Unit I

UNDERSTANDING ENVIRONMENT

1.1 The Environment

The word environment is derived from a French word 'Environner', which means to encircle or surround. Environment can be defined as the sum total of external factors, substances and conditions which influence organisms. Environment is usually divided into two parts.

- The physical environment consists of forces of nature like wind, gravity, conditions like temperature and light, time, and non-living materials like soil and water.
- The biotic environment is made of all living beings including their reactions, interactions and interrelated actions. Any constituent or condition of the environment which affects directly or indirectly the form of functioning of the organism in any specific way is called environmental factor or ecological factor.

It is universally accepted that environment creates favorable conditions for the existence and development of living organisms. The environment for any living organism has never been constant or static. It has always been changing sometimes slowly and sometimes rapidly or drastically. Like other organisms, man is also affected by his environment and these changes in environment may benefit or harm him. Thus, we can say that every living species of plants or animals influence its environment and in turn gets influenced by it.

Since the ancient times, man started interfering with the environment; he devastated forests by cutting down trees for the wood and for other household needs. He removed stretches of forests for bringing land under cultivation. He killed the animals; the gentle ones for blood and the fierier ones for safety. He has polluted rivers with chemicals from factories, thereby making the water unfit for his needs. All these activities however did not affect the environment too seriously up to a fairly long time because population was not too high and life style was not so complex.

No country in the world can build a brick wall around its air, so if the air pollution occurs in one part, it is likely to affect another part of world. And who is to blame for all this; certainly the one and the only man who has actively damaged and polluted the environment, thereby interfering with natural processes and trying to twist them to his advantage.

In short we can say that the way we are exploiting, deteriorating and polluting the environment will take ages to discuss and write.

Let take pledge today to safe guard Mother –Earth.

Environmental Science and Its Multidisciplinary Nature

Environmental science in its broader sense is "the science of complex interactions that occur among the terrestrial, aerial, aquatic and living environments". It includes all the disciplines such as chemistry, physics, biology, microbiology, toxicology, law, sociology, ecology etc. that affect or describe these interactions. In simple sense environmental science can be defined as the study of the earth, air, water and the living environment and the effects of technology on it.

The current interest in the states of environment began with the philosophers like Thoreau but received an additional attention by the organization of the first earth day on 22ndApril 1970 and Stockholm Conference on 5th June 1972. This commitment was further enhanced by Rio Conference on 13th June 1992. As a result, environmental science is now a standard course. Most of the concepts covered by environmental science courses have been previously taught in ecology, conservation, geography etc. The physical and biological ideas were incorporated, along with input from social sciences such as economics, sociology and political science, into a new multidisciplinary field of environmental science.

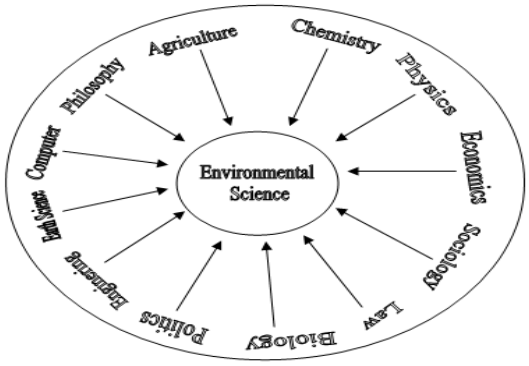


Fig 1.1

Scope and Importance of Environmental Science

Environmental science is an interdisciplinary and multidisciplinary subject in its scope. It enables us to understand the following main components of environmental management.

- Environment perception and people awareness.
- Control of environmental degradation and pollution.
- Control of over population and over consumption.
- Maintenance of environmental quality.
- To restrict and regulate the exploitation of natural resources.
- Environmental science helps us to adopt engineered technology without creating adverse effects on the environment.
- Helps us to participate in afforestation programmes.
- Helps us to participate in programmes aimed at minimising air, water and noise pollution.

Although all the above points of environment management are of extreme importance, yet it is quoted.

"If you plan for one year, plant rice.

If you plan for ten, years grow trees.

If you plan for hundred years, educate the people".

Importance of Environmental Science

Environmental science has become a very important subject as it addresses many issues like;

- Global warming and climate change
- Ozone layer depletion
- Acid rain
- Pollution
- Over population
- Sustainable development
- Over exploitation of natural resources

Environment which is global in nature belongs to all and is thus important for all. Every person irrespective of age or gender will be affected by environment and will also affect the environment by their deeds. Example atmosphere has no boundaries and thus pollutants produced at one place can be dispersed and transported to other place. The river water polluted at one point can ultimately affect the whole aquatic life.

1.2 Components of environment

As mentioned previously Environment can be broadly defined as one's surroundings. To be more specific we can say that it is the physical and biological habitat that surrounds us. The environment can be divided into two broad components as follows:

(A) Abiotic Component: External physical factors like air, water, and land etc. This is also called the **Physical Environment.**

(B) Biotic Component: All living organisms around us viz. plants, animals, and microorganisms. This is also called the **Living Environment.**

Earth's environment can be further subdivided into the following four segments:

A. Lithosphere
B. Hydrosphere
C. Atmosphere
D. Biosphere

A. Atmosphere

The Atmosphere is an abiotic component of our environment. It is a complex fluid of gases, water vapours and suspended particles that form an envelope around the Earth. The Atmosphere can be vertically divided into various layers based on temperature and composition of gases. These layers are;

a) Troposphere
b) Stratosphere
c) Mesosphere
d) Thermosphere

Troposphere: It is the bottom layer of the atmosphere. It contains 70% mass of the atmosphere. It extends to an average height of 14 km. However, its thickness varies from poles to equator. The thickness of atmosphere over poles is only about 8 kms whereas its thickness above equator is about 20 kms. In this layer the temperature decreases with height and drops to about -60^{o}C at the upper troposphere. The rate at which temperature decreases with height is known as lapse rate. Troposphere ends at tropopause. Tropopause is just like a lid over the troposphere, where temperature stops decreasing with height.

Stratosphere: It lies just above the tropopause. It extends to a height of 50 kms from earth's surface. This layer contains Ozone (O_3) which prevents the harmful ultra-violet (UV) rays from reaching the earth. This Ozone is present in the ozonosphere which is present within the Stratosphere. Thus, this layer acts as a protective umbrella. In this layer, temperature increases with height and reaches from -60^{o}C to about 0^{o}C. Above the stratosphere, temperature neither decreases nor increases with height up to some level. This small layer is called, **stratopause** which marks the end of stratosphere.

Mesosphere: It starts from the edge of the stratopause, and extends to height of 80 km from ground. In this layer, temperature decreases with height to about -90^{o}C. This layer, as such does

not have any impact on life. But, it gains importance as it plays crucial role in radio communication. Just above the mesosphere lies, **mesopause**, in which temperature neither decreases nor increases.

Thermosphere: It is found approximately above 80 km from earth's surface and extends to the edge of space. Temperature keeps rising with altitude in this layer. It is likely to reach 900 °C at an altitude of 350 km. In this layer too, ionization of molecules take place which results in the creation of charged ions. These layers also reflect radio waves and have influence over radio communications. Thermosphere as such has no definable upper boundary and gradually blends with space.

Composition of Earth's Atmosphere: The gaseous mantle surrounding the earth's surface is constituted by about 5.15 x 10^{15} metric tons of gas which exert a pressure of 1 kg per sq. cm. on the surface of earth's crust. Most of these gasses are compressed in the lower most layer due to the pressure of layers above it. Following table shows the composition of earth's atmosphere.

