What is an Ecosystem

An ecosystem is a structural and functional unit of ecology where the living organisms interact with each other and the surrounding environment. In other words, an ecosystem is a chain of interactions between organisms and their environment. The term “Ecosystem” was first coined by A.G.Tansley, an English botanist, in 1935.

Structure of the Ecosystem

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

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

- Biotic Components
- Abiotic Components

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

Biotic Components

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

- **Producers** include all autotrophs such as plants. They are called autotrophs as they can produce food through the process of photosynthesis. Consequently, all other organisms higher up on the food chain rely on producers for food.
- **Consumers** or heterotrophs are organisms that depend on other organisms for food. Consumers are further classified into primary consumers, secondary consumers and tertiary consumers.
    - ***Herbivores (Primary consumers)*** are always herbivores as they rely on producers for food. Eg. Rabbit, Cows etc.
    - ***Carnivores (Secondary consumers)*** depend on primary consumers for energy. Eg. Lizard, Fox etc.
    - ***Top Carnivores (Tertiary consumers)*** are organisms that depend on secondary consumers for food. Tertiary consumers can also be carnivores or omnivores.
    - ***Quaternary consumers*** are present in some food chains. These organisms prey on tertiary consumers for energy. Furthermore, they are usually at the top of a food chain as they have no natural predators.
- **Decomposers** include saprophytes such as fungi and bacteria. They directly thrive on the dead and decaying organic matter. Decomposers are essential for the ecosystem as they help in recycling nutrients to be reused by plants.

Abiotic Components

Abiotic components are the non-living component of an ecosystem. It includes air, water, soil, minerals, sunlight, temperature, nutrients, wind, altitude, turbidity, etc.

Inorganic substances which are involved in mineral cycles. Ex: C, N, P, K, S, H etc.

Organic substances present in the biomass or in the environment. They form the living body and influence the functioning of the ecosystem. Ex: Carbohydrate, proteins, lipids, humus etc.

Climatic factors having strong influence on the ecosystem.

There are the different types of abiotic Components. These are:

1. Water

Water covers more than 70% of the earth's surface in one form or the other. Compared to that, living organisms require a small amount of water to live. Water is critical to survival.

2. Atmosphere

The atmosphere has important components like oxygen and carbon dioxide, which animals and plants breathe to live and combine to produce carbohydrates, other organic materials, parts of DNS, and proteins.

3. Sunlight

Sunlight is one of the most important abiotic factors and is the primary source of energy. Plants require it for photosynthesis.

4. Soil

Soil is a critical abiotic factor. It is composed of rocks as well as decomposed plants and animals.

Functions of Ecosystem

The functions of the ecosystem are as follows:

1. It regulates the essential ecological processes, supports life systems and renders stability.
2. It is also responsible for the cycling of nutrients between biotic and abiotic components.
3. It maintains a balance among the various trophic levels in the ecosystem.
4. It cycles the minerals through the biosphere.
5. The abiotic components help in the synthesis of organic components that involve the exchange of energy.

So the functional units of an ecosystem or functional components that work together in an ecosystem are:

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

Food Chain

The order of living organisms in a community in which one organism consumes other and is itself consumed by another organism to transfer energy is called a food chain. Food chain is also defined as “a chain of organisms, existing in any natural community, through which energy is transferred”.

A food chain starts with a producer such as plants. Producers form the basis of the food chains. Then there are consumers of many orders. Consumers are organisms that eat

other organisms. All organisms in a food chain, except the first organism, are consumers.

Plants are called producers because they produce their own food through photosynthesis. Animals are called consumers because they depend on plants or other animals for food to get energy they need.

In a certain food chain, each organism gets energy from the one at the level below. In a food chain, there is reliable energy transfer through each stage. All the energy at one stage of the chain is not absorbed by the organism at the next stage.

Trophic Levels in a Food Chain

Trophic levels are different stages of feeding position in a food chain such as primary producers and consumers of different types.

Organisms in a food chain are categorized under different groups called trophic levels. They are as follows.

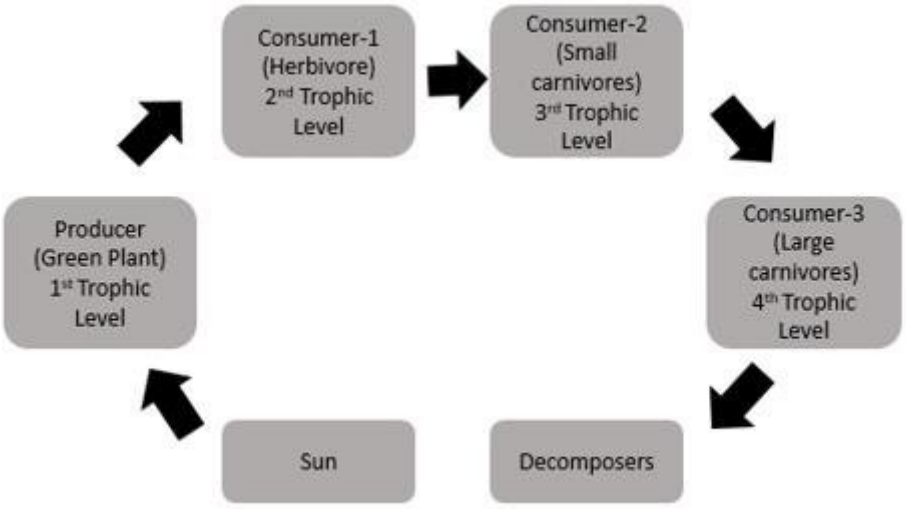
Producers (First Trophic Level) − Producers otherwise called autotrophs prepare their food by themselves. They form the first level of every food chain. Plants and one-celled organisms, some types of bacteria, algae, etc. come under the category of Autotrophs. Virtually, almost all autotrophs use a process called photosynthesis to prepare food.

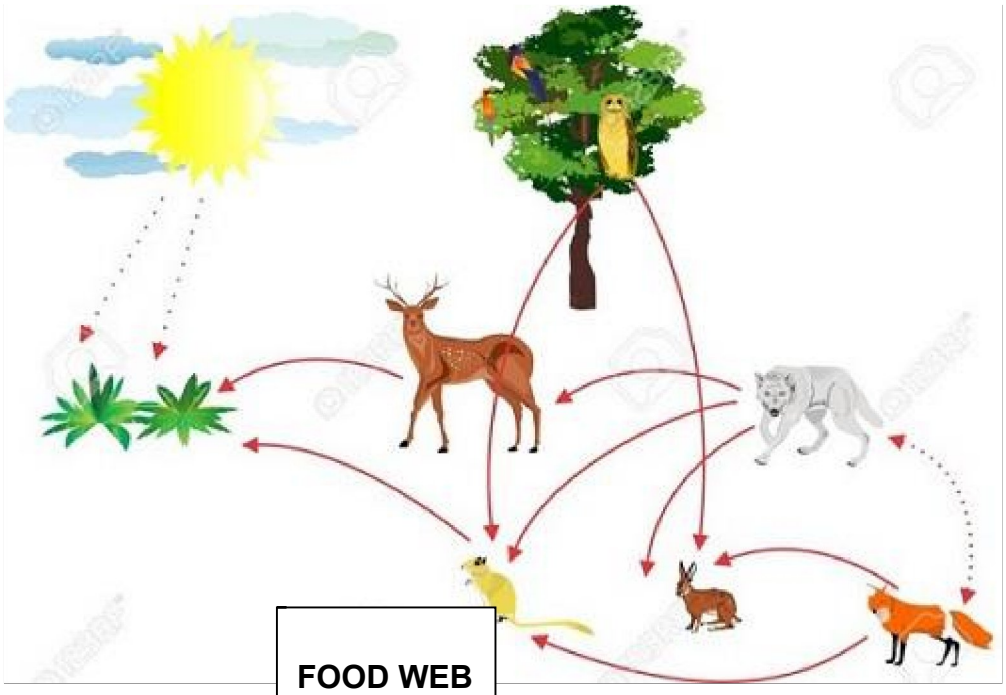
Consumers − At the second trophic level, there are consumers who depend upon others for food.

- **Primary Consumers (Second Trophic Level)** − Primary consumers eat the producers. They are called herbivores. Deer, turtle, and many types of birds are herbivores.
- **Secondary Consumers (Third Trophic Level)** − Secondary consumers based at the third trophic level eat plants and herbivores. They are both carnivores (meat eaters) and omnivores (animals that eat both animals and plants). In a desert ecosystem, a secondary consumer may be a snake that eats a mouse. Secondary consumers may eat animals bigger than they are. Some lions, for example, kill and eat buffalo. The buffalo weighs twice as much as the lions do.
- **Tertiary Consumers (Fourth Trophic Level)** − Tertiary consumers are animals eating other carnivores. The secretary bird in Africa and the King Cobra specialize in killing and eating snakes but all snakes are carnivores. The leopard seal eats mostly other carnivores - mainly other seals, squids, and penguins, all of which are carnivores.

Decomposers − Decomposers which don’t always appear in the pictorial presentation of the food chain, play an important part in completing the food chain. These organisms break down dead organic material and wastes. Fungi and bacteria are the key decomposers in many ecosystems; they use the chemical energy in dead matter and wastes to fuel their metabolic processes. Other decomposers are detritivores—detritus eaters or debris eaters.

Understanding the food chain helps us know the feeding interrelationship and interaction between an organism and the ecosystem. It also enables us to know the mechanism of energy flow in an ecosystem.





FOOD WEB

2. 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 organism of a biotic community.

A food chain cannot stand isolated in an ecosystem. The same food resource may be a part of more than one chain. This is possible when the resource is at the lower tropic level.

A food web comprises all the food chains in a single ecosystem. It is essential to know that each living thing in an ecosystem is a part of multiple food chains.

A single food chain is the single possible path that energy and nutrients may make while passing through the ecosystem. All the interconnected and overlapping food chains in an ecosystem make up a food web.

Food webs are significant tools in understanding that plants are the foundation of all ecosystem and food chains, sustaining life by providing nourishment and oxygen needed for survival and reproduction. The food web provides stability to the ecosystem.

The tertiary consumers are eaten by quaternary consumers. For example, a hawk that eats owls. Each food chain ends with a top predator and animal with no natural enemies (such as an alligator, hawk, or polar bear).

3. Ecological Pyramids

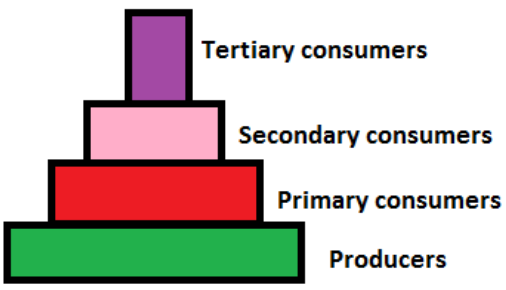
Ecological Pyramid refers to a graphical (pyramidal) representation to show the number of organisms, biomass, and productivity at each trophic level. It is also known as **Energy Pyramid**. There are three types of pyramids. They are as follows −

Types of Ecological Pyramid

Three types of ecological pyramid exist. They are as follows:

Pyramid of Numbers

In this type of ecological pyramid, the number of organisms in each trophic level is considered as a level in the pyramid. The pyramid of numbers is usually upright except for some situations like that of the detritus food chain, where many organisms feed on one dead plant or animal.



Pyramid of numbers

The pyramid of numbers represents the number of individuals at each tropic level. The shape of pyramid of numbers can be upright, partly upright and inverted depending on the type of ecosystem.

