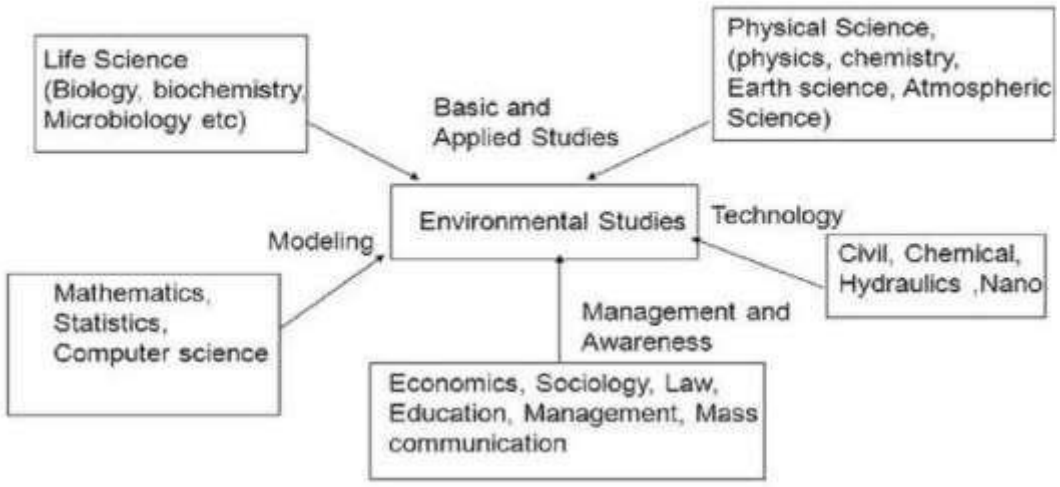
UNIT 1

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:**

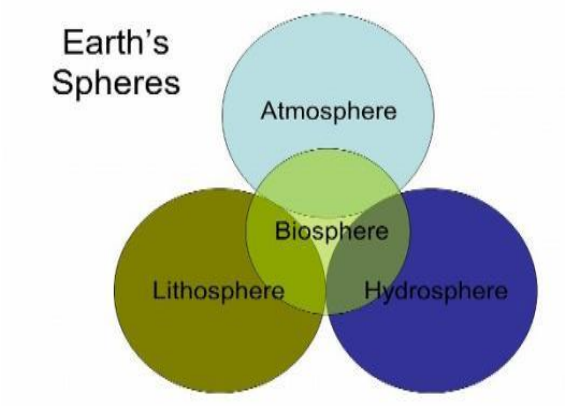
It covers more than 75% of the earth surface either as oceans or as fresh water. Hydrosphere includes sea, rivers, oceans, lakes, ponds, streams etc.

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 moneyin 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.

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.

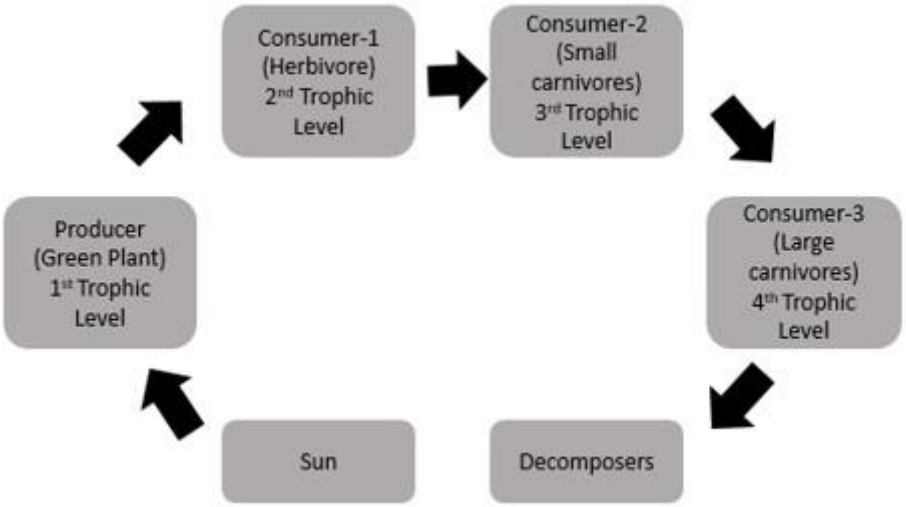
Consumers − At the second trophic level, there are consumers who depend upon others for food.

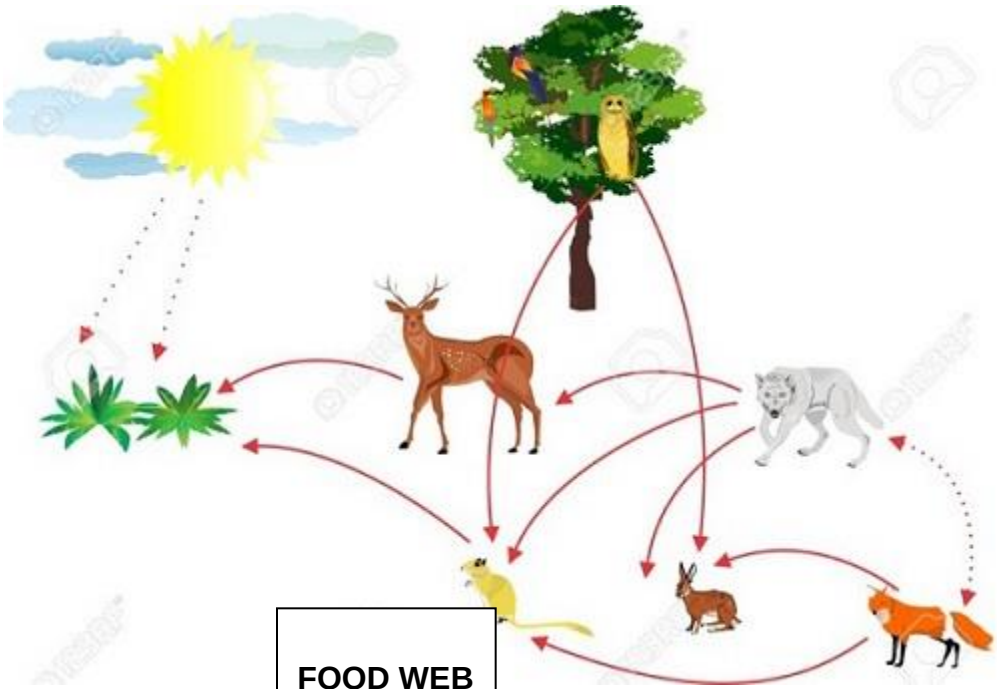
- **Primary Consumers (Second Trophic Level)** − Primary consumers eat the producers. They are called herbivores. Deer, turtle, and many types of birds are herbivores.
- **Secondary Consumers (Third Trophic Level)** − Secondary consumers based at the third trophic level eat plants and herbivores. They 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

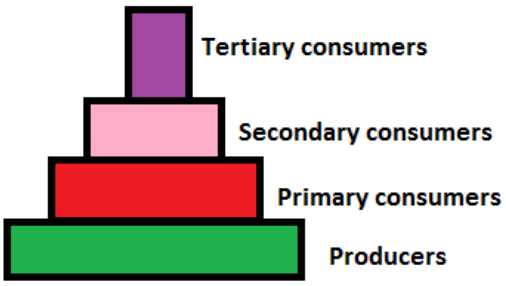
Ecological Pyramid refers to a graphical (pyramidal) representation to show the number of organisms, biomass, and productivity at each trophic level. It is also known as **Energy Pyramid**. There are three types of pyramids. They are as follows −

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

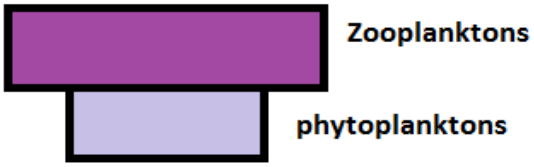
In a forest ecosystem, there is less number of producers that support a greater number of herbivores who in turn support a lesser number of carnivores. The shape of the pyramid of numbers is partly upright or spindle type.

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.

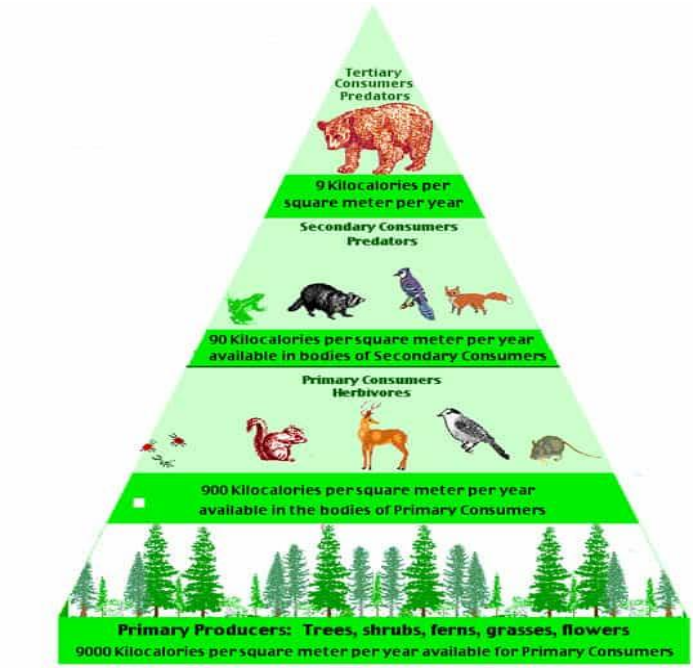


Pyramid of biomass in oceans

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.