Gas	Relative percentage	Parts per million (ppm)
Nitrogen	78.08	780832
Oxygen	20.95	209460
Argon	0.93	9340
Carbon dioxide	0.03	403
Neon	0.0018	18
Ozone	0.000007	0.07

Importance of Atmosphere: The atmosphere is responsible for creating the suitable conditions for the existence of life on this planet. The atmosphere also contains some important gasses like oxygen and carbon dioxide which are vital for the survival of animals and plants. The importance of the atmosphere can be summed up as follows:

i) *Regulation of temperature:* Atmosphere regulates the temperature of earth. The gases present in the atmosphere are capable of absorbing the radiations of the sun and thereby maintaining the temperature of earth. Moon on the other hand has no atmosphere. That is why its temperature rises to about 101^{o}C during day and drops down to -180^{o}C during night.

ii) *Filtration and Protection:* The incoming solar radiations contain the ultra-violet (UV) radiations which are very harmful. These UV radiations are absorbed in the stratosphere by the vital ozone layer. Thus atmosphere protects us from these damaging radiations.

iii) *Mixing of pollutants:* Due to air currents (waves) and vertical temperature gradient, constant mixing of gases takes place. This prevents the accumulation of harmful gases and other pollutants at a particular spot.

iv) *Weather pattern:* All weather processes occur in because of atmosphere. The gasses present in the lower troposphere get heated. The air becomes warm and lighter. It rises up and cools down, Cooling condenses the water vapours and results in the formation of rain, snow etc.

B. Hydrosphere

Hydrosphere comprises all the water that is present in the oceans, seas, rivers, glaciers, snow in the soil, rocks and in the atmosphere. This comprises all water resources both surface and ground water. The world's water is found in oceans and seas, lakes and reservoirs, rivers and streams, glaciers and snow-caps in the Polar Regions in addition to ground water below the land areas. The distribution of water among these resources is as under

Components of hydrosphere	**Percentage (%)**
Oceans and seas	97.2
Ice caps and glaciers	2.15
Ground water	0.62
Surface water	0.03

Humans use water in the home, in industry, in agriculture, and for recreation. These applications differ widely in the quantities and quality of water that they require. In one way or another, we use all available sources like inland waters, ground water and ocean water. We pollute it, re-purify it and reuse it, over and over again.

The demand for global water resources increase day-by-day though pure fresh water availability decreases severely. Thus we should use water carefully and must appreciate its conservation and storage.

C. Lithosphere

It is the outer boundary layer of solid earth. The outer boundary forms a complex interface with the atmosphere and hydrosphere and is also the environment in which life has evolved. Basically lithosphere is nothing but a crustal system composed of various layers. Various elements constitute such crustal layer in mixture of different proportion. In general the earth crust is composed of three major classes of rocks which include igneous rocks, sedimentary rocks and metamorphic rocks. There are two types of crusts

- *Continental crust*
- *Oceanic crust*

Interaction between the crustal system of the lithosphere and the atmosphere and the biosphere takes place where continental crust is exposed above sea level. At the land/air interface the crust becomes exposed to inputs of solar, radiant energy, precipitation and atmospheric gases. Lithosphere is very important for us because we live on it, grow crops and forests, build factories, roads, rail lines, canals etc. We get many metallic and non metallic minerals from rocks of the earth's crust. Many elements are present in earth's crust as given in the table below:

Sl. No.	Elements	Percentage (%)
1	Oxygen	46.6
2	Silicon	27.7
3	Aluminum	8.1
4	Iron	5
5	Calcium	3.6
6	Sodium	2.8

D. Biosphere

The word 'bios' is an ancient Greek word meaning 'life'. The part of the earth in which all forms of life exist is called biosphere. Human beings form an important part of the biosphere. It developed on earth since 4.5 billion year through evolutionary processes. Life is present at the top layer of lithosphere, throughout the hydrosphere and into the lower atmosphere.

The size of the living organisms in the biosphere ranges from very minute microorganisms that we cannot see with our naked eyes to huge trees and animals like the elephants on land and whales in the ocean waters.

The biosphere is made up of distinct areas each with its own climate, soil, plant and animal communities and these areas are called ecosystems. The biotic components interact with the physical surroundings and also with each other.

1.3 Ecosystem

The term ecosystem was proposed by A.G. Tansley in 1935 and he defined it as the system resulting from the integration of all the living and non-living factors of the environment.

Ecosystem is also defined as any unit that includes all the organism in a given area interacting with the physical environment, so that a flow of energy leads to clearly defined trophic structure, biotic diversity and material cycles within the system (Odum1971)

Kinds of ecosystem

An ecosystem can be natural or artificial, temporary or permanent, large or tiny and thus various constituent ecosystems of the biosphere fall in following categories.

1) **Natural ecosystem:** These types of ecosystems operate by themselves without any major interference by man. Based upon the particular kind of habitat, these are further categorised as:
   a) **Terrestrial ecosystem:** Such as forests, grasslands, deserts, a single tree etc.

   b) **Aquatic ecosystem:** Which may be further distinguished as follows:

      i) **Fresh water ecosystem:** These may be lotic (running water as spring, brook, stream river), or lentic (standing water as lake, pond, puddle ditch, swamp etc.)

      ii) **Marine ecosystem:** These include deep bodies such as oceans or shallow ones like seas or estuaries etc.

2) **Artificial (man engineered) Ecosystem:** These are maintained artificially by man by addition of energy and planned manipulations; natural balance is disturbed regularly. Examples are Croplands Lake maize, wheat, and rice fields etc. where man tries to control the biotic community as well as the physico-chemical environment.

Structure of an Ecosystem

The structure of an ecosystem is basically a description of the biotic and abiotic components of an ecosystem.

1.3.1 Biotic or living component

Biotic component includes all plants, animals and microorganisms living in an ecosystem. The biotic components can be classified into following groups depending on the way of obtaining food.

a) **Autotrophs:** Autotrophs (auto-self, trophos-feeder) are also known as producers as they synthesize their own food from solar energy with the help of simple inorganic substances such as water and carbon dioxide and organic substances such as enzymes. The autotrophs are of two types.

   i) Photo-autotrophs: Which contain chlorophyll to convert the solar energy of sun into food e.g. trees, grasses, algae, phyto-planktons, photosynthetic bacteria and cyanobacteria (Blue green algae).

$$6CO_2 + 6H_2O + \text{Sunlight} \longrightarrow C_6H_{12}O_6 + 6O_2$$

   ii) **Chemo-autotrophs:** These are the organisms which produce their food through oxidation of certain chemicals. They are not dependent on the solar energy e.g. microorganisms such as Beggiatoa, Sulphur bacteria etc.

b) **Heterotrophs:** Heterotrophs (Heteros-Other, trophos-feeder) are the organisms which lack the ability to synthesize their own food and have to depend on other organisms for nutrition. They are also known as consumers because they consume the materials built up by producers. These are further categorised as:

   i) **Primary consumers or herbivores**: The animals which feed on the producers or plants are known as herbivores. Examples; Sheep, cattle, deer, caterpillar etc

   ii) **Secondary consumers or primary carnivores**: The animals which feed on the herbivores are known as primary carnivores. Example; fox, snake etc

   iii) **Tertiary consumers**: The animals that feed on the secondary consumers or carnivores are known as tertiary consumers. Example; wolves etc

   iv) **Quaternary consumers or Top carnivores**: These are the largest carnivores which feed on the tertiary, secondary as well as primary consumers and are not eaten up by any other animal. Example; lion and tiger

   v) **Omnivores**: They feed on both plants and animals. Example; Man, rat, crow etc

   vi) **Decomposers**: Decomposers are the organisms that feed on the dead organic matter of plants and animals and break down complex organic compounds of dead

organisms. They are also known as reducers or saprotrophs. Example; bacteria, fungi etc

Abiotic or Non-living component

Abiotic component of the ecosystem comprises of three components:

c) **Climatic condition and physical factors of the given region**: Such as pH, soil, temperature, light, precipitation, humidity, wind etc.

d) **Inorganic substances:** They include water, minerals, and gases all of which are involved in cycling of materials in the ecosystem (i.e. biogeochemical cycles). The amount of these inorganic substances present at any given time in an ecosystem is called as the standing state or standing quality.

e) **Organic substances:** Such as proteins, carbohydrates, lipids, etc. present either in the biomass or in the environment i.e. biochemical structures that link the biotic and abiotic component of the ecosystem.

