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1 Chapter

Environmental Studies – A Multidisciplinary Subject

Inside This Chapter

1.1 Definition of Environment
1.2 Components of Environment
1.3 Types of Environment
1.4 Environmental Education
1.5 Objectives of Environmental Education
1.6 Importance of Environmental Education
1.7 Scope of Environmental Education
1.8 Need for Public Awareness

1.1 DEFINITION OF ENVIRONMENT

Our environment is like a patchwork quilt. Each "patch" is dependent on those around it. If one part unravels, it affects the rest – Hemeon

Don't blow it - good planets are hard to find - Quoted in *Time* magazine

"*We shall never understand the natural environment until we see it as a living organism*" Paul Brooks.

'Environment' is derived from the French word *Environner* which means to encircle or surround. All the biological and non-biological things surrounding an organism are thus included in environment. **Environment is the totality of circumstances surrounding an organism or group of organisms, especially the combination of external physical conditions that affect and influence the growth, development, and survival of organisms.**

Environment is the complex of physical, chemical, and biotic factors (as climate, soil, and living things) that act upon an organism or an ecological community and ultimately determine its form and survival.

According to Environment (Protection) Act, 1986, **Environment is sum of total water, air and land, inter-relationship among themselves and also with the human beings, other living organism and property.** Thus we can say, Environment means our '*surroundings*'.

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Chemicals on earth are distributed among four major environmental compartments or conceptual spheres: atmosphere, hydrosphere, lithosphere and biosphere. While such a compartmentalization of nature is a somewhat arbitrary, it helps in organizing and extending our knowledge of the distribution and flow of chemicals. A schematic representation of the four environmental compartments and their interrelationships is shown in Figure 1.1.

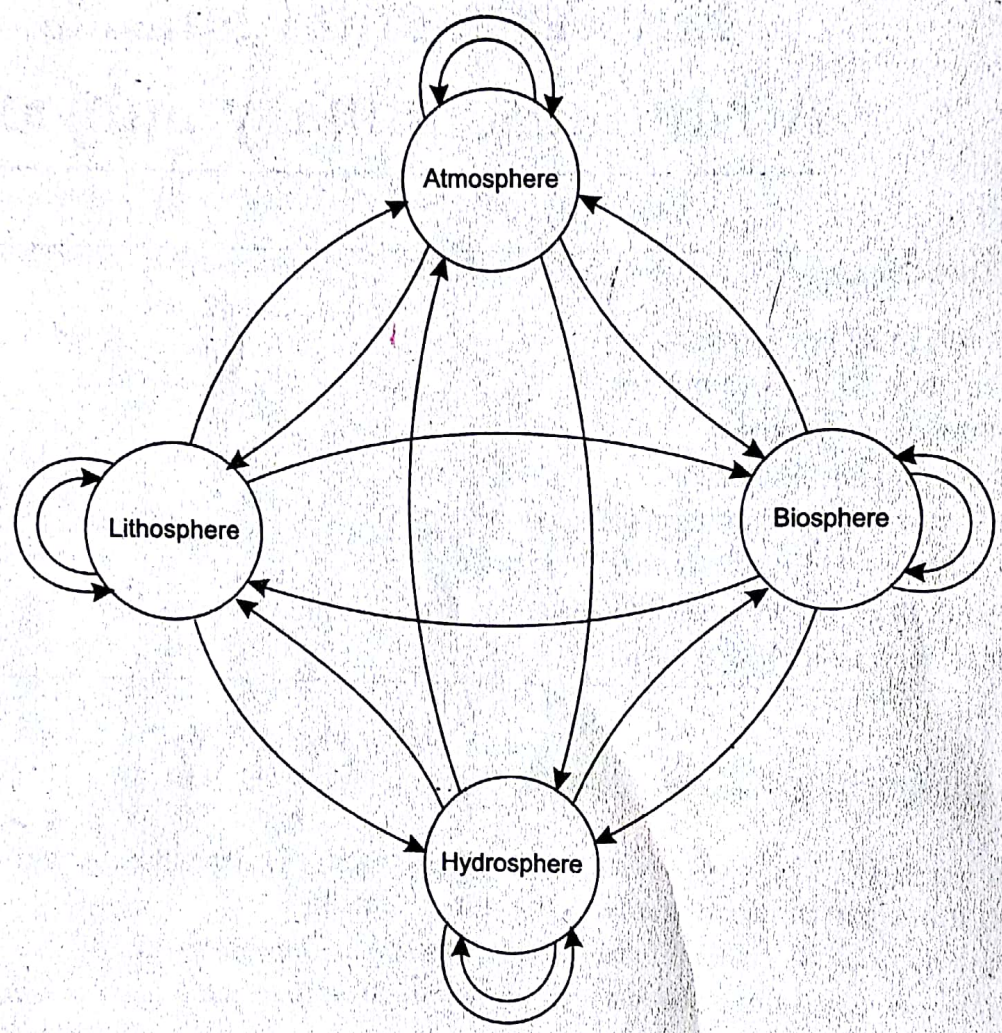

Fig. 1.1 The Four Environmental Spheres

The circles represent the spheres and the curved arrows the flow pathways of matter. In the diagram, circles and curved arrows are used instead of boxes and straight line connections to emphasize the close, dynamic, inseparable, organic coupling among the environmental compartments; if one compartment or linkage changes, all other compartments respond.

In this conceptual frame, every sphere has a two-way linkage to every other sphere, including itself. The two-way linkage signifies that matter may flow from one compartment to another in both directions. Some arrows show the transfer within a given compartment from one location to another indicating movement of the substance from one physical location to another without leaving the sphere. Since matter cannot be created or destroyed, the question one seeks to answer is the location and chemical form of the substance at given time.

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1.2 COMPONENTS OF ENVIRONMENT

1.2.1 Atmosphere

The earth's atmosphere contains several different layers that can be defined according to air **temperature**. According to temperature, the atmosphere contains four different layers. The first layer is called the **troposphere**. The width of this layer varies from about 8 to 16 kilometers. Greatest depths occur at the tropics where high temperatures cause vertical expansion of the lower atmosphere. From the tropics to the earth's polar regions, the troposphere becomes gradually thinner. The depth of this layer at the poles is roughly half as thick when compared to the tropics. Average depth of the troposphere is approximately 11 kilometres.

