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2.1 Introduction

An ecosystem is a functional unit of nature where a community of living organisms interact among themselves and with the surrounding physical environment. An ecosystem varies greatly in size. They may be as large as a forest or sea or as small as a small fishpond or the back of a spider crab’s shell, which provides a home for plants and other animals, such as sponges, algae and worms. In an ecosystem, complex interactions between its biotic (living) and abiotic (non-living) components take place.

The term ‘ecosystem’ is coined by combining two words “Eco” which means the environment and ‘System’ which means a set of interacting and inter-dependent living and non-living (inorganic or abiotic) components.

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<td>Ecology includes the study of relationships between living organisms and their environment.</td>
<td>Environment means surrounding in which organisms live. It is the sum total of conditions that surround us at a given point in time and space.</td>
<td>An ecosystem is a functional unit of nature where a community of living organisms interact among themselves and with the surrounding physical environment. An ecosystem is a sub-part of Ecology.</td>
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2.2 Components of Ecosystem

Abiotic Component (Non-Living)

The Abiotic component of the ecosystem includes the non-living part of the ecosystem which enters the body of a living organism, taking part in many physiological activities including metabolism and return to the environment in the end. The abiotic component can further be divided into following three categories:

Physical Factors

The distribution of living organisms in a particular habitat may be affected by physical factors. These factors include various environmental factors like temperature, humidity, light and atmospheric pressure among others.

Temperature

There are different temperature zones in the different parts of the earth generally referred to as tropical, subtropical, temperate and alpine. The high, as well as low temperature, leads to the organism inactivity. The major effect of temperature is on the enzymes controlling metabolic reactions. As a rule, plants will develop more rapidly in warmer temperatures, as will ectothermic animals.

Temperature variations influence the distribution of organisms more in terrestrial habitats than aquatic habitats. Temperature affects the physiology of organisms. Very few organisms can survive below 0 degree Celsius as metabolism is severely affected below this temperature. Also, above a certain temperature, enzyme degradation can take place. Thus, organisms need to maintain the internal temperature in order to survive. For the same temperature rise, the water bodies show resistance to change in temperature. Thus, temperature variation affects the distribution of organism in terrestrial habitat.

Though, many organisms show adaptability to change in temperature. It is partly due to temperature that migrations occur. For example, Arctic tern makes a 40,000 km round trip flight each year between the southern hemisphere and the Arctic Ocean to escape the winter.

In the same way, Global warming is causing disturbance to the stability of an ecosystem.
Humidity

Humidity reflects the amount of water vapor in the atmosphere. High humidity means more water vapor in the atmosphere and vice versa. Humidity is one of the deciding factors affecting the rate at which water evaporates from the surface of an organism such as sweating or transpiration, thus affecting their distribution on earth. Humidity determines the amount of water an organism loses in the air. For example, in a desert ecosystem, only plants and animals adapted to live in low humidity will survive and retain as much water as possible. For the same reason, ferns (especially Boston fern) require high humidity. In lower humidity areas, fern will excessively drop leaves, creating a mess.

Light

Sun is the main source of energy to all forms of life on the earth. Green plants and photosynthetic bacteria need light to manufacture their food. Therefore, more plants will be found where there is plenty of available light, rather than in places with less light. An aquatic system can be divided into euphotic, mesophotic and aphotic zones depending on the extent of penetration of light in the water. Plenty of light is available to plants and animals in the euphotic zone. No light is available in the aphotic zone.

Plants develop strategies in order to cope with different amounts of available light. They may have larger leaves; develop photosynthetic pigments that require less light; reproduce when light availability is at an optimum. For example, in Tundra biomes, many plants are dark in color. Some of them are even red which helps them absorb solar heat like Arctic willow.

Animals depend on plants for food. Light affects living things in terms of intensity, quality and duration. Light intensity and quality affect photosynthesis, flowering and germination of plants, while in animals, it affects migration, hibernation and reproduction.

Soil

The type of soil, pH, amount of water it holds, available nutrients, etc. determine what type of organism can successfully live in or on the soil. For example, cacti live in sand, cattails in soil saturated with water.

Atmospheric Pressure

Atmospheric pressure is the pressure of the atmosphere on the Earth's surface. Atmospheric pressure varies with altitude. It indirectly affects the ecosystem as it affects the amount of Oxygen available for respiration and of carbon dioxide for photosynthesis.

Inorganic Factors

In the same way, distribution of living organisms in a particular habitat may be affected by inorganic substances. These include various factors like water, oxygen, Carbon Dioxide and Nitrogen among others.

Water

In defining the distribution of organism, water perhaps is the most important factor as every organism require water in varying degree for their survival and growth. Thus, the availability of water sources is a major factor affecting the distribution of organisms and, in turn, the ecosystem.

In an ecosystem, water cycles through the atmosphere, soil, rivers, lakes, and oceans. Some water is stored deep in the earth. Surface water, on the other hand, is the source that sustains life on land. Rivers, lakes, and other bodies of water divide environments into different habitats, effectively defining where some organisms can live and others cannot.

Oxygen

All the organism, whether terrestrial or aquatic, needs oxygen for various reasons including respiration, and photosynthesis. The atmosphere has 21 percent oxygen concentration. In water, oxygen moves much slower i.e. the amount of dissolved oxygen depends on the rate of diffusion of atmospheric oxygen across the water's surface, which is a slow process. So oxygen consumption through respiration often exceeds production through photosynthesis, resulting in daily shifts in dissolved oxygen concentrations. Similarly, oxygen penetration in saturated soil is much slower than in dry soil which leads to different oxygen concentrations in different parts of the soil as there is more space between the dry soil pores to occupy. Dry soil has more microorganisms compared to the wet soil as these organisms also require oxygen. These organisms ultimately lead to enriching the soil with required nutrients. These factors regulate the distribution of the organism.

Carbon Dioxide

Carbon dioxide is an important part of photosynthesis. Also, dissolution of Carbon dioxide in the oceans define their pH level, thus defining the zone in which aquatic organism can live. Increase in dissolved carbon dioxide increases the acidic character of the oceans which leads to the dissolution of outer shells of marine organism. With ocean acidification, corals cannot absorb the calcium carbonate they need to maintain their skeletons and the stony skeletons that support corals and reefs will dissolve. Also, carbon dioxide is playing a greater role in global warming affecting the life on earth.

Nitrogen

Nitrogen is a component of amino acids and urea. Amino acids are the building blocks of all proteins. Proteins comprise not only structural components such as muscle, tissue and organs but also enzymes and hormones essential for the functioning of all living things. Thus, Nitrogen is essential for all living organisms.
Organic Substances

These substances make a link between the biotic and abiotic components as they are the main building blocks of living systems. These substances include Carbohydrates, proteins and lipids among others.

Protein

Proteins are of great nutritional value and are present in all living organisms. They are responsible for nearly every task of cellular life, including cell shape and inner organization, product manufacture and waste cleanup, and routine maintenance. A protein molecule consists of many amino acids joined together to form long chains.

Animals cannot synthesize amino acids but plants can. Thus, animals need to obtain these amino acids from outside sources. Also, animals that only eat plants require a large amount of plant material as the protein content of most plants is very low.

Carbohydrates

Carbohydrates are the primary source of energy for plants and animals and thus its an essential compound of all organic lives. During photosynthesis, plants use the sun’s energy and carbon dioxide to produce carbohydrates.

These carbohydrates form the foundations of almost all ecosystems on Earth. Using carbohydrates for energy prevents proteins being used for energy. This is important because it allows proteins to be used for other purposes such as metabolism and muscle contraction.

Lipids

These are the molecules that make up the building blocks of the structure and function of living cells and they contain hydrocarbons. Examples of lipids include fats, oils, waxes, certain vitamins, hormones and most of the non-protein membrane of cells. Lipids are involved mainly in long-term energy storage.

Biotic Components (Living)

Biotic components of an ecosystem include living beings like all the plants, animals, fungi and microorganisms that make up ecological communities. These organisms are interdependent and closely associated with members of food chains. These can be divided into following categories:

Producers (Autotrophs)

These are organisms which manufacture their own food and thus for the entire ecosystem through the process of photosynthesis. They are also called Autotrophs (i.e. self-nourishment or self-feeding). In Photosynthesis, green plants, carrying chlorophyll, absorb water and nutrients from the soil, carbon dioxide from the air, and capture solar energy for this process.

Some producers manufacture food through chemosynthesis, using the energy released from chemical reactions instead of the energy of sunlight. Bacteria living in aphotic areas (less sunlight area) of the ocean are able to survive by chemosynthesis.

Consumers (Heterotrophs)

Those organisms which are incapable of manufacturing their own food and thus they rely on others. They depend on producers directly or indirectly for their food. Consumers obtain energy by ingesting other organisms or by absorbing food molecules.

Consumers can again be grouped into three categories according to their food preferences:

Herbivores: Those consumers who are directly dependent on producers as they eat plant leaves, flowers, stems, roots and foliage from trees. The herbivorous animals include for example hare, deers, goats, horses and elephants that live on plant life. These consumers are vegetarian animals as they do not eat meat of other animals.

