under the influence of gravity**.

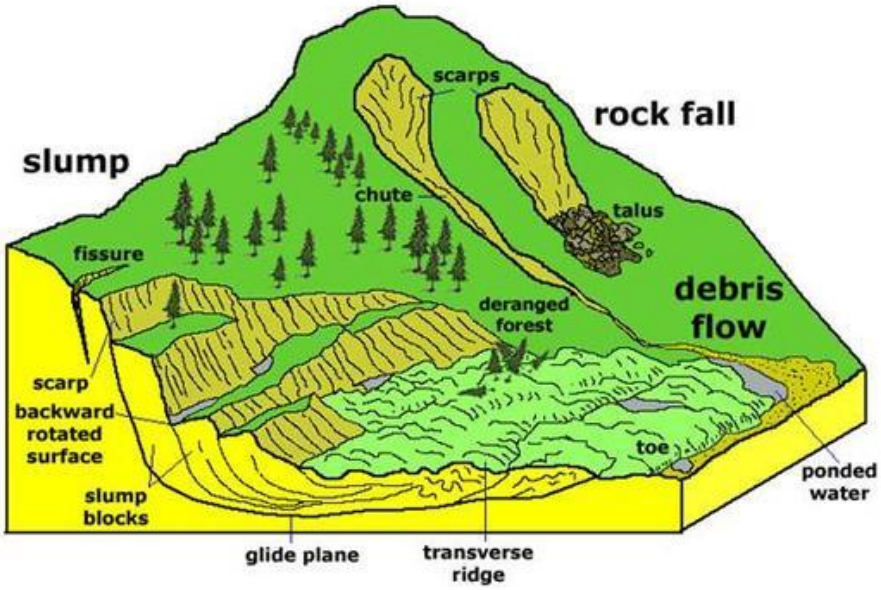
➢ It may be induced by natural agencies, e.g., **heavy rain, earthquake, or it may be caused by human over-interference with the slope – stability.**

➢ Man breaks rocks for constructing roads, railways, buildings, tunnels, etc. In such cases rocks become loose and landslides occur.

➢ Earth flow, mass movement, mudflow, rotational slip, and avalanches are all examples of landslides.

➢ **Landslides are rarely on a scale comparable to seismic or volcanic events**.

➢ The intensity and magnitude of the landslide, however, depends on the geological structure, angle of dip of the slope, nature of sedimentary rocks, and the human interaction with the slope.



➢ Types of landslides

1. **Falls:** It happens due to the abrupt movements of masses of geologic materials, such as rocks and boulders that become detached from steep slopes or cliffs.
2. **Topples:** It happens due to the forward rotation of a unit or units about some pivotal point, below or low in the unit, under the actions of gravity and forces exerted by adjacent units or by fluids in cracks
3. **Slides:** In this type, rocks, debris or soil slide through slope forming material.
4. **Spread:** It usually occurs on very gentle slopes or flat terrain.