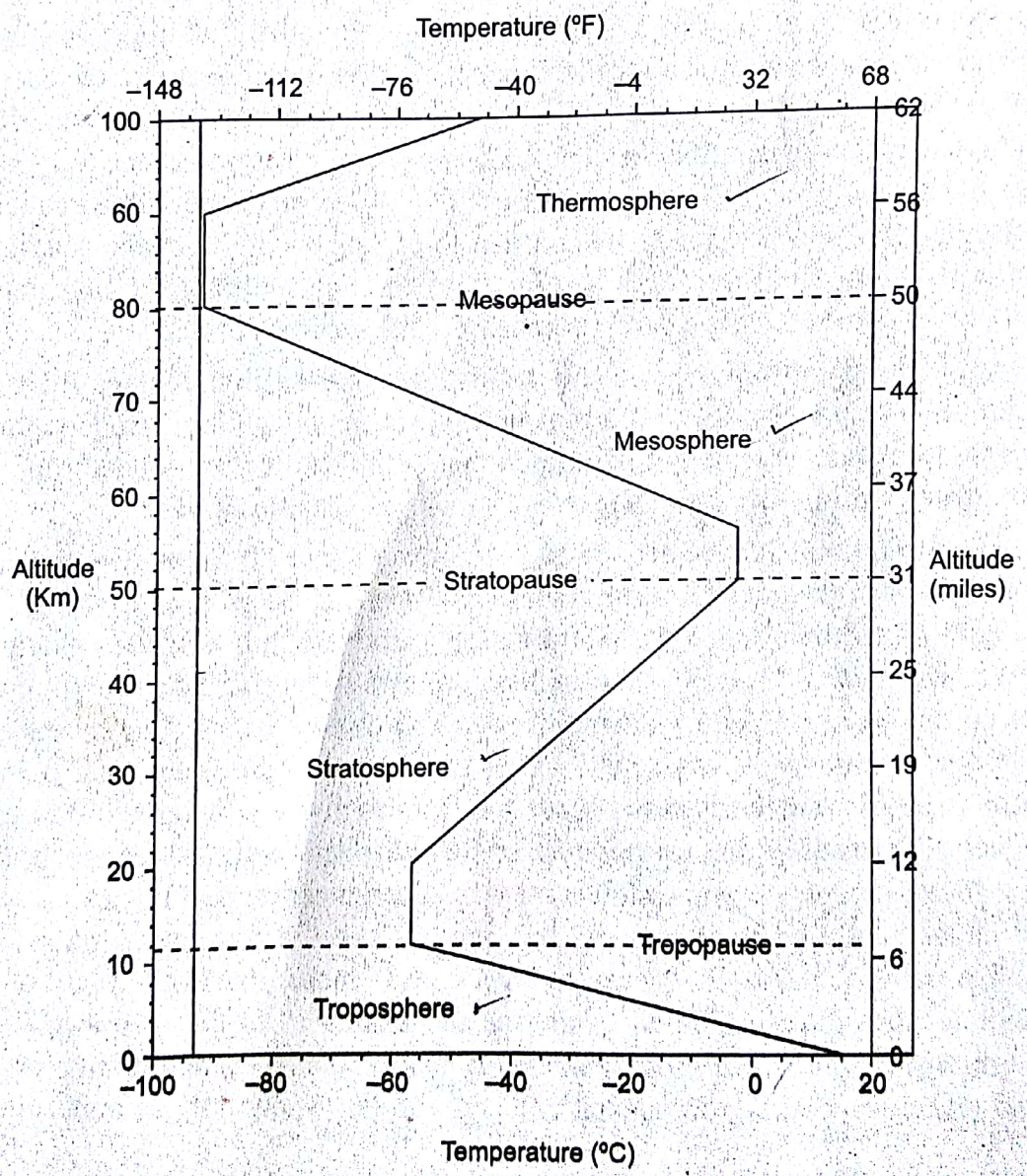

Fig. 1.2

About 80% of the total mass of the atmosphere is contained in troposphere. It is also the layer where a variety of our weather occurs. Maximum air temperature occurs near the earth's surface in this layer. With increasing height, air temperature

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drops uniformly with altitude at a rate of approximately 6.5° Celsius per 1000 metres. This phenomenon is commonly called the **Environmental Lapse Rate**. At an average temperature of –56.5° Celsius, the top of the troposphere is reached. At the upper edge of the troposphere is a narrow transition zone known as the **tropopause**.

Above the tropopause is the **stratosphere**. This layer extends from an average altitude of 11 to 50 kilometres above the Earth's surface. This stratosphere contains about 19.9% of the total mass found in the atmosphere. Very little weather occurs in the stratosphere. Occasionally, the top portions of thunderstorms breach this layer. In the first 9 kilometres of the stratosphere, temperature remains constant with height. A zone with constant temperature in the atmosphere is called an **isothermal layer**. From an altitude of 20 to 50 kilometres, temperature increases with an increase in altitude. The higher temperatures found in this region of the stratosphere occurs because of a localized concentration of **ozone** gas molecules. These molecules absorb ultraviolet sunlight creating heat energy that warms the stratosphere. Ozone is primarily found in the atmosphere at varying concentrations between the altitudes of 10 to 50 kilometres. This layer of ozone is also called the **ozone layer**. The ozone layer is important to organisms at the earth's surface as it protects them from the harmful effects of the sun's ultraviolet radiation. Without the ozone layer life could not exist on the earth's surface.

Separating the **mesosphere** from the stratosphere is transition zone called the **stratopause**. In the mesosphere, the atmosphere reaches its coldest temperatures (about –90° Celsius) at a height of approximately 80 kilometres. At the top of the mesosphere is another transition zone known as the **mesopause**.

The last atmospheric layer has an altitude greater than 80 kilometres and is called the **thermosphere**. Temperatures in this layer can be as high as 1200°C. These high temperatures are generated from the absorption of intense solar radiation by oxygen molecules (O_2). While these temperatures seem extreme, the amount of heat energy involved is very small. The amount of heat stored in a substance is controlled in part by its mass. The air in the thermosphere is extremely thin with individual gas molecules being separated from each other by large distances. Consequently, measuring the temperature of thermosphere with a thermometer is a very difficult process. Thermometers measure the temperature of bodies via the movement of heat energy. Normally, this process takes a few minutes for the conductive transfer of kinetic energy from countless molecules in the body of a substance to the expanding liquid inside the thermometer. In the thermosphere, our thermometer would lose more heat energy from radiative emission then what it would gain from making occasional contact with extremely hot gas molecules.

1.2.2 Lithosphere

The lithosphere contains all of the cold, hard solid land of the planet's crust (surface), the semi-solid land underneath the crust, and the liquid land near the centre of the planet. It is composed of soil particles and the underlying rocks down

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to a depth of 50 km. The soil layer is also referred to as the pedosphere, a mixture of inorganic and organic solid matter, air, water and microorganisms. Within the soil, biochemical reactions by microorganisms are responsible for most of the chemical changes of matter. However, soil and rock are mainly storage compartments for deposited matter.

The solid, semi-solid, and liquid land of the lithosphere form layers that are physically and chemically different. If someone were to cut through earth to its center, these layers would be revealed like the layers of an onion. The outermost layer of the lithosphere consists of loose soil rich in nutrients, oxygen, and silicon. Beneath that layer lies a very thin, solid crust of oxygen and silicon. Next is a thick, semi-solid mantle of oxygen, silicon, iron, and magnesium. Below that is a liquid outer core of nickel and iron. At the centre of earth is a solid inner core of nickel and iron.

1.2.3 Hydrosphere

The hydrosphere is composed of all of the water on or near the earth. This includes the oceans, rivers, lakes, and even the moisture in the air. It ranges from 10 to 20 kilometres in thickness. The hydrosphere extends from earth's surface downward several kilometres into the lithosphere and upward about 12 kilometres into the atmosphere.

The hydrosphere may be envisioned as two compartments: a conveyor, a river system that collects the substances within the water shed and delivers them to the second hydrologic compartment, oceans.

Ninety-seven per cent of earth's water is salty. The salty water collects in deep valleys along earth's surface. These large collections of salty water are referred to as oceans. The remaining three per cent is fresh water; three-quarters of the fresh water is solid and exists in ice sheets. This water flows as precipitation from the atmosphere down to earth's surface, as rivers and streams along earth's surface, and as groundwater beneath earth's surface. Most of earth's fresh water, however, is frozen.

1.2.4 Biosphere

The biosphere is composed of all living organisms. Plants, animals, and one-celled organisms are all part of the biosphere. Most of the planet's life is found from three metres below the ground to thirty metres above it and in the top 200 metres of the oceans and seas.

Within the biosphere, living things form ecological communities based on the physical surroundings of an area. These communities are referred to as **biomes**. Deserts, grasslands, and tropical rainforests are three of the many types of biomes that exist within the biosphere. It is impossible to detect from space each individual organism within the biosphere. However, biomes can be seen from space.

It occupies the least volume of all of the spheres but it is the heart, or the chemical pump, of much of the flow of matter through nature. Weathering through

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the hydrological cycle, blowing wind, and volcanic releases are the other mobilizing agents. The biosphere is responsible for the grand scale recycling of energy and matter on earth. The mobilization of matter by biota is by no means restricted to small geographic regions. The periodic burning of forests and savannas, for example, not only change the chemical form of matter, but also result in long-range atmospheric transport and deposition. Some of the biologically released chemicals, including carbon, nitrogen, and sulphur have long atmospheric residence times, resulting in continental and global-scale redistribution.

1.3 TYPES OF ENVIRONMENT

Environment can be conveniently divided into two categories:

1. **Natural environment:** The environment that comes in its existence by its own or naturally without the influence of human being is called as *natural environment*. It operates through self-regulating mechanism that is known as homeostasis.
2. **Man-made or anthropogenic environment:** The environment which has been modified by human activities is called man-made environment. When in a specific area temperature, humidity etc. are controlled by human being that is anthropogenic environment. The increase in the scientific technology which is the result of human brain is deteriorating the natural environment.

1.4 ENVIRONMENTAL EDUCATION

The systematic study of our environment and our interaction with it is known as *environmental science*. Environmental science is not a single subject but it has the characteristics of various disciplines of life science as botany, zoology, microbiology, biochemistry, biotechnology and genetics. Besides these fields of life sciences it also interact with basic science as physic, chemistry and mathematics and some other aspects of life such as religion, laws, economics, management and social issues. Therefore, it may be conclude that environmental science is a multidisciplinary topic of discussion dealing with almost each and every aspect of life that is related to us in anyway.

Environmental engineering is one of the most complex and fastest growing disciplines in engineering. Environmental education is the education through environment, about the environment and for the environment. It is the process of recognising values of environment and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the interrelatedness of human being, his culture and his biophysical surroundings.

Environmental education has been defined and redefined over the last twenty-five years. Definitional issues are inherent in a field this broad and encompassing. It is generally agreed that environmental education is a process that creates awareness and understanding of the relationship between humans and their many environments – natural, man-made, cultural, and technological. Environmental education is

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concerned with knowledge, values, and attitudes, and has as its aim responsible environmental behaviour.