Carnivores: Also called as secondary consumers, these are animals that eat herbivores. They don’t eat plants. The carnivorous animals like snakes, hawks, tigers, leopards, jackals, foxes and small wild cats are few examples of carnivores. In seas, carnivorous fish live on other fish and marine animals. They range in size from microscopic forms to giant mammals like the whale.

Omnivores: These are the animals that can eat plants as well as other animals. Some examples of omnivorous animals are rats, human beings, etc that eat both plants and animals.

Decomposers (Saprotrophs)

Organisms produce waste in large quantities of organic matter, such as dead leaves (and other parts of plants); feathers, hairs and other parts of an animal’s body; and faeces from animals. It becomes toxic if it is accumulated. So, decomposers use it as a source of nutrition and breaks dead and deceased organisms. Moreover, they utilize these organic substrates as a source of energy, carbon, and essential nutrients for their development and growth.

Decomposers are important parts of food chains that ensure the energy flow through ecosystems and constitute the continuance of life as both are involved in decomposing the dead biological matter. They are mostly bacteria, fungi, insects and worms that feed on dead decomposed and the dead organic matter of plants and animals by secreting enzymes outside their body on the decaying matter. Saprotrophic bacteria and fungi break
down carbon compounds in dead organic matter and release elements such as nitrogen into the ecosystem—which are then used again by other organisms. Other decomposers are detritivores—detritus eaters or debris eaters that obtain organic nutrients from detritus by internal digestion. These are usually multicellular animals such as earthworms, crabs, slugs, or vultures. They not only feed on dead organic matter but often fragment it as well, making it more available for bacterial or fungal decomposers. Decomposition, thus, plays a vital role in recycling of nutrients as without this, all the nutrients would be tied up in dead matter and no new life could be produced. Decomposers play a vital role in keeping ecosystems healthy. They break down dead material and wastes and release nutrients that can be recycled and used as building blocks by primary producers.

**Interactions among Biotic and Abiotic Components**

All living organisms depend upon abiotic factors for food, shelter and site of breeding. Plants use the abiotic factors of non-living components for carbon dioxide, water and energy from the sun. This plant also gets preyed by herbivorous organisms or parasites. Moreover, plants are dependent on soil for its mineral nutrients and support. This clearly shows the interaction of plant, a biotic component, with the abiotic components.

![Abiotic and Biotic Interactions](image)

Also, the abiotic components and biotic components influence each other. For example: the type of soil and the climatic conditions determine the type of flora and fauna found in that region. Thus, these biotic and abiotic components are linked to each other through nutrient cycles and energy flows.

Abiotic and biotic components interact and work together in an environment that is best for all living organisms. There are diverse factors of ecosystem but each factor plays its own role in the maintenance of the ecosystem.

### 2.3 Types of Ecosystem

**Natural Ecosystem**

Natural ecosystem is a community of living and non-living organisms, where each component interacts together as a unit through biological, physical and chemical processes. The distinctiveness of natural ecosystems is that they are purely natural and their formations are not influenced by any human intervention. It is solely powered by the solar energy. For example, forest, grassland, an estuary ecosystem. In natural ecosystems genetic diversity is greater and thus they are more stable as compared to the man-made ecosystems. Also the ecological succession would automatically take place in these systems over a period of time.

Natural Ecosystems are of two types: Terrestrial and Aquatic ecosystem.

**Terrestrial Ecosystem**

Terrestrial ecosystems are those ecosystems that are found on the land i.e. the interactions between the living and the non-living parts of an ecosystem takes place on the land masses. Major terrestrial ecosystems are of four following types:

**Forest Ecosystem**

Forests is spread over approximately 30 percent of the world’s land and are those areas which support rich growth of trees. These ecosystems primarily develop in those areas where temperature and rainfall are plentiful to support a tree cover. Depending upon these factors, dense and open forests are grown. Forests can be divided further into following different subgroups:

**Tropical Evergreen Forests:** They are also known as the tropical rainforests. These forests are found near the equator and close to the tropics where the temperature is generally high and rainfall is heavy and continues throughout the year. They are also called Evergreen forests as the trees do not shed their leaves altogether because there is no particular dry season. These ecosystems have
average annual temperature of 25 degree Celsius and average annual rainfall of about 250 cm. Despite receiving almost 12 hours of sunlight every day, less than 2 percent of that sunlight actually reaches the ground. It is because these forests have thick canopy because of which sunrays cannot penetrate the forests even in day times. Thus, growth at ground level is very limited.

The tropical rainforest is the richest biome in the world, containing more species per square mile than any other forest as warm temperature and abundant rainfall can support many plants and animals. The same condition also makes the ecosystem ideal for bacteria and other microorganisms which quickly decomposes matter. Due to heavy rainfall, most of the nutrients in the soil are leached out, rendering the soil acidic.

The largest tropical rainforests are in the Amazon Basin of South America, in Western African countries, as well as South Pacific countries such as Indonesia and the Philippines.

In India, these forests are found in the areas of very high rainfall, generally more than 200 cm and insolation throughout the year. These types of forests are mainly found within rainy slopes of the Western Ghats, plains of West Bengal and Orissa and north-eastern India and include both tropical evergreen forests and tropical semi-evergreen forests. Ebony, mahogany and rosewood are the main trees of these forests. The common animals found in these forests are elephants, monkey, lemur and deer. The one horned rhinoceros are found in the jungles of Assam and West Bengal.

Tropical Deciduous forests: These are also called monsoon forests and are found in those areas where there are alternate wet and dry seasons. Here rainfall is very high but is concentrated in 3-4 months of wet season. “Deciduous” means to fall off, or shed, seasonally. As the leaves are broad in these forests, they tend to lose too much water during the dry season. To overcome this and preserve water, the trees in these forests shed their leaves during the dry season and regain during the start of rainy season. The average annual rainfall is about 100-200 cm. The soil of these forests are very fertile as the soil absorbs the nutrients freed by the decomposition of these leaves.

These forests also have dense canopy in wet season but comparatively lesser than the rainforests. As they are less dense than the rainforests so the sunrays penetrate more as compared to the rainforests and hence the plants close to the ground are more developed. These forests are mainly found in the large part of India, northern Australia and in central America.

In India, these forests are also known as Monsoon forests as they are the most widespread forests in India. These forests are found in the area receiving 70-200 cm of rainfall. These forests can again be classified into two groups based on amount of rainfall.

- **Moist Deciduous**: These are spread in areas receiving 100-200 cm of rainfall. For example: in the northeastern states along the foothills of Himalayas, eastern slopes of the Western Ghats and Odisha. Important species here are Teak, sal, shisham, hurga, mahua, amia, semul, kusum, sandalwood, etc.

- **Dry Deciduous**: These are spread in areas receiving 70-100 cm of rainfall and cover large part of the country. For example: in rainier areas of the Peninsula and the plains of Uttar Pradesh and Bihar. Important species here are Tendu, palas, amaltas, bel, khair, axelwood, etc.

**Temperate Evergreen Forests**: These forests are found in mid-latitudinal coastal region and are commonly found in the eastern margin of the continents. For example, forests in South-eastern parts of USA, Australia, Brazil and China. These forests are characterized by rainfall spread throughout the year and relatively milder winter. These forests receive rainfall in the range of 100 to 175 cm and are dominated by the broadleaved evergreen trees.

They are also called Mixed forest as they comprise both hardwood and softwood tree like eucalyptus, pine etc. Temperate broadleaved evergreen tree leaves are generally thick with smooth margins as opposed to deciduous leaves, which by comparison are generally thin and lobed. These differences are in part due to higher levels of rainfall and humidity. The soils in these forests are highly leached and thus not productive.

**Temperate Deciduous Forests**: These forests are located in the mid-latitude areas with rainfall in the range of 75 to 150 cm, for example, in the eastern part of the United States and Canada, most of Europe and parts of China and Japan. As these forests are exposed to cold air mass from the polar region and warm air masses from the tropical areas, they have four distinct seasons, winter, spring, summer and fall.

These areas have cold winters and wet summers with average annual temperate of 10 degree Celsius. Leaves change color in autumn, fall off in the winter, and grow back in the spring. This adaptation allows plants to survive cold winters. As the winter season is too cold, these trees have thick bark for protection from cold. Animals in these forests also show adaptation to changing seasons, for example, many animals migrate or hibernate in the winter.

In India, these are the montane forests found in the higher reaches of the western Himalayas between 1500-2400 meter altitudes. These forests are dominated by the Oak species which may grow up to 25-30 meter in height. Though, these trees do shed their leaves but not
completely this makes them evergreen species. Epiphytes are also common here as the tree canopy is dense.

**Mediterranean Vegetation:** This vegetation is found on the western and south-western margins of the continents and is characterized by hot dry summers and mild rainy winters. For example, areas around the Mediterranean Sea in Europe, Africa and Asia; South Western South America and South West Australia.

The ecosystem does not get rainfall more than 90 cm annually and goes through four to five months of dry summer season. Due to this climate, the vegetation life found here are mainly shrubs made up of flowering shrubs and some small evergreen trees. To adapt to the period of droughts, plants in this ecosystem have developed long tap roots for searching water and swollen bulbous roots store water away from the hot sun.