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.

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.

Biogeochemical Cycle

"Biogeochemical cycles mainly refer to the movement of nutrients and other elements between biotic and abiotic factors."

The term biogeochemical is derived from **"bio"** meaning **biosphere**, **"geo"** meaning the **geological components** and "**chemical**" meaning the **elements that move through a cycle**.

The earth obtains energy from the sun which is radiated back as heat, rest all other elements are present in a closed system. The major elements include:

- Carbon
- Hydrogen
- Nitrogen
- Oxygen
- Phosphorus
- Sulphur

These elements are recycled through the biotic and abiotic components of the ecosystem. The atmosphere, hydrosphere and lithosphere are the abiotic components of the ecosystem.

Types of Biogeochemical Cycles

Biogeochemical cycles are basically divided into two types:

- **Gaseous cycles** – Includes Carbon, Oxygen, Nitrogen, and the Water cycle.
- **Sedimentary cycles** – Includes Sulphur, Phosphorus, Rock cycle, etc.

Carbon Cycle

Carbon Cycle Definition

Carbon cycle is the process where carbon compounds are interchanged among the biosphere, geosphere, hydrosphere, and atmosphere of the earth.

In the carbon cycle, plants absorb carbon dioxide from the atmosphere through the photosynthesis process and convert this CO_2 and water into oxygen and carbohydrates, which they need for growth. Animals breathe in this oxygen, eat the plants and use the carbon of carbohydrates to build their own tissues. These animals return carbon di oxide into the air, when they breathe and when they die, as the carbon is returned to the soil during decomposition. The carbon atoms in the soil may then be used in a new plant or small organisms. When we burn fossil fuels like oil, the carbon in the fuel combines with atmosphere oxygen to form carbon di oxide.

Carbon exists in the non-living environment as

- Carbon dioxide in the atmosphere and by forming bicarbonates, it gets dissolved in water.
- Carbonate rocks (like limestone $CaCO_3$)
- Deposits of coal, petroleum and natural gas derived from living things.
- Dead organic matter eg. Humus in the soil

Carbon enters the biotic world through the action of producers

- Primarily photoautotrophs (like plants). They use the energy of light to convert carbon dioxide to organic matter.
- And to small extent, chemotrophs (like bacteria).

Carbon returns to the atmosphere by

I) Respiration (as CO_2)
II) Burning or combustion of fossil fuels
III) Decay of animal and plants body

Nitrogen Cycle

The nitrogen cycle is a biogeochemical process in which nitrogen is circulated from the atmosphere to the living organisms and later back to the atmosphere. Living organisms require nitrogen for the synthesis of nucleic acid and proteins. The atmosphere contains almost 78% of nitrogen present in an inert form (N_2). This nitrogen cannot be used by living organisms unless it is converted to ammonia, nitrates, and other usable compounds of nitrogen.

The nitrogen cycle is a cyclic process where the nitrogen travels from inorganic form in the atmosphere and to the organic way in the living organisms. The nitrogen cycle contains several steps, such as nitrogen fixation, nitrification, assimilation, ammonification and denitrification. This cycle is essential in maintaining a proper ecological balance.

Nitrogen Cycle Steps

There are several steps of the nitrogen cycle as mentioned above, the complete process can be classified into several steps. Each of the steps is described below in the article.

Nitrogen Fixation

The first step involves the fixation (conversion) of atmospheric inert nitrogen into a usable form of nitrogen.

There are two ways nitrogen fixation can take place.

Atmospheric Nitrogen Fixation: When the lightning strikes, the inert nitrogen gas present in the atmosphere reacts with oxygen and converted into nitrates which plants can easily absorb. However, the nitrogen fixation in atmosphere contributes small amount of nitrogen in the cycle.

Biological Nitrogen Fixation: Nitrogen-fixing bacteria present in roots of legumes convert nitrogen present in the atmosphere into Ammonia.

Nitrification

The large amount of nitrogen fixation is accomplished by the free living bacteria in the soil. They can convert ammonia into nitrates that can be absorbed by the roots of the plants. The process in which the ammonia is converted into nitrates by Nitrifying bacteria is called Nitrification.

Assimilation

The nitrates from the soil are absorbed by the roots of plants to make their own amino acid to produce proteins which are needed for their growth and photosynthetic activity. This process of absorbing nitrates from the soil by the roots of plants is Assimilation.

Ammonification

The process of converting dead organic matter into ammonia through the action of bacteria and fungi is Ammonification. Ammonia is also converted into nitrates through nitrification. The nitrifying bacteria transform the ammonia into nitrates and assimilate by the tree. Ammonification increases the concentration of ammonia in the ground.

Denitrification

Denitrifying bacteria found in the soil convert nitrates of the soil to free nitrogen which escape to the atmosphere and thus completes the cycle and maintains the atmospheric balance of nitrogen concentration.

Sulphur cycle

Sulphur is one of the most abundant elements on the earth. It is a yellow, brittle, tasteless, odourless non-metal. Sulphur is present in all kinds of proteins. Plants directly absorb sulphur-containing amino acids.

Sulphur enters the atmosphere through natural and human sources in the form of oxides of sulphur. It reacts with rain and falls into earth as acidic sulphate deposition. The sulphate is absorbed by plants as it is required for making amino acids, protein etc. Animals consume these plants so that they take up enough sulphur to maintain their health. This is because sulphur is important for the functioning of enzymes and proteins.

A simplified version of the pathways, transformations and chemical species in a sulphur cycle is illustrated in figure.

(i) Sulphate ($SO4^{-2}$) is reduced to hydrogen sulphide by sulphate reducing bacteria.

(ii) Some sulphate is assimilated by organisms to form cell components such as amino acids and cofactors.

(iii) Organic sulphur is converted to H_2S upon minerization

(iv) H_2S is transformed to elemental sulphur (S)

(v) Sulfide oxidizing bacteria convert S into $SO4^{-2}$

(Vi and Vii) Anoxygenic phototrophic bacteria also convert H_2S to $SO4^{-2}$ via elemental sulphur

(Viii) Sulphur reducing bacteria transform back the elemental sulphur to H_2S

ix) Some H_2S complexes with iron to form black FeS precipitates, whose recycling is slow.

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.

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	Influence on climate gets disturbed.

environmental respectively.	

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.

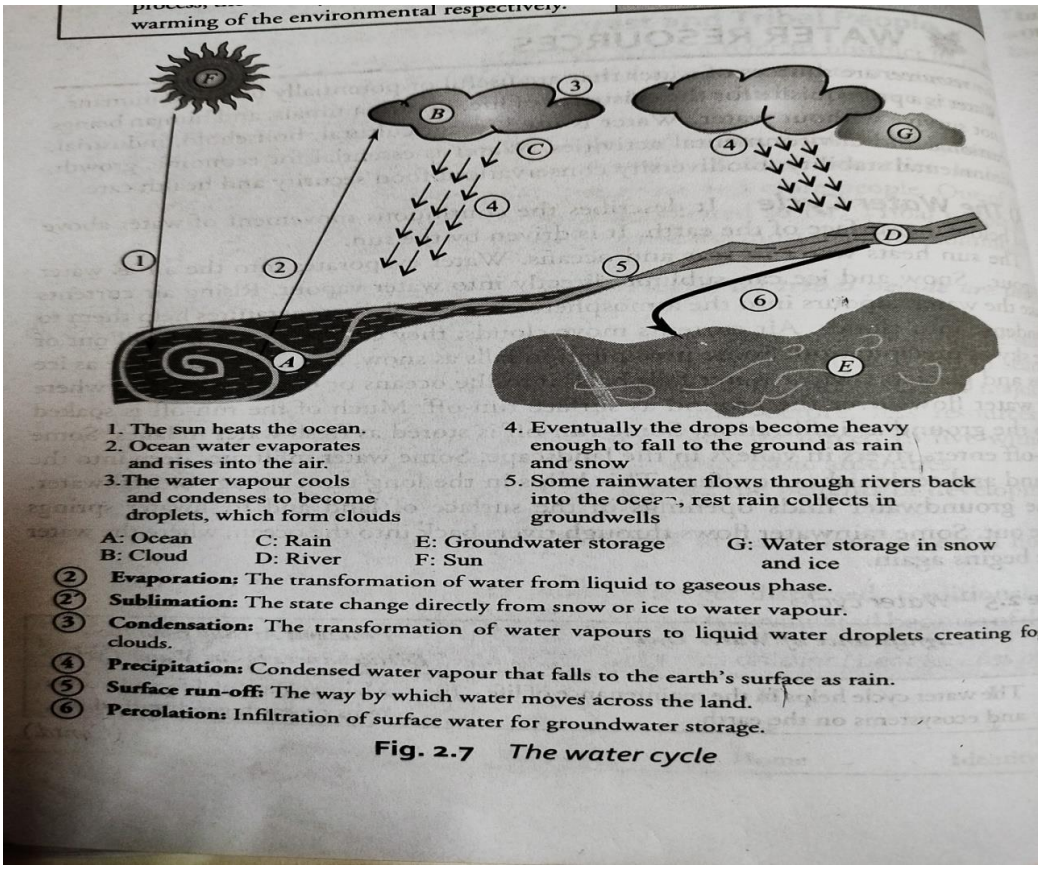


Fig. 2.7 *The water cycle*

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.