Environmental education has long been defined to include three critical components: awareness, leading to understanding which in turn creates the potential and capacity for appropriate actions. More specifically, environmental education includes:

1. Developing personal awareness of the environment and one's connections to it;
2. Developing an understanding of environmental concepts and knowledge of ecological, scientific, social, political and economic systems;
3. The capacity to act responsibly upon what a person feels and knows, in order to implement the best solutions to environmental problems.

(Staniforth & Fawcett, 1994)

1.5 OBJECTIVES OF ENVIRONMENTAL EDUCATION

The world's first Intergovernmental Conference on Environmental Education was held in Tbilisi, Georgia. At the Tbilisi Conference adopted the Tbilisi Declaration, which challenged environmental education to create awareness and values amongst humankind in order to improve the qualities of life and the environment.

A major outcome of Tbilisi was detailed descriptions of the objectives of environmental education. Most environmental educators have since universally adopted these objectives.

1. **Awareness:** To help social groups and individuals acquire an awareness and sensitivity to the total environment and its allied problems.
2. **Knowledge:** To help social groups and individuals gain a variety of experience in, and acquire a basic understanding of, the environment and its associated problems.
3. **Attitudes:** To help social groups and individuals acquire a set of values and feelings of concern for the environment and the motivation for actively participating in environmental improvement and protection.
4. **Skills:** To help social groups and individuals acquire the skills for identifying and solving environmental problems.
5. **Participation:** To provide social groups and individuals with an opportunity to be actively involved at all levels in working toward resolution of environmental problems. (UNESCO, 1978)

1.6 IMPORTANCE OF ENVIRONMENTAL EDUCATION

Environmental issues affects, and are affected by, all our activities to varying degree. The need to have a working knowledge of environmental issues is not confined to environmental scientist, engineer and policy-makers. In our society,

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all educated people need to have working understanding of the fundamental principles involved for environmentally responsible decision-making. The main importances of environmental education are as follows:

1. Environmental education helps in economy and welfare of human society.
2. It helps us in solving the different issues like pollution measures, over exploitation of natural resources, food problems and sustainable development.
3. Environmental education helps us to find ways and means to maintaining ecological balance.
4. As the industrialisation is increasing and new technologies are growing, to conserve and protect the environment we need eco-friendly product and methods, it can be achieve only through proper knowledge of environment.
5. As the population is increasing we need large amount of food and other resources and different disposal method for the removal of waste, this can only be possible by environmental education by which we can achieve our goal without destroying it.
6. Environmental education trains us to conserve our fast depleting natural resources.
7. It helps to understand different food chains and the ecological balance in nature.
8. Environmental education helps in inculcating attitude and values, encouraging environmental protection and understanding of interdependence of nature and man.

1.7 SCOPE OF ENVIRONMENTAL EDUCATION

Scope of environmental studies is broad based. It encompasses a large number of areas and aspects and influence living and non-living organisms each moment of their life. They are broadly listed below:

1. Natural Resources – their conservation and management
2. Ecology
3. Biodiversity and its conservation
4. Environmental pollution and control
5. Natural disasters
6. Development
7. Social issues in relation to development and environment
8. Human population and environment

1.8 NEED FOR PUBLIC AWARENESS

The environmental studies is a distinct programme that gives the students an opportunity to experience the interdisciplinary nature of the subject. The environmental studies educate students in the fundamentals of environmental issues.

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As this programme provides a holistic view of the environment and human-environment relationships, students undergoing environmental studies will acquire the knowledge and technical skills for active participation in environmental careers.

An understanding of working of the environment requires the knowledge from wide ranging fields. Thus environmental education is aimed at increasing the public awareness and knowledge about the environmental issues and provides facts, opinions or the skills to make informed decisions and take environmentally responsible actions. It does not advocate a particular viewpoint or cause of action. It teaches individuals how to weigh various sides of an issue through critical thinking and it enhances their own problem solving skills.

The United Nations Conference on Environment and Development held in Rio de Janerio in 1992, popularly known as *'Earth Summit'* have first highlighted the key issues of global environmental concern and have attracted the attention of the general public towards the deteriorating environment. Any government at its own level cannot achieve the goals of sustainable development until the public has a participatory role in it. Public participation is not possible only when the public is aware about the ecological and environmental issues.

There is a Chinese proverb '*if you plan for one year, plant rice, if you plan for 10 years, plant trees and if you plan for 100 years, educate people.*' If we want to manage our planet earth, we have to make all the persons environmentally educated.

Nowadays, everybody talks of environment, but only a few have clear ideas about what need to be done and still fewer have the actual experience or expertise in the field. Environmental problems are in part the result of the large number of human beings on the planet. Therefore, individual actions, summed over large number of people, can influence the environment greatly. So we must do more then simply identify and discuss environmental problems and solutions. We must think critically about them. It has to be recognised that the basis of human power and superiority lies in his knowledge of the environment. Individuals can involve themselves in many ways in the process of improving the environment. Some are listed below:

1. We should not extracting unnecessarily and exhaustively the natural resources such as underground water, minerals etc.
2. We should not harness too much energy such as from burning of fossil fuel (solid, liquid or gaseous fuel).
3. We should not cut the trees and use timber for aesthetic pleasure such as in decorating our houses.
4. We should preserve forest cover area
5. We should formulate and obey the moral codes meant for achieving a better environment.

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SUMMARY

Environment is sum total of water, air, land, their inter-relationship among themselves, with the human beings, other living organism and property. Whole environment is divided in four major conceptual spheres or compartments on the basis of chemical distribution. They are called atmosphere, hydrosphere, lithosphere and biosphere.

The Earth is surrounded by a blanket of air, which we call the *atmosphere*. It reaches over 560 kilometers (348 miles) from the surface of the Earth. The atmosphere absorbs the energy from the Sun, recycles water and other chemicals, and works with the electrical and magnetic forces to provide a moderate climate. The atmosphere also protects us from high-energy radiation and the frigid vacuum of space. The envelope of gas surrounding the Earth changes from the ground up. Four distinct layers have been identified using thermal characteristics (temperature changes), chemical composition, movement, and density. These layers are naming the troposphere, the stratosphere, the mesosphere and the thermosphere.

The *lithosphere* contains all of the cold, hard solid land of the planet's crust (surface), the semi-solid land underneath the crust, and the liquid land near the center of the planet. It is composed of soil particles and the underlying rocks down to a depth of 50 km.

The *hydrosphere* is composed of all of the water on or near the earth. This includes the oceans, rivers, lakes, and even the moisture in the air. It ranges from 10 to 20 kilometers in thickness.

The *biosphere* is composed of all living organisms. Plants, animals, and one-celled organisms are all part of the biosphere. Most of the planet's life is found from three meters below the ground to thirty meters above it and in the top 200 meters of the oceans and seas.

Environment can be conveniently divided into two categories: *Natural environment* that comes in its existence by its own or naturally without the influence of human beings and *Man-made* or *Anthropogenic environment,* which having been modified by human activities is called man-made environment.

The systematic study of our environment and our interaction with it is known as '*environmental science*'. Environmental engineering is one of the most complex and fastest growing disciplines in engineering. Environmental education is education through the environment, about the environment and for the environment. Environmental education has long been defined to include three critical components: awareness, leading to understanding which in turn creates the potential and capacity for appropriate actions.

Providing awareness, knowledge, a positive attitude about the environment, skills and the human participation toward resolution of environmental problems are the major objectives of environmental education.

The environmental education is important because it helps in increasing economic growth and welfare of human society, maintains ecological balance, provides proper knowledge of environment to understand different food chains, solves different issues like pollution measures, over-exploitation of natural resources, food problems, and inculcates attitude and values.

The United Nations Conference on Environment and Development held in Rio de Janerio in 1992, popularly known as *'Earth Summit'* first highlighted the key issues of global environmental concern and attracted the attention of the general public towards the deteriorating environment. Any government at its own level cannot achieve the goals of sustainable development until the public has a participatory role in it. Public participation is possible only when the public is aware about the ecological and environmental issues.

As this program provides a holistic view of the environment and human-environment relationships, students undergoing environmental studies will acquire the knowledge and technical skills for active participation in environmental careers. Thus environmental education is aimed at increasing the public awareness and knowledge about the environmental issues and provides facts, opinions or the skills to make informed decisions and take environmentally responsible actions.