Functions of an Ecosystem

Every ecosystem maintains itself through some functions like;

a) Food chain and food web
b) Nutrient cycling
c) Productivity (primary and secondary)
d) Energy flow

1.3.2 Food Chain

A food chain is a process of eating and being eaten. It is also defined a process through which transfer of energy takes place from producers to herbivore and then to carnivores. Each food chain is represented by a diagram including a series of arrows pointing from one species to another.

In each step in the food chain a large portion of the energy is lost as heat. As a result, organism in each trophic level passes on lesser energy to the next trophic level. This limits the number of steps in any food chain to 4 or 5. Longer the food chain lesser energy is available for final members. A food chain is always unidirectional in nature. Examples;

a) Grassland ecosystem

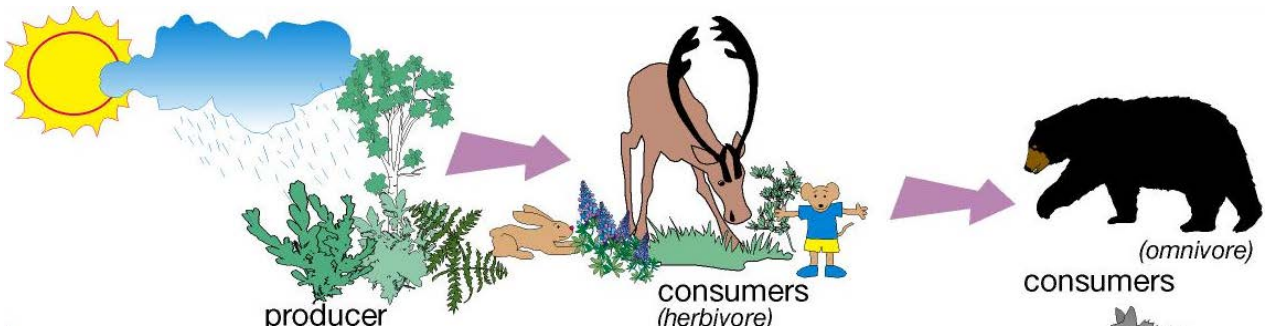
Grass ⟶ Grasshopper ⟶ Bird ⟶ Hawk

b) Pond ecosystem

Phytoplankton ⟶ Zooplankton ⟶ Fish ⟶ Shark

Types of food chains

Grazing Food chain: This type of food chain starts from the living green plants, goes to grazing herbivores and then to carnivores. Ecosystems with this type of food chains are directly dependent on solar radiation. Most of the ecosystems in nature follow this type of food chain. Following diagram represents grazing food chain.



Detritus food chain: This type of food chain starts from dead organic matter. The food or energy present in dead organic matter is consumed by bacteria and fungi which are then consumed by other organisms like detritivores. This type of food chain is less dependent on the solar energy. These food chains help in nutrient cycling. Example;

Dead organic matter ⟶ Bacteria ⟶ Detritivores

Food web

A single food chain never occurs in nature. There are many food chains that exist in an ecosystem which are never independent. Many food chains are interconnected with each other to form an interlocking pattern known as **food web**. The food webs provide the alternative options of food to the organisms e.g. if a particular crop is destroyed due to some disease, the herbivores in that area do not perish as these can graze on other crops or herbs. Greater the number of these alternative options, more stable is the ecosystem.

Significance of food chains and food webs

a) Food chains and food webs play a very significant role in the ecosystem because the two most important functions of energy flow and nutrient cycling takes place through them.

b) The foods chains also help in maintaining and regulating the population size of different animals thus maintaining the ecological balance.
c) The food webs provide the alternative pathways of food availability e.g. if a particular crop is destroyed due to some disease, the herbivores in that area do not perish as these can graze on other crops or herbs. Greater the number of these alternative pathways more stable is the ecosystem.
d) Food webs also help in ecosystem development.

Ecological pyramids

An ecological pyramid is a graphical representation of an ecological parameter like number or biomass or accumulated energy at different trophic levels in a food chain in an ecosystem. The idea of ecological pyramids was developed by Charles Elton (1927) and is also known as Eltonian pyramid. Sometimes they are also known as food pyramids or trophic pyramids.

In ecological pyramids, the producer form the base and the successive trophic levels make up the apex. The shape of the pyramid may be upright, inverted or irregular. There are three types of ecological pyramids as discussed below;

1) Pyramid of Number: It depicts the number of individuals in different trophic levels of an ecosystem. The shape of the pyramid of number can be upright, inverted or irregular. For example; In a grass land the producers mainly grasses are always maximum in number and then show a decrease towards the primary consumers (herbivores) which are lesser in number than grasses. The secondary consumers like lizards, are lesser in number than the rabbits and mice. Finally the top (tertiary) consumers are least in number. Thus the pyramid is upright. Similar is the case in pond ecosystem (Fig. A).

In a parasitic food chain the pyramid is always inverted. This is due to fact that a single plant may support the growth of many herbivores and each herbivore in turn may provide nutrition to several parasites which support many hyper parasites. Thus from producers to consumers the number of organisms gradually shows an increase making the pyramid inverted in shape (Fig. B).

However in a forest ecosystem the pyramid of numbers is somewhat irregular in shape. The producers mainly large sized trees, are lesser in number and form the base of pyramid. The herbivores (fruit eating birds, elephants, deer etc.) are more in number than producers but there is also a gradual decrease in number of successive carnivores. Thus the pyramid is upright (Fig. C).