Aquatic and Grassland ecosystems:

In aquatic and grassland ecosystems, the numbers of producers are always more than that of primary consumers. Thus, the producer organisms remain in abundance near the base of the food chain and the consumers gradually decrease in number towards the apex. As a result, the shape of the pyramid is upright.

Forest Ecosystem

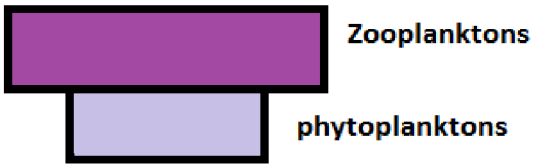
In a forest ecosystem, there is less number of producers that support a greater number of herbivores who in turn support a lesser number of carnivores. The shape of the pyramid of numbers is partly upright or spindle type.

Parasitic Food chain

In a parasitic food chain, one primary producer supports numbers of parasites which again support still more hyper parasites. The pyramid is inverted in shape because the producers are least in number and the predators are greater in number as we move up the food chain.

Pyramid of Biomass

In this particular type of ecological pyramid, each level takes into account the amount of biomass produced by each trophic level. The pyramid of biomass is also upright except for that observed in oceans where large numbers of zooplanktons depend on a relatively smaller number of phytoplanktons.

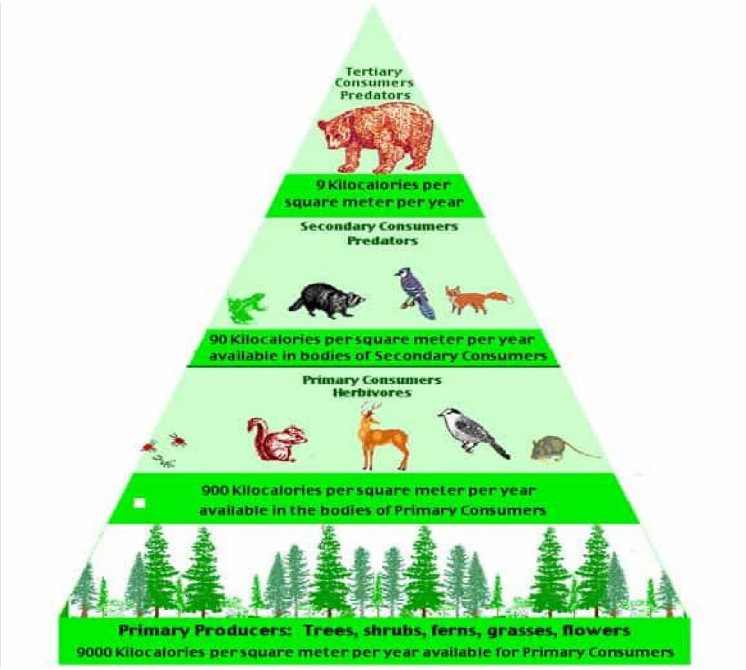


Pyramid of biomass in oceans

Upright Pyramid of Biomass

Ecosystems found on land mostly have pyramids of biomass with large base of primary producers with smaller trophic level perched on top, hence the upright pyramid of biomass.

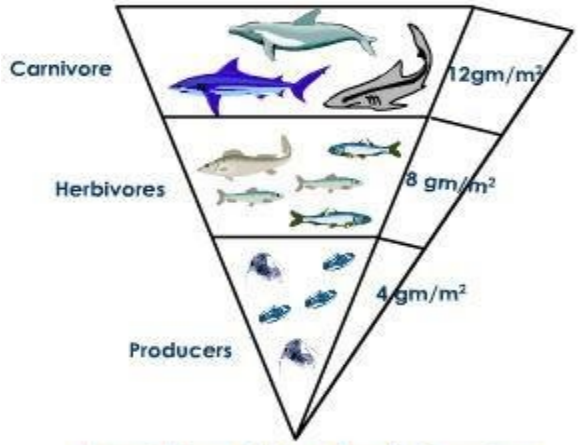
The biomass of autotrophs or producers is at the maximum. The biomass of next trophic level, i.e. primary consumers is less than the producers. Similarly, the other consumers such as secondary and tertiary consumers are comparatively less than its lower level respectively. The top of the pyramid has very less amount of biomass.



Inverted Pyramid of Biomass

On the other hand, a reverse pyramidal structure is found in most aquatic ecosystems. Here, the pyramid of biomass may assume an inverted pattern. However, pyramid of numbers for aquatic ecosystem is upright.

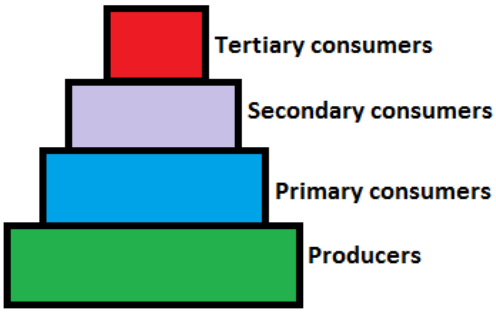
In a water body, the producers are tiny phytoplankton that grow and reproduce rapidly. In this condition, the pyramid of biomass has a small base, with the producer biomass at the base providing support to consumer biomass of large weight. Hence, it assumes an inverted shape.



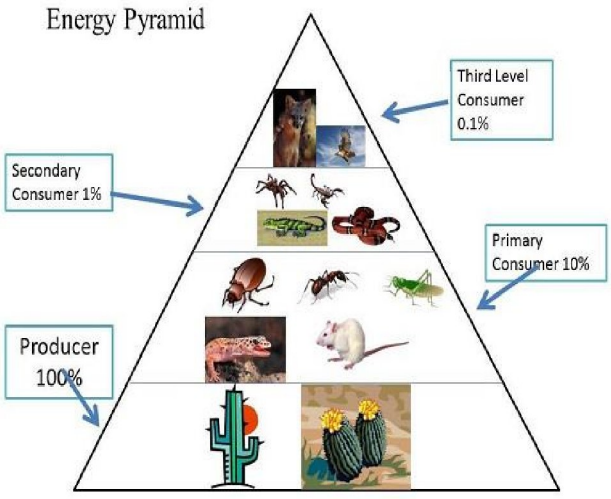
Inverted Pyramid in an Aquatic Ecosystem

Pyramid of Energy

Pyramid of energy is the only type of ecological pyramid, which is always upright as the energy flow in a food chain is always unidirectional. Also, with every increasing trophic level, some energy is lost into the environment.



Pyramid of energy



Types of Ecosystem

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

1. **Natural Ecosystems**

They operate by themselves under natural conditions without any interference by humans. They are classified as:

- Terrestrial Ecosystem
- Aquatic Ecosystem

2. **Artificial Ecosystems**

   These ecosystems are controlled and manipulated by humans. These are created by humans in order to fulfill certain needs. They are sub classified into the following two types:

   - Agriculture Ecosystem
   - Aquaculture Ecosystem

Natural Ecosystems

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Terrestrial Ecosystem

The terrestrial ecosystem refers to the ecosystem of different land forms only. The atmosphere in the terrestrial ecosystem is quite different from the aquatic ecosystem.
The major types of ecosystems are forest, desert, rain forest, grassland, tundra, savanna and mountain ecosystem.

- **Rain-forest Ecosystem**

The atmosphere in the rain forest regions is very adorable. This ecosystem is covered with green views all around this region. The excessive rainfall provides a dense environment in the rain forest ecosystem. This is why you can find different varieties of plants & animals in the rain forest ecosystem.

- **Desert Ecosystem**

Desert ecosystem has a high amount of flora & fauna. The desert ecosystem has covered almost 17% of the Earth's surface. Excessive temperature, extreme sunshine, less water available, etc. do not allow a variety of plants & animals to live in a desert ecosystem. You can find some plants such as cactus in the desert ecosystem. These types of plants can conserve water as much as they can. In this region, we can find animals like camels, reptiles, a few insects, etc.

- **Forest Ecosystem**

The forest ecosystem has a huge variety of flora and fauna living together in a specific area. There are different types of forest ecosystems based on climatic conditions such as tropical, temperate, boreal, etc.
In a tropical ecosystem, we can find a large variety of vegetation as compared to another terrestrial ecosystem. This is the reason that you will always find tropical regions loaded with lush green landscapes.

On the other hand, the temperate regions the ecosystem may be coniferous, deciduous, or a combination of both. The forest ecosystem is one of the crucial terrestrial ecosystems that provide shelter to thousands of plant & animal species.

- **Tundra Ecosystem**

There is limited life in the tundra ecosystem due to the harsh environment of this region. The tundra region refers to the lower altitudes of polar areas. Most of the time in a year, the land in this region is covered with snow, which makes the survival very tough. This is the reason for the limited flora & fauna found in this kind of ecosystem.

- **Savanna Ecosystem**

Most of people have a perception that savannas are similar to deserts. The savannas ecosystem is a little different from the desert ecosystem due to the amount of rainfall in savannas. Savannas get more rainfall as compare to the desert ecosystem, which supports the life of the flora & fauna.

- **Grassland Ecosystem**

As the name suggests, the grassland ecosystem mainly contains grasses along with some species of shrubs & trees. Grassland is a perfect region for grazing animals. The atmosphere in the grassland ecosystem is quite pleasant, and the climatic conditions are very similar to semi-arid regions. The mostly found organisms in the grassland ecosystem are grazing animals, herbivorous, insectivorous, etc. Tropical & temperate are typical regions of the grassland ecosystem.

- **Mountain Ecosystem**

The mountain ecosystem is packed with a huge variety of plants & animals. However, survival in mountain ecosystem is quite challenging due to alpine vegetation. The animals found on higher altitudes are covered with long & thick fur to protect themselves from cold. The animals of the mountain ecosystem also have to spend a long period of hibernation. The life in mountain ecosystem is quite tough in terms of habitats & survival.

Aquatic Ecosystem

The ecosystem found in different water bodies is known as an aquatic ecosystem. The major types of aquatic ecosystems are – marine ecosystems and freshwater ecosystems.

- **Marine Ecosystem**

Marine ecosystem covers almost 70% of the area on Earth's surface, hence known as one of the biggest kinds of ecosystems on the Earth. Water is the main component of the marine ecosystem, which contains various minerals & salt dissolved in it.
Many organisms such as sharks, cephalopods, brown algae, echinoderm, corals, dino flagellates, etc. contribute to be a part of the marine ecosystem.

- **Freshwater Ecosystem**

Freshwater is another type of aquatic ecosystem that covers less area as compared to the marine ecosystem. The freshwater ecosystem covers almost 0.8% of the Earth's surface. The major kinds of freshwater ecosystems are *lentic, lotic, and wetlands*.

Lentic ecosystem refers to stagnant water bodies such as ponds, lakes, etc. whereas the lotic ecosystem means fast-flowing water bodies such as a river. On the other hand, in wetland areas, the land becomes saturated and remains for a long period.

Functional components of ecosystem

There are essential functional components of the ecosystem:

Abiotic factors

Abiotic factors refer to all the non-living things present in the atmosphere. Abiotic factors include air, water, soil, sunlight, temperature.

Biotic factors

Biotic factors relate to all the living things in the ecosystem, including:

Producers

An organism that can prepare its food by their self. Producers include all green plants and other autotrophs.