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DESCRIPTIVE TYPE QUESTIONS

1. With the help of neat sketch discuss the structure of atmosphere along with temperature profile of atmosphere and related phenomenon. **[5 Marks](UPTU 2006)**
2. Unawareness or ignorance with protection of environmental will lead to detrimental consequences—comment with illustration. **[5 Marks](UPTU 2006)**
3. Define the term "Environment". Explain the importance of environmental studies in present context. **[5 Marks](UPTU 2006)**
4. What is meant by environment? Enumerate and discuss its various components.
5. What is environmental science? Discuss the multidisciplinary nature of environmental science. How would environment awareness help to protect our environment?
6. What is an environment? Discuss the various segments of environment in brief.
7. Explain the need foe public awareness about the environment and its degradation.
8. Define Environmental studies. What are the objectives and guiding principles of environmental studies?
9. Write an explanatory note on the multidisciplinary nature of environmental studies.
10. Explain the scope of environmental studies.
11. Explain the importance of environmental education in the present day context.
12. Explain the significance of biosphere, atmosphere, hydrosphere and lithosphere.
13. Name and describe the four major layers of the atmosphere. What are the important chemical species found in each layer?
14. Define the following
    (a) Tropopause (b) Stratopause
    (c) Mesopause (d) Thermopause

SHORT QUESTIONS WITH ANSWERS

Q. 1. Define the term 'environment'.

Ans. Environment is sum of total water, air and land and their inter-relationship among themselves and also with the human beings, living organism and property. Environment means surroundings and encircle around us.

Q. 2. What do you understand by environmental science?

Ans. Environmental science is the branch of science which deals with the study of our environment and our interaction with it. Environmental science has the characteristic various disciplines of life science as botany, zoology, microbiology, biochemistry, biotechnology and genetics.

Q. 3. What are the major objectives of environmental education?

Ans. Providing awareness, knowledge, a positive attitude about the environment, skills and the human participation toward resolution of environmental problems are the major objectives of environmental education.

Q. 4. What is the role of science and engineering in the protection of the environment?

Ans. Science and engineering plays a major role in the protection of environment by helping in increasing economic growth and welfare of human society, maintains ecological balance, provides proper knowledge of environment, solve different issues like population measure and food problem and inculcates attitude and values.

Q. 5. List the four conceptual spheres in the earth's environment.

Ans. Four conceptual spheres in the earth are-

(i) Lithosphere
(ii) Hydrosphere

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(iii) Atmosphere
(iv) Biosphere

Q. 6. Differentiate between biosphere and lithosphere.

Ans. The biosphere is composed of all living organisms includes plants, animals and one celled organisms while lithosphere is composed of soil particle which includes all of the cold, hard solid land of the planet's crust, the semi-solid land underneath the crust and the liquid land near the centre of the planet.

Q. 7. What do you understand by ozone layer?

Ans. Ozone is primarily found in the atmosphere at varying concentration between the altitudes of 10 to 50 kilometers. This layer of ozone is called the ozone layer. The ozone layer is important to organism at the earth's surface as it protects them from the harmful effects of the sun's ultraviolet radiation.

Q. 8. 'Ozone is a pollutant in troposphere while life saver in stratosphere'. Justify this statement.

Ans. As ozone is present in troposphere it is a pollutant because in presence of sunlight it breaks into O_2 and O and reacts with oxides of nitrogen and hydrocarbons which results smog but in the stratosphere it absorbs the UV radiation of sun and protects the living organisms as known as life saver in stratosphere.

Q. 9. Define the term 'biomes'.

Ans. Within the biosphere, living organisms form ecological communities based on the physical surrounding of that area, these communities are referred as biomes. Deserts, grasslands and tropical rainforest are the few examples of biomes that exist within the biosphere.

Q. 10. How an individual can improve the environment?

Ans. An individual can improve the environment by the following ways:

(i) By minimizing the unnecessarily and exhaustive extraction the natural resources
(ii) By saving the non-renewable energy sources such as fossil fuel.
(iii) By increasing the forest cover area

By obeying the moral codes meant for achieving a better environment.

MULTIPLE CHOICE QUESTIONS

1. The objective of environmental education is
(a) raise consciousness about environmental condition
(b) to teach environmentally appropriate behaviour
(c) create an environmental ethic that fosters awareness about the ecological inter-dependence of economic, social and political factors in a human community and the environment
(d) All of the above

2. Which of the following is not influenced by human activities?
(a) Depletion of ground water
(b) Destruction of mangroves and wetlands
(c) Increased extinction rates of species
(d) None of the above

3. Environmental education should be imparted only at
(a) Primary school stage (b) Secondary school stage
(c) College stage (d) All stages

4. Increasing industrialization is causing much danger to man's life by
(a) Polluting the environment (b) Producing more goods
(c) Providing more jobs (d) Utilizing waste land

5. Which of the following one is not related to the loss of productivity of croplands?
(a) Desertification (b) Water logging
(c) Salt buildup in topsoil (d) None of the above

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6. The environment which has been modified by human activities is called
   (a) Natural environment (b) Anthropogenic environment
   (c) Urban environment (d) Modern environment
7. Which of the following conceptual components of the environment are effective transporters of matter
   (a) Atmosphere and hydrosphere (b) Atmosphere and lithosphere
   (c) Hydrosphere and lithosphere (d) Lithosphere and biosphere
8. Short term properties of the atmosphere at a given place and time is referred as
   (a) Climate (b) Microclimate
   (c) Season (d) Weather
9. Biosphere is
   (a) the solid shell of inorganic materials on the surface of the Earth.
   (b) the thin shell of organic matter on the surface of earth comprising of all the living things.
   (c) the sphere which occupies the maximum volume of all the spheres.
   (d) all of the above
10. Which of the following statements about environmental education is false?
   (a) Environmental education is evolving to be education for sustainable and ethical development both at a local and global level.
   (b) Environmental education will prepare the next generation to plan appropriate strategies for addressing development environmental issues.
   (c) Environmental education does not advocate a particular viewpoint or course of actions.
   (d) Environmental education is essential for the young generation only.
11. Which of the following conceptual sphere of the environment is having the least storage capacity for matter
   (a) Atmosphere (b) Lithosphere
   (c) Hydrosphere (d) Biosphere
12. Which of the following is an example of impact of development activities on the Hydrosphere
   (a) air pollution (b) soil pollution
   (c) soil erosion (d) water pollution
13. Global atmospheric temperatures are likely to be increased due to
   (a) burning of fossil fuel (b) water pollution
   (c) soil erosion (d) none of the above
14. Which of the following is a management option for air pollution
   (a) Regulations and standards (b) Emission changes
   (c) Transport planning (d) All of the above

Match the Following Terms

Match the terms of column I with appropriate terms of column II –

Column I	Column II
(i) Ozone	(a) Bacteria and fungi
(ii) Hydrosphere	(b) Earth crust
(iii) Edaphic	(c) Soil
(iv) Lithosphere	(d) Stratosphere
(v) Decomposers	(e) Water

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Fill in the Blanks

1. .....teach us how to treat nature.
2. The inter government conference on environment education in 1977 was held in .....
3. The ecological factors related to soil and substratum is called ..... factors.
4. A zone with constant temperature in the atmosphere is called an .....
5. Temperatures in ..... layer can be as high as 1200° C.
6. Separating the ..... from the stratosphere is transition zone called the stratopause.
7. With increasing height, air temperature drops uniformly with altitude, this phenomenon is commonly called the .....

ANSWERS

Multiple Choice Questions

1. (d)	2. (d)	3. (d)	4. (a)	5. (d)	6. (b)	7. (a)
8. (d)	9. (b)	10. (d)	11. (a)	12. (d)	13. (a)	14. (d)

Match the Following Terms

(i) d (ii) e (iii) c (iv) b (v) a

Fill in the Blanks

1. Environmental Studies
2. Tbilisi, Georgia
3. Edaphic
4. Isothermal layer
5. Thermosphere
6. Mesosphere
7. Inversion.

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2 Chapter

Natural Resources

Inside This Chapter

2.1 Natural Resources
2.2 Forest Resources
2.3 Water Resources
2.4 Mineral Resources
2.5 Food Resources
2.6 Energy Resources
2.7 Land Resource
2.8 Role of an Individual in Conservation of Resources
2.9 Equitable Use of Resources for Sustainable Lifestyle

2.1 NATURAL RESOURCES

The word resources mean a source of supply or support that is generally held in reserves. In other words the natural resource are the materials which living organism can take from nature for their life or any component of the natural environment that can be utilised by man to promote his welfare. A natural resource can be a substance, an energy unit or a natural process or phenomena, e.g., water, air, soil, minerals, coal, forests, crops and wildlife are all the example of natural resources.

The nature of resource varies from society to society. The variation is related to the culture, the label of the development and the nature of work of a society. Depending upon the availability and abundance, natural resources are of the two types: renewable and non-renewable.