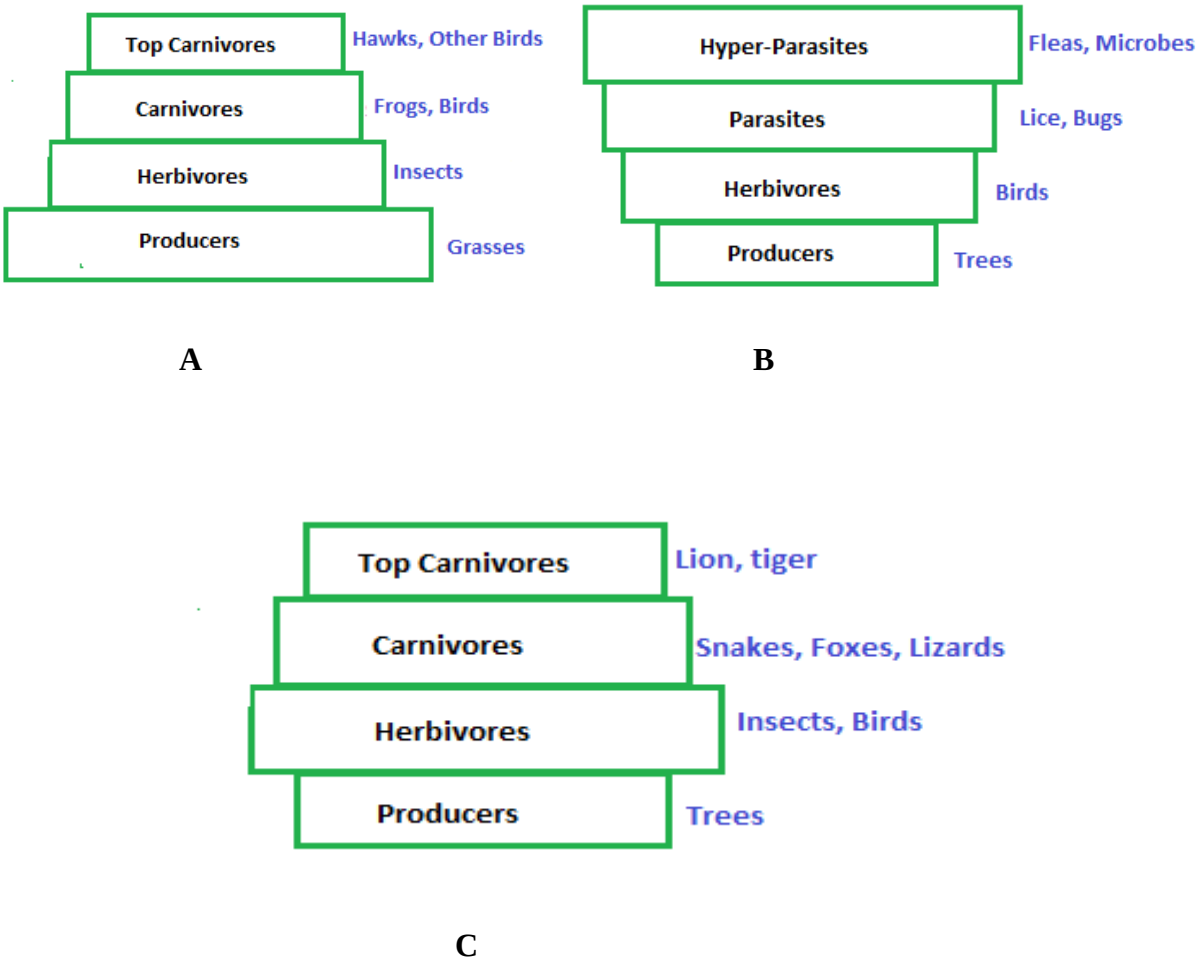
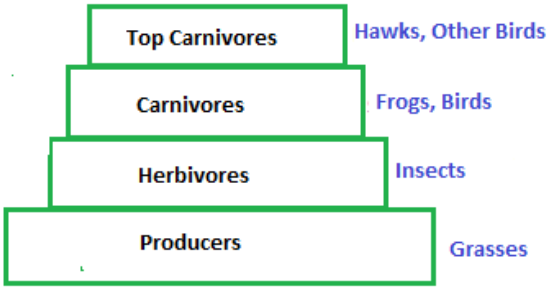


Figure-Pyramid of number, A-Grassland, B-Parasitic food chain, C-forest

2) Pyramid of biomass (living matter): The total amount of living or organic matter present at any time in different trophic levels of an ecosystem forms the pyramid of biomass. This is indicated by weight or other means of measuring material. In grasslands and forests, there is generally a gradual decrease in biomass of organisms at successive levels from the producers to the top carnivores. Thus pyramids are upright (Fig. D). However in a pond as the producers are small organisms their biomass is least and the value gradually shows an increase towards the apex of pyramid thus making the pyramid inverted in shaped (Fig. E).



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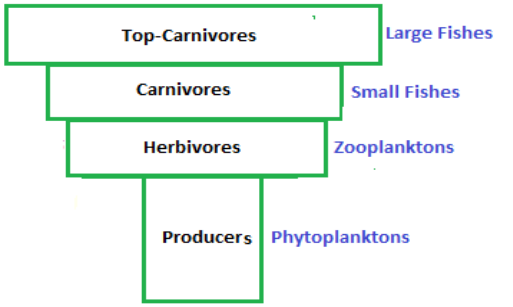

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Figure-Pyramid of biomass, D-Grassland, E-Pond

3) Pyramid of energy: It depicts the amount of energy trapped per unit time and area in different trophic levels of a food chain. Pyramid of energy gives the best representation of the trophic relationship and is always upright (Fig. F). According to the second law of thermodynamics, at each transfer 80-90% of energy available at lower trophic level is used to perform metabolic activities and only 10% is available to next trophic level. The law of retaining only 10% of chemical energy at each trophic level is called ten percent law. It was proposed by Lindeman (1942).

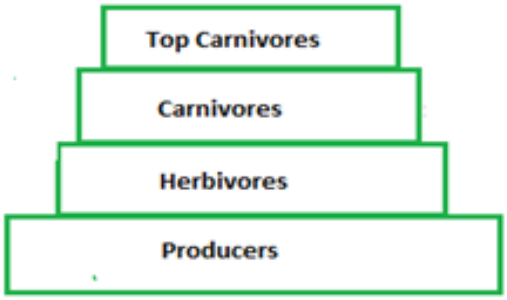

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Fig. F-Pyramid of energy

1.3.3. Energy Flow in an ecosystem

Energy flows from one organism to another in an ecosystem in a unidirectional manner

Flow of energy in an ecosystem takes place through the food chain and it is this energy flow which keeps the ecosystem going. The most important feature of this energy flow is that it is unidirectional. Unlike the nutrients (like carbon, nitrogen, phosphorous) which move in a cyclic manner, energy is not reused or recycled in the food chain.

The flow of energy in an ecosystem follows the two laws of thermodynamics;

***1st Law of thermodynamics**: It states that energy can neither be created nor be destroyed but it can be transformed from one form to another. The solar energy captured by the green plants gets converted into biochemical energy of plants and later into that of consumers.*

***2nd Law of thermodynamics**: It states that energy dissipates as it is used or in other words, it gets converted from a more concentrated form to dispersed form. As energy flows through the food chain, there occurs dissipation of energy at every trophic level. The loss of energy takes place through respiration, locomotion, running and other activities. At every level there is about 90% loss of energy and the energy transferred from one trophic level to the other is only about 10%.*

Productivity of an ecosystem

The productivity of an ecosystem refers to the rate of production i.e. the amount of organic matter accumulated in any unit.

1) **Primary Productivity(P.P.):** It is defined as the rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producers and is of following types:

    a) **Gross Primary Productivity (G.P.P.):** Is defined as the total rate of photosynthesis including the organic matter used up in respiration. GPP depends on the chlorophyll content. The rate of primary productivity is estimated as chl/g dry weight/ unit area or photosynthetic number i.e. amount of CO_2 fixed /gchl/ hour. This is also sometimes referred to as Total (Gross) Photosynthesis or Total Assimilation.

    b) **Net Primary Productivity (N.P.P.):** It is the rate of storage of organic matter in plant tissues in excess of the respiratory utilisation by plants. This is thus the rate of increase of biomass and is also known as apparent photosynthesis or net assimilation. Thus NPP refers to balance between gross photosynthesis and respiration and other plant losses such as death etc.
    N.P.P. = G.P.P. – R

2) **Secondary Productivity (S.P.):** It is the rate of energy storage at consumer levels- herbivores, carnivores and decomposers. Consumers tend to utilise already produced food materials in their respiration and also convert the food matter into different tissues by an overall process, so secondary productivity is not divided into gross and net. That is why some ecologists use the term assimilation rather than production (Odum 1971) at this level. **S.P** in fact remains mobile (i.e. keeps on moving from one organism to another and does not live in situ like the primary productivity.