➢ Causes of Landslides

➔ Rainfall and Snowfall

➔ Earthquakes and Volcanic Eruptions

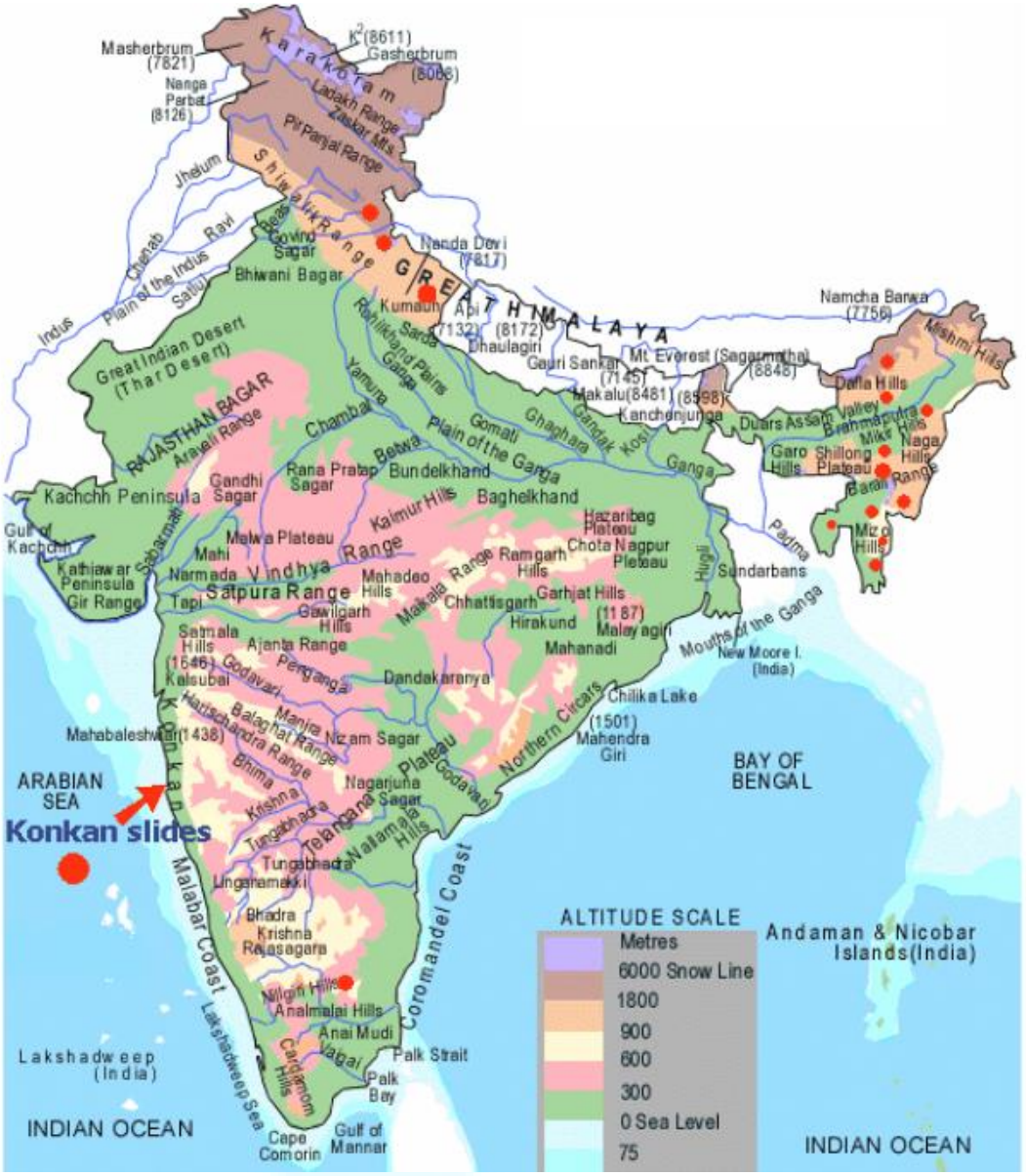
➔ Mining, Quarrying and Road cutting

➔ Loading by construction of houses

➔ Deforestation

➢ Impact of Landslides

Short Term Impacts	Long Term Impacts
Loss of Lives and Properties	Changes in the landscape that can be permanent
Roadblocks, destruction of railway lines	Loss of cultivable land
Channel blocking due to rock – falls	Environmental impact in terms of erosion and soil loss
Diversion of river courses due to landslides causing floods	Population shift and relocation of populations and establishments
Loss of natural Beauty	Drying up of sources of water



- Degradation
  - ❖ Environmental degradation is the deterioration of the environment through depletion of resources such as **air, water and soil; the destruction of ecosystems; habitat destruction; the extinction of wildlife; and pollution. It is defined as any change or disturbance to the environment perceived to be deleterious or undesirable.**
  - ❖ **<u>Causes of Environmental Degradation</u>**
    - ➢ **Land Disturbance**:
    - ➢ **Pollution**

- ➔ Pollution, in whatever form, whether it is air, water, land or noise is harmful to the environment.
- ➔ **Air pollution** pollutes the air that we breathe which causes health issues.
- ➔ **Water pollution** degrades the quality of water that we use for drinking purposes.
- ➔ **Land pollution** results in the degradation of the earth‘s surface as a result of human activities.
- ➔ **Noise pollution** can cause irreparable damage to our ears when exposed to continuous large sounds like the honking of vehicles on a busy road or machines producing large noise in a factory or a mill

➢ **Overpopulation**

- ➔ Rapid population growth puts a strain on natural resources which results in the degradation of our environment.
- ➔ The mortality rate has gone down due to better medical facilities which have resulted in increased lifespan.
- ➔ **More population simply means more demand for food, clothes, and shelter**

➢ **Landfills**

- ➔ **Landfills pollute the environment and destroy the beauty of the city.**
- ➔ Landfills come within the city due to the large amount of waste that gets generated by households, industries, factories, and hospitals.
- ➔ Landfills pose a great risk to the health of the environment and the people who live there.
- ➔ Landfills produce a foul smell when burned and cause huge environmental degradation.

➢ **Deforestation**

- ➔ Deforestation is the cutting down of trees to make way for more homes and industries.
- ➔ Rapid growth in population and urban sprawl are two of the major causes of deforestation.
- ➔ Apart from that, the use of forest land for agriculture, animal grazing, harvest for fuelwood, and logging are some of the other causes of deforestation.
- ➔ **Deforestation contributes to global warming as decreased forest size puts carbon back into the environment**.