The natural resources are of two kinds:

- Renewable resources which are in-exhaustive and can be regenerated within a given span of time, e.g. forests, wildlife, wind energy, biomass energy, tidal energy, hydropower etc. Solar energy is also a renewable form of energy as it is an in-exhaustive source of energy.
- Non-renewable sources which cannot be regenerated e.g. fossil fuel like coal, petroleum; minerals etc. Once we exhaust these reserves, the same cannot be replenished.

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Even our renewable resources can become non-renewable if we exploit them to such extent that their rate of consumption exceeds their rate of regeneration. It is very important to protect and conserve our natural resources and use them in a judicious manner so that we don't exhaust them. The major natural resources:

1. Forest resource
2. Water resource
3. Mineral resource
4. Food resource
5. Energy resource
6. Land resource

2.2 FOREST RESOURCES

About 420 million years ago, during the Silurian period, ancient plants and arthropods began to occupy the land. Over the millions of years that followed, these land colonisers developed and adapted to their new habitat. The first forests were dominated by giant horsetails, club mosses, and ferns that stood up to 40 feet tall.

The landscape changed again during the Pleistocene Ice Ages—the surface of the planet that had been dominated by tropical forests for millions of years changed, and temperate forests spread in the Northern Hemisphere.

Forests are one of the most important natural resources on this earth. Covering the earth like a green blanket. These forests not only produce innumerable material goods, but also provide several environmental services which are essential for life. It is estimated that forests covered 1/4th of the earth's entire land area in 1940 and 1/5th in 1980. There are approximately 1.2 billion hectares of open woodlands and Savannah and nearly 2.5 billion hectares of closed forest.

Present day forest biomes, biological communities that are dominated by trees and other woody vegetation (Spurr and Barnes), can be classified according to numerous characteristics, with seasonality being the most widely used. Distinct forest types also occur within each of these broad groups. There are three major types of forests, classed according to latitude:

Tropical forests: Tropical forests are characterised by the greatest diversity of species. They occur near the equator, within the area bounded by latitudes 23.5 degrees N and 23.5 degrees S. One of the major characteristics of tropical forests is their distinct seasonality: winter is absent, and only two seasons are present (rainy and dry). The length of daylight is 12 hours and varies little.

Temperature is on average 20-25°C and varies little throughout the year. The average temperatures of the three warmest and three coldest months do not differ by more than 5 degrees.

Precipitation is evenly distributed throughout the year, with annual rainfall exceeding 2000 mm.

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Soil is nutrient-poor and acidic. Decomposition is rapid and soils are subject to heavy leaching.

Canopy in tropical forests is multilayered and continuous, allowing little light penetration.

Flora is highly diverse. One square kilometre may contain as many as 100 different tree species. Trees are 25-35 m tall, with buttressed trunks and shallow roots, mostly evergreen, with large dark green leaves. Plants such as orchids, bromeliads, vines (lianas), ferns, mosses, and palms are present in tropical forests.

Fauna include numerous birds, bats, small mammals, and insects. More than 1/2 of tropical forests have already been destroyed.

Temperate forests: Temperate forests occur in Eastern North America, North East Asia, and Western and Central Europe. Well-defined seasons with a distinct winter characterise this forest biome. Moderate climate and a growing season of 140-200 days during 4-6 frost-free months distinguish temperate forests.

Temperature varies from –30°C to 30°C.

Precipitation (75-150 cm) is distributed evenly throughout the year.

Soil is fertile, enriched with decaying litter.

Canopy is moderately dense and allows light to penetrate, resulting in well-developed and richly diversified understory vegetation and stratification of animals.

Flora is characterised by 3-4 tree species per square kilometre. Trees are distinguished by broad leaves that are lost annually and include such species as oak, hickory, beech, hemlock, maple, basswood, cottonwood, elm, willow, and spring-flowering herbs.

Fauna is represented by squirrels, rabbits, skunks, birds, deer, mountain lion, bobcat, timber wolf, fox and black bear.

Only scattered remnants of original temperate forests remain.

Boreal forests: Boreal forests, or taiga, represent the largest terrestial biome. Occurring between 50 and 60 degrees north latitudes, boreal forests can be found in the broad belt of Eurasia and North America. Two-thirds in Siberia with the rest in Scandinavia, Alaska, and Canada. Seasons are divided into short, moist, and moderately warm summers and long, cold, and dry winters. The length of the growing season in boreal forests is 130 days.

Temperatures are very low.

Precipitation is primarily in the form of snow, 40-100 cm annually.

Soil is thin, nutrient-poor and acidic.

Canopy permits low light penetration and as a result, understory is limited.

Flora consists mostly of cold-tolerant evergreen conifers with needle-like leaves, such as pine, fir, and spruce.

Fauna include woodpeckers, hawks, moose, bear, weasel, lynx, fox, wolf, deer, hares, chipmunks, shrews and bats.

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2.2.1 Uses of Forest

Forests are vital to the ecological functioning of the planet, producing 60% of the net productivity of all terrestrial ecosystems. They also form the habitat for a large portion of the earth's plant and animal species, providing the basis for the biodiversity which is essential for the biosphere's future.

The diverse functions of forests can be stated as follows:

Production function: From time immemorial the forest has supplied man with useful goods; fuel for warmth and cooking, and materials for shelter, tools and transport. Though wood products have now changed in both degree and kind, and modern chemistry enables wood to be plasticised, moulded, laminated, impregnated and turned into a bewildering number of products, still roughly half our wood is used for fuel. And much of the remainder still goes, as in primitive times, into relatively crude materials for shelter and transport.

Without the forests we would have much less oxygen. One acre of forest provides over 6 tons of oxygen per year! This is because trees (and all green plants) use a process called photosynthesis, during which they take in carbon dioxide and, as a by-product, produce oxygen. Plants "breathe" carbon dioxide, like we breathe oxygen. There has been a balance between species that breathe out carbon dioxide and take in oxygen, and species that take in carbon dioxide and exhale oxygen. Since the 1800's this balance has been upset. Fossil fuels, when burned, create carbon dioxide, so carbon dioxide levels have risen dramatically. Unfortunately, this gas, in large amounts, acts like an insulator and keeps heat near the surface of the earth. This is called the "greenhouse effect." In addition to the other important aspects of the ancient forests, some individual species, such as the yew tree (*Taxus brevifolia*), have shown great importance in the medical field. The bark of the yew tree provides taxol, an anti-cancer agent. It helps treat ovarian, lung and breast cancer. This property of the yew tree was only discovered in recent years, and if the forests that are home to the yew trees are lost, other medical treatments may also be lost as well.

Protective functions: Forests protect our waters and manage our climate. When it rains in the forests, the leaves allow the water to slowly drip to the ground. When a forest has been clear-cut, the rain pours down hard on the unprotected soil. The dirt then washes into streams, muddying the waters. This is unhealthy for the fish, and can cause flooding. Also, without trees, the moisture in the air evaporates quickly, changing the climate of nearby forests. This process prevents trees from receiving the water they need. Vegetation, plant roots, and soil quality also mitigate the impact of floods and erosion. Biomass production is vitally important for human beings. Moreover, when used for construction or as a source of energy, wood is a raw material. Its production can meet sustainability criteria (including those referring to climate change: balanced CO_2 cycle).

Plant cover, root systems, and the quality of topsoil enable good infiltration and water retention. Forests also play a role as landscape and recreation areas. They often have cultural and spiritual value

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Regulative function: Forest regulates temperature (reducing global warming), humidity, precipitation, shape soil environment and different geochemical cycles.

2.2.2 Overexploitation of Forests

Since time immemorial, humans have depended heavily on forests for food, medicine, shelter, wood and fuel. With growing civilisation the demands for raw material like timber, pulp, minerals, fuel wood etc. shooted up resulting in large scale logging, mining, road-building and cleaning of forests. Our forests contribute substantially to the national economy. The international timber trade alone is worth over US$ 40 billions per year. Excessive use of fuel wood and charcoal, expansion of urban, agricultural and industrial areas and overgrazing have together led to over exploitation of our forests leading to their rapid degradation.

2.2.3 Deforestation

Deforestation is the permanent destruction of indigenous (original) forests and woodlands. Deforestation is defined as the complete cleaning of tree formation and their replacement by using land for other purpose. The term does not include the removal of industrial forests such as plantations of gums or pines. Deforestation has resulted in the reduction of indigenous forests to four-fifths of their pre-agricultural area. Indigenous forests now cover 21% of the earth's land surface. The main factors that cause deforestation are natural factors (fire, soil erosion and drought), economical factors (agriculture, commercial logging and establishment of heavy industries) and traditional factors (shifting cultivation, grazing and fuel). Deforestation rate is relatively less in temperate countries but it is very alarming in tropical countries where it is as high as 40-50 per cent and at the present rate it is estimated that in the next 60 years we would lose more than 90 per cent of our tropical forests.