1.4 Ecosystem Services

Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth.

Economic or Provisioning Services

These are the products obtained from ecosystems, including:

- Food and fibre
- Fuel wood
- Genetic resources.
- Medicines, and pharmaceuticals
- Ornamental resources
- Fresh water

Ecological and Regulating Services

These are the benefits obtained from the regulation of ecosystem processes, including:

- Air quality maintenance
- Climate regulation
- Water regulation
- Erosion control
- Water purification and waste treatment
- Ground water recharge
- Regulation of human diseases
- Pollination
- Storm protection

Social and Cultural Services

These are the services of the ecosystem associated with social life, customs, religion etc

- Cultural diversity

- Spiritual and religious values
- Knowledge systems
- Educational values
- Inspiration
- Social relations
- Cultural heritage values
- Recreation and ecotourism

Aesthetic and Recreation Services

Ecosystems add beauty to nature and thereby provide various aesthetic services to people. People love spending time outdoors and appreciate natural sceneries like forests, mountains, oceans, valleys, lakes etc. Most of us love flowers and enjoy bird watching, wild animals, big trees etc which are nothing but aesthetic services provided by the ecosystems.

Informational Services

Ecosystems also provide an opportunity to study them and collect a lot of information and knowledge about them. We can collect information related to plants, animals, microorganisms, water, air etc. The various branches of science like Zoology, Botany and Geography study animals, plants and the earth features respectively. Similarly Environmental Science explores all the components of the ecosystem in detail.

Unit 2

Natural Resources

Introduction

Our environment provides us with a variety of goods and services necessary for our day to day lives. These goods and services are known as natural resources and include, air, water, soil, minerals, along with the climate and solar energy, which form the non-living or 'abiotic' part of nature. The 'biotic' or living parts of nature consist of plants and animals, including microbes. Many of these living organisms are used as our food resources.

2.1 Land Resources

Land is our basic resource. Throughout history, we have drawn most of our sustenance and much of our fuel, clothing and shelter from the land. It is useful to us as a source of food, as a place to live, work and play. It forms about one fifth of the earth's surface covering about 13393 million hectares and is the source of many materials essential to man and other organisms. Most human or natural activities need space for their location and development which is provided by land. The various purposes for which land can be used include agriculture, horticulture, forestry, grazing, fishing and mining. It has many physical forms like mountains, hills, plains and valleys. It is characterized by climate from hot to cold and from humid to dry.

Soil as a natural resource

The surface layer of the land is called soil. The word soil has been derived from the Latin word 'Solum' meaning upper crust of the earth. Soil is generally defined as upper layer of the earth differentiated into various horizons and capable of supporting life. It is a collection of natural bodies on the earth's surface containing living as well as non-living matter and supporting or capable of supporting plants.

Soil is a dynamic layer of earth's crust which is constantly changing and developing. Soil formation takes place with the decomposition of rocks and minerals. Soil properties like soil texture, structure, permeability, soil water, porosity, soil pH, organic and inorganic content,

cation exchange capacity, microbial properties etc. play an important role in determining productivity. The topography climate and biotic factors control the conditions of the soil.

Soil is renewable natural resource. It plays a very vital role in the determination of the quality and composition of the biosphere. In fact the biosphere develops over the soil. It is not only the home for microbes but also gives nutrition for plants. Some of the important functions of the soil are as under.

1) It provides mechanical support to the flora.

2) Due to its porosity and water holding capacity the soil serves as a reservoir of water and supplies water to the plants (even when the land surface is dry).

3) The ion exchange capacity of soil ensures the availability and supply of micro and macro nutrients for the growth of plants, microbes and animals.

4) Soil also helps in preventing excessive leaching of nutrient ions, while maintaining proper pH.

5) Soil contains a wide variety of bacteria like nitrifying nitrogen fixing bacteria), fungi, protozoans and many other microbes which help in the decomposition and mineralization of organic matter and regeneration of nutrients.

Land use pattern

Land is natural resources and can be used by humans for many purposes. The ways in which the human beings make use of the land resource is termed as **Land Use**. Land use differs greatly from one country to other. The ever increasing human population can use the land for agricultural expansion, resource extraction, urbanization, developmental projects etc. It is very important for a country to have a proper assessment of its land under different uses. Such information can be used for natural resource management and a proper and sustainable development.

Land use changes have greatly changed the global environment. Humans have altered terrestrial ecosystems since pre-historic times, for use of fire, domestication of plants and animals etc. Increasing the agricultural land use occurred at the expense of forests, grass lands and wetlands.

As mentioned, the lands use pattern varies from country to country. A country which depends more on the agricultural would be having most of the land under agriculture. Similarly a country where most of the people depend on the development and industries would be having most of the land urban cover and industrial areas. On average the following table shows the **global land use pattern**:

Land use pattern	Percentage of land
Agricultural land	11%
Pasture and Meadows	24%
Forest land	31%
Other land	34%

As far as India is concerned it is very interesting to note that it has only 2.4% of the world's total land area but holds almost 16% of the world's total population. India has a total geographical area of 328 million hectares. Out of this land utilization statistics are available for 305 million hectares only. The balance 23 million hectares remains un-surveyed and inaccessible. The land use pattern in India has a great variation than that of the global land use pattern as can be seen in the following table;

Land use pattern	Percentage of land
Agricultural land	51.00%
Pasture and Meadows	6.40%
Forest land	23.80%
Other land	18.80%

Land degradation and its causes

Land degradation refers to deterioration or loss of fertility or loss of productive capacity of the soil. All modern and growth oriented activities are having their direct or indirect impact on land. The factors which are mainly responsible for land degradation are:

1) **Soil erosion:** Soil erosion refers to the loss or removal of the top layer of the soil by the action of wind, water or human actions. The factors that influence the extent to which soil erosion will occur include;
   - Distribution intensity and amount of rainfall
   - Slope of the ground
   - Soil type
   - Vegetation cover
   - Soil Management

2) **Salination:** Salination refers to increase in the concentration of soluble salts in the soil. Poor drainage of irrigation and flood waters results in accumulation of dissolved salts on the soil surface. In arid and semi – arid areas with poor drainage and high temperatures, water evaporates quickly leaving behind a white crust of salts on the soil surface.

Salinity, however, can be checked by improving the drainage, and the salinated lands can be reclaimed by leaching with plenty of water (i.e. heavy irrigation).

3) **Water logging:** Water logging may be due to surface flooding or due to high water table. Excessive use of canal irrigation may disturb the water balance and create water logging as a result of seepage or rise in the water table of the area. The productivity of water logged soil is severely reduced due to lesser availability of oxygen for the respiration of plants.

4) **Shifting (Jhum) cultivation**: Shifting cultivation a very peculiar practice of slash and burn agriculture, prevalent among many tribal communities inhabiting the tropical and subtropical region of Africa. This practice has led to complete destruction of forests in many hilly areas of India, especially the north east and Orissa, and caused soil erosion and other associated problems of land degradation.

5) **Urbanization**: Human activities are responsible for the land degradation of forests, crop lands and grass lands. The productive areas are fast reducing because of urbanization i.e. the developmental activities such as human settlements and industries

6) **Landslide**: Human activities such as construction of road and railway, canal, dams and reservoir and mining in hilly areas have affected the stability of hill slopes and damaged the protective vegetation cover both above and below roads and other such developmental works. This has upset the balance of nature, making such areas vulnerable to landslides.