Consumers

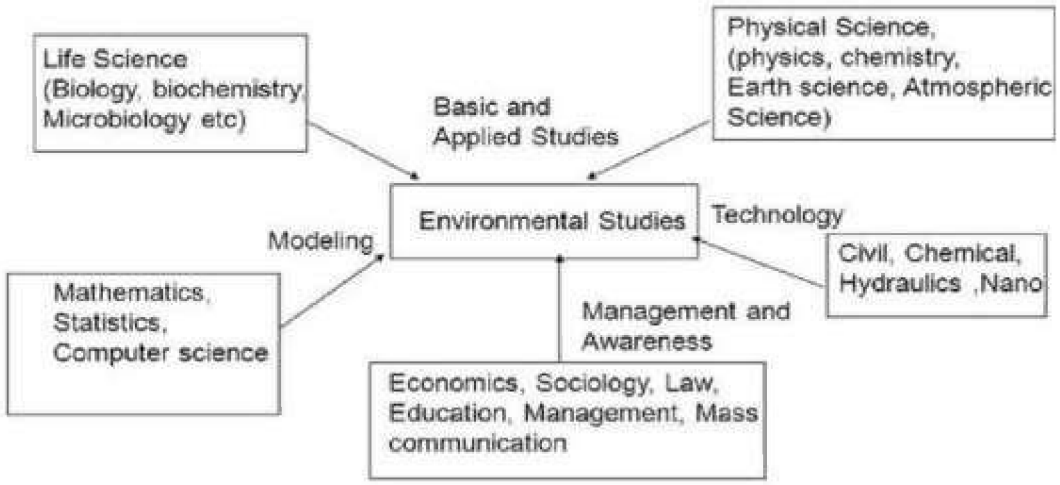
An organism that obtains energy by feeding on other organisms. Consumers include all animals.

Decomposers

This organism feeds on dead and decaying matter, thus making organic nutrients available to the ecosystem. Decomposers include saprophytes such as fungi and bacteria, etc.

MULTIDISCIPLINARY NATURE OF ENVIRONMENT STUDIES

Environmental studies deals with every issue that affects an organism. It is essentially a multidisciplinary approach that brings about an appreciation of our natural world and humanimpacts on its integrity. It is an applied science as it's seeks practical answers to making human civilization sustainable on the earth's finite resources. The complex relationship that exist in our natural environment among people, animals, others organisms, water soil, air tree, ocean, and so on. The interconnections are numerous and involve many different disciplines. We need inputs from diverse disciplines such as biology, botany, zoology, soil science, technology oceanography, atmospheric science, economics, sociology, anthropology and ethics. Environmental studies involve educating the people for preserving the quality of environment.



Definition of the Environment

Environment is defined as the social, cultural and physical conditions that surround, affect and influence the survival, growth and development of people, animals and plants.

Environment includes everything around us. It encompasses both the living (biotic) and non-living (abiotic) components of the earth.

There are four different segment of environment:

1. **Atmosphere:**

The air envelope surrounding the earth is known as Atmosphere. This protective envelop surrounding earth sustain life on earth and protect us from unfriendly environment of outer space. It consists of life saving gases like O_2 for human beings and animals and CO_2 for plants.

2. **Hydrosphere:**

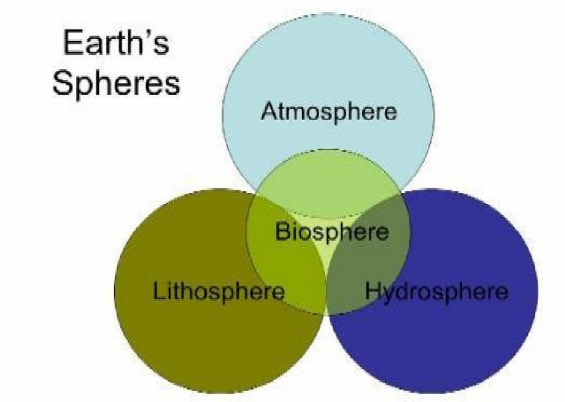
It covers more than 75% of the earth surface either as oceans or as fresh water. Hydrosphere includes sea, rivers, oceans, lakes, ponds, streams etc.

3. **Lithosphere:**

The solid component of the earth is called Lithosphere, which includes soil, earth, rocks and mountains etc.

4. **Biosphere:**

This segment of environment consists of atmosphere (air- 02, N2, C02). Lithosphere (land- minerals, salts, food, nutrients) and hydrosphere (water- dissolved oxygen, Salts) which influences and support the entire biotic and abiotic life systems.



Scope of Environmental Studies

Read and understand

[As we look around at the area in which we live, we see that our surroundings were originally a natural landscape such as a forest, a river, a mountain, a desert, or a combination of these elements. Most of us live in landscapes that have been heavily modified by human beings, in villages, towns or cities. But even those of us who live in cities get our food supply from surrounding villages and these in turn are dependent on natural landscapes such as forests, grasslands, rivers, seashores, for resources such as water for agriculture, fuel wood, fodder, and fish. Thus our daily lives are linked with our surroundings and inevitably affects them. We use water to drink and for other day-to-day activities. We breathe air, we use resources from which food is made and we depend on the community of living plants and animals which form a web of life, of which we are also a part. Everything around us forms our environment and our lives depend on keeping its vital systems as intact as possible.

Our dependence on nature is so great that we cannot continue to live without protecting the earth's environmental resources. Thus most traditions refer to our environment as 'Mother Nature' and most traditional societies have learned that respecting nature is vital for their livelihoods. This has led to many cultural practices that helped traditional societies protect and preserve their natural resources. Respect for nature and all living creatures are not new to India.

The industrial development and intensive agriculture that provides the goods for our increasingly consumer oriented society uses up large amounts of **natural resources** such as water, minerals, petroleum products, wood, etc. **Non renewable** resources, such as minerals and oil are those which will be exhausted in the future if we continue to extract these without a thought for subsequent generations. **Renewable** resources, such as timber and water, are those which can be used but can be regenerated by natural processes such as regrowth or rainfall. But these too will be depleted if we continue to use them faster than nature can replace them. For example, if the removal of timber and firewood from a forest is faster than the regrowth and regeneration of trees, it cannot replenish the supply. And losses of forest cover not only depletes the forest of its resources, such as timber and other non-wood products, but affect our water resources because an intact natural forest acts like a sponge which holds water and releases it slowly. Deforestation leads to floods in the monsoon and dry rivers once the rains are over. Such multiple

effects on the environment resulting from routine human activities must be appreciated by each one of us, if it is to provide us with the resources we need in the long-term. Our natural resources can be compared with money in a bank. If we use it rapidly, the capital will be reduced to zero. On the other hand, if we use only the interest, it can sustain us over the longer term. This is called **sustainable utilization or development.**

Scope of Environmental Studies

The scope of environmental studies is very wide and it deals with many areas like

- Conservation and management of natural resources (like forest and water resources etc.)
- Conservation of bio diversities (like ecosystem and landscape diversity etc.)
- Control of environmental pollutions (like air, water, soil, noise etc)
- Control of human population
- Replacement of development like urbanization, economic growth (industrialization) with sustainable development.

1. Developing an awareness and sensitivity to the total environment and its related problems.
2. Motivating people for active participation in environmental protection and improvement.
3. Developing skills for active identification and development of solutions to environmental problems.
4. Imbibe and inculcate the necessity for conservation of natural resources.
5. Evaluation of environmental programmes in terms of social, economic, ecological and aesthetic factors.

IMPORTANCE OF ENVIRONMENTAL STUDIES

The environment studies make us aware about the importance of protection and conservation of our mother earth and about the destruction due to the release of pollution into the environment. The increase in human and animal population, industries and other issues make the survival cumbersome. A great number of environment issues have grown in size and make the system more complex day by day, threatening the survival of mankind on earth. Environment studies have become significant for the following reasons:

Environment Issues are being of Global: It has been well recognized that environment issues like global warming and ozone depletion, acid rain, marine pollution

and biodiversity are not merely national issues but are global issues and hence require international efforts and cooperation to solve them.

Development and Environment:

Development leads to Urbanization, Industrial Growth, Telecommunication and Transportation Systems, Hi-tech Agriculture and Housing etc. However, it has become phased out in the developed world. The North intentionally moves their dirty factories to South to cleanse their own environment. When the West developed, it did so perhaps in ignorance of the environmental impact of its activities. Development of the rich countries of the world has undesirable effects on the environment of the entire world.

Explosive Increase in Pollution:

World census reflects that one in every seven persons in this planet lives in India. Evidently with 16 per cent of the world's population and only 2.4 per cent of its land area, there is a heavy pressure on the natural resources including land. Agricultural experts have recognized soil health problems like deficiency of micronutrients and organic matter, soil salinity and damage of soil structure.

Need for an Alternative Solution:

It is essential, especially for developing countries to find alternative paths to an alternative goal. We need a goal as under:

- A true goal of development with an environmentally sound and sustainable development.
- A goal common to all citizens of our planet earth.
- A goal distant from the developing world in the manner it is from the over-consuming wasteful societies of the “developed” world.

It is utmost important for us to save the humanity from extinction because of our activities constricting the environment and depleting the biosphere, in the name of development.

Need for Wise Planning of Development

Our survival and sustenance depend on resources availability. Hence Resources withdraw, processing and use of the products have all to be synchronized with the ecological cycle. In any plan of development our actions should be planned ecologically for the sustenance of the environment and development.

Need for public awareness

The need of the hour is to make the public aware of the consequences of the environmental degradation, if not corrected and reformative measures undertaken, would result in the extinction of life. In today's world because of industrialization and increasing population, the natural resources has been rapidly utilized and our environment is being increasingly degraded by human activities, so we need to protect the environment. It is not only the duty of government but also the people to take active role for protecting the environment, so protecting our environment is economically more viable than cleaning it up once, it is damaged. The role of mass media such as newspapers, radio, television, etc is also very important to make people aware regarding environment. There are various institutions, which are playing positive role towards environment to make people aware regarding environment like BSI (Botanical Survey of India, 1890), ZSI (Zoological Survey of India, 1916), WII (Wild Life Institute of India, 1982) etc. It is also necessary to face the various environmental challenges and to act accordingly to make the acts eco-friendly. The major challenges ahead are the following:

Population: A population of over thousands of millions is growing at 2.11 per cent every year. Over 17 million people are added each year. India accounts for 16 % of the world population, but with only 2.4 per cent of the land area. This makes considerable pressure on the natural resources and reduces the gains of development. Hence, the greatest challenge before us is to limit the population growth. Although the population control does automatically lead to development, yet the development leads to a decrease in population growth rates. For this development to be happened, knowledge of the women is essential. The future population growth has to be linked to the resource base in order to have sustainable development.

Poverty Alleviation: India has often been described a rich land with poor people. The poverty and environmental degradation are inter-dependent. The vast majority of our people are directly dependent on the natural resources of the country for their basic needs of food, fuel, fodder and shelter. About 65 % of Indians are poor and about 40% of our people are still below the poverty line. Environment degradation has adversely affected the poor who depend upon the natural resources of their immediate surroundings. Thus, the challenge of poverty and the challenge of environment degradation are two facets of the same challenge. The population growth is essentially a function of poverty.

Agricultural Growth: The people must be acquainted with the methods to sustain and increase agricultural growth without damaging the environment. Fertilizers and pesticides are causing major threats to the environment in the form of soil and water pollution. It is evident that it is very difficult that these chemicals will be kept out of soil,

water and food chain if they are extensively and continuously used in crop production. Highly intensive agriculture has caused soil salinity and damage to the physical structure of soil.