Major Causes of Deforestation

- Population growth;
- Shifting cultivation;
- Fuel requirements – felling of trees for firewood and building material;
- Raw materials for industrial use;
- Development projects;
- Growing food need-conversion of forests and woodlands to agricultural land to feed growing numbers of people;
- Overgrazing;
- Fires;
- Acid rain;

Consequences of deforestation: Effects of deforestation are numerous. Rise in temperature, low rainfall, accelerated soil erosion, loss of habitat and species and range of secondary effects. The concomitant effects are:

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- It threatens the existence of many wildlife species due to destruction of their natural habitat. *Extinction of species* which depend on the forest for survival. Forests contain more than half of all species on our planet – as the habitat of these species is destroyed, so the number of species declines.
- Biodiversity is lost and along with that genetic diversity is eroded.
- Hydrological cycle gets affected, thereby influencing rainfall. Trees draw groundwater up through their roots and release it into the atmosphere (transpiration). In Amazonia over half of all the water circulating through the region's ecosystem remains within the plants. With removal of part of the forest, the region cannot hold as much water. The effect of this could be a drier climate.
- Problems of soil erosion and loss of soil fertility increase. With the loss of a protective cover of vegetation more soil is lost.
- *Silting of water courses, lakes and dams.* This occurs as a result of soil erosion. In hilly areas it often leads to landslide and flood.
- Silting of reservoirs and agricultural lands.
- Decreases of recharge to groundwater.
- *Desertification* — The causes of desertification are complex, but deforestation is one of the contributing factors.
- *The carbon cycle.* Forests act as a major carbon store because carbon dioxide (CO_2) is taken up from the atmosphere and used to produce the carbohydrates, fats, and proteins that make up the tree. When forests are cleared, and the trees are either burnt or rot, this carbon is released as CO_2. This leads to an increase in the atmospheric CO_2 concentration. CO_2 is the major contributor to the greenhouse effect. It is estimated that deforestation contributes one-third of all CO_2 releases caused by people.

CASE STUDY

The Chipko movement

The Chipko movement of the Uttarakhand region in the northwest part of India began as a communal reaction of local villagers to protect their forests from commercial deforestation practices. The term "Chipko" which literally means "to embrace", was designated to these villagers who reacted by actually hugging the trees. It became so popular that the movement spread throughout the India and different parts of Asia. Local women of the region are central to the movement's success and continue to be its backbone. In fact over the decades, Chipko has been known for its ecofeminist strategies. This case study will examine the development of the envrionmental problems over the decades and study the social and cultural elements implicit in the communities of the Uttarakhand Himalyan region.

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Himalay Case Issue (HIMALAY Case)

Case Name: *Himalayan Trekking*

The Himalayan mountain range in India is one of the most beautiful ecological wonders in the world. At the same time, it is one of the most threatened. Increasing numbers of mountaineers, trekkers, and nature-lovers have been making the annual pilgrimage to these mountains in such volume that the environment's natural equilibrium is in jeopardy. Roads have replaced trees, campsites have replaced meadows - the sign of visitation is everywhere through a trail of non-recyclable rubbish. Wildlife has been squeezed into remote and often desolate areas to escape the influx of humans and to search for a better source of food within a disrupted food-chain ecosystem. National and local government need these foreign tourists in order to support the economy, however it is obvious that at the present rate of destruction, the longevity of the "infant" tourism sector will in itself be compromised.

Sandalwood Case

Case Name: *Indian Sandalwood Trade*

The Indian sandalwood tree has become endangered in recent years, and in an attempt to curb its possible extinction the Indian government is trying to limit the exportation of sandalwood. The tree is already government controlled, and removal is prohibited whether on private or temple grounds until the tree is thirty years old. This has not stopped many poachers from cutting trees down as soon as authorities are not watching. Smuggling of sandalwood has created socio-economic and law and order problems in areas bordering the state of Tamil Nadu.

Economics of bamboo basket making: a case-study: Bhanjdas, the basket making community of Haryana, live mostly in the northern part of the state in the hilly belt of Siwaliks. They are dependent on bamboos from the forest areas for making baskets for their sustenance and employment. This study looks into various aspects of resource availability and utilization, volume of basket production and employment generated, and economics of various sizes of baskets make. It also investigates the problems of marketing these baskets made. It also investigates the problems of marketing these baskets, the role of middlemen and the net profits accruing to the *Bhanjdas* in the ultimate analysis. Keeping in view the socio-economic structure of the *Bhanjdas*, the likely options for the betterment of the lot of this forest community and sustaining productivity of the forests have been discussed.

2.3 WATER RESOURCES

Water is indispensable natural resources, on which all life depends. Water is needed for daily use by organisms, for irrigation, navigation, industrial use, electricity production and domestic use. Of the total water resource of the earth, 97.3% is salt water and the rest fresh water. About 97% of the earth's surface is covered

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by water and most of the animals and plants have 60-65% water in their body.

Of this about 77.2% is permanently frozen, 22.4% occurs as groundwater and soil moisture, 0.35% is found in lakes and wetlands and 0.01% in rivers and streams. The total volume of groundwater found in underground reservoir, called aquifers, is estimated to be 42.3×10^{10} m^3. At present about 25% of the groundwater is being used by man.

Water is characterised by certain unique features which make it a marvelous resource:

- It exits as a liquid over a wide range of temperature i.e. from 0° to 100°C. Water can exist on our planet in three physical states (i.e. state of matter) under ambient conditions that normally occur. Water can be a liquid (water), a gas/vapour (clouds), or a solid (ice).
- It has the highest specific heat (how much energy is needed to increase the temperature of each gram of substance to one degree) and a high "latent heat of fusion," which is the energy required to melt 1 gram of ice at 0°C. These properties make lakes slow to thaw and warm in the spring and slow to cool and freeze in the fall, thus providing exceptionally stable thermal environments for aquatic organisms.
- It has a high latent heat of vapourisation (a change of state from liquid to vapour at constant temperature also requires the input of energy) hence; it takes a huge amount of energy for getting vapourised. That's why it produces a cooling effect as it evaporates.
- Due to high surface tension and cohesion it can easily raise through great heights trunk even in the tallest of the trees.
- It has anomalous expansion behaviour i.e. as it freezes; it expands instead of contracting and thus becomes lighter.
- It is an excellent solvent for several nutrients. Thus it can serve as a very good carrier of nutrients, including oxygen, which is essential for life. More substances dissolve in water than in any other liquid. For this reason, water is often called the *Universal Solvent*. The reason for water's excellent dissolving capability relates to its polarity; water offers positive and negative charges to which other atoms of molecules can attach.
- The temperature/density relationship of water is also unique. Most liquids become denser (heavier) as they cool. Water also rapidly becomes denser as its temperature drops, but only to a certain point. Water reaches its maximum density at 39.09 °C (3.94°C), and then it decreases slightly in density until it reaches 32°F (0°C), the freezing point. At this point, ice forms and its density decreases sharply. Ice, therefore, is much lighter than liquid water and thus forms at the surface of lakes rather than at the lake bottom. A second important consequence of the temperature/density relationship of water is the thermal stratification of lakes. Energy is required to mix fluids of differing densities, and the amount of energy necessary is related to the difference