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.

Pollution

(i) Source: It is the system (material or activity) which releases the pollutant.

(ii) Sink: It is the store where the pollutant is received and stored for a long time.

"Pollution is the introduction of substances (or energy) that cause adverse changes in the environment and living entities."

Pollution need not always be caused by chemical substances such as particulates (like smoke and dust). Forms of energy such as sound, heat or light can also cause pollution. These substances that cause pollution are called pollutants. A pollutant creates damage by interfering directly or indirectly with the biogeochemical process of an organism.

Pollutants may be −

- **Natural Pollutants** − Natural pollutants are caused by natural forces such as volcanic eruption and forest fire.
- **Man-made Pollutants** −These refer to the release of excess amount of gases or matter by human activities. For instance, increase in the number of automobiles adds excess carbon monoxide to the atmosphere causing harmful effect on vegetation and human health.

Classification of Pollution

As stated before, there are different types of pollution, which are either caused by natural events (like forest fires) or by man-made activities (like cars, factories, nuclear wastes, etc.) These are further classified into the following types of pollution:

- Air pollution
- Water pollution
- Noise pollution
- Soil or land pollution
- Thermal pollution
- Radiation pollution

Air Pollution

"Air Pollution is the release of pollutants such as gases, particles, biological molecules, etc. into the air that is harmful to human health and the environment." It is the contamination of air by harmful gases, dust and smoke which affects plants, animals and humans drastically.

There are a certain percentage of gases present in the atmosphere. An increase or decrease in the composition of these gases is harmful to survival. This imbalance in the gaseous composition has resulted in an increase in earth's temperature, which is known as global warming.

Types of Air Pollutants

There are two types of air pollutants:

Primary Pollutants

The pollutants that directly cause air pollution are known as primary pollutants. Some are released by natural processes, like ash from volcanoes. Most are released by human activities.

- Carbon oxides are released when fossil fuels burn.
- Nitrogen oxides form when nitrogen and oxygen combine at high temperatures. This occurs in hot exhausts from vehicles, factories, and power plants.
- Sulfur oxides are produced when sulfur and oxygen combine. This happens when coal that contains sulfur burns.
- Toxic heavy metals include mercury and lead.. Both metals come from industrial uses.
- Volatile organic compounds (VOCs) are carbon compounds, such as methane. VOCs are released by many human activities.
- **Particulates** are solid particles. These particles may be ash, dust, or even animal wastes. Many are released when fossil fuels burn.

Examples of primary pollutants include sulfur dioxide (SO2), carbon monoxide (CO), nitrogen oxides (NOX), and particulate matter (PM).

Secondary Pollutants

The pollutants formed by the intermingling and reaction of primary pollutants are known as secondary pollutants. Smog, formed by the intermingling of smoke and fog, is a secondary pollutant. Photochemical smog is also secondary pollutants. This type of smog is seen as a brown haze in the air. Photochemical smog forms when certain pollutants have a chemical reaction in the presence of sunlight. Photochemical smog consists mainly of **ozone** (O_3). This ozone is harmful to humans and other living things. However, ozone in the stratosphere protects Earth from the Sun's harmful ultraviolet radiation.

Examples of secondary pollutants include photochemical oxidants (ozone, nitrogen dioxide, sulfur trioxide) and secondary particulate matter.

Sources of Air pollution

The rising number of air pollutants has made breathing fresh, clean air next to impossible. As pollutants in the air cannot be seen with our naked eyes, we don’t realize the sources of the increasing pollution levels. In order to understand the sources of air pollution, we need to first go through the basic causes of air pollution.

Following are the important causes of air pollution:

Burning of Fossil Fuels

The combustion of fossil fuels emits a large amount of sulphur dioxide. Carbon monoxide released by incomplete combustion of fossil fuels also results in air pollution.

Automobiles

The gases emitted from vehicles such as jeeps, trucks, cars, buses, etc. pollute the environment. These are the major sources of greenhouse gases and also result in diseases among individuals.

Agricultural Activities

Ammonia is one of the most hazardous gases emitted during agricultural activities. The insecticides, pesticides and fertilizers emit harmful chemicals in the atmosphere and contaminate it.

Factories and Industries

Factories and industries are the main source of carbon monoxide, organic compounds, hydrocarbons and chemicals. These are released into the air, degrading its quality.

Mining Activities

In the mining process, the minerals below the earth are extracted using large pieces of equipment. The dust and chemicals released during the process not only pollute the air, but also deteriorate the health of the workers and people living in the nearby areas.

Domestic Sources

The household cleaning products and paints contain toxic chemicals that are released in the air. The smell from the newly painted walls is the smell of the chemicals present in the paints. It not only pollutes the air but also affects breathing.

Effect of air pollution on environment

The effects of air pollution on the environment are disastrous. However, air pollution has been around before man evolved – in the form of forest fires and volcanic eruptions. The environmental crisis that we know today, began only with anthropogenically introduced air pollution. Ever since the use of coal began, greenhouse gases began to accumulate in the atmosphere. This has a negative impact on the planet, which consequently affects all life too.

Effects of air pollution can manifest themselves in different ways. It can occur as smog or as acid rain.

These are the some effects of air pollution

- Ecosystems can become imbalanced from air pollution
- Pollution particulates eventually fall back to earth, contaminating the soil
- Air pollution creates acid rain, which can damage plants.
- Acid rain also changes soil chemistry, which can alter plant growth.
- Animals also get affected by air pollution – reproduction may get damaged, and reproductive anomalies may occur.
- Furthermore, air pollution can also cause health and respiratory issues for animals.
- Air pollution is also one of the major causes of global warming
- Global warming can also lead to more destructive natural calamities such as storms and cyclones.
- Burning certain substances may release potentially carcinogenic substances.

Air Pollution Control

Following are the measures one should adopt, to control air pollution:

Avoid Using Vehicles

People should avoid using vehicles for shorter distances. Rather, they should prefer public modes of transport to travel from one place to another. This not only prevents pollution, but also conserves energy.

Energy Conservation

A large number of fossil fuels are burnt to generate electricity. Therefore, do not forget to switch off the electrical appliances when not in use. Thus, you can save the environment at the individual level. Use of energy-efficient devices such as CFLs also controls pollution to a greater level.

Use of Clean Energy Resources

The use of solar, wind and geothermal energies reduce air pollution at a larger level. Various countries, including India, have implemented the use of these resources as a step towards a cleaner environment.

Other air pollution control measures include:

- By minimising and reducing the use of fire and fire products.
- Since industrial emissions are one of the major causes of air pollution, the pollutants can be controlled or treated at the source itself to reduce its effects. For example, if the reactions of a certain raw material yield a pollutant, then the raw materials can be substituted with other less polluting materials.
- Fuel substitution is another way of controlling air pollution. In many parts of India, petrol and diesel are being replaced by CNG – Compressed Natural Gas fueled vehicles. These are mostly adopted by vehicles that aren't fully operating with ideal emission engines.
- Although there are many practices in India, which focus on repairing the quality of air, most of them are either forgotten or not being enforced properly. There are still a lot of vehicles on roads which haven't been tested for vehicle emissions.
- Another way of controlling air pollution caused by industries is to modify and maintain existing pieces of equipment so that the emission of pollutants is minimized.
- The last and the best way of reducing the ill effects of air pollution is tree plantation. Plants and trees reduce a large number of pollutants in the air. Ideally, planting trees in areas of high pollution levels will be extremely effective.

Air Quality

When air quality is good, the air is clear and contains only small amounts of solid particle and chemical pollutants. Poor air quality which contains high levels of pollutants is often hazy and dangerous to health and the environment. Air quality is described according to the Air Quality Index (AQI), which is based on the concentration of pollutants present in the air at a particular location.

Major air pollutants emitted from thermal power plants

The main emissions from coal combustion at thermal power plants are **carbon dioxide (CO_2), nitrogen oxides, sulfur oxides, chlorofluorocarbons (CFCs), and airborne inorganic particles such as fly ash and soot**; CO_2, methane, and CFCs are greenhouse gases.

WATER POLLUTION

Water pollution can be defined as the contamination of water bodies. Water pollution is caused when water bodies such as rivers, lakes, oceans, groundwater and aquifers get contaminated with industrial and agricultural effluents.

When water gets polluted, it adversely affects all life forms that directly or indirectly depend on this source.