**Coniferous Forests:** These forests are found in the higher latitudes (50-70 degree latitudes), for example in the broad belt of Eurasia and North America, Siberia, Scandinavian countries, Alaska, and Canada. These forests are also found in higher altitudes, for example in the Himalayas. The climate in these areas is extreme, with long and severe (up to six months with mean temperatures below freezing) and short summers (50 to 100 frost-free days).

These forests are also called as Taiga (or Boreal Forests) and they represent the largest terrestrial biome. (Taiga means swampy moist forests in Russian language). Due to extreme climatic conditions, the biodiversity is very limited. These forests have Coniferous trees, needle-leaved trees that are usually evergreen and shallow rooted and usually bear cones which are very tolerant to the thin nutrient poor and acidic soils common in the extreme northern latitudes.

These trees adapt to the harsh climate in many ways. The conical shaped leaves let the snow slide off. In winters, the soil is frozen thus to minimize the water loss, the leaves are needle-like, reducing the surface area. The vegetation here is also dark green which helps absorb maximum sunrays during the short growing season.

In India, these are found in higher reaches of Himalayas between 1700 to 3000 meter altitudes. The coniferous trees rise up to 30-35 meter height and have evergreen canopy with needle like leaves which always remains green. The forests have many trees which have great economic value. These trees include pine (Pinus wallichiana) deodar (Cedrus deodara), Cypress (Cyperus torulosa), Spruce (Picea sitchensis) and siver fir etc.

**Grassland Ecosystem**

Grasslands are found in those region which have the ability to support vegetation but not to the extent of supporting big trees. These are the intermediate stage (seral stage) of an ecological succession, culminating finally into forested areas. Grasses are the main dominating species here, though interspersed trees are also found. Classification of Grasslands are as under:

**Tropical Grasslands:** There are regions in the tropical area which do not receive enough rainfall to support extensive tree cover, thus forming grasslands. These grasslands are also known as Savannah. These areas are dry but not as much as the desert areas. Tropical grasslands are found mainly in the Sahel south of the Sahara, in East Africa, and in Australia. The region has two predominantly different seasons: a very long dry season (winter), and a very wet season (summer). Elephants, zebras, giraffes, deer, leopards are common in tropical grasslands.

These areas are though dominated by tall grasses of 3 to 6 feet in height, some drought-resistant, fire-resistant trees are also found. Here fire and drought prevent the proper development of trees. To adapt to these type of climate, both vegetation and animal life show some modifications.

To discourage animals from grazing upon them, the grasses are too sharp or bitter tasting. Animals also have long legs or wings to migrate to other places during dry seasons. Many burrow underground to avoid the heat or raise their young. Trees found here shed their leaves during the dry cold season to prevent loss of water and also have broad trunks to store water to survive during the dry season.

**Temperate Grasslands:** These grasslands are found in the mid latitude region and in the interior parts of the continents where the rainfall is low to moderate. Here the grasses are short but nutritious. These grasslands are known from different names in the different regions of the world, for example pampas in Argentina, downs in Australia, Prairies in Central North America plains, Puszta in Hungary, Steppe in Russia, Veldts in South Africa. The annual precipitation ranges from 25 cm to 75 cm, most of which is in the form of snow, and temperature variation is high as these regions experience hot summer and cold winters.

Grasses in these ecosystems have long deep roots which in turn enriches the soil when they are decomposed. Due to this, soil becomes fertile and many of the grasslands have been converted to farmlands for this reason. The ecosystem has low diversity of wildlife. Major Carnivores include wolves, coyotes, swift foxes, badgers and black-footed ferrets.

**Grasslands of India**

In India, grasslands are found as Village grazing grounds (Gauchar) for cattle as well as extensive low pasture lands in the dry regions of western India. These are also found
in Himalaya above 3600 meter altitude (Alpine Himalaya). As the grasses are the primary producer here, it supports variety of herbivores from minute insects to very large mammals. Rats, mice, rodents, deer, elephant, dog, buffalo, tiger, lion, ferrets are some common mammals of grasslands. They have been discussed below:

**Himalayan Pasture Belt:** Himalayan pasture belt is found up to the snow line, below which it exists with broadleaved forests. Many animals migrate up to higher altitude during the summer season where they can easily survive. Similarly, when the grasslands are covered with snow during the winter, the animals migrate to lower latitudes. Variety of plant life is found in these areas which include grasses and herbs including medicinal plants.

**Terai Belt:** Terai region of northern India runs parallel to the lower ranges of the Himalayas. It stretches from the Yamuna River in the west to the Brahmaputra River in the east. This belt possesses tall elephant grasslands, with grasses growing to a height of about five meters which are interspersed with a Sal forest ecosystem.

**Desert Ecosystem**
Deserts are those regions which receives an extremely low amount of rainfall (less than 25 cm annually) resulting in less vegetation compared to humid areas. They experience a wide range of temperature and climate variation. The Desert ecosystem can again be categorized into two types: Hot deserts and Cold deserts.

**Hot Deserts:** Rainfall in these ecosystems are generally too low (below 25 cm) to support a proper vegetation. The soil is also coarse with good drainage so most of the rain water percolates into the soil. These ecosystems are characterized by a warm season throughout the year with extreme variation in temperature between the night and day. This is due to the fact that these deserts cool down rapidly during the night. Examples of hot deserts include Kalaanari (south-west Africa), Sahara (North Africa), Monte (Argentina) etc.

To survive in these harsh climatic conditions, plants and animals develop different types of adaptations. Many of the plants have long and developed roots system in order to maximize the collection of water during the rainfall and also to search water. These plants are known as xerophytes. Other plants have glossy leaves to reflect more radiant energy. The seeds of annual plants stay dormant until a time when there is adequate rainfall available to support a young plant. In some plants even the stem contains chlorophyll for photosynthesis.

Animals also show great adaptability to these conditions. For example, Critically Endangered African Addax has the ability to fulfill its water needs from the plants that it eats for food. Camel’s store fats in their hump and also have large hoofs that enable them to walk across the sand without sinking in too deep. They are nocturnal in habit to avoid the sun’s heat during day time.

In India, it is found in the Thar region of Rajastahan, extending into some parts of Haryana, Punjab and Gujarat. It has long sandy plains with changing sand-dunes. Though it is one the smallest desert in the world, it has the highest population density for a desert. Since the region has high heat and dryness with shifting sand-dunes, it cannot support life. However, the Indira Gandhi Canal has been instrumental in supporting some vegetation. The main crops of desert are bajra, millet, wheat, barley, maize, jowar, guar etc. As for the animal species, the desert supports many threatened animals including Asiatic lion, wild ass, bats, scaly ant eater, desert fox, Indian gazelle, and four horned antelopes, white browed Bushchat, Great Indian Bustard, Cranes and Sandgrouse.

**Cold deserts or Temperate Deserts:** The cold deserts are mainly found in higher latitude regions or the higher altitude in the tropical areas. Rainfall is scant and thus dry
conditions prevail which may be due to remoteness from the coasts or presence of high mountains separating the desert from the coast. For example, Sierra Nevada (USA), Ladakh (India) and Andes (Argentina) among others. Due to clear skies and sparse vegetation, the radiation heat loss is quick and high. Plant life is scarce due to the harsh conditions. Whatever plant life is there, they survive by shedding their leaves to counter the dry conditions. Many animals dig burrows during the winter seasons including kangaroo rats, kangaroo mice, pocket mice, grasshopper mice etc.

In India, the Cold Desert is situated in the Himalayas and stretches from Ladakh in the north to Kinnaur (in the state of Himachal Pradesh, or H.P) in the south. It is located at a height of 3000 meters in Kargil to 8000 meters in Karakoram. Due to high altitude, the air is very thin and climate is extremely cold. Due to thin air, intensity of sunlight can be felt. As it lies in the rain shadow region of the Greater Himalaya, it receives very low rainfall. Other water resources are minimal and comprise glacier-fed streams. Blizzards, snowstorms and avalanches are common here.

The soil is not very fertile and the climatic conditions allow very short growing seasons making it a bare landscape. Important bird species of the region include Tibetan snowcock, raven, robins etc while the important animal species include wild goat, yak, blue sheep etc.

These ecosystems are found in those areas which have long severe cold winters and very short cool summer. Tundra means "barren land" because it is extremely hard to survive in these conditions. These areas have very low precipitation of less than 25 cm and that takes place in the form of snow. There are two types of Tundra: Arctic and Alpine.

**Arctic Tundra:** As the name suggests, this region is located around close proximity to the arctic circle. A unique characteristic of this tundra is that it's a permafrost region i.e. even the soil is permanently frozen here, except the top layer which thaws in the summer season. During the summer, snow melts and percolates in the upper layer but cannot percolates into the permanently frozen soil. Thus the top layers is saturated with water. Also, this region receive very low amount of sunlight during the whole year.

As it is very hard to survive here, most of the birds and animals only live here in the summer time. Those animals that live for whole year, have shown adaptation to the climate. For example, the brown beer only wakes up to eat in the summer time and spends the whole winter hibernating to conserve energy. Musk Ox has two layers of fur. Air is trapped between the furs and gets warm by the body heat which insulate the body from the harsh cold.