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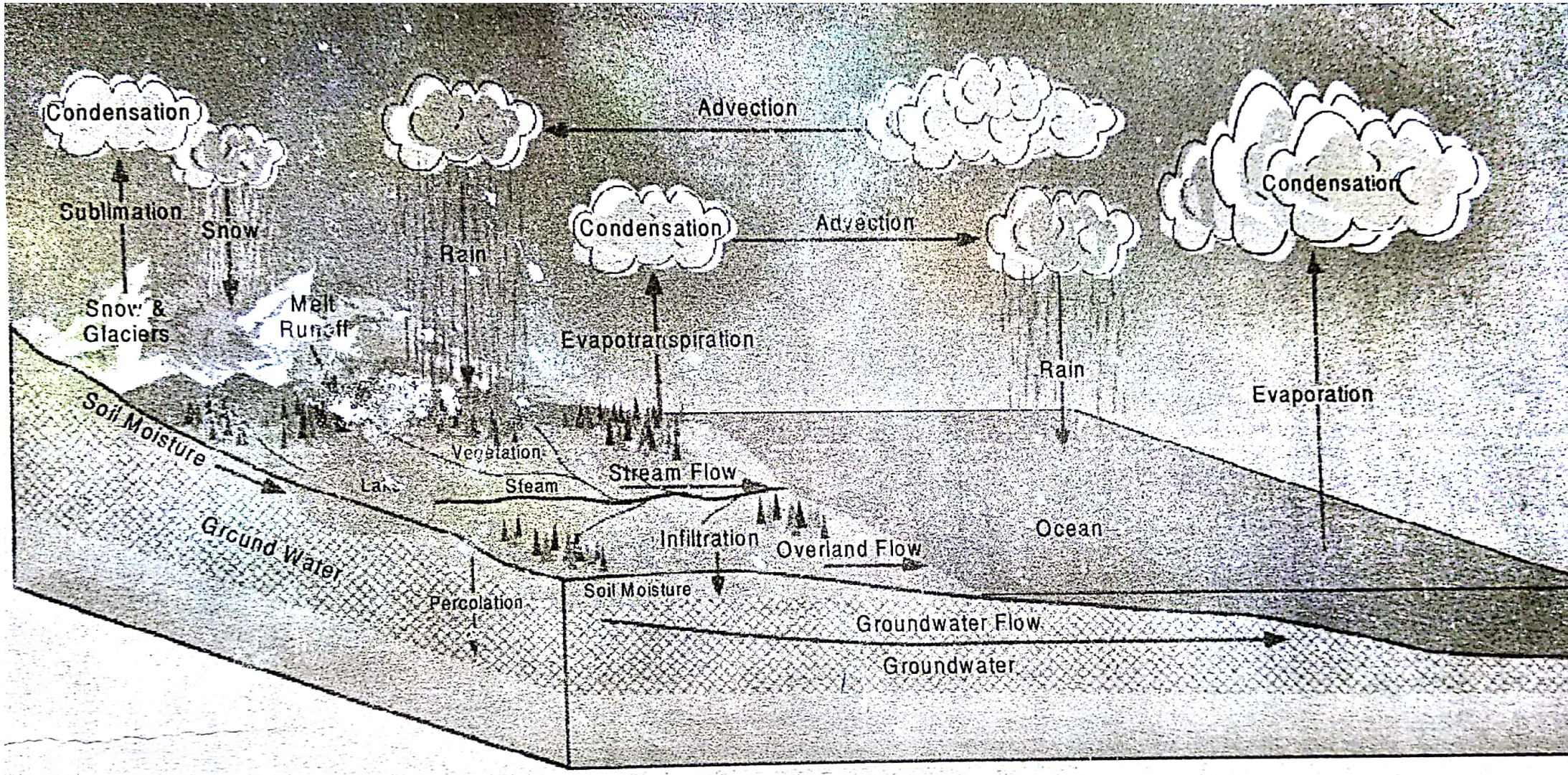

Fig. 2.1 Hydrologic Cycle

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in density. In the case of lakes, this energy is provided primarily by wind. Therefore, the changes in water density that accompany rapidly decreasing water temperatures in the metalimnion during summer stratification are of great importance. The metalimnetic density gradient provides a strong and effective barrier to lake mixing.

2.3.1 Hydrological Cycles

The water we use keeps on cycling endlessly through the environment, which we call as hydrological cycle. Water moves from one reservoir to another by way of processes like evaporation, condensation, precipitation, deposition, runoff, infiltration, sublimation, transpiration, melting and groundwater flow. The oceans supply most of the evaporated water found in the atmosphere. Water is in a constant state of motion. Atmospheric water condenses and falls to the earth as rain, snow or some other forms of precipitation. Once on earth's surface, water flows into streams, lakes and eventually the oceans or percolates through the soil and into aquifers that eventually discharge into surface waters. Through evaporation from surface water or by evapo-transpiration from plants, water molecules return to the atmosphere to repeat the cycle. Although the movement through some parts of the cycle may be relatively rapid, complete recycling of groundwater must often be measured in geological time (Ref. Fig. 2.2).

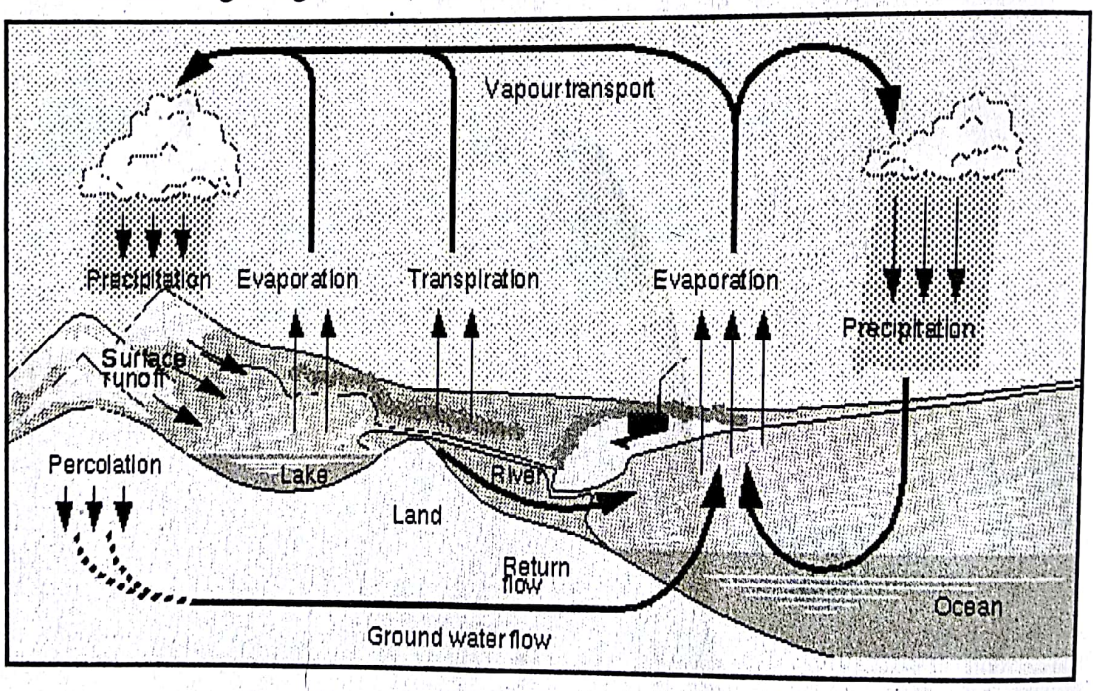

Fig. 2.2 Hydrological cycle

2.3.2 Use and Overexploitation of Surface and Groundwater

Due to its unique properties water is of multiple uses for all living organisms. Water is absolutely essential for life. Most of the life processes take place in water contained in the body. Human beings depend on water for almost every developmental activity. Water is used for drinking, irrigation, transportation, washing

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and waste disposal for industries and used as a coolant for thermal power plants. Water shapes the earth's surface and regulates our climate.

Overuse of groundwater for drinking, irrigation and domestic purposes has resulted in rapid depletion of groundwater in various regions leading to lowering of water table and drying of wells. Pollution of groundwater aquifers has made many of these wells unfit for consumption. Overexploitation of ground water lowers water tables, which may damage wetlands, cause ground subsidence, and induce salt-water intrusion in coastal aquifers.

Rivers and streams have long been used for discharging the waters. Most of the civilisation have grown and furnished on the banks of rivers but unfortunately, growth in turn, has been responsible for pollution of the rivers.

Effect of Groundwater Usage

Subsidence: When groundwater withdrawal is more than its recharge rate, the sediments in the aquifer get compacted, a phenomenon known as *ground subsidence*. Ground subsidence at the surface can be regarded as ground movement which takes place due to the intensive abstraction of groundwater. It is attributed to the consolidation of sedimentary deposits in which the groundwater is present, consolidation occurring as a result of increasing effective stress. The total overburden pressure in partially saturated or saturated deposits is borne by their granular structure and the pore water. It occurs where excessive pumping of groundwater removes ground support, particularly in areas of unconsolidated sediments and sedimentary rocks. Removal of water causes sediment compaction. The weight of buildings can also cause compaction and subsidence.

Lowering of water table: Occurs where groundwater is withdrawn faster than it can be recharged. It can cause wells to dry up; For example: in some areas of the mid-West, 2-10 times more water is being withdrawn from the High Plains aquifer than is being recharged. It is not advisable to do excessive mining as it would cause a sharp decline in future agricultural production, due to lowering of water table.

Water logging: Another problem associated with excessive irrigation on poorly drained soils is water logging. This occurs (as is common for salinisation) in poorly drained soils where water can't penetrate deeply. For example, there may be an impermeable clay layer below the soil. It also occurs on areas that are poorly drained topographically. What happens is that the irrigation water (and/or seepage from canals) eventually raises the water table in the ground — the upper level of the groundwater — from beneath. Growers don't generally realise that water logging is happening until it is too late — tests for water in soil are apparently very expensive.

The raised water table results in the soils becoming waterlogged. When soils are water logged, airspaces in the soil are filled with water, and plant roots essentially suffocate — lack oxygen. Water logging also damages soil structure. Worldwide, about 10% of all irrigated land suffers from water logging.