7) **Soil pollution**: Soil pollution (such as pesticides, chemical, radioactive and industrial wastes, plastics, bottles and tin cans, clothes, carcasses etc.) have an adverse effect on the physical, chemical and biological properties of soil and hence reduce its productivity.

Desertification and its causes

Desertification is a slow process of land degradation that leads to desert formation. It is like a skin disease over the planet wherein patches of degraded land, erupting separately, gradually join together. For example, the Thar Desert (in India) was formed by the degradation of thousands of hectares of productive land. It may result either due to a natural phenomenon linked to climatic change or due to abusive use of land.

Increasing human population has put a great pressure on the land. Vast areas of land have been cleared for agriculture, industrial, and other purposes. Over cultivation, overgrazing, deforestation, poor irrigation practices, all contribute towards desertification. These activities bring about changes in rainfall, temperature, wind velocity, etc. and lead to soil erosion. Such changes then lead to desertification of the productive lands. The topsoil, which takes centuries to build up, can be lost in just a few years through such practices.

Causes of desertification

Desertification can occur by a number of factors, some of which are mentioned below:

- Climate change
- Population explosion
- Deforestation
- Overgrazing
- Industrialization
- Urbanization
- Dam construction
- Mining

Control of desertification

Following measures can be taken to control desertification;

- *Control of soil erosion*
- *Afforestation and reforestation*
- *Improvement in irrigation practices*
- *Control of human population*
- *Sustainable development practices*
- *Avoiding overgrazing*

2.2 Forest resource

Forests are important renewable resources. A forest is a biotic community, predominantly of trees, shrubs or any other woody vegetation usually with a closed canopy. Forests vary in composition and density and are distinct from meadows and pastures. Forests contribute substantially to the economic development of the country. They are the vast natural resources for man that has been providing a broad array of commodities, amenities and environmental services. Fuel wood, timber, wild life habitat, pasture for livestock, industrial forest products animal products, recreation, soil moisture retention, climate regulation, production of atmospheric oxygen, a source of new agricultural or grazing land and spiritual renewal are a few examples.

The total land area which is covered by the forests is about 31%. In India the forest cover represents about 24% of the land area (Ministry of Environment and Forests, 2013). Similarly our state Jammu and Kashmir has 19.1% of land under forests.

Importance/Uses of forests

Forests are of immense value to the life and prosperity of human beings and of nations. They provide a rich variety of good useful both to the efficient industrial societies and rural poor. The importance/uses of forests include.

1) **Wood**: Wood is the major forest produce used wood for cooking and heating. About 1.5 billion people demand on fuel wood as their primary energy source.

2) **Timber**: It is used to make lumber, ply wood, veneer, boards, doors, windows, furniture, carts, ploughs, tool handles, sports goods etc.

3) **Minor forest products**: Forest provide resins, fruits, nuts, herbs, medicinal plants, pharmaceuticals, oil, forage, commercial flowers, spices and syrups. Bamboos (also called the poor man's timber) are used in rafters, roofing, walling, flooring, matting, basketry and cart wood and also used as a raw material in paper and rayon industry. Canes are used for making furniture, ropes, walking sticks, umbrella stands and sports goods.

4) **Vital role in the life and economy of tribal**: forests play a vital role in the life and economy of forest dwellers and tribes living in forests. Forests provide food (fruits, roots, tubers and leave of plants and meat from animals), medicines and many other commercial products that are necessary for forest based subsistence pattern.

5) **Ecological significance of forests**: Forest ecosystems provide a host of environmental services including;
    - Maintenance of biological diversity
    - Habitat for wild life
    - Nutrient cycling
    - Oxygen production
    - Reducing atmospheric pollution
    - Control of global warming
    - Role in hydrological cycle

6) **Aesthetic and other values**: Forests have a great aesthetic value. There is hardly any part on earth where people do not appreciate the beauty and tranquillity of forests.

Additionally forests provide areas for ecosystem research provide opportunities for recreation and spiritual renewal and inspire music, literature, religion and art.

Over exploitation and Deforestation

The huge population of the world is putting a lot of pressure on the forest resources. People need space to live, food to eat and money for economic development and many more things for fulfilling their needs. This has resulted in the loss of the forest resource directly or indirectly. One of the direct ways by which man has over consumed these forests is the process of deforestation.

Deforestation is defined as the complete clearing of tree formations and their replacement by using land for other purposes. There are several factors that case deforestation. However, natural factors like fire, soil erosion and drought too can deplete forest resources. Economic factors, i.e. agriculture, commercial logging and establishment of heavy industries also contribute to deforestation.

Causes of deforestation

These are many factors which lead to deforestation as discussed below:

1) **Expansion of agriculture:** Due to population explosion more and more food needs to be produced. One way to fulfil this increased demand is by converting the forest areas to the agricultural ones. The same has been done in previous decades and this has resulted in the great loss of forests. Forests have been clear cut, so that land could be made available for agricultural purposes.

2) **Shifting cultivation (also called 'Jhum cultivation')**: It is also known as slash and burn method of farming. Annually about five thousands km^2 of forest is cleared for this type of farming.

3) **Demand of wood for industry and commercial purposes**: Wood is being used for several industrial processes, such as making boxes, crates, packing cases, furniture, match boxes, paper and pulp, plywood etc.

4) **Forest fire**: Forest, sometimes may suffer from forest fire. In fact, some of the forest fires are due to deliberate burning of trees by smugglers.

5) Deforestation also occurs due to overgrazing and conversion of forest to pasture for domestic animals.

6) Fuel wood gathering is also an important deforestation agent in dry forests.

7) Deforestation also occurs due to mining, quarrying, and irrigation and industrial projects.

8) Expansion of agribusiness that grows oil palm, rubber, fruit trees and ornamental plants has also resulted in deforestation.

9) Finally, government – sponsored programmes that resettle landless farmers on forested sites have contributed to deforestation all around the world.

Consequences of deforestation

Deforestation adversely and directly affects the environment and humans. Some of the ill – effects of deforestation (due to timber extraction, mining, construction of dams etc.) on forests and tribal people are as under:

1) **Soil erosion**: In the absence of forests/trees, especially on slopes, the soil gets washed away with rainwater.

2) **Decrease in rainfall**: Forests bring rains due to high rate of transpiration and precipitation. In the absence of forests, rainfall declines considerably.

3) **Loss of fertile land**: Less rainfall results into the loss of fertile land owing to less natural vegetation growth.

4) **Effect on climate**: The climate of a region is mainly controlled by the rainfall, snowfall etc. Deforestation causes decrease in rainfall, which in turn increases the climatic temperature.

5) **Lowering of water table**: Decrease in rainfall results into a lowered water table due to lack of recharging of underground reservoirs.

6) **Economic losses**: Deforestation will cause loss of industrial timber and non – timber products and loss of long- term productivity on the site.

7) **Loss of biodiversity**: Certain species of flora and fauna are getting extinct from the face of planet, mainly due to deforestation. This has resulted in the loss of biodiversity which resulting in disturbance of ecological balance worldwide.

8) **Loss of medicinal plants**: There are many species of plants which have medicinal and other advantages, like neem (Indian margosa) which has been used in India for centuries as insecticide, fungicide, in medicine and in bio-fertilizers. Deforestation may lead to the extinction of such types of valuable plants.

9) **Environmental changes**: The air we breathe is purified by forests. So, deforestation will lead to increase in carbon dioxide and other air pollutants concentration. This will lead to global warming which is a serious effect as well as threat.

10) Expansions of deserts denuded land mass gradually get converted into sand deserts due to the action of strong winds laden by fragmented rock dust. This effect is more pronounced in rain scarce areas.