Protecting Ground Water from pollution: Because of intensive agriculture, increase in number of industries, rapid urbanization and population growth, the need for water is growing at a faster rate. This leads to the fast depletion of groundwater table. It is very essential of rationalizing the use of groundwater now. Factors like community wastes, industrial effluents and chemical fertilizers and pesticides have polluted our surface water and affected the quality of groundwater also. The need of the hour is to restore the water quality of our rivers and other water bodies as lakes and to avoid the groundwater pollution. Finding suitable strategies for consecration of water, provision of safe drinking water and keeping water bodies clean which are difficult challenges ahead. Rain water harvesting and water management can help to an extent in this regard.

Development and Forests: Forests provide raw materials for construction of houses and for industries like paper and pulp manufacturing, packaging, fire wood and fodder for people etc. Forests serve as catchments for the rivers. With increasing demand of water, huge dams were constructed in independent India leading to submergence of large forest areas; displace local people and damage flora and fauna. As such, the dams on the river Narmada, Bhagirathi and elsewhere have become areas of political conflicts and scientific debate. Forests in India have been shrinking for several centuries owing to pressures of agriculture and other uses. Vast areas of forests in many states are now converted as agricultural lands for growing hilly vegetables and plantation crops and mining. These areas are to be brought back under forest cover. The tribal communities inhabiting forests respects the trees and birds and animal that gives them sustenance. We must recognize the role of these people in restoring and conserving forests. The modern knowledge and skills of the forest department should be integrated with the traditional knowledge and experience of the local communities. The strategies for the joint management of forests by the government officials and tribal people should be evolved in a well-planned way to implement afforestation.

Degradation of Land: At present out of the total 329 mha of land, only 266 mha possess any potential for production. Of this, 143 mha is agricultural land and 85 mha suffers from varying degrees of soil degradation. Of the remaining 123 mha, 40 mha are completely unproductive. The remaining 83 mha is classified as forest land, of which over half is denuded to various degrees. Nearly 406 million head of livestock have to be supported on 13 mha, or less than 4 per cent of the land classified as pasture land, most of which is overgrazed. Thus, out of 226 mha, about 175 mha or 66 per cent is degraded to varying degrees. Water and wind erosion cause further degradation of almost 150 mha This degradation is to be avoided.

Reduction of Genetic Diversity: Immediate measures to conserve genetic diversity need to be taken at the earliest. At present most wild genetic stocks have been disappearing from nature. The protected areas network like sanctuaries, national parks, biosphere reserves are isolating populations. Remedial steps are to be taken to check decreasing genetic diversity.

Evil Consequences of Urbanization: Nearly 27 per cent Indians live in urban areas. Urbanization and Industrialization has given birth to a great number of environmental problems that need urgent attention. Over 30 percent of urban Indians live in slums. Out of India's 3,245 towns and cities, only 21 have partial or full sewerage and treatment facilities. Hence, coping with rapid urbanization is a major challenge.

Air and water Pollution: Majority of our industrial plants are using outdated treatment technologies and makeshift facilities devoid of any provision of treating their wastes. A great number of cities and industrial areas that have been identified as the worst in terms of air and water pollution. Acts are enforced in the country, but their implementation is not so easy. The reason is their implementation needs great resources, technical expertise, political and social will. Again, the people are to be made aware of these rules. Their support is indispensable to implement these rules.

Since our environment is getting degraded due to human activities, we need to do something about it to sustain the quality. We often feel that government should take proper measuring steps. But all of us are equally responsible to protect our environment. Hence public awareness needs to be created. Both print media and electronic media can strongly influence public opinion. Politicians should respond positively to a strong publicly supported activity. NGOs can take active role in creating awareness from grass root levels to the top-most policy decision makers. Environment is an integration of both living and non-living organisms. Water, air, soil, minerals, wild life, grass lands, forests, oceans, agriculture are all life supporting systems. Since these natural resources are limited, and human activities are the causative factors for environmental degradation, each one of us need to feel responsible to protect the environment.

The activities help in creating awareness among public are

• Join a group to study nature such as WWF-I or BNHS or any other organization

• Read newspaper articles and periodicals like Down to earth, WWF-I newsletter, BNHS, Hornbill, Sanctuary magazine.

• Discuss environmental issues with friends and relatives.

• Join local movements that support activities like saving trees in your locality, reducing use of plastics, going for nature treks, practicing 3 Rs i.e. reduce, reuse, & recycle.

• Practice and promote good civic sense and hygiene such as enforcing no spitting or tobacco chewing, no throwing garbage on the road and no urinating in public places.

• Take part in events organized on World Environment Day, Wildlife week etc.

• Visit a National park or sanctuary or spend time in whatever natural habitat you have near your home.

Natural resources

Natural resources can be defined as the resources that exist (on the planet) independent of human actions.

These are the resources that are found in the environment and are developed without the intervention of humans. Common examples of natural resources include air, sunlight, water, soil, stone, plants, animals and fossil fuels.

Classification of natural resources:

Classification of natural resources can be done in several ways based on their origin, level of development and uses, stock or deposits, and their distribution.

On the basis of their origin, natural resources can be classified into living or biotic and non-living or abiotic resources.

Living or Biotic Resources

If natural resources come from living things or organic materials, they are termed as living or biotic resources. Biotic resources include plants, animals and fossil fuels. Fossil fuels such as coal, oil and natural gas are classified as biotic resources as they are formed from the decay of organic matter over millions of years.

Non-living or Abiotic Resources

On the other hand, if the resources are derived from nonliving or inorganic materials, they are termed as abiotic resources. For instance, air, sunlight, and water are abiotic natural resources. Minerals are also considered abiotic.

On the basis of deposit or stock, natural resources can be classified as renewable and non-renewable.

Renewable: resources that are available in infinite quantity and can be used repeatedly are called renewable resources. Example: Forest, wind, water, etc.

Non-Renewable: resources that are limited in abundance due to their non-renewable nature and whose availability may run out in the future are called non-renewable resources. Examples include fossil fuels, minerals, etc.

Difference between Renewable and Non-Renewable Resources

Renewable resource	**Non-renewable resource**
It can be renewed as it is available in infinite quantity	Once completely consumed, it cannot be renewed due to limited stock

Sustainable in nature	Exhaustible in nature
Low cost and environment-friendly	High cost and less environment-friendly
Replenish quickly	Replenish slowly or do not replenish naturally at all

The 5 Most Important Natural Resources are:

1. **Air:** Clean air is important for all the plants, animals and humans to survive on this planet. So, it is necessary to take measures to reduce air pollution.
2. **Water:** 70% of the Earth is covered in water and only 2 % of that is fresh water. Initiative to educate and regulate the use of water should be taken.
3. **Soil:** Soil is composed of various particles and nutrients. It helps plants grow.
4. **Iron:** It is found as mineral silica and is used to build strong weapons, transportation and buildings
5. **Forests:** Forests provide clean air and preserve the ecology of the world. Trees are being cut for housing and construction projects.

Resources obtained from nature, i.e. from the earth are called **natural resources**. These resources occur naturally, and humans cannot make them. The raw materials used in artificial or man-made resources are natural resources.

TYPES OF NATURAL RESOURCES

1. Water Resources
2. Mineral Resources
3. Land resources
4. Energy Resources

Water resources

Water resources are sources of water that are useful or potentially useful to humans. Water is a prerequisite for the existence of life. Plants, animals, and human beings cannot survive without water. Water is used in agricultural, household, industrial, recreational and environmental activities. Water is essential for economic growth, environmental stability, biodiversity conservation, food security and heath care.

The Water Cycle It describes the continuous movement of water above and below the surface of the earth. It is driven by the sun.

The sun heats water in seas and oceans. Water evaporates into the air as water vapour. Snow and ice can sublime directly into water vapour. Rising air currents take the water vapours into the atmosphere where cooler temperatures help them to condense into clouds. Air currents move clouds; they collide, grow, and fall out of the sky as precipitation. Some precipitation falls as snow, and can accumulate as ice caps and glaciers. Most water falls back into the oceans or onto land as rain where the water flows over the ground as surface run-off. Much of the run-off is soaked into the ground as infiltration. Some run-off is stored as fresh water in lakes. Some run-off enters rivers in valleys in the landscape. Some water infiltrates deep into the ground and replenishes aquifers. This helps in the long-term storage of freshwater. Some groundwater finds openings in the surface of land and freshwater springs come out. Some rainwater flows through rivers back into the ocean, where the water cycle begins again.

Significance of Water Cycle	***Problems Arising from the Disturbances to the Water Cycle***
The water cycle helps in the maintenance of life and ecosystems on the earth.	Maintenance of life and ecosystems on earth get disturbed.
The water cycle helps in the transport of minerals from one part to different parts of the globe.	Mineral transport to different parts of the globe gets disturbed.
The water cycle purifies water by transferring water from one reservoir to another.	Water purification process gets disturbed.
The water cycle helps in the replenishing of the land with freshwater.	Replenishing of the land with fresh water gets disturbed.
Processes such as erosion and sedimentation associated with the water cycle helps in reshaping the geological features of the earth.	Processes for reshaping the geo- logical features of the earth get disturbed.
Through the evaporation and condensation process, the water cycle helps in the cooling and warming of the environmental respectively.	Influence on climate gets disturbed.

Water cycle

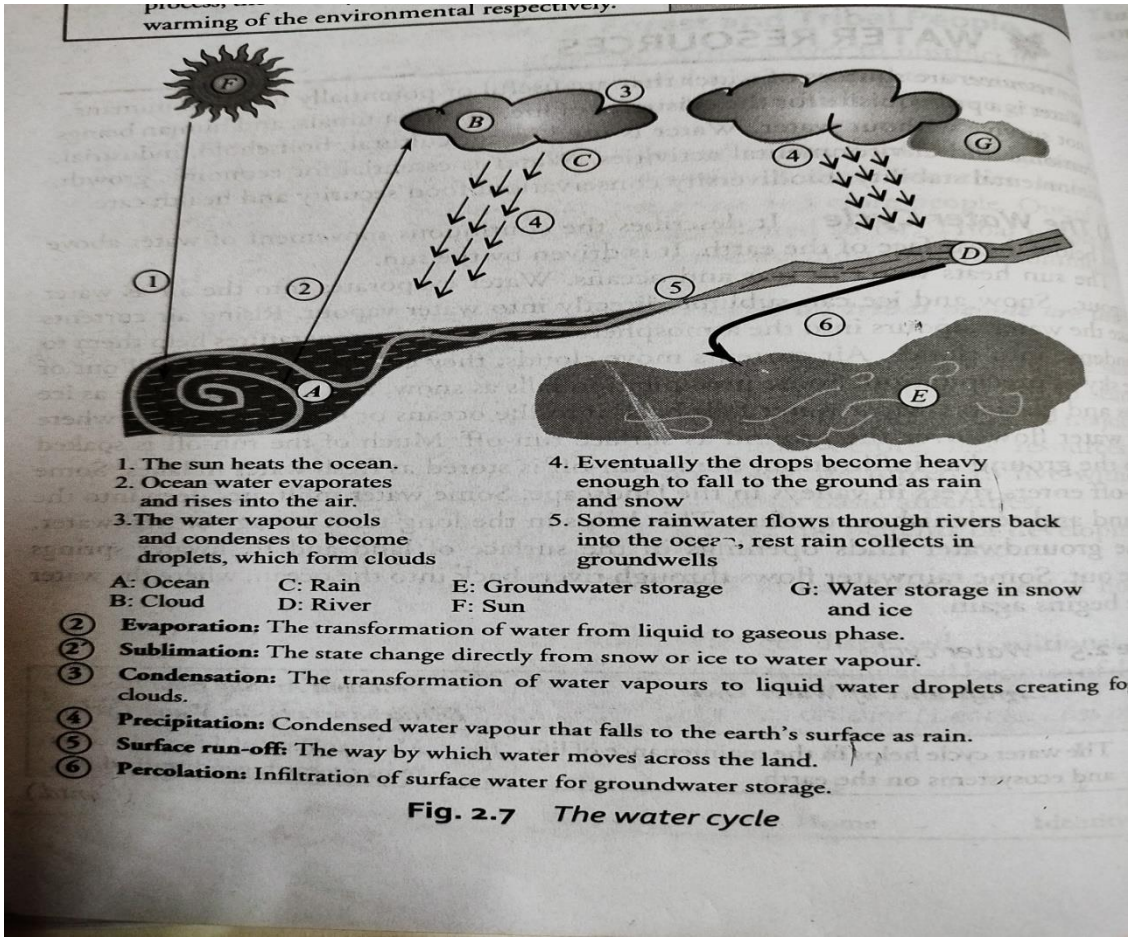


Fig. 2.7 *The water cycle*

Sources of Water*:* 97.5% of water on the earth is salt water in oceans. Only 2.5% is fresh water. Sources of fresh water are briefly described below:

(i) ***Surface Water:*** Water in a lake, river or freshwater wetland is known as surface water.