Plants need sunlight and water to survive. Only during the short summer season, little bit of sunlight is available so, the plants grow during this period. They don't have long roots as permafrost soil do not allow the roots to pass through. Some of the plants found here are mosses, lichens, low-growing shrubs, and grasses, but no trees can be seen here.

**Alpine Tundra:** These are found at high mountains above the tree line at all latitudes. It does not contain trees as it is too cold and windy to support any tree system. The average elevation where alpine tundra occurs is generally higher near the equator than at the poles due to the earth's bulge at the equator. These types of forest can be seen in Himalayas, Rocky Mountains in the USA and the Alps in Europe.

Again, due to harsh conditions, very few animals are found here. Animals have adapted to these conditions in many ways, for example Yellow bellied marmots that live in Colorado will hibernate for as many as 8 months out of the year. Other animals, who don't hibernate, hide from the weather under rocks in the boulder fields.

Similarly, though plant life is scarce, plants have also shown adaptability. Most plants are long-lived perennial plants. They don't grow stems, leaves, flowers and fruit each season. These plants are also matted against the earth for protection against the heavy winds.
In India, these forests are found in the highest reaches of Himalayas above 3600 meters of altitudes. As we move up the mountain, the conditions become harsher for tree growth and thus the plant show stunted growth. Important trees of this forests include silver fir, pine, juniper and birch. Higher up the reaches, alpine grasslands are found as the condition is not suitable for tree growth. The vegetation like lichen and mosses are also found in high altitudinal regions.

**Other Ecosystems found in India**

**Mountain Ecosystem**

Himalayan mountain system is an important feature of Indian subcontinent as it plays an important role in imparting the region a distinct identity as they are not only the physical barrier, they are also a climatic, drainage and cultural divide. However, there are large-scale regional variations within the mountain system and for this reason, the mountain system can be divided into various subdivisions based on relief, alignment of ranges and other factors. The Himalayas support many diverse systems leading to extremely rich in biodiversity which include forests, grasslands, marshes, swamps, lake streams and rivers.

**Ghats Ecosystem**

The Ghats of India are the two mountain ranges on the eastern and western edges of the Deccan Plateau. They have been classified into Western Ghats and Eastern Ghats.

**Western Ghats:** These hill ranges continuously from the Tapti river in the north to Kanyakumari in the south. They run parallel to the west coast of India and are also known as Sahyadri. These areas receive orographic rainfall of about 100-500 cm from the Arabian sea branch of the southwest monsoon. The western Ghats is very important for the peninsular rivers as it act as a source of most of the rivers flowing in this region. Coupled with warm atmosphere throughout the year, these areas support great wealth of biodiversity and thus counted among the 36 biodiversity hotspots of the world.

The region hosts the country’s largest population of Asian elephants (Elephas maximus) as well as Bengal tigers (Panthera tigris tigris), lion-tailed macaques (Macaca silenus), sloth bears (Ursus ursinus), nilgiri tahr (Hemitragus hylocrius) and much more.

**Eastern Ghats:** These ranges run parallel to the east coast and are a series of discontinuous hill ranges as many great rivers cut across it including the Mahanadi, Godavari and Krishna rivers. They receive 60-160 cm of rainfall. The ghats lies in tropical climate. The climate here varies from semi-arid to semi-humid and accordingly, the vegetation ranges from evergreen trees to dry savannas. This is the only region in India which boasts dry evergreen forests in India.

The Papikonda National Park which lies in the northern section of the eastern ghats, north of the Godavari River, has moist deciduous and semi-evergreen forests. Important fauna here includes the Golden Gecko, Jeypore Ground Gecko, tiger, leopard, sloth bear, wild dog, smooth coated otter, leopard cat, sambar, chital, and the four-horned antelope.

The region is rich in biodiversity and particularly famous for variety of medicinal plants including Acorus Calamus, Aegle Marmelos and Costus Speciosus etc.

**Aquatic Ecosystems**

An aquatic ecosystem is that ecosystem where interactions among the different organisms and its environment takes place in water bodies. These ecosystems can again be classified in two categories based on their salinity levels: (a) Freshwater ecosystem (b) Marine ecosystems.

**Freshwater Ecosystem**

Freshwater ecosystem is defined as the aquatic ecosystem having salt concentration usually less than 1% and is continuously cycling. For example, pond ecosystem, lake ecosystem and river ecosystem. Only 0.8 percent of earth’s surface is covered by the freshwater ecosystem. Diurnal and seasonal variations of temperature is regulated here. For example, in tropical lakes, surface temperature never
goes below 4°C, in temperate fresh waters, never goes above or below 4°C and in polar lakes never above 4°C.

Based on the mobility of water in these ecosystems, the freshwater ecosystem can again be categorized into Lotic and Lentic freshwater ecosystem.

**Lentic Freshwater Ecosystem**: These are the systems where the water is stagnant and has no exit. These are generally formed in a depression on earth’s surface where water from other sources accumulates. Lentic systems, therefore, are closed systems. These ecosystems experience stratification as the water is stagnant. Thus there are two distinct layers: above layer close to surface is generally warmer, due to direct sunlight, and the layer close to the bed is cooler. Apart from the light oxygen also acts a limiting factor in the plant production and the dependent species.

**Lotic Freshwater Ecosystem**: These ecosystems are characterized by rapid unidirectional flow of water. For example, rivers and streams, springs, mountain brooks etc. These ecosystems serve the function of transferring the surplus rainwater back to the ocean.

As compared to the lentic ecosystem, the plant diversity is low as the moving water poses a survival threat to plants, especially the big ones. But many plants have shown adaptation like having long stems with their roots firmly attached in the river bed. Others on the other hand have their leaves floating on the water surface.

The animals, which include protozoans and some freshwater sponges, gets attached to mass of a plant or the water bank surface. For food, they have branching out tentacles, trapping microscopic organisms (planktons). Some of the animals also have flattened body to reduce the friction due to moving water.

Freshwater ecosystems can also be classified into lakes, flood ponds and rivers.

**Lakes**: A body of water is considered a lake when it is inland, not part of the ocean large and deeper than a pond. It is an area of variable size filled with water, localized in a basin which is surrounded by land, apart from any river or other outlet that serves to feed or drain the lake. Natural lakes on the earth are generally found in mountainous areas, rift zones and areas with ongoing or recent glaciations. Other lakes are found in endorheic basins or along the course of rivers. As far as these lakes are concerned they are both natural and man-made. Main producers in the lake are the algae which, in turn, is eaten by microscopic animals. In the lake, there are species of fish which are dependent on algae also. Important lakes of India include Sultanpur lake, Bardhal Lake, etc.

**Flood Ponds**: Most of the ponds are filled up during the rainy season only and are dried up in other seasons. In its dry phase, many life forms such as the algae and microscopic animals, aquatic insects, snails, and worms etc remain dormant and become active in the monsoon season. Gradually crabs, frogs and fishes also return. Main vegetation here include floating weeds and rooted vegetation. When the pond ecosystem is fully established, large number of food webs are formed. Algae is the main producer, which is eaten by microscopic animals and so on. Bank of large rivers have numerous flood ponds.

**Rivers**: These are the flowing water bodies on land surfaces, carrying surplus water of rain to discharge into an ocean. For example, river Yamuna, Ganga and Tapti, Krishna, Kaveri, Narmada etc. Different organisms adapt differently to different rate of flows of the river. For example, many plants and animals develop the ability to withstand the rapid flow, for example snails and other burrowing animals. Others adapt by living in the region where flow of water is not rapid, for example water beetles and skaters. Some species of fish, such as Mahseer, go upstream from rivers to hill streams for breeding as they need crystal clear water to be able to breed. They lay eggs only in clear water so that their young ones can grow successfully.

**Marine Ecosystem**

These ecosystems cover around 71 percent of the earth’s surface. They include: oceans, estuaries, lagoons, mangroves and coral reefs, the deep sea and the sea floor. Marine ecosystem have high concentration of salts. Salinity of an open sea is 3.6 % which is more of less constant.
As we move from coastal area to the ocean, the depth of water increases and thus different types of ecosystems develop. The producers in this ecosystem vary from microscopic algae to large seaweeds. There are millions of zooplankton and a large variety of invertebrates on which live fish, turtles and marine mammals. Also, range of temperature variation is less in the seas as compared to on the land.

Factors Affecting Marine Ecosystem

The organisms in marine ecosystems are not evenly distributed and depend on many factors including the availability of light, water depth, proximity to land, and topographic complexity.

Availability of Light: Oceans are divided into many zones. Photic zone is the illuminated zone which can again be divided into euphotic and dysphotic zones. While Euphotic zone is near the surface and has enough sunlight for photosynthesis, Dysphotic zone is poorly illuminated that rates of respiration exceed those of photosynthesis. For this reason, marine organisms are highly abundant in the photic zone, especially in the euphotic zone.

Proximity to Land: Areas close to the lands are rich in nutrients brought about by many rivers. This is the reason maximum diversity of marine organisms is found in the tidal zone that is near the shore.