11) Migration of local and tribal population from deserts to other fertile land in search of food, leaving behind vast tracks of sands only.

12) In many places the lack of fuel wood due to deforestation challenges local/tribal people, especially where fuel wood had already been scarce.

13) Agriculture may be negatively impacted if deforestation causes soil loss or compaction, or sedimentation of irrigation systems

14) Indigenous people may be forced into a new way of life for which they are unprepared.

15) Deforestation may also increase the incidences of floods that may affect the people and property.

2.3 Water resource

Water is a crucial natural resource. The availability of water greatly influences the health of the people. Proper assessment of the availability of this resource from surface and sub surface sources is crucial for its proper planning, development and efficient management.

Water is, literally, the source of life on earth. Approximately 70.8% of the earth's surface is covered with water mainly in the form of oceans. Of this about 97% is in the oceans and seas, where the high salt content does not permit its use for human consumption. About 2% of the water resource is locked in the glaciers and ice caps, while less than 1% is available as fresh water in surface water sources (such as rivers, streams, lakes and reservoirs) and ground water sources.

Uses of Water resource

Water is a natural resource, which is essential for different purposes. Water is mainly used for drinking and other domestic purposes, industrial cooling, power generation, transportation, agriculture and waste disposal. As water is a source of life for man, plants and other forms of life, it cannot be replaced.

1) **Irrigation**: In agricultural fields, water is used for irrigation. On an average basis near about 70% of the water is used for irrigation.

2) **Domestic water use**: It includes drinking, food preparation, washing, cleaning etc.

3) **Power Generation**: In Power generation, water is used in thermal power plants for condenser cooling.

4) **Industrial water**: Industrial water is used for cooling, processing, cleaning and removing industrial waters. Major water users are steel, textile, paper pulp, chemicals and petroleum refining which account for nearly 80 % of industrial water demand.

5) **Recreation**: the water can be used for many recreational purposes as well. Some of the activities include swimming, boating, water sports, diving etc.

6) **Fire extinguisher**: Water can also be used as a fire extinguisher. The high heat of vaporization makes it a suitable liquid for fire extinguishing.

7) **Navigation**: For ships, boats etc

Consequences of over use of water

More than 99% of earth's water is unavailable or unsuitable for beneficial human use. Thus, the amount of fresh water for which all people, animals and plants on earth compete is even less than 1% of the total. This small of water comes from various sources like river streams, lakes and ground water sources.

Over exploitation of fresh water resources has resulted in many serious problems which directly affect the present and future needs of the people. It has resulted in water scarcity, water logging, deterioration of water quality etc. As per United Nations estimation, about one billion people don't have access to safe drinking water

The over exploitation of ground water for drinking, irrigation and other purposes has resulted in serious problems like;

- Declining of water levels
- Ground subsidence
- Declining of well yield
- Drying of shallow wells
- Deterioration of ground water quality
- Sea water intrusion into coastal aquifers
- High cost of energy required to lift the water from great depths.

Concept of Rain Water Harvesting

Rain water harvesting is the activity of collection of rain water. The rain water collected can be stored and then directly used or can be recharged into ground water. It can be undertaken through a number of ways like;

- Capturing runoff from roof tops
- Capturing runoff from local catchments
- Capturing seasonal flood water from local streams

There are various objectives of rain water harvesting as follows

- To reduce loss of water through run off
- To avoid flooding of roads
- To meet the increasing demands of water
- To help in ground water recharging

Methods of Rain Water Harvesting

Rain water can be mainly harvested by storing it tanks or reservoirs, by constructing pits, dug wells, check dams, trenches, lagoons etc. and also by recharging the ground water. Some of the methods are discussed as follows:

1) Traditional Rain water harvesting: This simply involves storing the rain water in lakes, ponds, irrigation tanks etc. This method is a simple one, and is being practiced from ancient times.

2) Modern methods of Rain Water harvesting: This involves;

- Percolation pit method,
- Dug wells
- Check dams
- Open well method with filter bed sump
- Roof top harvesting

Roof top Harvesting: This has become a very popular method of water conservation especially in the urban areas. Rain water harvesting essentially means collecting rain water on the roofs of building and storing it underground for later use. This is known as roof top harvesting and is the most common method of harvesting the water especially in the cities. The flow of rainwater from the roofs of the buildings is directed into a storage tank. Thus the rain water can be stored and alter used for various purposes.

The rain water harvesting can serve many functions like;

1) Reduces runoff losses
2) Avoids over flooding of roads
3) It can be used to meet the demands of people
4) It can be used to recharge the ground water and thereby raises the water table
5) The water stored can be used during the dry seasons

Watershed Management

A watershed is simply the geographic area through which water flows across the land and drains into a common water body whether a stream, river, lake or ocean. In other words watershed is the catchment area of a stream or a river. People and livestock are the integral part of watershed and their activities affect the productive status of watersheds and vice versa.

Watershed management is the study of relevant characteristics of watershed. It is aimed at the sustainable distribution of its resources.

The various objectives of water shed management are:

1) To protect, conserve and improve the land of watershed for more efficient and sustained production.

2) To protect and enhance the water resource originating in the water shed.

3) To check soil erosion

4) To increase infiltration of rain water

5) To improve and increase the production of timbers, fodder and wild life resources.

6) To enhance the ground water recharge.

7) To reduce the occurrence of floods and the resultant damage by adopting strategies for flood management.

8) To provide standard quality of water by encouraging vegetation and waste disposal facilities.

Watershed Management can be done through;

- Proper farming and forestry practices to reduce runoff
- Minimizing ploughing and forest cutting on steep slopes
- Retaining of crop residue on fields reduces flooding
- Conservation of wetlands
- Control of soil erosion through various practices

Water Conflicts

Water conflict means a fight or a disagreement between groups, states or countries over the water resource. Such conflict may arise due to dispute over the usage and allocation of water resource. As we know that water is necessary for many purposes and still a great population of people do not have the proper access to this resource. This results in the conflicts over water between various parties, groups, states and countries.

Conflicts may also arise when a country tries to control the water resources of other country, thus making water resources a political issue. Conflicts can be seen over rivers and river basins shared by many countries around the world. One such example is Ganges-Brahamputra basin where Bangladesh, India and Nepal argue for the best use of the water. India and Nepal want to exploit the basin's huge hydroelectric power- generating potential, whereas Bangladesh wants the water managed in such a way as to minimize flooding during monsoon months and water shortages during dry months.

In India there are many interstate river water disputes some of which are briefly describes below:

a) **The Cauvery dispute:** The core of the Cauvery dispute relates to the re-sharing of waters that are already being fully utilized. Here the two parties to the dispute are Karnataka and Tamil Nadu. Between 1968 and 1990, 26 meetings were held at the ministerial level but no consensus could be reached.

b) **The Ravi-Beas dispute:** The main current parties in this dispute are Punjab and Haryana. Both of these two states are both agricultural surplus states, providing large quantities of grain for the rest of India. Because of the scarcity and uncertainty of rainfall, the agricultural activities mostly depend on the irrigation.

2.4 Energy resource

Energy is the basic requirement for domestic, industrial and economic development. We use energy for household use, agriculture, production of industrial goods and for running transport. Industry uses energy to power manufacturing units. Energy-demanding roads and railway lines are built to transport products from place to place. The need of energy resources is increasing day by day. From last few decades the energy consumptions has increased by many folds.

Classification of energy resources

The energy resources can be classified in many ways:

a) *Commercial resources*: These include coal, lignite, petroleum products, natural gas and electricity.