(ii) ***Groundwater:*** Fresh water located in the pore space of soil and rocks is called groundwater.

(iii) ***Ice Caps and Glaciers****:* Fresh water from ice caps and glaciers is relatively inaccessible.

***Causes of Water Crisis in the World**:* The causes for shortage of water leading to water crisis are the following:

(i) *Growing population and with better lifestyles*, per capita use of fresh water is increasing, causing shortage of water.
(ii) *Freshwater resources are reduced by pollution*. Industrial wastes, chemicals, human waste and agricultural wastes (fertilizers, pesticides and pesticide residues) are disposed off within water.
(iii) Increase in extreme weather conditions like *floods, droughts, typhoons, cyclones, etc*., are also responsible for worsening of water quality and availability.

Recently, it is estimated that

- Climate change will account for about 20% of the increase in global water scarcity
- 50% of the population of developing countries are exposed to polluted water sources

Overutilization of Surface and Ground Water

Water scarcity has become a burning global issue. The UN has held several conventions on water in recent decades. Continuous overutilization of surface and ground water has led to virtual water scarcity in the world today.

The depleting sources for high growth in human population over the centuries and increased man-induced water pollution across the world have created unforeseen water scarcity around the globe.

Groundwater is the major source of water in many parts of the world. However, there has been continuous depletion of this source due to its overexploitation by rising human population and the rapid rise in industrialization and urbanization in modern times.

Consequences of Overutilization

Water scarcity now becomes an important topic in international diplomacy. From village to the United Nations, water scarcity is a widely-discussed topic in decision making.

According to World Health Organization (WHO) sources, a combination of rising global population, economic growth and climate change means that by 2050 five billion (52%) of the world's projected 9.7 billion people will live in areas where fresh water supply is under pressure. Researchers expect about 1 billion more people to be living in areas where water demand exceeds surface-water supply.

Climate Change

Scientists, environmentalists, and biologists worldwide are now alarmed that climate change can have an impact on the drainage pattern and hydrological cycle on the earth thereby severely affecting the surface and groundwater availability.

Climate change is believed to rise the global temperature at an increasing pace. Temperature increase affects the hydrological cycle by directly increasing evaporation of available surface water and vegetation transpiration.

As a result, precipitation amount, timing and intensity rates are largely affected. It impacts the flux and storage of water in surface and subsurface reservoirs.

Floods & Draughts

Floods and droughts are two well-known natural hazards in the world. The former is due to excess in water flow and the latter is due to scarcity of water.

The amount of rainfall received by an area varies from one place to another depending on the location of the place. In some places it rains almost throughout the year whereas in other places it might rain for only few days. India records most of its rainfall in the monsoon season.

Heavy rains lead to rise in the water level of rivers, seas, and oceans. Water gets accumulated in the coastal areas, which results in floods. Floods bring in extensive damage to crops, domestic animals, property and human life. During floods, many animals get carried away by the force of water and eventually die.

On the other hand, droughts set in when a particular region goes without rain for a long period of time. In the meantime, the soil will continuously lose groundwater by the process of evaporation and transpiration. Since this water is not brought back to earth in the form of rains, the soil becomes very dry.

The level of water in the ponds and rivers goes down and in some cases water bodies get dried up completely. Ground water becomes scarce and this leads to droughts. In drought conditions, it is very difficult to get food and fodder for the survival. Life gets difficult and many animals perish in such conditions.

Frequent floods and droughts are mostly due to climate change and global warming. Various environmental organizations world over are of the view that climate change is a long-term change in weather patterns, either in average weather conditions or in the distribution of extreme weather events.

Importance of Water

Next to air, water is the most essential thing for our survival. We must drink water to avoid dehydration which means less or insufficient levels of water and important body salts of sodium and potassium in our body. The kidneys, brain, heart and other important body organs cannot function property without salt and water.

Water is also helpful in maintaining the relatively constant body temperature through the homeostasis process. It helps in avoiding upsetting of metabolic reactions by preventing sudden changes in temperature.

Water helps in the digestion process. Different types of food products, after being broken down to simple molecules (e.g. large starch molecules are broken down to simple sugars) are solubilized in the universal solvent ‘water’. Different enzymes facilitate this

digestion process. Oxygen gas is also dissolved in water to some extent. This Dissolved Oxygen (DO) helps in the respiration process of many organisms who live in water and spend most of their time underwater.

"Life is impossible without water. It is needed for health, ecosystem services, economic development, poverty reduction, and protection of greenery, production of food and imparting of aesthetic beauty."

Water Conservation

"Water conservation is the most cost-effective and eco-friendly way to reduce our demand for water."

(i) Need for Water Conservation: On an average, a citizen in most parts of the world is allocated 2.5 gallons of water per day for sustainability. However, the average American citizen uses 80–100 gallons of water per day. The poor do not have ac-cess to safe drinking water. More than 4000 children are dying every day as a result of diarrhoeal diseases caused from unsafe drinking water, lack of access to sanitation and inadequate availability of water. Thus, it is very essential to conserve water.

Measures to Conserve Water

(a) Recharge groundwater by harvesting rainwater.
(b) Use water wisely for household, agricultural and domestic purposes.
(c) Reuse water whenever possible. For example, waste water after bath can be used for the toilet.
(d) Avoid transmission and distribution losses by checking leaks in pipes, hoses, etc.
(e) Prevent flow of untreated sewage to lakes and rivers. This will reduce the likelihood of water pollution and help in water conservation.
(f) Collect water by building dams and reservoirs, and digging wells.
(g) Use drip irrigation, precision sprinklers for agriculture. Practice organic farming.
(h) Adopt *fairer policies* for treatment, access and pricing of water.
(i) Prevent flow of industrial effluents to natural water resources to avoid water pollution.
(j) Do protect forests to protect rivers, lakes, wells and other sources of water.

Major Factors Responsible for Water-Quality Degradation

(i) Insufficient and incomplete treatment of domestic and industrial waste water
(ii) Eutrophication
(iii) Pathogens, and pesticide contamination
(iv) Stagnation of domestic sewage and contamination of groundwater

Water-Borne Diseases

Water-borne diseases are illnesses caused by consuming water contaminated by pathogenic microorganisms.

Often lack of access to hygienic water, poor sanitation and rise in population of pathogenic microorganisms like protozoa, viruses, bacteria and intestinal parasites breeding in on water are considered the main causes of water-borne diseases.

According to the World Health Organization, diarrhoeal disease is responsible for the deaths of 1.8 million people every year and a majority of them are children in developing countries.

The best ways to prevent water-borne diseases are

(i) avoid drinking untreated water,
(ii) avoid consuming undercooked food,
(iii) maintain good personal hygiene (e.g. wash hands before eating), and
(iv) Educate for clean sanitation.

Fluoride Problem in Drinking Water

At low concentrations in drinking water, fluoride has beneficial effects on teeth. But excessive exposure to fluoride in drinking water can give rise to number of adverse effects. Although the *concentration* (mg/*litre*) of fluoride added to water can be controlled, but we cannot control the *dose* (mg/day). This is because one cannot control how much water people drink or how much fluoride they get from other sources.

(i) Sources of Fluoride
  (a) Fluoridated water supplies
  (b) Food processed with fluoridated water
  (c) Mouthwash enhanced with fluoride
  (d) Toothpaste enhanced with fluoride
  (e) Food supplements

Fluoridation is not necessary

(a) The level of fluoride in mother's milk is 0.004 ppm. It means a bottle-fed baby, where fluoridated tap water (with 1 ppm fluoride) is used to make up the formula milk, will get 250 times more fluoride than nature intended.
(b) Fluoride works from the outside of the tooth, not from inside the body, so it is not required to swallow fluoride or drink fluoridated water.

Fluoride's Dangers: Fluoride damages teeth, bone, brain and endocrine system. It may cause osteosarcoma.

MINERAL RESOURCES

"Natural resources in the form of minerals are known as *mineral resources*." They include the ores of base metals such as copper, iron and lead as well as strategic and critical metals such as chromium, titanium, platinum, cobalt, manganese, palladium, etc.

Minerals and Their Classification

Minerals are naturally occurring, inorganic, solid, crystalline substances which contain a specific composition of elements.

A mineral which can be extracted and processed at a profit is known as an *ore*.

Types of minerals

Minerals are broadly classified into two categories: Metallic and non-metallic.

Importance of Minerals

(i) Almost all rocks are made of minerals.
(ii) They have high aesthetic value, e.g. gemstones.
(iii) They have natural resource value:
  (a) Minerals are sources of metals needed for electronic manufacture, airplanes, cars, etc.
  (b) Minerals are raw materials for making window glass, plaster, etc.

Environmental Effects of Extracting and using Mineral Resources

The impacts on forest, land, occupation, water, ecological functions, rehabilitation of population, or impact on flowers due to pollution created during extraction and use of mineral resources are

(i) Deforestation including to loss of flora and fauna.
(ii) Degradation of land due to excavations.
(iii) Occupational health hazards.
(iv) Pollution of ground and surface water resources due to accidental or periodic discharge of pollutants.
(v) Damage to local ecological functions, nutrient cycling and biodiversity due to alterations in water availability or quality.
(vi) Problem in rehabilitation of affected population.
(vii) Pollution of air due to emission of dust and poisonous gases during mining and processing stages. Problems in providing living environment and clean water, air, etc., for the survival of large number of workers who have migrated nearby mine sites.
(viii) Problems in the safe disposal of tremendous amounts of solid waste generated during mining.

Conservation of Mineral Resources

The mineral resources are very essential for the growth and development of a country. The ever-increasing population in the world with improved lifestyles is responsible for the rapid consumption of mineral resources. The geological processes of mineral formation are so low that the rates of replenishment are very small in comparison to the present rates of consumption. Thus, mineral resources are valuable but they will be available for a limited time.