Depth of Water: It plays a significant role as the pressure increases with the depth. Thus, organisms at great depths show adaptation to this increased pressure. Some marine organisms such as sperm whales and certain seals can dive to the great depths and swim back to the surface without difficulty.

The organisms also show a great level of adaptability to survive and grow in the marine ecosystem. Marine organisms are especially tolerant to high concentration of salts. The swimming animals have their body flattened to reduce the friction with water. Also, deep sea forms show bioluminescence (they emit light).

Types of Marine Ecosystem

Open Marine Ecosystems: Open Marine Ecosystem includes types of sea life that float or swim, such as algae, plankton, jellyfish and whales. Many creatures living in the open ocean inhabit the upper layer of the ocean where the sun’s rays penetrate. This is known as the euphotic zone and extends to a depth of about 150 meters.

Ocean Floor Ecosystems: Marine life not only exists in the open ocean waters, but on its floor as well. Species that live in this ecosystem include certain types of fish, crustaceans, clams, oysters, worms, urchins, seaweed and smaller organisms. In the shallow water, sunlight can penetrate to the bottom. However, at greater depths, sunlight cannot penetrate, and organisms inhabiting this deep water rely on the sinking of organic matter above for survival. Many such organisms are small and generate their own light to find or attract food sources. Another challenge in the ocean floor ecosystem is pressure. Many deep sea animals have soft bodies so that they aren’t crushed under the high pressure that is found at extreme depths. Examples of ocean floor ecosystem includes invertebrates such as crabs, jellyfish, squids, corals, sperm whales, etc.

Estuaries: Estuaries are the meeting place of river carrying freshwater and silt load with the saline water of the oceans. It represents an ecotone, a transition zone, between the freshwater ecosystem and the marine ecosystem. Here the salinity varies as we move towards the ocean.

These ecosystems are highly dynamic as the river is continuously bringing the load with it and the amount of load is also varying. Examples of estuaries are coastal bays, tidal marshes, lagoons and deltas.

As it is continuously replenished by the sediments brought by the freshwater sources and also from the ocean, they tend to have very high level of nutrition which in turn supports very high diversity of organisms. This biodiversity is generally higher than both the freshwater and marine water ecosystem as it has characteristics of both the ecosystems. In general, the phytoplankton of estuaries are diatoms, dinoflagellates, green algae, blue-green algae. Towards the sea coast of the estuaries there are large algae and sea grasses. Near the mouth of the rivers and deltas there are mangrove forests.

Threats: These ecosystems are under grave threat due to variety of reasons which include population growth in the coastal areas thus changing the land use pattern and putting excessive burden on the ecosystem, polluted runoff from human activities like waste from industries and urban centers, construction of dams blocking upstream and downstream passage for migrating fish, isolating them from vital spawning and feeding areas, global warming leading to submergence of coastal areas among others.

Mangroves: Mangrove trees are salt-tolerant plant species with roots that dangle into the water. Forests of these plants provide shelter for a variety of marine life and are important nursery areas for young marine animals. These ecosystems are generally found in warmer areas between the latitudes of 32 degrees north and 38 degrees south.

They are a very productive ecosystem and highly rich in biodiversity. Mangrove forests are home to a large variety of fish, reptiles such as sea turtles, land turtles, alligators, crocodiles, caimans, snakes, and lizards and invertebrates such as crabs, shrimp, oysters, tunicates, sponges, snails, and insects.
Mangroves are type of tree species that grow in intertidal salty environments near the mouths of the delta of rivers along the coasts because they can tolerate frequent flooding and are able to obtain fresh water from rivers and also the nutrients required from salt water. The dense root systems of mangrove forests trap sediments flowing down rivers and off the land. This helps stabilizes the coastline and prevents erosion from waves and storms. In areas where mangroves have been cleared, coastal damage from hurricanes and typhoons is much more severe.

These forests are one of the best example of ecotone as they are basically a transition zone between the terrestrial ecosystem and marine ecosystem. These forests grow in sheltered low lying coasts, estuaries, mudflats, tidal creeks, backwaters marshes and lagoons of tropical and subtropical regions.

Since the salinity is very high, the mangroves are adapted to the condition. They can secrete salt from their leaves to balance the salt intake. Also, as they regularly experience tidal waves, they have grown resistant to it. Similarly, the trees have developed roots bearing pneumatophore (or aerial roots) as the mangrove mud is rather anaerobic. These forests have also become quite resistant to high temperature.

Some of the best mangroves in the world occur in the alluvial deltas of Ganga, Godavari, Krishna, Kaveri and in the islands of Andaman and Nicobar. This mangrove vegetation all along Indian coastline in sheltered estuary, tidal creeks, back waters, salt marshes.

<table>
<thead>
<tr>
<th>State/Union Territories</th>
<th>Mangrove Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Bengal</td>
<td>Sunderbans</td>
</tr>
<tr>
<td>Orissa</td>
<td>Bhitarkanika, Mahani, Subarnarekha, Devi, Chilka, Dhamra, Mangrove Genetic Resources Centre</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>Coringa, East Godavari, Krishna</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>Pichavaram, Muthupet, Ramnad, Pulicat, Kazhuveli</td>
</tr>
<tr>
<td>Andaman and Nicobar</td>
<td>North Andamans, Nicobar</td>
</tr>
<tr>
<td>Kerala</td>
<td>Vembnad, Kannur (Northern Kerala)</td>
</tr>
<tr>
<td>Karnataka</td>
<td>Coondapur, Dakshin Kannada/Honnnavar, Karwar, Manglore Forest Division</td>
</tr>
<tr>
<td>Goa</td>
<td>Goa</td>
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<tr>
<td>Maharashtra</td>
<td>Achr-Ratnagiri, Devgarh-Vijay Durg, Veldur, Kundalaka-Revdanda, Mumbra-Diva, Vikrol, Shreevardenh, Vaitarna, Vasai-Manori, Malvan</td>
</tr>
<tr>
<td>Gujarat</td>
<td>Gulf of Kutchh, Gulf of Khambhat, Dumas-Uphrat</td>
</tr>
</tbody>
</table>

Threats: Mangroves are under threat from both natural as well as anthropogenic factors so much so that, in India, more than 50 percent of Mangroves have been lost during the last forty years. Natural calamities like tsunamis and cyclones have been causing a lot of damage.

Anthropogenic factors include clearing of mangrove forests for agricultural purposes, human settlements and infrastructure (such as harbors), and industrial areas. Mangroves trees are in demand for wood and fodder. The overharvesting of the trees has led to decline of the forests.

Due to construction of dams the salinity of the mangrove area has increased to a very high level which the trees cannot adapt to. Also blocking of the river water has also dried out the area. Also, the pollution from agricultural fields and industries including fertilizers, pesticides, and other chemicals carried by river systems can kill the animals living in the mangrove forests. Oil pollution can also suffocate the trees.

Mangrove forests also need stable sea level to survive but global warming and climate change has led to change in the sea level which disturbs the delicate balance and thus threatens the ecosystem.

Coral Reefs: Coral reefs are one of the most biologically diverse ecosystems on earth, rivaled only by tropical rain forests. They are made up not only of hard and soft corals, but also sponges, crustaceans, mollusks, fish, sea turtles, sharks, dolphins and much more. Competition for resources such as food, space and sunlight are some of the primary factors in determining the abundances
and diversity of organisms on a reef. Each component of a coral reef is dependent upon and interconnected with countless other plants, animals and organisms. This means that fluctuations in the abundance of one species can drastically alter both the diversity and abundances of others. While natural causes such as hurricanes and other large storm events can be the stimulus for such alterations, it is more commonly anthropological forces that effect these types of shifts in the ecosystem.

These ecosystems are extremely rich in the biodiversity as they support more species per unit area than any other marine environment. The ecosystem is important for finding new medicines also as many drugs have already been developed from the system as a possible cure for cancer, arthritis, human bacterial infections, viruses, and other diseases.

Coral reefs also act as buffer protecting the shoreline from wave action and reduces the intensity of cyclones and tsunamis. The reefs have high economic values as they are a rich source of fishes and also a growing tourists' sites which provides employment to locals.

Mangrove forests and seagrass beds are two of the most important facets of the greater coral reef ecosystem. Mangroves are salt-tolerant trees that grow along tropical and sub-tropical coasts. Their complex root systems help stabilize the shore line, while filtering pollutants and producing nutrients. Their submerged roots and detritus provide nursery, breeding, and feeding grounds for invertebrates, fish, birds, and other marine life. Many of the animals raised in mangroves migrate to coral reefs for food, spawning and habitat.

Seagrasses are flowering plants that often form meadows between mangrove habitats and coral reefs. They form the foundation of many food webs, providing nutrients for everything from sea urchins and snails to sea turtles and manatees. Seagrass also provides protection and shelter for commercially valuable species such as stone crabs, snappers and lobsters. Additionally, they filter the water column, prevent seabed erosion, and release oxygen essential for most marine life.

The ecosystem services of mangroves and seagrass are vital to the long term health of coral reefs.