Sources of Water Pollution

i. **Point Sources:** When the cause and place of pollution is easily identifiable, it is known as a point source of water pollution. *Examples:* Municipal and industrial discharge pipes.
ii. **Nonpoint Sources:** When the cause and place of pollution cannot be readily identified, it is known as a nonpoint source of water pollution. *Examples:* Mining runoff and acid rain.

The most significant sources of water pollution are:

- **Sewage (Waste Water):** The sewage water carries pathogens, a typical water pollutant, other harmful bacterias, and chemicals that can cause serious health problems and thereby diseases.
- **Agricultural Pollution:** Chemical fertilizers and pesticides are used by farmers to protect crops from insects and bacterias. However, when these chemicals are mixed up with water, they produce harmful pollutants for plants and animals.
- **Oil Pollution:** Oil spill poses a huge threat to marine life when a large amount of oil spills into the sea and does not dissolve in water. It causes problems for local marine wildlife, including fish, birds, and sea otters.
- **Industrial Waste:** Industries produce a tremendous amount of waste, which contains toxic chemicals and pollutants, causing water pollution and damage to our environment.
- **River and Marine Dumping:** The garbage produced by households in the form of paper, plastic, food, aluminium, rubber, and glass, is collected and dumped into the rivers and seas. They not only cause water pollution but also harm aquatic animals.

Water Pollutants

(i) Organic Pollutants : They include oil, synthetic organic compounds, sewage and agricultural run-off, disease-causing wastes and oxygen-demanding wastes.

(ii) Inorganic Pollutants : They include metals, metal compounds, organometallic compounds, mineral acids, inorganic salts, etc.

(iii) Suspended Solids and Sediments: They comprise of sand, silt and minerals eroded from the land.

(iv) Radioactive Materials: They include radioactive isotopes from nuclear reactors, nuclear power plants, research, industrial applications, agriculture and therapeutic as well as diagnostic medical applications.

(v) Thermal Pollution: They include discharge of waste heat to water bodies by thermal and nuclear power plants.

Types of Water Pollution

Surface water pollution

The water on the surface of the planet is made up of seas, oceans, lakes, rivers and other waterways. These bodies of water can become contaminated from point sources (such as industrial effluents and improper wastewater management systems) or non-point sources (such as agricultural run-off, precipitation and seepage). This can contaminate the surface water and make it unsafe for humans, animals and plants alike.

Groundwater pollution

When contaminants (such as fertilizers, pesticides, heavy metals and wastewater) are allowed to pollute the soil, they can penetrate far deeper and render groundwater supplies unpotable and unusable.

Chemical pollution

Chemicals are used in a wide variety of anthropogenic activities, from protecting agricultural crops from pests and disease to manufacturing consumer goods to transporting and consuming energy sources such as oil and petrol. Automatically some of these chemicals find their way into the natural environment, either through agricultural run-off after heavy rainfall, accidental spillage or improper disposal of waste products. This can have a dramatic impact on water sanitation.

Microbiological pollution

Microbiological pollution refers to that which is caused by microorganisms within the water. This type of contamination largely occurs naturally and, on many occasions, the bacteria, protozoa and viruses are harmless or even beneficial to the ecosystems they inhabit. However, this is not always the case and some microorganism kill off plant & animal life and causing disease among humans which consume or use this water.

Nutrient pollution

Fertilizers, pesticides and other products used during agricultural processes often contain significant amounts of nutrients, such as phosphorous and ammonia. These are specifically used to protect crops from pests or disease, or increase their growth and maximize yields. When run-off sends these chemicals into water sources, they can cause an imbalance of nutrients, promoting the growth of some organisms (such as algae) to the detriment of others.

Suspended matter pollution

Although water is often dubbed the universal solvent, some particles of pollution are simply too large to mix with water molecules. This means that they either form a layer of floating silt atop the water’s surface, or else sink to its floor in the form of a thick mud. Either way, they can inhibit the growth of marine life beneath the waves and compromise the quality of the water in their vicinity, posing a risk to humans as well as animals.

Effects of Water pollution

1. Diseases: In humans, drinking or consuming polluted water in any way has many disastrous effects on our health. It causes typhoid, cholera, hepatitis and various other diseases.

2. Destruction of Ecosystems: Ecosystems are extremely dynamic and respond to even small changes in the environment. Water pollution can cause an entire ecosystem to collapse if left unchecked.

3. Eutrophication: Chemicals in a water body encourage the growth of algae. These algae form a layer on top of the pond or lake. Bacteria feed on this algae and this decreases the amount of oxygen in the water body, severely affecting the aquatic life there.

4. Affects the food chain: Disruption in food chains happens when toxins and pollutants in the water are consumed by aquatic animals (fish, shellfish etc) which are then consumed by humans.

Eutrophication

Eutrophication is the process in which a water body becomes overly enriched with nutrients, leading to excessive growth (or bloom) of algae and plankton in a water body Eutrophication is considered to be a serious environmental concern since it often results in the deterioration of water quality and the depletion of dissolved oxygen in water bodies.

Marine pollution

When the salt content of a water body is equal to or more than 35 parts per thousand (ppt), then it is known as a *marine water body*.

Examples of Marine Water Bodies: Seas, oceans, brackish water, salt marshes, etc.

Marine Pollution refers to trash and pollutants that come from land sources to end up in the ocean. This pollution causes widespread damage to ocean life as well as to economic structures that rely on marine infrastructure.

Thus, marine pollution is harmful and is caused by human activities. Damages or disturbances caused by earthquakes, volcanic eruptions, tsunamis, etc., are not considered marine pollution.

Steps to control marine pollution

- Almost 80% marine pollution caused due to waste from lands. We can reduce this.
- Plastic bags, bottles etc. have become one of the big reasons for marine pollution. We need to stop using plastic made material to save marine life and our environment.
- We all need to put efforts to clean the sea beaches. If beaches will be cleaned, marine pollution can be reduced to some extent.
- The farmers should use organic farming techniques instead of using chemical pesticides and fertilizers. When these fertilizers and pesticides entered into ocean water causes various health issues to the plants & animals of the sea.
- We all need to make sure that only rainwater goes into the drainage because most of the drain water goes into oceans. If we allow sewage and waste material to get into the drainage, it will eventually affect the marine life.
- Most of the rivers flow into the oceans and also the wastes get entered in the sea water. Hence we also need to take care of the cleanliness of the rivers so that it cannot contaminate the marine life.

- We should stop using single-use plastic to protect the marine ecosystem.
- Say “NO” to disposables such as straws, tumblers, plastic carry bags, etc. These items only increase the amount of waste that ultimately goes into oceans.
- Recycling helps a lot to protect ocean ecology.
- We should try to minimize energy use to reduce the oceanic temperature.
- Give preference to buy Eco-friendly products and materials.

Point Sources	**Non-point Sources**
Pollutants are discharged directly into water bodies.	Pollutants are discharged away from water bodies and at various places.
Easy to treat the pollutants in the water treatment plant before they enter the water bodies	Difficult to treat the pollutants before they enter water bodies.
More harmful	Less harmful in comparison to point source water pollution.
For Example- Sewage outlets in the municipal area, power plants, oil wells, and underground coal mines close to water bodies.	For Example- Garden, roads, construction sites, runoff water from the field, etc.

BOD and COD: Biochemical oxygen demand (BOD) is the amount of oxygen required by the microorganisms to break down organic materials. In contrast, chemical oxygen demand (COD) is the amount of oxygen required to break down the organic material via oxidation.

Biological Oxygen Demand	**Chemical Oxygen Demand**
It is the amount of oxygen the microbes require to decompose the organic matter under aerobic conditions.	It is the total amount of oxygen required to break down the organic matter by chemical oxidation.
Test: It can be determined by putting a sealed water sample under specific temperature conditions for five days.	Test: It can be determined by placing a water sample with a strong oxidizing agent under specific temperature conditions for a short period.
Value: Lower than COD	**Value:** Higher than BOD
It is used to waste loadings in treatment plants. Evaluation of BOD removal efficiency of the waste plants.	To quantify the amount of oxidisable pollutants found in water bodies. It provides a measurement on how an effluent will affect the water body.

SOIL/LAND POLLUTION

Soil pollution is defined as the presence of toxic chemicals (pollutants or contaminants) in soil, in high enough concentrations to pose a risk to human health and the ecosystem or in simple words Alteration in the natural soil due to human activities is termed Soil Pollution. For example, exposure to soil containing high concentrations of benzene increases the risk of contracting leukaemia.

Types of Soil Pollutants

- Agriculture soil pollution is caused due to the excessive use of pesticides and insecticides.
- Soil Pollution by industrial discharges of chemicals from mining and manufacturing of goods.
- Solid waste / poor management or inefficient disposal of waste.
- Soil Pollution due to urban activities.

Effects of Soil Pollution

The harmful effects of soil pollution are briefly described below:

(i) Fluorosis occurs as a result of consumption of fluoride containing maize and jawar *crops*. The fluoride is absorbed by the crops from the fluoride-contaminated soil.
(ii) Emission of toxic gases (from dumped solid wastes on land) is detrimental to health. The unpleasant smell and spread of insects cause inconvenience to people.
(iii) Poisoning of the ecosystem takes place by soil pollution.
(iv) *Contamination* of underground and surface drinking *water* takes place by soil pollution.
(v) Reduction in the fertility of *soil* takes place by soil pollution.