A sincere effort has to be made in order to use the mineral resources in a planned and sustainable manner. The following four steps are very useful for the conservation of mineral resources:

- Encourage use of improved technologies so as to reduce waste generation.
- Encourage recycling of metals.
- Regulate the use of mineral resources.
- Reduce the purchase of unwanted products made from mineral resources.
- Encourage research for providing suitable ecofriendly alternatives for fossil fuels, metals, etc.

These are known as *4R's* for the sustainable use of mineral resources.

Land Resources

Land is a naturally occurring finite resource. It provides the base for survival of living beings. It holds everything that constitutes terrestrial ecosystems. Increased demand on land in modern times due to the rise in human population and resultant activities has resulted in degradation of land quality and quantity, decline in crop production, and competition for land. Land resources are essential for the survival and prosperity of humanity. These resources are also essential for the maintenance of all terrestrial ecosystems.

The basic functions of land in supporting human and other terrestrial ecosystems are given below:

(i) Land is a storehouse of minerals and raw materials for human use.
(ii) Land helps in the production of food, fibre, fuel, etc.
(iii) Land is the biological habitat for many plants, animals and microorganisms.
(iv) Land regulates flow of surface water and stores groundwater.
(v) Land enables or hampers movement of people and animals between one place to another.
(vi) Land is a buffer, filter or modifier for chemical pollutants.
(vii) Land is co-determinant in the global energy balance and the global hydrological cycle, which provides both a source and sink for greenhouse gases.
(viii) Land is the physical space for settlements, industry and recreation.
(ix) Land stores and protects evidence of past climates, archaeological remains from the historical or pre historical record.

Forest Resources

Forests are the dominant terrestrial ecosystem of Earth, and are distributed across the globe. Forests account for 75% of the gross primary productivity of the Earth's biosphere, and contain 80% of the Earth's plant biomass.

A forest constitutes many components that can be broadly divided into two categories that are biotic (living) and abiotic (non-living) components. Forest is made up of many layers such as forest floor, understory, canopy, and emergent layer.

Forests can be classified in various ways such as Boreal, Temperate, Tropical types with their numerous subtypes. Due to increasing population and consequential expansion of modern civilization, there has been continuous depletion of natural forests over the centuries.

Over the past 25 years, global carbon stocks in forest biomass have decreased by almost 11 gigatonnes (Gt). This reduction has been mainly driven by conversion to other land uses and to a lesser extent by forest degradation.

Usefulness of Forest Resources

- Forest is an important natural resource. Forests are vital for the ecological balance and play an important role in temperature regulation in the atmosphere.
- Forests are natural and vast reservoir of food and shelter for animals. They provide natural habitats for numerous species of plants, animals and micro-organisms.
- Forests provide timber, bamboo, canes, leaves, grass, oil, resins, gums, shellac, tanning materials, dyes, hides, fur, fruits, nuts, roots, tubers and other useful things for human beings.
- Forests provide raw materials for forest-based industries.
- Forests are the natural home to medicinal herbs and plants.
- Forest directly or indirectly affects the climate (temperature, precipitation, moisture, underground water-table).
- Forests prevent floods and soil erosion, land degradation and improve the quality of air and water.
- Forests help in purifying air, water, and soil pollution.

Energy Resources

Energy is defined by physicists as the capacity to do work. Energy is found on our planet in a variety of forms, some of which are immediately useful to do work, while others require a process of transformation. The sun is the primary energy source in our lives. Besides, water, fossil fuels such as coal, petroleum products, water, nuclear power plants are sources of energy.

Growing Energy Needs

Energy has always been closely linked to man's economic growth and development. Present strategies for development that have focused on rapid economic growth have used energy utilization as an index of economic development. This index, however, does not take into account the long-term ill effects on society of excessive energy utilization.

For almost 200 years, coal was the primary energy source fueling the industrial revolution in the 19th century. At the close of the 20th century, oil accounted for 39% of the world's commercial energy consumption, followed by coal (24%) and natural gas (24%), while nuclear (7%) and hydro/renewable (6%) accounted for the rest.

Industrialization, urbanization, and unbelievable rise in human settlements have multiplied the energy requirement by several times. Modern lifestyle and man's growing dependence on machines and equipment for his personal and professional work has added to the energy demand. Global oil demand continues to grow until 2040, mostly because of the lack of easy alternatives to oil in road freight, aviation and petrochemicals, according to WEO-2016, published by International Energy Agency.

Renewable Energy Resources

Renewable energy systems use resources that are constantly replaced and are usually less polluting. Examples include hydropower, solar, wind, and geothermal (energy from the heat inside the earth). We also get renewable energy from burning trees and even garbage as fuel and processing other plants into bio-fuels.

Renewable and Nonrenewable Energy Sources

Conventional and Nonconventional Sources of Energy

Conventional energy sources are energy sources which are nonrenewable. However, *nonconventional energy sources* are energy sources which are renewable and ecologically safe.

Important energy sources

The important differences between conventional and nonconventional sources of energies are summarized.* below:

Differences between conventional and nonconventional sources of energies

Conventional Sources of Energy	**Nonconventional Sources of Energy**
They are fully developed.	They are still undergoing development
They use nonrenewable resources.	They use renewable resources.
Inexpensive	Expensive
Require established technologies	Require new technologies which are still under research and development.
Ecologically not safe for usage	Ecologically safe to use
Available in limited quantity	Available in plenty
Carbon and other greenhouse gas emissions from the combustion of coal, natural gas, etc., are known to have disastrous environmental and health consequences. These gases are also major culprit in climate change.	Free from such problems.
Examples: Petroleum, coal, etc	*Examples:* Solar, wind and hydropower, etc.

Renewable energy resources

Wind Energy

The moving air or wind has huge amounts of kinetic energy, and it can be transferred into electrical energy using wind turbines. The wind moves the blades, which spins a shaft, which is further connected to a generator, which generates electricity.

Solar Energy

Solar energy is the energy received by the earth from the sun that is converted into thermal or electrical energy. Solar energy influences the earth's climate and weather and sustains life. Although solar energy only provides 0.15% of the world's power, experts believe that sunlight has the potential to supply 5000 times as much energy as the world currently consumes. Wind, biomass and hydropower are all forms of solar energy.

Biomass Energy

The term *biomass* is used for the dead plants and trees (e.g. wood, crop residue, etc.) and

the waste material of living organisms (e.g. cattle dung, sewage, etc.). *Biomass energy* or *bioconversion* means the direct burning of waste paper, wood, cattle dung or converting them to a fuel.

The various ways of using biomass as a fuel:

(i) Biomass can be directly used as a fuel.
Example Burning of biomass like cattle dung in *chulhas*.

(ii) The biomass is first converted into a fuel and then these fuels are used for heating purposes, more effectively. *Example* Conversion of cattle dung into biogas.

Hydropower

Hydroelectricity or hydroelectric power is the electricity obtained by harnessing the power of water flowing down from a high level. It is a renewable, affordable and pollution-free source of energy.

Tidal and Wave Power

The earth's surface is 70% water. By warming the water, the sun creates ocean currents and the wind that produces waves. It is estimated that the solar energy absorbed by the tropical oceans in a week could equal the entire oil reserves of the world – 1 trillion barrels of oil.

Geothermal Energy

It is the energy stored within the earth ("geo" for earth and "thermal" for heat). Geothermal energy starts with hot, molten rock (called magma) deep inside the earth which surfaces at some parts of the earth's crust. The heat rising from the magma warms the underground pools of water known as geothermal reservoirs. If there is an opening, hot underground water comes to the surface and forms hot springs, or it may boil to form geysers. With modern technology, wells are drilled deep down the surface of the earth to tap into geothermal reservoirs. This is called direct use of geothermal energy, and it provides a steady stream of hot water that is pumped to the earth's surface.

Non Renewable energy resources

Fossil Fuels

Petroleum and coal are formed from the fossilized remains of animals and plants, hence they are known as *fossil fuels*. As they are used up much more rapidly than they are replenished by nature, it might ultimately result in fuel shortage.

Coal

Coal is defined as stratified rock, consisting of organic matter of fuel value derived from the partial decay and alteration of accumulated plant materials by the action of heat and pressure over millions of years.

Petroleum

Petroleum is a complex mixture of paraffinic, olefinic and aromatic hydrocarbons with small quantities of organic compounds containing oxygen, nitrogen and sulphur. It is also called mineral oil because it occurs beneath the earth. Petroleum refining of crude oil or petroleum provides many liquid fuels that are in current use.

(i) **Gasoline or Petrol** It is a mixture of hydrocarbons from pentane to octane. It is highly volatile and inflammable. It is used as a fuel for internal combustion engines.

(ii) **Diesel Oil** It is a mixture of higher hydrocarbons (C_{15} to C_{18}). It is used as a fuel for diesel engines.

(iii) **Kerosene Oil** It is a mixture of hydrocarbons (C_{10} to C_{16}). It is used as domestic fuel in stoves.

Gaseous Fuels

(i) **Natural Gas:** It is obtained from wells dug in the oil-bearing regions. It is mainly composed of methane, ethane and other hydrocarbons. It is also called *marsh gas* because it mainly consists of methane (about 88.5%).

(ii) **Compressed Natural Gas (CNG)**: The natural gas compressed at very high pressure of about 1000 atmosphere is called CNG. The use of CNG as a fuel for automobiles has reduced pollution in urban cities. As it undergoes complete combustion in CNG engine so there is nil possibility of release of CO in the atmosphere. Further, CNG is much safer fuel with lower operating cost.

(iii) **Liquified Petroleum Gas (LPG):** The main constituents of LPG are *n*-butane, isobutane, butylene and propane. It is mainly used as domestic fuel. To help in the detection of gas leakage, a strong-smelling substance, viz. ethyl mercaptan, is added to the LPG gas cylinders. LPG is also used as motor fuel because it easily mixes with air and burns cleanly without residue and without knocking.

Types of Ecological Pyramids

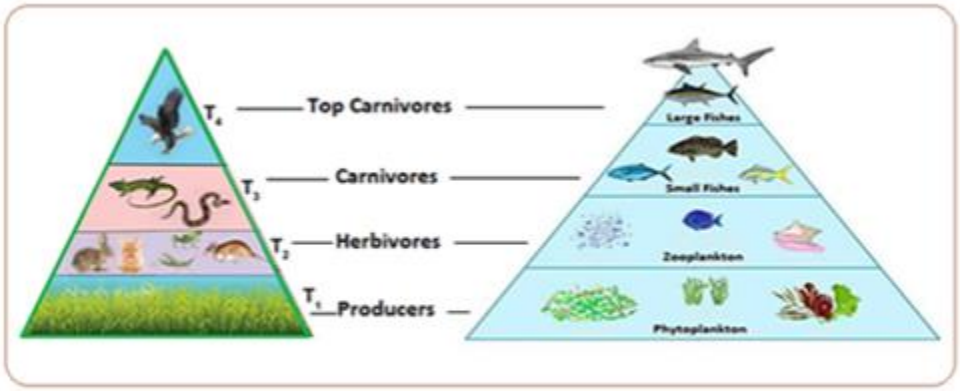
Pyramid of Numbers

This represents the **total numbers of individuals** (population) present in each trophic level. This pyramid is quite convenient especially when it comes to counting the number of organisms

This is divided into following different forms depending on the number of organisms

In the Upright pyramid of numbers, the numbers of organisms mostly reduce from bottom to top.

It usually occurs in pond and grassland ecosystems where plants occupy the base of the pyramid.