Many species are found on coral reefs. These includes invertebrates like crabs, shrimp, lobsters, anemones, worms, bryozoans, sea stars, urchins, nudibranchs, octopus, squid, and snails in addition to hundreds of species of coral. Many vertebrates are also found including a wide variety of fish, sea turtles, and marine mammals such as seals and dolphins.

In India, the coral reefs, especially around shallow areas of Kutch and Andaman and Nicobar island, are very rich in biodiversity. Many species including Fish, crustacea, starfish, jellyfish and the polyps that deposit the coral are a few of the thousands of species that form this incredible world under the shallow sea.

Threats: Of the total coral reefs of the world, one-fourth has already been destroyed beyond repair due to many factors. Corals survive in a very narrow range of temperature. Global warming has lead to increased temperature and consequent coral bleaching.

Fishing methods including cyanide fishing, blast or dynamite fishing and bottom trawling etc have been posing a threat to the ecosystem. Whereas the overfishing in the coral reef area have disturbed the ecological balance, disrupting the food chain.

Pollutants, nutrients and litter enter near shore waters through rivers, streams, underground seepage, waste water and storm water runoff. Even areas hundreds of miles from the coast can affect the clarity and quality of water flowing to the reef. It does not matter how far removed a pollutant may seem, it all flows down stream and it can all impact our marine environment and our reefs.

Tourism with scant regard to the coral reef, which include careless boating, and recreational activities with people touching reefs, stirring up sediment, collecting coral, and dropping anchors on reefs, have led to destruction of the ecosystem.
Urban and industrial waste carried by the rivers have been poisoning the reefs. Also the sediments carried by the rivers muddies the water. This cuts off the algae from the sunlight and thus killing it.

**Human Modified Ecosystems**

Over the period of time, Human beings have modified and changed the natural ecosystem in response to increasing human population, increasing human needs and changing life styles. These ecosystems differ from the natural ecosystems as Human modified ones may or may not depend on the solar energy for survival, growth and stability. For example, in an industry energy is provided in the form of fossil fuel or electricity.

These ecosystems are highly simplified as they are established for a definite purpose. The species diversity is also very low, as the aim is to maximize certain output which leads to providing importance to one component and ignorance of non-essential components of the ecosystems. Due to low diversity, the food chain is also very simple and small. As these systems are very simple and have low diversity, they are susceptible to epidemic disease and are highly unstable for this reason. The important ones include:

**Agro-ecosystems**

An ecosystems designed for agricultural use is called Agro-ecosystems. These are practiced mainly in areas endowed with good quality of soil. Here Commercial Crop plants are sown and harvested by humans for economic purposes. For this reason, they are also known as the Crop-ecosystems where mostly monoculture is practiced.

As mainly monoculture is practiced so they are highly simplified with the species diversity at its lowest. They need human interventions in the form of applications of irrigation, pest control etc for survival and growth. In the areas with poor quality of soil, fertilizers are also applied to supplement for nutrients deficiency in the soil. Pest control is needed because the monoculture makes this system susceptible to epidemics.

**Economic Importance**

The main aim of this ecosystem is to achieve food security for human beings thus producing food, fruits, edible oils etc. With concentrated efforts on a focused area, Good quality grains can be produced with high yield. At the same time, this ecosystem has been providing livelihood to a large number of population since ancient times. Even today, around 60 percent of Indian population is engaged in this practice.

This also enables a country to export the surplus food stocks to other countries thus earning the foreign exchange. For example, India exports excess food and agricultural products which includes jute, tea, tobacco, coffee, spices, and sugar.

It also provides the raw material for agro-based industries where these inputs are processed and value-addition is done. For example, packaged and processed food items. These industries also employ a significant share of workforce previously engaged in the agriculture sector thus reducing the disguised employment and improving productivity of the workforce.

**Disadvantages of Agro-ecosystem**

The agro-ecosystems have many pronounced disadvantages which include severe loss of native biodiversity as the large scale monoculture is practiced. High yield varieties of crop plants are important for food security but they tend to be more susceptible to disease e.g. smut of sugarcane, maize and sorghum and rust of wheat and bajra are common plants diseases. To overcome this issue, large scale use of pesticides and chemicals is required which is not only costly but also pollute the environment.

Chemical fertilizers are even more harmful as they can become air pollutants and may lead to destruction of ozone layer and contribute to global warming. Fertilizers can also be washed away to other ecosystems and interfere with their stability for example, eutrophication of lakes ecosystems.

Other issues include loss of soil fertility, depletion of nutrient reserves, salinization and alkalization, pollution of water systems, loss of fertile croplands to urban development etc. At the same time, excessive use of groundwater has depleted the water table and created water scarcity. In many areas, excessive reliance on water-intensive crops, even in areas with scarce water resources, has led to over-exploitation of available water resources and created drought like conditions.

**Plantation Forests**

Plantation forests are the man-made ecosystems, a type of managed ecosystems in which the trees of a particular species are planted on barren land, private land, village panchayat land, roadsides, canal banks, along with railway line and on land not suitable for agriculture.

**Characteristics**

Here the trees are of approximately the same age and are planted uniformly to maximize the space of the site. In this ecosystem, fast growing trees are preferred which have high commercial value. For example, plantations of Jatropha curcas have become very popular for obtaining biodiesel. These forests are again monoculture for example oil palm plantation, rubber plantation, coffee plantation. Due to
this reason, the biodiversity is very low and thus require constant human care and management.

**Economic Importance**

Plantation forests have high economic value as they are raised for fruits, oil, rubber, coffee, timber, fire wood, pulp wood for making rayon and paper industries. In doing so, these forests provide alternative employment opportunity to many. They help better utilize the wasteland and thus make them more productive. These forests are also a source of higher net income in a short period of time as the fast growing trees are preferred. These forests also have aesthetic value and make the environment in big cities more habitable. These can also function as a wind breaks or shelter breaks apart from control soil erosion and thus increasing soil fertility.

**Dams and Reservoirs**

A reservoir is mainly a man-made water body formed by construction of a dam, a barrier constructed to stop or restrict the flow of water and a reservoir. They are created for many purposes. Irrigation is by far the most common purpose of dams. Other purposes include production of electricity (hydroelectric generation), water supply, flood control, recreation, navigation and fish farming.

**Advantages**

Dams and reservoirs are very useful to mankind. These can be used for controlling the flood by temporarily storing the flood volume and releasing it later. For this, an Integrated water management is needed which include lowering of the reservoir level to create more storage before the rainy season.

Irrigation continues to be the main purpose of dams. In areas where the rainfall is concentrated in 3-4 months, water storage becomes necessary, especially in countries like India where still 40 percent of area is not covered by irrigation facility. Thus with increasing population and consequent demand for food, more areas must be included under irrigation and that is where the advantage of dams lie.

When it comes to renewable energy, dams are the largest renewable energy source world over as more than 90 percent of the world’s renewable energy comes from dams. This system also has the unique ability to quickly respond to peak demands. During the nights, when the energy demand is low, the energy created is used to pump the water back to high reservoir. This water can again be used during the peak demand.

This system is also crucial for meeting the water demands of people. Rainfall is generally concentrated in a season and most of it falls on the sea. A big portion of rainfall falling on the land ends up as a runoff. Thus dams are created to store the water to consistently fulfil the demand of the mankind.

The system can be used for inland navigation. It is highly economical as compared to railway and highway transport. It is also less energy intensive and thus more environment friendly. Added advantage is avoiding traffic congestion which is more frequent in road transports.

**Disadvantages**

Dam basically blocks the flow of water thus if there are organism dependent of the flow of water to reproduce or as a part of their life cycle would be put in danger. For example, the migratory fishes are unable to mate in these condition and their population decline. The dam wall itself blocks fish migrations, which in some cases and with some species completely separate spawning habitats from rearing habitats.

Another impact is the transformation of free flowing river ecosystem to artificial reservoir habitat. Changes in temperature, chemical composition, dissolved oxygen levels and the physical properties of a reservoir are often not suitable to the aquatic plants and animals that evolved with a given river system.

Also the flowing water carries loads with it which is rich in nutrients and thus very important for soil fertility. Due to construction of dams, the downstream areas are deprived of these nutrients which ultimately results into loss of soil fertility and consequent loss in productivity.

Building a large dam also leads to altering the natural water table of the region, especially the downstream areas.

Construction of dams require very high initial capital and has long period of return. This puts a severe strain on a country’s capability. Also, it requires periodic management as the silt tends to build up over the period of time which reduces dam’s effectiveness. This maintenance is again very costly.

Construction of dams can submerge a large area which can not only displace lakhs of native people but also destroy the biodiversity of the region. Rehabilitation of displaced people has become a big issue. For example, Jaj towards agra on Narmada river by people in Madhya Pradesh who were displaced due to the construction of Omkareshwar dam.

Large dams put pressure on the region which can lead to earthquake. For example, Hoover dam in USA triggered a series of earthquakes.

**Aquaculture**

Aquaculture is an industrial process of raising aquatic organisms up to final commercial production within properly partitioned aquatic areas, controlling the
environmental factors and administering the life history of the organism positively. It is primarily done for cultivating certain commercially important edible species of fresh and marine water fishes, molluscs, crustaceans and aquatic plants etc. Other purposes include affordable source of protein rich diet, recreational values, aesthetic values etc.