Control of Soil Pollution

The soil pollution can be controlled by the following methods:

(i) Polluted soil can be *treated* by *bioremediation*. It uses microorganisms (yeast, fungi or bacteria) to break down, or degrade, hazardous substances into less toxic or nontoxic substances (such as CO_2 and H_2O). Proper treatment of liquid wastes from industries and mines must be done.
(ii) The principles of three Rs, namely, *Recycle*, *Reuse* and *Reduce*, help in minimizing the generation of solid waste. For example, use of bio fertilizers and natural pesticides help in minimizing usage of chemical fertilizers and pesticides.
(iii) Proper disposal methods must be employed. For example, composting of biodegradable solids and incineration of non-biodegradable solids should be done.
(iv) Planned *afforestation* helps in preventing soil erosion.
(v) Formulation and effective implementation of stringent pollution-control *legislation* also helps in controlling soil pollution.
(vi) Faulty *sanitation practices* must be improved.

NOISE POLLUTION

Noise pollution is defined as environmental noise or an unwanted sound that is annoying, distracting, or physically harmful. Harms include hearing loss, stress, sleeplessness etc. Noise pollution is also known as sound pollution.

Sources of Noise

Source is the equipment or process directly responsible for sound generation.

The major sources of noise are summarized below:

(i) **Transportation Sources** Railways, road traffic and air traffic.

(ii) **Industrial Sources** Noise is generated in mostly all industrial activities such as power generation, processing, product fabrication and product assembly.

(iii) **Public Address System Sources** Use of loudspeaker at any occasion like marriages, functions, festivals, etc.

(iv) **Agricultural Machine Sources** Use of tractors, tubewells, farm machines for agriculture.

(v) **Defence Equipment Sources** Shooting practices, wars, bomb explosion, etc.

(vi) **Household Sources** Mixer-grinder, lawn mowers, food blenders, vacuum cleaners, etc.

(vii) **Other Sources** Rock concerts, barking dogs, construction equipment, etc.

Effects of Noise Pollution

Noise affects human health in the following ways:

(i) **Physical Effects:** Damage to ear drum, temporary impairment of hearing, permanent deafness.

(ii) **Physiological Effects**: Muscular strain, headache, eye strain, decreased color perception, nervous breakdown, pain in heart, etc.

(iii) **Psychological Effects**: Emotional disturbance, depression, fatigue, frustation, irritation, reduced efficiency, etc.

Prevention of Noise Pollution

Some noise pollution preventive measures are provided in the points below.

- Honking in public places like teaching institutes, hospitals, etc. should be banned.
- In commercial, hospital, and industrial buildings, adequate soundproof systems should be installed.
- Musical instruments' sound should be controlled to desirable limits.
- Dense tree cover is useful in noise pollution prevention.
- Explosives should not be used in forest, mountainous and mining areas.
- Turn off Appliances at Home and offices
- Shut the Door when using noisy Machines
- Use Earplugs
- Lower the volume
- Stay away from Noisy area
- Follow the Limits of Noise level

- Control Noise level near sensitive areas

THERMAL POLLUTION

Thermal pollution may be defined as the degradation of water quality by any process that changes ambient water temperature.

Thermal pollution is best known as sudden increases or decreases in the temperature of water bodies like oceans, seas, rivers, lakes, streams, etc. Usually, the industries use water for cooling purposes for machinery or other production processes.

Causes of Thermal Pollution

Causes (or sources) of thermal pollution are briefly described below:

(i) **Coal-fired Power Plants**: River water is used for cooling the condenser rods of coal-fired thermal power plants. When water used as a coolant is returned to the river, its temperature is high which lowers down the dissolved oxygen of water and affects ecosystem composition.

(ii) **Nuclear Power Plants:** Large amount of heat along with toxic radionuclides are discharged into nearby water streams by nuclear power plants. Radiation leakages are also responsible for increasing the temperature of water bodies. Nuclear experiments and nuclear explosions are also responsible for thermal pollution.

(iii) **Domestic Sewage:** Normally, the municipal water sewage has a higher temperature than normal water. When domestic sewage is discharged into lakes, rivers, etc., it causes thermal pollution.

(iv) **Industrial Effluents:** Textile, sugar, paper, pulp and various other industrial effluents when discharged into lakes, rivers, etc., cause thermal pollution.

(v) **Deforestation**: When shade-providing trees are cut down, water temperature rises.

Effects of Thermal Pollution

The harmful effects of thermal pollution are described below:

(i) **Reduction in DO**: Elevated temperature typically decreases the level of dissolved oxygen in water. This can harm aquatic animals.

(ii) **Change in Quality**: With rise in temperature, the density, viscosity and solubility of gases in water decreases.

(iii) **Damage to Biological Activity**: Above 37°C, biological activity of enzymes of aquatic flora and fauna gets severely damaged.

(iv) **Interference with Reproduction Capability** Temperatures higher than 9 to 10°C interferes with reproduction capabilities of certain fishes.

(v) **Increase in Metabolic Activity**: At increased temperatures, metabolic activities such as oxygen uptake, food intake and mobility of fishes are increased.

(vi) **Increased Mortality Rate:** At higher temperatures, the mortality rate of fish and all other aquatic organisms increases.

(vii) **Malnutrition**: High temperatures can lead to the denaturing of life-supporting enzymes. It means, within the quaternary structure of the enzymes, hydrogen bonds and disulphide bonds break down.

(viii) **Ecological Effects of Cold Water** Elimination of native fish species and drastic alteration of macro invertebrate fauna has been observed by releases of unnaturally cold water from reservoirs like dams.

Control Measures of Thermal Pollution

Heated water from power plants, petroleum refineries, pulp and paper mills, steel mills and chemical plants can be cooled down for controlling thermal pollution by using cooling ponds, cooling towers, etc.

(i) ***Cooling ponds*** are man-made bodies of water which help in reducing the temperature of water by evaporation, convection and radiation.

(ii) ***Cooling towers*** transfer waste heat to the atmosphere through evaporation and/or heat transfer.

(iii) ***Cogeneration*** is a process for recycling waste heat for domestic and/or industrial heating purposes.

(iv) ***Storm water management facilities*** absorb urban run-off or direct it into groundwater, such as bioretention systems. Otherwise, urban run-off can have significant thermal impact during summers on small streams, as storm water passes over hot parking lots, roads and sidewalks.

(v) ***Afforestation*** By planting trees along streams and shorelines, thermal pollution can be controlled. If these trees and tall plants are not there for providing shade, the water warms by as much as 10°C. Even removal of vegetation far away from a lake can speed up the erosion of soil into water, making it muddy. Muddy water absorbs more energy from the sun than clear water does, resulting in further heating, Afforestation controls erosion, keeps water clearer and thus, cooler.

RADIATION POLLUTION [NUCLEAR HAZARDS]

Radioactive contamination is defined as the deposition or introduction of radioactive substances into the environment, where their presence is unintended, or the levels of radioactivity are undesirable. Such type of pollution is harmful to life due to the emission of ionizing radiation. This type of radiation is potent enough to cause damage to tissues and DNA in genes.

Sources/Causes of Nuclear Hazards:
Radioactivity can occur in one of two ways:

- Naturally occurring radioactivity
- Man-made radioactivity

Natural and man-made sources of nuclear hazards are briefly described below:

(A) Natural Radioactive Sources

Natural radioactivity, as the name suggests, occurs naturally in our environment. Some radioactive elements such as uranium and thorium are present in rocks and soil. Interestingly, humans and all other living organisms contain nuclides such as carbon-14, which are created by cosmic rays.

(i) **Cosmic Radiation** It is a stream of ionising radiation that enters the earth's atmosphere from outer space. The intensity of cosmic rays in the biosphere is low. Therefore, they are not a health hazard. However, cosmic rays are a major hazard in space.

(ii) **Terrestrial Radiation** It is long-wave electromagnetic radiation emitted by naturally radioactive materials on the earth including radon, uranium and thorium.

Humans have been exposed to low levels of radiation from these natural sources for

thousands of years. But it is the man-made sources which are posing a threat to mankind.

(B) Artificial (or Man-Made) Radioactive Sources

Man-made radioactivity is the result of nuclear weapon discharge or a nuclear reactor containment breach. In such scenarios, all living organisms in the vicinity of the nuclear event will become contaminated by fission products and remnants of nuclear fuel. This can be in the form of radioactive dust or even particles that are found on various surfaces.

These sources of radioactivity are waste materials that contain radioactive nuclei produced during the

(i) mining and processing of radioactive ores,
(ii) use of radioactive materials in nuclear weapons,
(iii) use of radioactive isotopes in medical, research and industrial applications, and
(iv) use of radioactive materials in nuclear power plants.

Radioactive materials are composed of unstable atoms. *Radioactivity* is a process by which an unstable atom emits radiation until it becomes stable. Radiation cannot be detected by sight, smell, etc., but it has harmful effects on humans. The longer a person is exposed to radiation, the greater the risk.

Effects of Nuclear Hazards

The effects of nuclear hazards may be somatic or genetic.