The next levels of the pyramid include the consumers

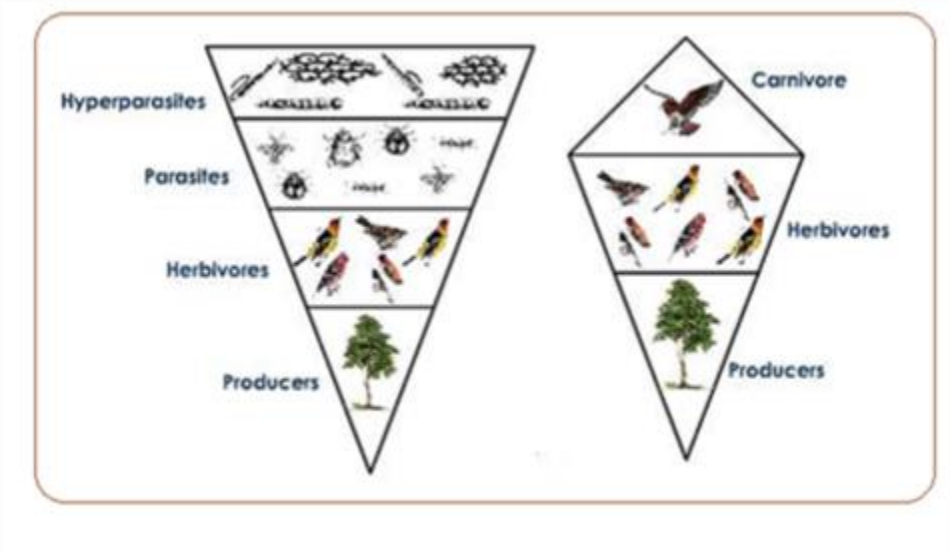
An inverted pyramid is actually the opposite of the upright pyramid.

It can closely be observed in tree ecosystem, where trees are the producers and insects are the consumers

The producers in the tree ecosystem are the least in numbers, and the population of consumers gradually increases at each trophic level

Spindle-shaped Pyramid of Number is known as a **partially upright pyramid,** because there is neither sequential increase nor decrease in the number of individuals in an ecosystem

This type of pyramid of numbers is found in the forest ecosystem without parasites.



In a forest ecosystem however, the producers are large sized trees which make the base of pyramid. The herbivores such as fruit eating birds, deer, elephants etc. make the primary consumers which are more numerous than the trees. These herbivores support fewer numbers of carnivores and thus the pyramid of numbers is thus spindle shaped.

The population of higher tropic individuals usually become **continuously lower** because of food wastage during eating, wastage of food during digestion and finally use of food in the process of respiration and physical activities

Amongst the three ecosystem pyramids, the pyramid of number is the **most incorrect**, as it **does not take into consideration** the exact population.

Hence, it cannot completely elaborate on the trophic structure in a system

This pyramid **ignores the biomass of species** and it doesn't show the energy transferred between individual groups

Pyramids of numbers are **not very functional** as they **do not give a clear or true picture** of the food chain

Also, They do not indicate specifically the **absolute effects** of the geometric, food chain, size factors of specific organisms

Pyramid of Biomass

Biomass is the **amount per unit area product** of the living material existing in an individual or a number of individuals at in particular trophic level

This pyramid indicates the total mass of organisms in a particular trophic level

The pyramid is usually larger at the bottom but as it goes up it reduces in size and becomes smaller.

There is always a reduction of biomass with an increase in trophic level.

Approximately 10% to 20% of the biomass is passed from one trophic level to the other.

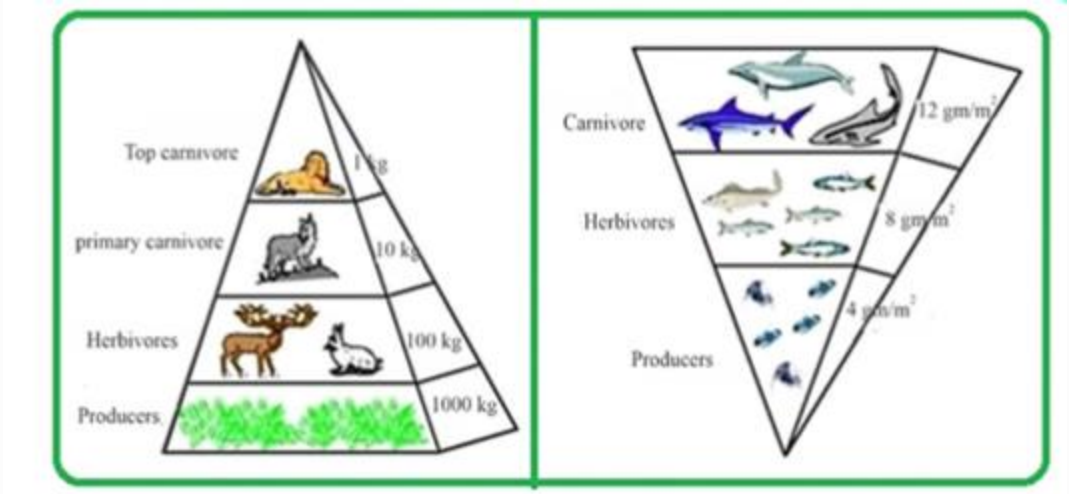
The pyramid of biomass has two forms **inverted and upright pyramids**

The aquatic ecosystem is characterized by an **inverted pyramid** because phytoplankton producers are located at the base of the pyramid, while consumers have larger biomass and they are located at the top

Upright pyramid example is the **terrestrial ecosystem**. It has a large base mainly consists of primary consumers, the smaller trophic levels are located at the top

This pyramid can be used to solve the **particular issue** in the pyramid of numbers because it shows the exact representation of the amount of energy present in each trophic level.

When there is a reduction of biomass with a rise in trophic levels, it signifies wastage and consumption of biomass at every transfer level.



Upright Pyramid of Biomass & Inverted Pyramid of Biomass

Pyramid of Energy

Pyramid of energy is an upright pyramid that illustrates the flow of energy from producers to consumers

It indicates the actual role played by various organisms in energy transfer. Energy pyramids indicate how much energy is required in the next trophic level as it flows upwards

The pyramid of energy is based on the concept of the flow of energy in a food chain.

Only **10% of the total energy** is transferred to the successive trophic levels and creating the biomass”

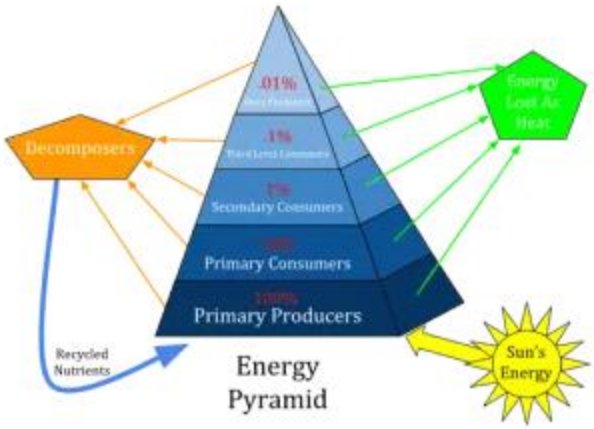
Remaining is utilized in respiration, hunting, and other activities or is lost to the surroundings in the form of heat.

Hence the energy available at each trophic level is 10% of the previous level. It is called **the ten percent law of energy**

This leads to the formation of an **upright pyramid of energy** that is invariably formed in each ecosystem.

The energy is highest at the producer level and gradually decreases as it moves to the subsequent levels, including herbivores (primary consumer), carnivores (secondary, tertiary consumers)

An example of the pyramid of energy can be illustrated as below:



Aquatic ecosystem

:

An aquatic ecosystem is a water-based ecosystem. It includes communities inhabiting water and their interaction with the environment. Ponds, lakes, wetlands, rivers, and estuaries are some examples of aquatic ecosystems.

Primary consumers or herbivores

:

Primary consumers or herbivores are organisms that are directly dependent on the producers for their food, i.e, they feed on the producers only.

Molluscs

Molluscs feed on photosynthetic algae or phytoplanktons present in the aquatic ecosystem. As they directly feed on the producers, they are considered to be the primary consumers or herbivores of an aquatic ecosystem.

Insects

Aquatic insects feed on all possible food sources such as dead plant material, heterotrophic zooplanktons, dead remains of small animals, bacteria, fungi, etc. Thus they are not necessarily primary consumers in a food chain and can occupy the trophic level of secondary consumers or carnivores too.

Birds and mammals

Aquatic birds, large fishes and aquatic mammals feed on secondary consumers such as smaller fishes and insects which in turn feed on primary consumers such as zooplanktons, molluscs, small crustaceans, etc. Thus, the aquatic birds and mammals are tertiary consumers or the top carnivores and occupy the highest level in any aquatic food chain.

Examples of Aquatic animals

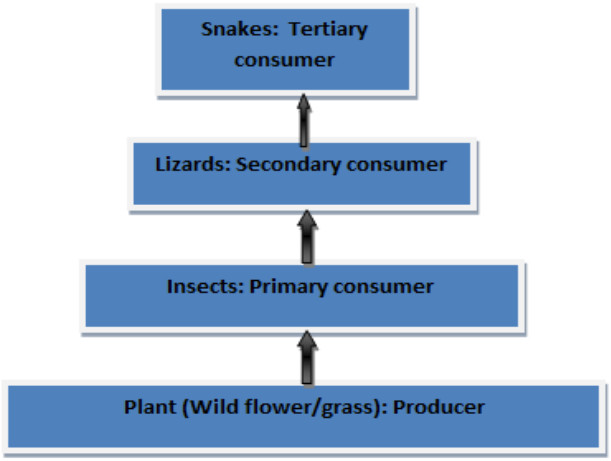
The larger fishes like tuna, barracuda, jellyfish, dolphins, seals, sea lions, turtles, sharks, and whales are tertiary consumers. They feed on the **primary producers like phytoplankton and zooplankton, as well as secondary consumers like fish, jellyfish, as well as crustaceans**.

TROPHIC LEVELS

The producers and consumers in the ecosystem can be arranged into different feeding groups and are known as trophic level or the feeding level.

1. The producers (plants) represent the first trophic level.
2. Herbivores (primary consumers) present the second trophic level.
3. Primary carnivores (secondary consumers) represent the third trophic level
4. Top carnivores (tertiary consumers) represent the last level.

DESERT ECOSYSTEM



The figure above shows an example of a food chain found in the desert ecosystem. The food chain is divided into nutritional levels whereby the lowest level is occupied by produces, the second level by primary consumers, the third level by secondary consumers, and the fourth level by tertiary consumers.

The desert ecosystem is often considered to be one of the harshest to living organisms. Plants such as shrubs, cactus, wildflowers, and grasses are the primary producers in the desert ecosystem where they produce energy through photosynthesis. Many desert plants have sharp spines and chemical-filled leaves to avoid being eaten by animals. An animal that feeds on plants in the desert ecosystem is classified as the primary consumer. Primary consumers such as the kangaroo, rat looks for seeds that are safe to eat. The energy manufactured by plants flows into primary consumers/herbivores such as Kangaroo, rats and jackrabbits, which are preyed on by secondary consumers/carnivores like snakes.