Fisheries and aquaculture differ when it comes to method as fisheries include extraction of food from the sea and the freshwater whereas aquaculture stands for rearing of aquatic organism in artificially made water bodies.

**Types of Aquaculture**

**Fish Farming:** It is cultivation of fish in a controlled environment often a coastal or inland pond, lake, reservoir or rice field (paddy) and harvesting when they reach the desired size.

**Fish Ranching:** It is a form of aquaculture in which a population of a fish species (such as salmon) is held in captivity for the first stage of their lives, then released, and later harvested as adults when they return from the sea to their freshwater birthplace to spawn. Adults are harvested when they return for spawning to the lagoons (for laying eggs) e.g. Salmon and Hilsa, which migrate to rivers to spawn, are cultivated by fish ranching method.

**Merits**

Aquaculture has the potential to meet the growing demand of seafood and reducing the pressure on fisheries. This would help in sustainable practice of fisheries. It is also ecologically highly efficient as only 2 kg of grains are required to add 1 kg of live weight.

As the practice is done in a controlled environment so selective breeding combined with genetic engineering can lead to improved quality of fish production and thus improving the nutritional health of people.

Aquaculture is highly profitable as high yield can be achieved in a small volume of water while maintaining the good quality. At the same time, the sector has very high potential to provide employment opportunities in food processing industries.

Natural fisheries have certain limitation as number of fishes dwindles with the season thus as an alternative, aquaculture can ensure consistent and large quantities of seafood. The added benefit is that the aquaculture has impact on the environment but it is only temporary and local in nature.

**Demerits**

Large input of feed: they require large input of feed, water and land. The inputs like fish feeds and wastes, chemicals and antibiotics, when released, can pollute water system affecting the ecosystem. It can even destroy Mangrove forests and other coastal other coastal vegetation when the waste water is released in the Mangrove’s occupied coastal areas.

Destruction of native aquatic biodiversity: As they are replaced by monoculture practice of economically more valuable fishes, it can lead to destruction of aquatic biodiversity.

Introduction of invasive species: The practice can introduce many invasive species of aquatic organisms which would alter the biodiversity profile of the area in a longer run, drastically affecting all other connected ecosystems. The Janitor fish, for one, is considered a threat to other freshwater species since they breed faster and compete with other fishes for food.

Contamination of Water Bodies: The aquaculture waste water may contaminate the water bodies and can lead to serious health issue if used for drinking purposes, especially in poorly monitored areas. It may even contaminate the water system and enter the homes for serious health consequences.

Use of Antibiotics and artificial supplements: It is also argued that fish producers tend to use antibiotics and artificial supplements. These chemicals can contaminate the fishes, affecting the people who buy these fishes. In aquaculture ponds, high population density is maintained that makes them highly vulnerable to diseases leading to total collapse of the crop.

**Fisheries and Aquaculture in India**

Indian fisheries and aquaculture is an important sector of food production, providing nutritional security to the food basket, contributing to the agricultural exports and engaging about fourteen million people in different activities. Indian fisheries and aquaculture accounts for about 6.3 percent of the global fish production, contributing to 1.1 percent of the country’s GDP and 5.5 percent of the Agricultural GDP.

With a coastline of over 7500 km, 3 million hectares of reservoirs and 1.2 million hectares of brackish water India has immense marine resource. Marine resources include the Arabian Sea, the Bay of Bengal, Indian Ocean, numerous gulfs, coral reefs, mangroves and brackish waters like lagoons and Chilika lakes in Orissa. India’s inland water resources include numerous rivers, canals, ponds, lakes and irrigation channels where culture fishery can be practiced.

Important cultivated fishes include various species of carps (Labeo, rohita, Catla catla) Chinese carp, green carp, mirror carps, cat fish etc. Tilapia, trouts, salmons and some more species of fishes are cultured in net pens. Milk fish and mullets are cultured in enclosures or bamboo
Ecosystem

Urban and Industrial Ecosystem

The urban life is a life in a city where many people live together and have a better health, educational and employment, among others, opportunities as compared to other regions. Presently we are going through urban revolution where people all over the world moving to cities and towns. In the year 1800, only 5 percent of the world population was urban-dwelling (50 million people) and in 1985 it increased to 2 billion. At present 45% of the world population is urban population and by 2030 there will be more than 60% people living in cities.

Urbanization and Industrialization support each other and thus in today's world, with the urban revolution Industrialization is also booming all over the world. The industrial processes involve mining, manufacturing, metallurgical processing, welding, grinding and synthesis of chemicals.

Characteristics

The main driving force of urbanization is the ability to provide better employment opportunities, better educational facilities and better health and medical facilities including specialized health care facilities etc.

Urban ecosystem is characterized by very high population density as compared to other regions which inevitably lead to highly congested roads. In the absence of proper planning, urbanization creates shortage of housing and thus leads to growth of slum areas.

Though the urban area has high population living and surviving, it cannot meet the demands of all on its own. Thus it imports increasing quantity of energy, food and various other materials from outside to survive.

This increased population also leads to generation of high volume of solid and liquid waste. The air quality is also poor due to high volume of traffic and other activities like house construction etc.

Advantages

There are multiple advantages of urban ecosystems.

Most important is the ability to provide diverse employment opportunities to a large number of people. These opportunities include both high and low salaried jobs.

These areas are economically highly developed and have many facilities including market, transport, banking etc which in turn attracts many industries. Over the period of time, the urban area is transformed into an industrial Hub, driving the economy of the nation.

As these areas have elaborate health care facilities the infant mortality and mother mortality rate is reduced significantly.

Also, as the urban area sustains people from diverse backgrounds, it creates a multicultural social environment which is an added benefit as it strengthens the unity of the nation.

Disadvantages

Sustainability: The most important issue of an urban ecosystem is the sustainability. Due to very high population density slum areas grows as poor people cannot afford to buy costly houses and also because there is scarcity of land. This leads to plethora of problems attached with the growth of slum areas which include poor hygiene, open defecation as sanitation facilities are not made available etc. For example, Dharavi slum area of Mumbai.

Disproportionate use of natural resources: Urban areas also consume disproportionate volume of resources to meet the demand of the people and in turn produces very high volume of solid and liquid waste. When the waste is not properly processed, it may create environmental pollution which includes air pollution by release of harmful gases and contamination of ground water resources. The urban and Industrial Ecosystem also suffers from high noise pollution which is caused by Industries and high volume of traffic which creates different health issues.

Land use and habitat destruction: To cater to the needs and greed of human beings, large tracts of land has been mined which fell primarily in the forested areas. This has destroyed the habitats of wild animals as also negatively interfering with these ecosystems. Industrial processes and traffic has also created the noise and thermal pollution which is seriously affecting growth and reproduction of wild species of plants and animals resulting in loss of biodiversity.

Human Health: Due to degradation of environment and pollution, many harmful chemicals have found their way into our bodies which has led to incidence of cancer, genetic mutations and damage to nervous, immune and hormonal systems. New disease such as AIDS, mad cow diseases, bird flu and swine flu have emerged in fast succession due to growing damage to ecology.

- Increased sensitivity to diseases: Cultivated species of plants, fishes and other domesticated animals have become increasingly sensitive to pest and diseases.
- Genetic Resistance: An increased use of insecticides, pesticides and antibiotics has speeded up directional natural selection and caused genetic resistance in the pathogens.
• **Effect on native populations:** Introduction of new alien species or non-native species reduces the population growth of native species.

• **Stress due to over harvesting:** Overgrazing by livestock results in soil erosion and loss of productivity. Similarly, over harvesting of edible fishes reduces population and may become completely extinct if the over fishing continues for long.

• **Effect on nutrient recycling:** Use of fertilizers in agricultural fields interferes with the natural biogeochemical cycles.

### 2.4 Functions of Ecosystem

The ecosystem has some functional properties which keep all the components interlinked and running together. The components of the ecosystem are seen to function as a unit when the below-mentioned aspects are considered:

- Productivity
- Decomposition
- Energy Flow
- Nutrient Cycling

#### Productivity

Solar Energy is necessary for any ecosystem to function. Primary production is defined as the amount of biomass or organic matter produced per unit area over a time-period by plants during photosynthesis. The rate of biomass production is called productivity.

Gross primary productivity of an ecosystem is the rate of production of organic matter during photosynthesis. A considerable amount of GPP is utilised by plants in respiration. Gross primary productivity minus respiration losses (R), is the net primary productivity (NPP).

Net primary productivity is the available biomass for the consumption to heterotrophs (herbivores and decomposers). Consumers define secondary productivity as the rate of formation of new organic matter.

Primary productivity depends on the plant species inhabiting a particular area. It also depends on a variety of environmental factors including availability of nutrients and photosynthetic capacity of plants. Therefore, it varies in different types of ecosystems. The annual net primary productivity of the whole biosphere is approximately 170 billion tons (dry weight) of organic matter. Of this, despite occupying about 70 per cent of the surface, the productivity of the oceans are only 55 billion tons. Rest of course, is on land.