(i) Somatic Effects Somatic Effects of nuclear radiation appear in the exposed person. The quantity of radiation that leads to the absorption of 100 erg per gram of the absorbing material is known as Radiation Absorbed Dose (RAD).

When an individual receives an acute dose (typically ≥ 10 RAD) in a short period of time, prompt somatic effects occurs.

For example, a dose of 400 RAD to the scalp results in temporary hair loss which occurs about three weeks after exposure. New hair is expected to grow within two months after the dose although the colour and texture may be different.

When an individual receives a small dose, *delayed somatic effects* are observed years after irradiation, for example, development of cataracts and cancer.

(ii) Genetic (or Heritable) Effects These effects appear as abnormalities in the future generations of the exposed person as a result of radiation damage to the reproductive cells.

Control Measures of Nuclear Hazards

Nuclear hazards can be controlled by practicing the following measures:

(i) Nuclear power plants should be located far from populated areas and should be provided with a suitable radiation-absorption zone around them to minimize the escape of radiation.
(ii) Safety measures should be enforced strictly to avoid nuclear accidents and occupational exposure.
(iii) Waste disposal must be effective, careful and efficient,
(iv) The following should be totally stopped:
Leakages from nuclear reactors, careless handling, transport and use of radioactive fuels and/or radioactive isotopes.

(v) Nuclear wastes have to be properly disposed off.

High-Level Wastes (HLW) like spent nuclear fuel has a very high radioactivity per unit volume. These are very dangerous. These wastes must be contained either by converting them into inert solids (ceramics) and then burying deep into earth or storing in deep salt mines.

Filters, reactor components, etc., are *Medium-Level Wastes* (MLW). These are solidified and mixed with concrete in steel drums before being buried in deep mines or below the sea bed in concentrate chambers.

Solids or liquids contaminated with traces of radioactivity are *Low-Level Wastes* (LLW). They are disposed of in steel drums in concrete-lined trenches in designated sites. After the disposal of nuclear waste, drilling activity must be prevented in and around the disposal site, and radioactivity must be monitored periodicallyaround the disposal sites.

Solid Waste

The waste materials which have been rejected for further use and which can neither readily escape into the atmosphere nor can be transported by water into streams are called solid waste.

All the discarded solid materials from municipal, agricultural and industrial activities are included in solid wastes.

Types and Sources of Solid Wastes

The various types of solid wastes are briefly described below:

(A) Municipal Wastes: These include *garbage* (i.e. biodegradable food waste), *rubbish* (i.e. non-biodegradable solid waste from homes, offices, markets, hotels, etc.). *Construction and Demolition Wastes*: *Sludges* from septic tanks, *wires*, ashes, *abandoned vehicles,* etc.

(B) Special Wastes: These include hazardous wastes like toxic substances (pesticides, heavy metal sludges), radioactive wastes, biological waste, explosives, inflammable substances, corrosive materials etc.

(C) Domestic Wastes These include wastes generated from domestic cooking and serving of food. *Examples* Garbage, waste paper, plastic, cloth, etc.

(D) Agricultural Wastes These wastes result from farms, feed lots and live- stock yards. *Examples:* Corn residues, bagasse from sugarcane manures, paddy husk, etc.

(E) Industrial Wastes These include the following:

(i) Process Wastes Here, waste depends on the products being manufactured. *Examples:* Plastic wastes, rubber wastes, metal scraps, food-processing wastes, etc.

(ii) Non-process Wastes Here, waste is common to all industries.
Examples: Office and cafeteria wastes, packing wastes, etc.

(F) E-Waste It is a new form of waste from discarded mobile phones, mobile chargers, remotes, CDs, headphones, batteries, computers/TVs, monitors, printers, CPUs, LCD/Plasma TVs, etc. It is also known as electronic waste.

Causes of Generation of Solid Wastes

The main causes for the rapid growth in the quantity of solid-waste generation are described below:

(i) Overpopulation Solid waste generated per person multiplied by total population results in increased generation of solid waste every day.

(ii) Urbanization: Urbanization requires various construction activities

like construction of buildings, markets, shopping malls, roads, railways, airports, bridges, dams, water supply and sewage disposal systems. Each construction activity also generates solid wastes.

(iii) Affluence: Consumers with high purchasing capacity discard 'obsolete goods'. This leads to solid waste generation.

(iv) Advances in Technology: These lead to large-scale production of goods for *consumption-based* society preferring disposable items and almost every item 'packaged'. All these results in generation of huge quantities of solid wastes.

Solid-Waste Management

The term solid waste management mainly refers to the complete process of collecting, treating and disposing of solid wastes. In the waste management process, the wastes are collected from different sources and are disposed of. This process includes collection, transportation, treatment, analysis and disposal of waste. It needs to be monitored so that strict regulations and guidelines are followed.

Important solid-waste management practices are briefly described below:

(i) Source Reduction : It involves changing the design manufacture or use of products and materials to reduce the amounts of solid-waste generation. *Examples:* Two-sided copying of paper, backyard composting, etc.

(ii) Recycling: From the waste stream; paper/glass/plastic/metal, etc., are sorted, collected, processed and then manufactured, sold and purchased as new products.

Advantages: Energy saving, prevention of emission of many greenhouse gases/ water pollutants, job creation, resource conservation for future.

(iii) Treatment: Suitable treatment is given depending on the nature of solid wastes.

(iv) Disposal: Solid wastes can be disposed in combustion facilities and land fills.

The most preferred method for solid waste management is source reduction (including reuse). It is followed by recycling and composting. Lastly, disposal of solid waste is done.

Solid-Waste Disposal

The various methods commonly employed for disposal of solid waste are explained below.

A. ***Composting:*** *Composting is the thermophilic and aerobic decomposition of organic matter present in solid waste by microorganisms, mainly bacteria and fungi*. As a result of this composting process, the organic matter is transformed into stable humus like substance, which is valuable manure for crops.

(i) Classification of Composting Techniques Based on Oxygen Use

(a) Aerobic Composting It requires high temperature and results in rapid decomposition of organic matter. Odors are also absent.

(b) Anaerobic Composting It requires low temperatures. Decomposition of organic matter of solid waste is slow. It needs minimum attention.

(ii) ***Vermicomposting*** It uses a special kind of earthworm and a container of food scraps. After some time, the food is replaced with worm droppings, a rich brown matter that serves as excellent natural plant food (manure).

Advantages of Vermicomposting Over Conventional Composting

- Vermicomposting needs less space than normal composting.
- Vermicomposting is ideal for apartments in high-density urban areas.
- Vermicomposting provides excellent natural plant food.

B. ***Illegal Dumping/Open Dumping/Fly Dumping/Midnight Dumping*** It is the disposal of solid waste by dumping in open areas, dumped from vehicles along roadsides, and/or dumped late at night.

(i) Advantages It is done to avoid either the time or effort required for proper disposal or to avoid disposal fees.

(ii) Disadvantages

(a) Illegal dumping of nonhazardous wastes often attract more waste, even the hazardous wastes.
(b) Illegal dump sites divert land from more productive uses.
(c) Property values decrease as a result of illegal dumping.
(d) Public nuisance is created by illegal dump sites.

C. Land Dumping

Solid wastes are dumped in low-lying areas outside the city/town limits. These areas have no provision of leachate collection and treatment. Moreover, landfill gas is neither collected nor used.

(i) Advantages

(a) It requires no planning.
(b) It is cheaper.

(ii) Disadvantages

(a) The waste is untreated, uncovered and not segregated. It is the breeding ground for flies, other insects, rats, etc., that spread diseases.
(b) Rainwater run-off from these dump sites contaminates nearby land and water thereby spreading diseases.

D. Landfills

A *landfill site is a pit that is dug in the ground*. The solid waste is dumped and the pit is

covered with a layer of soil to form a cell. The process is repeated every day so that many cells completely fill the landfill site. Finally, about 1 m of earth-layer covering is done.

(i) Advantages

(a) Breeding of insects is prevented.
(b) Landfill sites can be developed as parks or parking spaces.

(ii) Disadvantages

All types of wastes are dumped in landfill sites without segregation. When rainwater seeps through them, it gets contaminated and in turn pollutes the surrounding area and groundwater.

E. Sanitary Landfills

Sanitary landfill is a method of waste disposal where the waste is buried either underground or in large piles. This method of waste disposal is controlled and monitored very closely.

For sanitary landfills, the process starts by digging a large hole in the ground that is then lined with thick plastic (normally 2-4 feet thick) and a layer of impervious clay. The bottom of the landfill is also lined with a network of plumbing that functions as a collection system for any liquids. These components of the sanitary landfill help prevent materials and liquids from spreading to the surrounding ground and waterways.

Once the landfill is set up, waste can then be added to the landfill. Instead of simply filling the landfill completely with waste, the landfill is organized in layers. The layers alternate between waste and soil. This alternation of materials reduces odors and allows for more rapid **decomposition**, which is the breakdown of materials. When a landfill is full, it is sealed and covered in a thick layer of clay. Once the landfill has been evaluated and considered safe, it can be converted into a park or open space for human use.