➢ **Natural Causes**

- ➔ Things like avalanches, quakes, tidal waves, storms, and wildfires can totally crush nearby animal and plant groups to the point where they can no longer survive in those areas.
- ➔ This can either come to fruition through physical demolition as the result of a specific disaster or by the long term degradation of assets by the presentation of an obtrusive foreign species to the environment.
- ➔ The latter frequently happens after tidal waves, when reptiles and bugs are washed ashore.

❖ **<u>Effects of Environmental Degradation</u>**

- ➢ Impact on Human Health
- ➢ Loss of Biodiversity
- ➢ Ozone Layer Depletion
- ➢ Loss for Tourism Industry
- ➢ Economic Impact

- Emerging environmental issues

❖ Pollution

➢ **Pollution of the air, water and soil caused by toxins such as plastics, heavy metals and nitrates, caused by factors such**

as toxins and gasses released by factories, combustion of fossil fuels, acid rain, oil spill and industrial waste.

- Global warming
  - The emission of greenhouse gasses due to human activity causes global warming, which in turn causes an increase in temperature that then leads to rising sea levels, melting of polar ice caps, flash floods and desertification.
- Overpopulation
  - We are facing a shortage of resources such as food, water and fuel to sustain the rising global population, particularly in developing countries.
  - Intensive agriculture attempting to lessen the problem actually leads to more damage through the use of chemical fertilizers, pesticides and insecticides.
- Waste disposal
  - An excessive amount of waste is produced and dumped in the oceans.
  - **Nuclear waste** is particularly dangerous, as well as plastics and electronic waste.
- Ocean acidification
  - The increase in the production of carbon dioxide by humans causes the oceans' acidity to rise, which has a negative impact on marine life
- Loss of biodiversity
  - Species and habitats are becoming extinct due to human activity. This causes an imbalance in natural processes like pollination and poses a threat to ecosystems – coral reef destruction is particularly affected.
- Deforestation

- ➢ **Loss of trees in order to make space for residential, industrial or commercial projects means that less oxygen is produced, and temperature and rainfall are affected**

❖ Ozone layer depletion

- ➢ Pollution caused by chlorofluorocarbons **(CFCs)** in the air creates a hole in the ozone layer, which protects the earth from harmful **UV radiation**

❖ Acid rain

- ➢ Pollutants in the atmosphere such as sulfur dioxide and nitrogen oxides cause acid rain, which has negative consequences for humans, wildlife and aquatic species.

❖ Public health issues

- ➢ **Lack of clean water is one of the leading environmental problems currently.**
- ➢ Pollutants in the air also cause issues such as respiratory disease and cardiovascular disease.

- Ecol Crisis
  - ❖ An ecological crisis occurs **when changes to the environment of a species or population destabilizes its continued survival.**
  - ❖ Some of the important causes include
    1. **Degradation of an abiotic ecological factor** (for example, increase of temperature, less significant rainfalls)
    2. **Increased pressures from predation**
    3. **Rise in the number of individuals** (i.e. overpopulation)
- environmental law and protection.
  - ❖ Environmental Laws in India
    1. Directive Principles of State Policy (Part IV) Article 48A
       - ➢ Protection and improvement of environment and safeguarding of forests and wildlife The State shall endeavor to protect and improve the environment and to safeguard the forests and wildlife of the country

2. Fundamental duties (Part IV A) Article 51A
    - ➢ To protect and improve the natural environment including **forests, lakes, rivers, and wildlife, and to have compassion for living creatures.**
3. The Wildlife (Protection) Act, 1972
    - ➢ The Act provides for the protection of wild animals, birds, and plants; and for matters connected therewith or ancillary or incidental thereto.
    - ➢ **It extends to the whole of India.**
    - ➢ It has six schedules that give varying degrees of protection
        - ➔ **Schedule I and part II** of Schedule provide absolute protection, offenses under these are prescribed the highest penalties.
        - ➔ **Species listed in Schedule III** and Schedule IV are also protected, but the penalties are much lower.
        - ➔ Animals under **Schedule V,** e.g. common crows, fruit bats, rats, and mice, are legally considered vermin and may be hunted freely.
        - ➔ The specified endemic plants in **Schedule VI** are prohibited from cultivation and planting.
    - ➢ Statutory bodies under WPA
        - ➔ **National Board for Wildlife and state wildlife advisory boards**
        - ➔ **Central Zoo Authority**
        - ➔ **Wildlife Crime Control Bureau**
        - ➔ **National Tiger Conservation Authority**
4. The Water (Prevention and Control of Pollution) Act, 1974
    - ➢ To provide prevention and control of water pollution.
    - ➢ Maintaining or restoring of wholesomeness and purity of water in the various sources of waterIt vests regulatory

authority in **Centre Pollution Control Boards (CPCB) and State Pollution Control Board (SPCB).**