Large trees such as the Joshua tree often play a critical role in the desert ecosystem. The trees provide homes for birds, lizards, and insects. Some birds feed on seeds or nectar, while others feed on insects that inhabit the trees. Fallen trees provide food for detritivores such as termites which are in turn eaten by lizards. The lizards are eaten by carnivores such as owls and snakes to continue the energy flow cycle. Decomposers in the desert ecosystem are mainly bacteria and fungi. The following food chains might also be found in the desert ecosystem:

Plants (forbs) → Mule Deer → Mountain lion
Plant (Shrub seeds) → Quail→ Coyote
Plant (Seeds) → Rats→ Snakes→ Hawk

Apart for the biotic factors, there are abiotic factors that also play a very important role in the maintenance of an ecosystem. The abiotic factors found in the desert ecosystem include air, sand, sunlight, temperature, and water.

BIODIVERSITY

Biodiversity, a shortened form of **Biological diversity**, refers to the existence of number of different species of plants and animals in an environment.

Biodiversity is also defined as the existence of variability among living organisms on the earth, including the variability within and between species, and within and between ecosystems.

The year 2010 was declared asthe International Year of Biodiversity.

Biodiversity represents the quality and characteristic features of life in an eco- system. Being a combination of genes, species and the ecosystem itself, biodiversity can be considered at three levels: genetic diversity; species diversity and ecosystem diversity.

These are briefly explained below.

Species Diversity

Species diversity refers to the variety of different species of plants, animals, fungi, and organisms that are present in a region. It is estimated that there are above 30 million species on the earth. Even within a small pond, we can notice a great variety of species. Species diversity differs from ecosystem to ecosystem. For example, in a tropical ecosystem more diversity is found than in temperate ecosystem. The most diverse group of species is invertebrates - animals without backbones.

At present, conservation scientists have been able to identify and categorize about 1.8 million species on earth. Many new species are being identified. Areas that are rich in species diversity are called ‘hotspots’ of diversity.

Genetic Diversity

It is the variation in genes that exists within a species. Genetic diversity corresponds to the variety of genes contained in plants, animals, fungi, and micro-organisms. It occurs within a species as well as between species. Each human being is different from all others. This genetic variability is essential for a healthy breeding of a population of species.

Ecosystem Diversity

It indicates the variation in the structure and functions of ecosystems. It tells about trophic levels, energy flow, food and total stability of ecosystems. The ecosystems can be of various types as governed by the species composition and the physical structure. Following are a few examples:

(i) Terrestrial ecosystems
(ii) Aquatic ecosystems
(iii) Artificial or man-made ecosystems

Significance of Biodiversity

Environmental services from species and smooth running cycles of ecosystems are necessary at global, regional, and local levels.

Biodiversity is essential for maintaining the water cycles, production of oxygen, reduction in carbon dioxide, protecting the soil, etc. It is also essential for preserving ecological processes, such as soil formation, circulation of and cleansing of air and water, global life support, fixing and recycling of nutrients, maintaining hydrological balance within ecosystems, maintaining rivers and streams throughout the year, etc.

Biodiversity has many values such as consumptive use value, productive use value, social values, ethical and moral values.

A healthy biodiversity offers many valuable services as follows.

- The more a region is rich in terms of biodiversity, better is the regulation of the different cycles. For example, forests regulate the amount of carbon dioxide in the air by releasing oxygen as a by-product during photosynthesis, and control rainfall and soil erosion.
- Protects water resources from being depleted, contaminated, or polluted.
- Helps in soil formation and protection.
- Helps in nutrient storage and recycling.
- Helps check pollution.
- Contributes to climate stability.
- Helps an ecosystem in recovery from unpredictable events.
- Provides biological resources such as food, medicinal resources, and pharmaceutical drugs, wood products, ornamental plants, breeding stocks, etc.
- Provides recreation and tourism facilities.
- Helps in research, education, and monitoring.
- Preservation of biological resources is essential for the well-being and long-term survival of mankind.

India as a Mega Diversity Region

Mega diversity refers to a country's ability to exhibit a high level of biodiversity. India is one of the world's 17 mega diversity countries.

Criteria as Mega Diversity region

- Have at least 5,000 endemic plant species
- Have marine ecosystems

Reasons why India is a Mega Diversity region

- India has only 2.4 percent of the world's land area, but it has 8.1 percent of the world's species diversity.
- 47,000 endemic plant species

- 90,000 animal species.
  Total 1,37,000 species
- 14 major river basins
- Different seasons
- Type of ecosystems
- Coastal Boundary
- 5 world heritage sites
- 18 biospheres reserves
- High rainfall
- Types of soil

The rich flora and wildlife of India are well-known. India is home to about 500 mammalian species, over 200 avian species, and over 30,000 insect species. The Zoological Survey of India, headquartered in Kolkata, is in charge of surveying India's faunal resources.

More than 18 percent of Indian plants are endemic (native to a particular region) to the country and found nowhere else in the world.

These are the reasons why India is Mega biodiversity region

Hotspots of biodiversity

The areas on earth which exhibit high species richness as well as high species endemism are termed hot spots of biodiversity.

To qualify as a hot spot, an area must satisfy the following criteria:

1. It has at least 1,500 vascular plants as endemic.
2. It must have lost more than 70% of its original habitat.

Hotspot covers 2.5 percent of the Earth's geographical area.

Across the world, about 36 areas are marked as hotspots of biodiversity and out of 36, 4 of them are in India

(a) The Western Ghats
(b) The Eastern Himalayas
(c) Indo Burma
(d) Sundaland

Many of the biodiversity hotspots exceed the two criteria. For example, both the Sundaland Hotspot in Southeast Asia and the Tropical Andes Hotspot in South America have about 15,000 endemic plant species.

ENDANGERED AND ENDEMIC SPECIES

(i) *Endemic species* can be defined as those species that have very restricted distribution and are confined over relatively small ranges. *Examples:* Lion-tailed Macaque, Nilgiri leaf monkey.

(ii) When there is no reasonable doubt that the last individual has died, the species is said to be *extinct*.
(iii) A species is *endangered* when it is not critically endangered but is facing a high risk of extinction in the wild in the near future.
(iv) A species is *vulnerable* when it is not critically endangered or endangered, but is facing a high risk of extinction in the wild in the near future.

Endangered species are provided with legal protection because their population decreases very rapidly. *Examples:* Tiger, Asian elephant, etc.

Endemic Species of India

The following is a list of the species that are unique to India and can only be found there:

Kashmir Stag, Kashmir Valley
Lion-Tailed Macaque, The Western Ghats and the
Purple Frog, Western Ghats
Sangai Deer, Loktak Lake
Nilgiri Tahr, Nilgiri Hills
Nilgiri Langoor
Pygmy Hog, Assam
Bronzeback Vine Snake, Western Ghats
Nilgiri Blue Robin, Nilgiri Hills
Malabar Civet, Western Ghats
Indian Giant Squirrel
Bonnet Macaque

Endangered species of India

Sumatran Rhinoceros
Javan Rhinoceros
Snow leopard
Red panda
Forest owlet
Asian Elephant
South Asian river Dolphin

RARE AND THREATENED SPECIES

Rare species, although are not vulnerable or endangered, have a very small population in the world.

Threatened species are those species which may become extinct if not protected. They include the rare, vulnerable and endangered species. *Examples:* Elephant, chinkara, Nilgiri tahr, Indian wild ass, lion-tailed macaque, tiger, cheetah, sloth bear, rhinoceros, etc.

THREATS TO BIODIVERSITY

In the last 150 years, the rate at which species are disappearing is about thousands per decade while the natural extinction rate is only one or two species per decade.

Some of the main causes are as follows:

(i) *Degradation of Habitat* A habitat is place where living beings find food, cloth and shelter and a safe place to reproduce and bring up their offspring. Thus, loss of habitat is the greatest threat to the world.

(ii) *Overexploitation of Resources* A number of species like tigers, giant pandas, etc., are on the verge of extinction because of overexploitation of resources.

(iii) *Pollution* Pollution is responsible for global climatic changes and for the extinction of most species.

(iv) *Poaching of Wildlife* Poaching is the illegal killing of wildlife for sale in the international trade market. The animals are killed due to the following reasons:

- Some wildlife species are killed for consumption (eating).
- Elephants are killed to obtain their teeth for financial gains.
- Tigers/lions are killed to extract their skin to be sold for decoration of drawing rooms of some people.

We can stop poaching and conserve wildlife by

(a) Reporting poaching incidents to the concerned officers
(b) Encouraging effective wildlife legislation, and law enforcement
(c) Spreading awareness about the importance of wildlife
(d) Refusing to purchase products that have been illegally obtained from animals

CONSERVATION OF BIODIVERSITY

As per the Ministry of Environment and Forests, Government of India, the objectives of conservation of biodiversity are

(i) To protect all endangered and rare *species*
(ii) To protect natural *habitats* for preserving all varieties of old and new flora, fauna and microbes
(iii) To increase public awareness through media, government agencies, NGOs, etc, and implement strict restrictions on export of rare plants and animals
(iv) To reduce *pollution*
(v) To maintain ecological balance
(vi) To utilize the natural resources in a sustainable way

There are two main methods for the conservation of biodiversity.

In-situ Conservation

In-situ or on-site conservation refers to the conservation of species within their natural habitats. This is the most viable way of biodiversity conservation. It is the conservation of genetic resources through their maintenance within the environment in which they occur.

Examples − National Parks, Wild Life sanctuaries, Biosphere Reserves

Ex-situ Conservation

Ex-situ conservation means the conservation of components of biological diversity outside their natural habitats. In this method, threatened or endangered species of animals and plants are taken out of their natural habitat and placed in special settings where they can be protected and provided with natural growth.

In ex-situ conservation methods, the plants and animals taken away from their habitats are taken care of in an artificially created environment.

Examples − Captive Breeding, Gene Banks, Seed Banks, Zoos, Botanical gardens, Aquaria, Tissue Culture.

Bioprospecting

Bioprospecting is the process of discovery and commercialization of new products based on biological resources.
Biodiversity, also known as bioprospecting, is a systematic exploration for natural molecular compounds, which has huge commercial and economic value in pharmaceutical, agriculture, cosmetics, bioremediation, aquaculture and biotechnology related industries. When a potential compound is discovered, it is analysed and screened for its commercial value. Once approved for use, the plant source can be cultivated on a larger scale to produce more product. This will in turn accelerate research, generate more revenue to the rural and regional people. Some of the bioprospecting-derived products are laccase enzymes from fungi to treat wastewater from beef factory, algal derived oligosaccharides to treat erythema and anti-fungal drug obtained from soil fungi. Currently, bioprospecting is performed on the lesser ventured ecosystems like seas and oceans.

Biopiracy

While biopiracy is when researchers and scientists use sources from nature and traditional knowledge without permission and exploit the indigenous cultures they're getting their information from.

The use of bio resources by the multinational companies and other organizations without any systematic approval from a nation or its related people without any compensatory payment is called biopiracy. Feeling is developing between developing and developed nations about injustice, inadequate compensation and benefits sharing. Due to this some nations are making rules to ban the use of their bioresources without prior permission.

Example of biopiracy:

1. Patenting of Azadirachta indica – Neem: We Indians have been using Neem since ancient times. We have shared our knowledge regarding neem across the globe. An American firm registered a patent in the United States for an insecticide whereas in 1994 the European Patent Office also granted a patent relating to fungicides but many Indian associations felt that these patents were confiscating ancestral knowledge as well as knowledge accumulated by farmers and Indian researchers over hundreds of years.

2. Basmati rice, Neem and turmeric are also are indigenous to the Indo-Pak subcontinent.