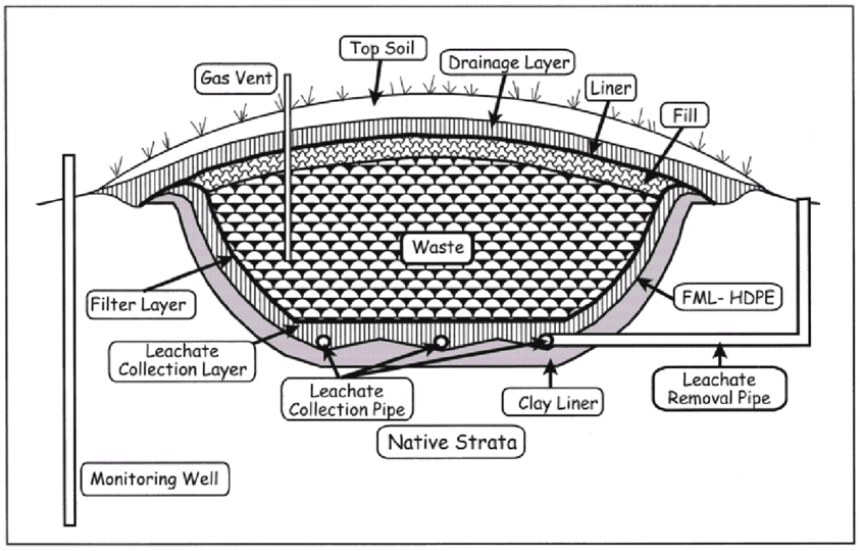
Sanitary Landfill- Advantages

- **Excellent Energy Source:** Sanitary landfills act as excellent energy sources due to the fact that they generate carbon dioxide and methane when the waste starts decomposing. These gasses can be extracted, purified, and used to generate energy.
- Sanitary landfills are eco-friendly.
- **The sanitary landfills are designed with engineering technology in mind; good soil lining and a leachate control system ensure minimal seepage or damage.**
- These are places where recyclable and non-recyclable waste can be dumped separately.
- **Good Storage Facility:** They also serve as a storage facility for more hazardous goods that must be kept away from the general population.
- **Low Cost Option:** The waste in the sanitary landfill will just have to travel a short distance to the dump, lowering transportation expenditures.
- **Pollution Reduction:** This will also help to reduce pollution caused by garbage transportation.
- The finished sanitary landfill can be used for the development of regions of recreation like parks, golf courses etc.

Sanitary Landfill- Drawbacks

a. Leachate from sanitary landfill site can contaminate the groundwater.
b. The sites cannot be used in future as productive farmland.

c. In a sanitary landfill, about 60% of methane gas (odorless) is generated. When its concentration in air reaches about 5%, it is explosive and so very hazardous.
d. Aesthetic problems may arise as a result of poorly operated landfill operations.



F. Combustion

Solid waste is burned at high temperature in combustion facilities.

(i) Advantages

(a) Energy is generated.
(b) Amount of waste is reduced by up to 90% in volume and 75% in weight.

(ii) Disadvantages

(a) Cost increases with rise in the moisture content of solid waste. This is because energy is required for preheating the solid waste.
(b) Ash formed after combustion has high concentrations of dangerous toxins such as dioxins and heavy metals. It results in air and water pollution.

G. Incineration

It is the controlled combustion of organic solid wastes so as to convert them into incombustible residue and gaseous products. The weight and volume of solid waste is reduced and often energy is also produced.

(i) Advantages

(a) As the volume of the waste is reduced, in taking the waste to the ultimate disposal site, less transportation cost is required.
(b) Larger wastes can be accommodated in a given landfill area because incineration reduces the land requirement to one-third.

(ii) Disadvantages

(a) Not applicable for radioactive wastes
(b) High capital and operational costs
(c) Air pollution chances if incineration is not properly done
(d) Highly trained manpower is needed

POLLUTION PREVENTION

Instead of complaining about the deteriorating environmental situation, individuals can play a very important role in pollution prevention.

Individuals can adopt the following activities in their daily routines for prevention of pollution:

(i) Whenever feasible, preferably use *public transport*, car pools and cycles instead of your own automobiles.

(ii) Purchase and use energy-efficient and pollution-free
   (a) vehicles
   (b) appliances (like refrigerators, ACs, etc.)
   (c) rechargeable batteries, etc.

(iii) Plant trees and help in *afforestation*.

(iv) *Conserve* natural resources; save water/electricity.

(v) *Reduce* consumption, waste generation, water leakages, etc.

(vi) *Reuse* paper and various products.

(vii) *Recycle* paper, metal, plastic, etc.

(viii) *Refuse* to buy and use toxic pesticides, fertilizers, lead-based paints, products without recycling symbol, products with unnecessary packaging, etc.

(ix) *Don't pollute* air, water, soil, etc.

(x) Advocate and *participate* in environment-friendly activities.

DISASTER

A disaster is defined as a disruption on a massive scale, either natural or man-made, occurring in short or long periods. Disasters can lead to human, material, economic or environmental hardships, which can be beyond the bearable capacity of the affected society.

Classification of Disasters

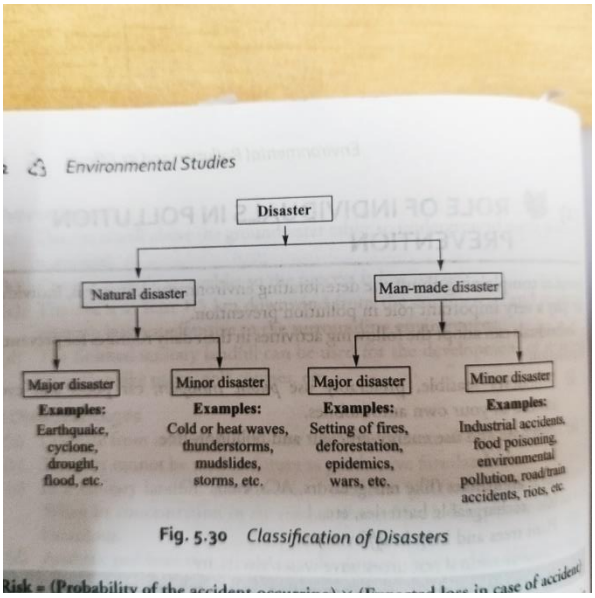


Fig. 5.30 *Classification of Disasters*

DISASTER MANAGEMENT

Disaster management is the practice of successful management of natural and manmade disasters.

The major objective of disaster management is to reduce the adverse effects of a disaster on the affected community and to help them return to normal life within the shortest possible time.

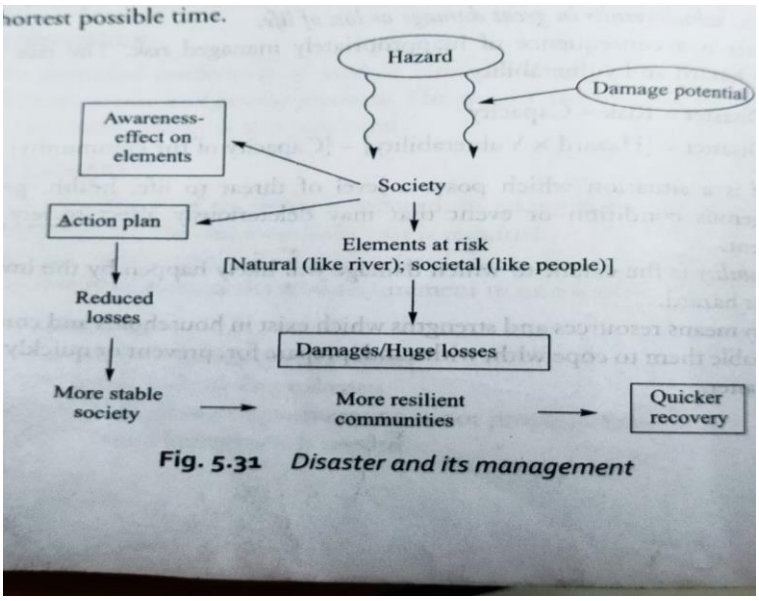


Fig. 5.31 *Disaster and its management*

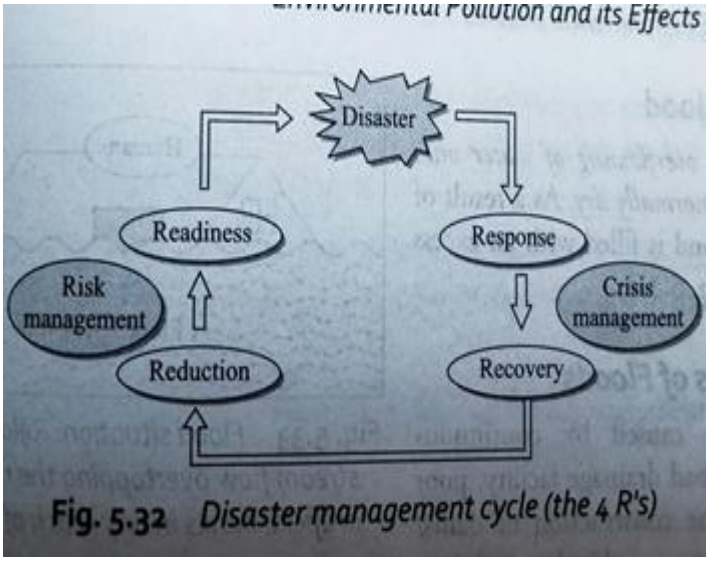


Fig. 5.32 Disaster management cycle (the 4 R's)

Response: It includes activities during a disaster such as public warning systems, emergency operations, search, rescue (i.e. save life) and relief (i.e., food aid).