- ➢ **CPCB and SPCB are statutory bodies created under the Water Act, 1974.**

5. The Air (prevention and control of pollution) act, 1981
   - ➢ To provide for **prevention, control, and abatement of air pollution.**
   - ➢ To provide for the establishment of the boards at the central and state levels to implement the act
   - ➢ It states that the sources of air pollution such as internal combustion engines, industry, vehicles, power plants, etc., are not permitted to release **particulate matter, lead, carbon monoxide, sulfur dioxide, nitrogen oxide, volatile organic compounds (VOCs), or other toxic substances beyond the predetermined limit.**
6. The Environment (Protection) Act, 1986
   - ➢ This act was passed under **article 253 (legislation for giving effect to international agreements)**
   - ➢ This was passed in the wake of the **Bhopal gas tragedy in December 1984.**
   - ➢ Statutory bodies under the **EPA, 1986**
     - ➔ **Genetic Engineering Appraisal Committee**
     - ➔ **National Coastal Zone Management Authority** (later converted to National Ganga Council under Ministry of Jal Sakthi)
7. The energy conservation act, 2001
   - ➢ It was enacted as a step towards improving energy efficiency and reducing wastage.
   - ➢ It specifies the energy consumption standards for equipment and appliances.

- ➢ **The Bureau of energy efficiency (BEE)** is a statutory body established under the act.

8. Biological diversity act 2002
   - ➢ It was implemented to give effect to the CBD**, Nagoya Protocol.**
   - ➢ To set up **National Biodiversity Authority (NBA), State Biodiversity Boards (SBBS), and Biodiversity Management Committees (BMCS)**
9. Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 (FRA)
   - ➢ The act recognizes and vests the forest rights and occupation in forest land in **Forest Dwelling Scheduled Tribes (FDST)** and **Other Traditional Forest Dwellers (OTFD)**who have been residing in such forests for generations.
   - ➢ This act comes under the aegis of the Ministry of Tribal Affairs
   - ➢ The act identifies four types of rights:
     1. Title rights
        - ➔ It gives **FDST and OTFD** the right to ownership of land farmed by tribals or forest dwellers subject to a maximum of **4 hectares.**
        - ➔ Ownership is only for land that is being cultivated by the concerned family and no new lands will be granted.
     2. Use rights
        - ➔ The rights of the dwellers extend to extracting Minor Forest Produce, grazing areas, pastoralist routes, etc.
     3. Relief and development rights

➔ To rehabilitation in case of illegal eviction or forced displacement and basic amenities, subject to restrictions for forest protection

4. Forest management rights

➔ It includes the right to protect, regenerate or conserve or manage any community forest resource which they have been traditionally protecting and conserving for sustainable use.

10. The National Green Tribunal Act, 2010

➢ It was established in concurrence to **Rio Summit 1992** to provide judicial and administrative remedies for the victims of the pollutants and other environmental damage.

➢ It also agrees with **article 21, the Right to a healthy environment to its citizens of the constitution.**

➢ The NGT has to dispose of the cases presented to it within **6 months of their appeals**.

➢ NGT has original jurisdiction on matters related to substantial questions of the environment

➢ NGT deals with the civil cases under the 7 acts related to the environment

1) Water (Prevention And Control Of Pollution) Act, 1974

2) Water (Prevention And Control Of Pollution) Cess Act, 1974

3) Air (Prevention And Control Of Pollution) Act, 1977

4) Forest Conservation Act, 1980

5) Environmental Protection Act, 1986

6) Public Liability Insurance Act 1991

7) **Biological Diversity Act, 200**

- ➢ The decisions of the NGT can be challenged in High Courts and the Supreme Court.

11. Compensatory Afforestation Fund Act, 2016
    - ➢ The CAF Act was enacted to manage the funds collected for compensatory afforestation which till then was managed by ad hoc **Compensatory Afforestation Fund Management and Planning Authority (CAMPA).**
    - ➢ As per the rules, **90% of the CAF money is to be given to the states while 10% is to be retained by the Center**
    - ➢ The funds can be used for the treatment of catchment areas, assisted natural generation, forest management, wildlife protection and management, relocation of villages from protected areas, managing human-wildlife conflicts, training and awareness generation, supply of wood saving devices, and allied activities.
12. Coastal Regulation zone notification 2018
    - ➢ It was notified based on the recommendations of the **Shailesh Nayak Committee.**
    - ➢ To promote sustainable development while taking into account the natural hazards such as increasing sea levels due to global warming
    - ➢ CRZs have been classified into 4 zones for regulation
        - ➔ **CRZ I**– ecologically sensitive areas such as mangroves, coral reefs, salt marshes, turtle nesting ground, and the intertidal zone.
        - ➔ **CRZ II**– areas close to the shoreline, and which have been developed.

- ➔ **CRZ III**- Coastal areas that are not substantially built up, including rural coastal areas.
- ➔ **CRZ IV**- water area from Low Tide Line (LTL) to the limit of territorial waters of India.