   Non-commercial resources: these include fuel wood, cow dung, agricultural wastes etc.

b) *Primary energy sources*: Primary energy resources are those which are mined or otherwise obtained from the environment. These include fossil fuels (coal, lignite, crude oil and natural gas), nuclear fuels, hydro energy, solar, wind and geothermal energy.

   Secondary energy resources: Secondary energy resources are those which don't occur in nature instead they are derived from primary energy resources. These include petrol, diesel, electrical energy (from coal, diesel and gas) etc.

c) *Conventional energy resources*: These include fossil fuels (coal, lignite, crude oil and natural gas), nuclear fuels and hydro energy.

   Non-conventional: These include solar, wind, geothermal, ocean (thermal, tidal and wave), biomass and hydrogen energy.

Renewable energy resources/Alternate Sources of Energy:

Renewable energy resources are those energy resources which are inexhaustible and can be used to produce energy again and again. These are available in unlimited amount in nature and develop in a relatively short period of time. Following are the examples of some of the renewable energy resources:

1) Solar energy
2) Wind energy
3) Hydel energy

4) Geothermal energy
5) Biomass energy

Solar energy

Of all the renewable energy sources, solar energy holds key to an inexhaustible, non-polluting energy supply, because heat and light from the sun is the most abundant form of energy.

One important factor about solar energy is the fact that the sun's radiation is free of cost to everyone and is available during all clear day. The solar energy received in the form of radiations can be converted directly or indirectly into other forms of energy like heat and electricity. The various applications of solar energy are:

a) heating and cooling of residential buildings
b) solar water heating
c) solar drying of the agricultural and animal products
d) solar cookers
e) solar photovoltaic cells
f) solar engines for water pumping

Wind Energy

Wind energy can be used to rotate wind turbines and convert kinetic energy in into electricity. This is one of the simplest natural resource on earth. People have used wind to move boats across oceans, to scatter grains, to pump water, and more recently to supply electricity for small towns. Wind is also a clean source of energy because wind turbines emit no air pollutants, or hazardous waste.

Wind energy can be used for the following purposes:

1) The energy of the wind is used to propel the sailing boats in rivers and seas for the purpose of transportation
2) The energy of the wind is used through the wind mills to run the pumps to draw the water from the ground
3) The energy of the wind is used to run flour mills to grind the grains such as wheat and corn into floor
4) Wind energy is also used to generate electricity by the rotation of the wind mill blades which in turn, turns the coil of the electric generator.

Although wind power is economical and safe means to generate electricity, this source is not used extensively for three main reasons:

- The first reason is because the wind generation plants are extremely loud

- The second reason is that wind energy is not available continuously.
- The wind power plant is not reliable for the modern lives. If there are a few calm days, an entire city could go dark.

Biomass energy

Biomass is the organic matter produced by the plants. It is basically the waste material of the living things. It includes forest crops, residues and crops grown especially for their energy content. Biomass is considered as the renewable energy source because plant life renews and adds itself every year unlike the fossil fuels which takes millions of years to form. Biomass resource can be converted into useful form of energy and it comes under three categories:

1) *Solid traditional biomass*: In this, biomass is burnt directly to get the heat energy
2) *Non-traditional form of the biomass*: Here biomass is converted into ethanol and methanol and used as the liquid fuels
3) *Anaerobic fermentation*: Here biomass is fermented an-aerobically to obtain the gaseous fuels like the biogas.

Hydel energy

This uses water flowing down a natural gradient to turn turbines to generate electricity known as 'hydroelectric power' by constructing dams across rivers. Between 1950 and 1970, Hydropower generation worldwide increased seven times. Advantages are;

- Long life of hydropower plants
- Renewable energy source
- Low operating and maintenance costs
- Absence of pollutants as in fossil fuels.

Geothermal energy

'Geo' means earth, and 'thermal' means heat, so geothermal means earth – heat. Geothermal energy is the heat from the earth which is clean and sustainable. The energy harnessed from the geothermal sources can either be used directly for space heating in houses and buildings or indirectly to generate electricity by the flashed steam method. The advantages of geothermal energy are

- It is renewable source of energy
- It is non-polluting and environment friendly
- Maintenance cost of geothermal power plants is very less
- Geothermal power plants don't occupy too much space and thus help in protecting natural environment.
- Unlike solar energy, it is not dependent on the weather conditions

Non Renewable energy sources:

Non renewable energy sources are those natural resources which are exhaustible and cannot be replaced once they are used. These are available in limited amount and develop over a long period of time. These include fossil fuels (such as coal, oil and natural gas) and nuclear power. Although they have accumulated in the earth for millions of years but as a result of their uncontrolled use they are likely to get exhausted one day. The non-renewable resources are also called as the conventional sources of energy.

Coal

Throughout history coal has been used as an energy resource, primarily burned for the production of electricity and heat and is also used for industrial purposes. Coal gets formed when dead plant matter is converted into peat, which in turn is converted to lignite and finally to anthracite. This involves biological and geological processes that take place over a long period of time. Coal is of three types namely lignite, bituminous and anthracite. Anthracite is the best form of coal as it has got the maximum carbon content of about 90%. This is followed by bituminous with carbon content of 80% and lignite with carbon content of 70%.

Petroleum

Petroleum is formed when large quantities of dead organisms, usually zooplanktons and algae are buried below the sedimentary rocks and subjected to both intense heat and pressure. The term petroleum in fact covers both naturally occurring unprocessed crude oil and the products that are made up of refined crude oil. Petroleum and/or crude oil is a fossil fuel and is mixture of hydrocarbons. It is interesting to note that today about 90% of the vehicular fuel needs are met by oil. The three top oil producing countries are Russia, Saudi Arabia and United states.

Natural gas

Natural gas is a naturally occurring mixture of hydrocarbon gases primarily containing methane. It is formed when layers of decomposing plant and animal matter are exposed to intense heat and pressure below the surface of earth. Natural gas is a fossil fuel and is a source of energy for heating, cooking and electricity generation. It is also used as fuel for vehicles. Natural gas is found in deep underground rocks. It is also present near the coal and petroleum deposits.

Limitations of Non-renewable resources

Energy consumption has increased dramatically over the last two decades and almost all the requirements have been fulfilled by the non-renewable sources of energy. However using such resources has got serious limitations as mentioned below;

- ***Exhaustibility***: these resources are available in limited amount and have developed over a very long period of time. Therefore these resources are going to get exhausted one day.

- ***Increased demand***: the increased demands of the fossil fuels like oil and gas are going to increase the price of such resources.

- ***Pollution***: This is also a serious problem of using these fossil fuels which are non-renewable. As our energy needs are increasing, we are burning more and more fuels and thus a lot of undesirable and poisonous chemical pollutants are going into the atmosphere.

- ***Climate change***: The burning of fossil fuels release various gases like carbon dioxide, carbon monoxide, sulphur dioxide, nitrogen dioxide etc. which upset our climate patterns by bringing undesirable changes in it.

Growing energy needs

Energy has always been closely linked to man's economic growth and development. The energy needs of man for development has increased as can be understood by following points;

- Between 1950 and 1990, the world's energy needs increased fourfold.
- The world's demand for electricity has doubled over the last 22 years.
- For almost 200 years, coal was the primary energy source fuelling 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.
- Among the commercial energy sources used in India, coal is a predominant source accounting for 55% of energy consumption estimated in 2001, followed by oil (31%), natural gas (8%), hydro (5%) and nuclear (1%).

The energy needs have grown because of the increase in following sectors;

- Transportation
- Power plants
- Industrialization
- Domestic purposes
- Space technologies
- Military and defence use