#### Decomposition

Earthworms help in the breakdown of complex organic matter as well as in loosening of the soil. Similarly, decomposers break down complex organic matter into inorganic substances like carbon dioxide, water and nutrients. The process is called decomposition. Dead plant remains such as leaves, bark, flowers and dead remains of animals, including faecal matter, constitute detritus, which is the raw material for decomposition.

[Diagram showing the decomposition cycle in a terrestrial ecosystem]

The significant steps in the process of decomposition are fragmentation, leaching, catabolism, humification and mineralisation. Detritivores (e.g., earthworm) break down detritus into smaller particles. This process is called fragmentation. By the process of leaching, water-soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts. Bacterial and fungal enzymes degrade detritus into simpler inorganic substances. This process is called as catabolism.

Humification and mineralisation occur during decomposition in the soil. It leads to accumulation of a dark coloured amorphous substance called humus that is highly resistant to microbial action and undergoes decomposition at an extremely slow rate. Being colloidal in nature, it serves as a reservoir of nutrients. Some microbes further degrade the humus and release of inorganic nutrients occur by the process known as mineralisation. Decomposition is largely an oxygen-requiring process.

The rate of decomposition is controlled by chemical composition of detritus and climatic factors. In a particular climatic condition, decomposition rate is slower if detritus is rich in lignin and chitin, and quicker, if detritus is rich in nitrogen and water-soluble substances like sugars. Temperature and soil moisture are the most important factors affecting decomposition.
climatic factors that regulate decomposition through their effects on the activities of soil microbes. Warm and moist environment favour decomposition whereas low temperature and anaerobiosis inhibit decomposition resulting in build-up of organic materials.

**Energy Flow**

All the components of an ecosystem are constantly interacting with each other. These interactions lead to the growth and regeneration of its plants and animal species for which energy is required. Sun is the ultimate source of energy for all the ecosystems in the world, except for the deep sea hydrothermal ecosystems.

Only 50 percent of the solar radiation is Photosynthetically Active Radiation (PAR). The producers capture only 2-10 percent of this PAR and this small amount of energy sustains the entire living world. This energy goes through different organisms occupying trophic levels in an ecosystem.

Photosynthetically Active Radiation (PAR) is the amount of light available for photosynthesis, which is light in the 400 to 700 nanometer wavelength range. PAR changes seasonally and varies depending on the latitude and time of day.

It is needed for photosynthesis and plant growth. Higher PAR promotes plant growth. Monitoring PAR is important to ensure plants are receiving adequate amount of light for this process.

**Trophic Levels**

A trophic level is a step in a food chain of an ecosystem. Based on the feeding behavior, the organisms are classified into different trophic levels. Thus, trophic levels are the feeding positions of all organisms in a specific ecosystem.

At the first trophic level, primary producers like green plants, algae, and some bacteria use solar energy to produce organic plant material through photosynthesis. The second trophic level is occupied by Herbivores, animals that feed solely on plants. Similarly, the third trophic level is occupied by Predators who eat herbivores. In places where larger predators are present, they represent still higher trophic levels. Organisms that feed at several trophic levels (for example, grizzly bears that eat berries and salmon) are classified at the highest of the trophic levels at which they feed. Decomposers that include bacteria, fungi, worms, molds and insects break down wastes and dead organisms and in process, return nutrients to the soil.

The highest amount of energy is concentrated in the first trophic level, subsequently dispersing into organisms of different trophic levels. The amount of energy decreases as one moves higher up in the trophic level in an ecosystem.

On an average, about 10 percent of net energy production at one trophic level is passed on to the next level. Processes that reduce the energy transferred between trophic levels include respiration, growth and reproduction, defecation, and non-predatory death (organisms that die but are not eaten by consumers). The nutritional quality of material that is consumed also influences how efficiently energy is transferred because consumers can convert high-quality food sources into new living tissue more efficiently than low-quality food sources.

For example, consider a grassland ecosystem having 10,000 kcal energy concentrated at the producer trophic level. Then about 1000 kcal will be transferred to the primary consumers and the next level will receive as little as 100 kcal energy. Energy pyramids such as this help to explain the trophic structure of an ecosystem: the number of consumer trophic levels that can be supported is dependent on the size and energy richness of the producer level.

As there is high energy loss at subsequent trophic levels, most terrestrial ecosystems have no more than five trophic levels and marine ecosystems generally have no more than seven.

This difference between terrestrial and marine ecosystems is likely due to differences in the fundamental characteristics of land and marine primary organisms. In marine ecosystems, microscopic phytoplankton carries out most of the photosynthesis that occurs, while plants do most of this work on land.
Phytoplankton are small organisms with extremely simple structures, so most of their primary production is consumed and used for energy by grazing organisms that feed on them. In contrast, a large fraction of the land plants produce, such as roots, trunks, and branches, cannot be used by herbivores for food, so proportionately less of the energy fixed through primary production travels up the food chain.

**Food Chains**

All the organisms need energy to grow, move and reproduce. For this purpose, smaller insects eat plants, bigger animals eat smaller insects and so on. This feeding relationship forms a food chain in an ecosystem. Thus, food chain is a linear sequence of organisms through which transfer of energy and nutrients takes place. The energy and nutrients flow in the form of food from organism to organism by eating and being eaten.

**Grazing Food Chains**

This type of food chain is more prevalent in those ecosystems where a substantial part of the net primary production is grazed on by herbivores. Thus, there is enough energy to support the higher trophic level and in turn a food chain. It starts from a green plant base, goes to grazing herbivores and on to carnivores. The grazing food chain is the most important food chain in nature. Ecosystems with such type of food chain are directly dependent on an influx of solar radiation.

**Detritus Food Chains**

This type of food chain starts with a dead organic matter which is decomposed by microorganisms, which in turn are eaten by other organisms. Clearly, it is less dependent on direct solar energy and more on the supply of organic matter produced by another ecosystem.

For example, in temperate forests, there is a plenty of organic matter in the form of fallen leaves in the soil. These organic matters are broken down into simple nutrients by decomposers (fungi, bacteria etc) which in turn are eaten by other small animals (detritivores) and so on.
**Food Web**

Food chain follows a single path as animals eat each other. In natural environment or an ecosystem, the relationships between the food chains are inter-connected. These relationships are very complex, as one organism may be a part of multiple food chains. Hence, a web like structure is formed in place of a linear food chain. The web like structure if formed with the interlinked food chain and such matrix that is interconnected is known as a food web.

![Food Web Diagram]

Food webs show how plants and animals are connected in many ways to help them all survive. They are an indispensable part of an ecosystem. These food webs allows an organism to obtain food from more than one type of organism of the lower trophic level. Every living being is responsible and is a part of multiple food chains in the given ecosystem.

<table>
<thead>
<tr>
<th>Food Chain</th>
<th>Similarity</th>
<th>Food Web</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single linear pathway</td>
<td>Represents who-eats-who</td>
<td>Made of several interconnecting pathways</td>
</tr>
<tr>
<td>Isolated food chains decrease stability of the ecological community</td>
<td>10% of energy passes from one trophic level to another</td>
<td>More complex food webs increase the stability of ecological community</td>
</tr>
<tr>
<td>One individual occupies one trophic level only</td>
<td>One individual occupies many trophic levels</td>
<td>More adaptive</td>
</tr>
<tr>
<td>Less adaptive</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Food web as interconnected Food chains**

Although it looks complex, it is just several food chains joined together. Here are some of the food chains in this food web:

- Berries → Butterfly → Frog → Snake
- Berries → Greenfly → Ladybird → Dragonfly → Frog → Snake → Buzzard
- Plantain → Rabbit → Fox
- Plantain → Mouse → Buzzard

**Ecological Pyramids**

Ecological Pyramid is the graphical representation of the relationship between the producer and different levels of consumers in terms of a number of species, biomass or energy accumulated. Simply put, they are the graphical representations of trophic levels in an ecosystem. Thus, producers are at the base of the pyramid and subsequent levels of the pyramid represent herbivore, carnivore and top carnivore levels. The width of each bar should be proportional to the quantity that is being displayed, and the height is usually the same for each bar. Food pyramids are often used in order to show the efficiency of transfer from one trophic level to the next.

There are three types of ecological pyramids:
- Pyramid of Numbers
- Pyramid of Biomass
- Pyramids of Energy

**Pyramid of Numbers**

When the relationship between the producers and various consumers is shown in terms of the population at each trophic levels. This type of pyramid is erect for most of the ecosystems but an inverted pyramid of numbers are not uncommon. Pyramid of numbers is advantageous over other because it is a simple method as one only needs to count the number of organisms and also it is good for comparing changes to the ecosystem at different times of years. However, it has limitations as number of species may be too high to measure accurately. It also includes all the organisms ignoring their sizes which lead to inverted pyramids.

**Erect Pyramid of Numbers:** This type of pyramid is found in the aquatic and grassland ecosystem. In these ecosystems, there are numerous small autotrophs which support lesser herbivores which in turn support smaller number of carnivores and hence this pyramid is upright. For Example: In grassland ecosystem, numbers of grasses are much more than the number of herbivores and, in turn, the number of herbivores is more than the number of carnivores.