Recovery: It includes activities following a disaster like rehabilitation and reconstruction which includes temporary housing; processing of insurance claims; distribution of grants; provisions for long-term medical care and counselling.

Mitigation or Reduction: It includes activities that reduce the effects of disasters like building codes and zoning, vulnerability analyses; public education.

Preparedness or Readiness: It includes activities prior to a disaster like preparation of emergency plans for disasters, emergency training through workshops; warning systems, etc.

To sum up, disaster management means the organization and management of resources and responsibilities for dealing with all humanitarian aspects of emergencies, in particular response, recovery, reduction and readiness, for reducing the impacts of disasters, *i.e. the 4R's.*

Flood

Flood is an overflowing onto land that's normally dry. As a result of flood, the land is filled with an excess of water.

A) Causes of Floods

A flood is caused by continuous heavy rain, bad drainage facility, poor design in the construction of dam/embankments, etc., blocking of river channels by landslides, silting of river bed,tsunami, cyclones, and melting of glaciers and sea tides.

Effects of Floods

(i) **Unavailability of Clean Water:** Water in wells, groundwater and piped water supply gets contaminated as a result of flood, resulting in shortages of clean water.

(ii) **Damage to Crops and Food Shortages** Standing crops are damaged by flood. Flood can erode the top soil layer causing land to become infertile. If sea water floods the area, the land turns saline.

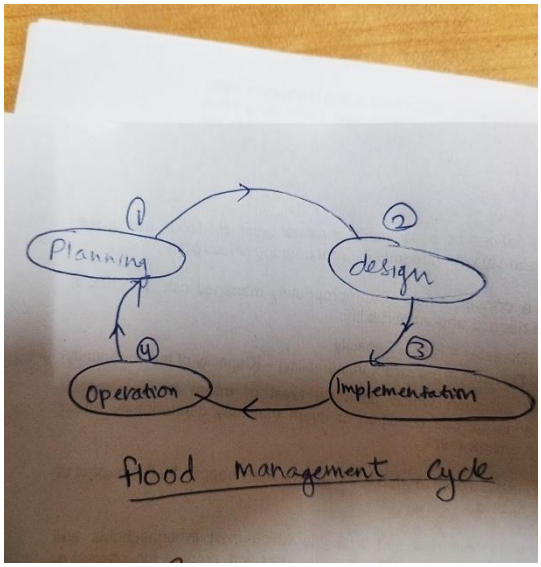
As a result of floods, godown and storage facilities get submerged in water resulting in spoilage of grains by fungus. Even entire harvests are lost as a result of flood resulting in sudden food shortages.

(iii) **Diseases and Deaths** Floods result in outbreaks of epidemics, diarrhoea, malaria and viral infections. Animals and humans die either due to these diseases or due to drowning.

(iv) **Physical Damage** In coastal areas, boats or fishing equipment may be lost or damaged. Property gets damaged or collapsed by flooding.

Flood Management: Management of flood requires a cyclic pattern linking

i) Planning ideas, proposals, consultations, adopting proposals, preparing guidelines.
ii) Design: Design of flood control structure
iii) Implementation: construction
iv) Operation: operating and maintaining finalized schemes



Earthquake

An earthquake is the vibration (sometimes violent) of the earth's surface that follows a release of energy in the earth's crust.

Or

Earthquake is any sudden shaking of the ground caused by the passage of seismic waves through Earth's rocks. Seismic waves are produced when some form of energy stored in Earth's crust is suddenly released, usually when masses of rock straining against one another suddenly fracture and "slip." Earthquakes occur most often along geologic faults, narrow zones where rock masses move in relation to one another. The *focus* is the point or center where the energy release starts. The epicenter is the point on the earth's surface directly above the focus of the earthquake.

Seismic waves are the waves of energy caused by the sudden breaking of rock within the earth or an explosion

Tsunami

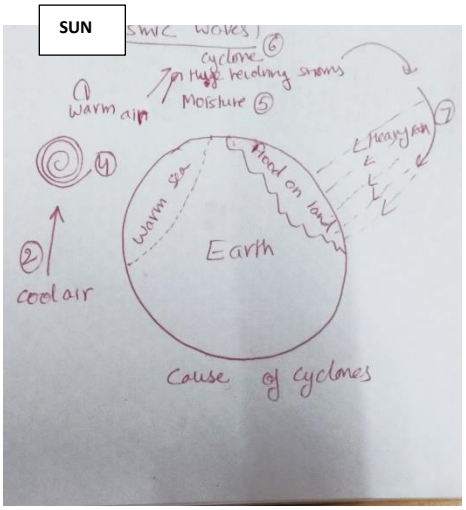
In Japanese, tsu means harbour and nami means waves. A tsunami is a series of waves in the ocean that can be hundreds of miles long and have been known to reach heights of 10.5 m. The massive December 26, 2004 tsunami travelled at a speed of 480 km per hour.

Origin of Tsunami The top layer of the earth (i.e, the lithosphere) is made up of a series of huge plates. They rest on an underlying viscous layer called the asthenosphere. On the earth, these plates are constantly in motion, moving along each other at a speed of 2.5 to 5 cm per year. When two plates come into contactat a plate boundary region, a heavier plate can slip under a lighter one, resulting in subduction. **When the energy of the force in transferred to the water, water is pushed upwards above normal sea level. This is the birth of a tsunami.**

Cyclone

Cyclones are swirling atmospheric disturbance in the form of huge revolving storms caused by powerful winds moving with very high velocities (sometimes exceeding 300 km/h). Cyclones are accompanied by rain and generate enormous waves in the ocean.

***(A)* Cause of Cyclones**



(1) Near the Equator, over warm seas, air heated by the sun rises upwards quickly and creates areas of very low pressures. (2) To fill the void that is left, cool air rushes in. (3) We know that the earth is constantly revolving around its axis. (4) Thus, the air is bent inwards and spirals outwards with great force.
(5) As the warm air rises, it becomes loaded with moisture which condenses into massive thunderclouds. (6) Due to the faster and faster rotation of the swirling winds, a huge circle of clouds get formed. The edge of a cyclone is called 'wall of the eye' which has a radius of 20 km–30 km. At the center of the cyclone, wind velocity is less. This calm, cloudless area is called the 'eye' of the cyclone.

When the cyclones move over the ocean, they drag clouds and moisture. They can also pick up energy when they travel across warm water. When cyclones move over land, they result in heavy rains leading to floods.

Effects of a Cyclone

Cyclones can cause the following damages:

(i) The standing *crop* and food stock lying in low-lying areas will be *ruined* due to powerful winds and heavy rain. Banana, coconut and other plantation crops are extremely vulnerable.
(ii) Sea water dragged through cyclones result in *inundation or flood of land*. This

increases salinity as a consequences of which soil becomes unfit for cultivation.

(iii) Heavy rain can cause *flooding*. This can lead to contamination of groundwater and surface water. Viral outbreaks, diarrhoea and malaria are consequences of contamination of water.

(iv) Gable-ended roofs made from cement, asbestos or tin sheets get high uplift as a result of powerful winds of cyclones. As these sheets are blown away, these then strikes against nearby buildings, animals and humans causing damage and deaths.

(v) Asymmetric buildings with empty pockets collapse due to the impacts of powerful winds.

(vi) Trees get uprooted and carried away along with powerful winds. These, then, destroy telephone lines, electricity poles, transmission line towers, etc. Thus, power supply and communication networks get disturbed.

(vii) Cyclones are powerful enough to damage loose or weak parts of buildings like doors, windows, etc.

Landslides

Landslide means downward sliding of a relatively dry mass of land and rock. It is alsoknown as landslip.

Effects of Landslides

(i) Landslides block or bury roads, lines of communication, railways lines, etc.

(ii) They destroy anything that comes in their path. They destroy settlements.

(iii) They destroy agricultural areas leading to loss to food production.

(iv) They block river flow; flooding may also occur.

(v) The flow of debris in landslides causes heavy casualties.

Landslides (Disaster) Management

or

Prevention and Mitigation

The following measures can be taken in this regard:

- The country should identify the vulnerable areas and actions should be taken in this regard on a priority basis.
- Early warning systems and monitoring systems should be there.
- Hazard mapping can be done to identify the areas which are more prone to landslides.
- Restriction on the construction in the risky areas should be imposed.
- Afforestation programs should take place.
- Restricting development in landslide areas and protecting the existing ones.
- The country should specify codes or standards etc. For the construction of the buildings and other purposes in such areas of risk.
- Insurance facilities should be taken by the people to deal with the loss.
- Terrace farming should be adopted in hilly areas.
- Response teams should be quick to deal with landslides if they occur.