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Fig. 2.3 Land subsidence

Saltwater incursion: Involves contamination of freshwater aquifers with saltwater. Fresh water floats as a lens on denser salt water. If too much fresh water is removed, a cone of depression is created in the fresh water lens. Lowering the water table by 1 foot results in raising the level of salt water by 40 feet. This situation occurs primarily in island or coastal communities, but is also threatening the Salinas Valley in California. It can be counteracted by

1. Reducing groundwater withdrawal.
2. Reinjecting treated wastewater into recharge wells.
3. Construction of recharge ponds.

Pollution: Sewage is the most common source of groundwater pollution. Landfills, underground storage tanks and hazardous waste disposal sites are other sources of contamination. Surface sources of pollution can affect groundwater where the ground is very permeable or where conduits to the water table are present. Pollution spreads with the flow of groundwater. Clean-up of contaminated groundwater is extremely difficult and expensive. High-level nuclear waste disposal may threaten groundwater quality in the future.

2.3.3 Floods

Floods are the most common and wide spread of all natural disasters except fire. Generally, the stream channels accommodate some maximum stream flow. However, due to heavy rains or sudden snow melts, the quantity of water in streams exceeds their capacity and water overflows the banks and causes inundation of surrounding land. This condition is called *flood*.

In some counties like India and Bangladesh rainfall does not occur throughout the year, rather 90% of it is concentrated into a few months (June-September). Heavy rainfall often causes floods in the low-lying coastal areas. Prolonged downpour can also cause the overflowing of lakes and rivers resulting into floods.

Deforestation, overgrazing, mining, rapid industrialisation, global warming etc. have also contributed largely to a sharp rise in the incidence of floods, which otherwise is a natural disaster.

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River floods, caused primarily due to the peculiarities of rainfall in the country, are the most frequent and often the most devastating disaster in India. The problem of floods is compounded by sediment deposition, drainage congestion and the synchronisation of river floods with sea tides in the coastal plains. The rivers originating in the Himalayas carry a large amount of sediment, causing erosion of the banks in the upper reaches and over-topping in the lower segments.

The most flood-prone areas are the Brahmaputra, Ganga and Meghana basins in the Indo-Gengetic-Brahmaputra plains in north and northeast India, which carry 60% of the nation's river flow.

People of India and Bangladesh are accustomed to moderate flooding during monsoon period and they utilise the flood water for growing paddy in their fields. However, severe floods like that in 1988 and 1991 resulting from excessive Himalayan runoff and storms, had very disastrous results causing massive loss of human life and damages to properties. In 1970 flood, nearly one million people were drowned while more than one lakh people died in 1991 floods.

2.3.4 Droughts

The term 'drought' is generally applied when the country receives less of long-term average rainfall. There are about 80 countries in the world, lying in the arid and semiarid regions that experience frequent spell of droughts, very often extending up to year long duration or more than that. Generally, such drought hit areas are often having a large population growth which leads to poor land use and make the situation worse.

Drought is a meteological phenomenon but due to several anthropogenic causes like over grazing, deforestation, mining etc. there is spreading of the deserts tending to convert more areas to drought affected areas. Erroneous and intensive cropping and increased exploitation of scarce water resources through well or canal irrigation to get high productivity has converted drought-prone areas into desertified ones.

Remedial Measures

- Carefully selected mixed cropping helps epitomise yield of crop and minimise the risks of crop failures.
- Social forestry and wasteland development can prove quite effective to fight the drought problem.
- Should be based on proper knowledge of ecological need and natural process, otherwise it may even boomerang.

2.3.5 Conflicts and Water

As water becomes increasingly scarce, national conflicts are expected to rise. Industry, agriculture, and citizens are in competition for the resource that is so desperately needed for further development. National tensions over the distribution of water can quickly escalate into discord between groups dependent on a shared resource.

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Water tensions are brewing over shared rivers and basins in many countries around the world. Over 200 bodies of water are shared by two or more countries or areas. Strife over water is plaguing states to include the Middle East, Eastern Europe, and South-East Asia. Of particular concern for this case is the dispute between Tamil Nadu and Karnataka, two states in India, over access to the Kaveri river.

Kaveri River Dispute: The Kaveri River is one of the most contentious water supplies in Southern India. The Kaveri watershed is divided between Karnataka and Tamil Nadu (both Southern Indian States). Tamil Nadu does not control any of the Kaveri headwaters, yet is in possession of the tributaries Bhavana and the Moyar. Similar to other divided watersheds (Mekong—Southeast Asia and Colorado—Western United States), there is peace in times of good rains. However, when the monsoons fail, violence erupts. There is a tendency now for water issues to reach a crisis which requires a quick fix, rather than pursuing a long term solution.

The Kaveri River Dispute has been a serious issue since 1974 when a 50 year old agreement between the Madras president and the princely Mysore state collapsed. Karnataka asserts that the 1924 agreement entailed a discontinuation of the water supply to Tamil Nadu after 50 years. The conflict between Tamil Nadu and Karnataka compounds a century old dispute over the vital interests of farmers in Tamil Nadu and Karnataka.

2.3.6 DAMS—Benefits and Problems

DAMS are structure those are made to restrict water for other beneficial purposes. River valley projects with big dams have usually been considered to play a key role in the development process due to their multiple uses.

Purpose and benefits of dams: Dams are made to fulfill the following purposes:

- For irrigation
- To generate electricity
- For flood control
- For industrial and domestic supply
- For fish farming
- Navigation

Problems with dams: Some of the problems associated with dams are as following:

1. The impacts of large dams of ecosystems are more negative than positive and in many cases, thighs has let to serious irrecoverable loss of species and ecosystem.
2. Large dams have serious consequences on the living conditions and culture and population, especially indigenous people. They have displaced large number of people who when resttled, have been unable to recover acceptable condition of existence.

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3. The loss of forest and wildlife habitat and the degradation of upstream catchments areas due to inundation of the reservoir area.
4. The loss of aquatic biodiversity of upstream and downstream fisheries and of the services of downstream flood plains, wetlands and revering, estuarine and advection marine ecosystem.
5. Cumulative impacts of water quality, natural flooding and species comparison where a number of dams are sited on the same river.
6. Sedimentation and the consequent long-term use of storage is a serious concern globally and the effects will be particularly felt by basins with high geological or human induced erosion rates, dams in the lower reaches of river and dams with smaller storage volumes.
7. Water logging salinity effect 1/5 of irrigated land globally and have severe long-term and often permanent impacts on land, agriculture and likehood where rehabilitation is not undertaken.

CASE STUDY

Sardar Sarovar Project

India's Sardar Sarovar Project (SSP) has gained international notoriety due to intense opposition by villagers. Led by the *Narmada Bachao Andolan* (Save the Narmada Movement), activists and villagers forced the World Bank to withdraw from the project in the early 90's. A case filed with the Indian Supreme Court stopped construction for nearly six years. However, on 18 October 2000, the Indian Supreme Court issued a controversial final ruling allowing construction to proceed.

About 200,000 people would be displaced for the reservoir; hundreds of thousands more will lose land or livelihood due to related developments. A disproportionate number of oustees are tribal people.

Thousands of people who have been resettled are struggling to survive on cramped plots with no arable land or source of livelihood. Faced with these future prospects, villagers have vowed to remain on their lands and face submergence behind the partly–built dam rather than face a life of certain destitution.

2.4 MINERAL RESOURCES

Minerals are naturally occurring inorganic, crystalline solid having a definite chemical composition and characteristic physical properties. There are thousands of minerals occurring in different parts of the world. However, most of the rocks, we see everyday are just composed of a few common minerals like quartz, feldspar, biotite, dolomite, calcite, laterite etc. These minerals, in turn, are composed of some elements like silicon, oxygen, iron, magnesium, calcium, aluminium etc. has been using minerals since the dawn of civilisation.

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2.4.1 Classification and Mineral Wealth of India

India has a thriving mining industry with mineral sector contributing about 3% of gross domestic product. The number of minerals mined in India is more than 80 and can be grouped into (i) fuel minerals like coal, petroleum, natural gas, lignite, (ii) metallic minerals like iron ore, chromium ore, bauxite etc., and (iii) non-metallic minerals like limestone, dolomite, phosphorite, clay etc.

Table 2.1

Non-metallic minerals	*State*
Asbestos	Rajasthan and Bihar
Ball clay	Andhra Pradesh and Rajasthan
Barites	Andhra Pradesh and Maharashtra
Calcite	Rajasthan and Gujarat
China clay	Rajasthan and West Bengal
Diamond	Madhya Pradesh
Dolomite	Madhya Pradesh and Orissa
Feldspar	Rajasthan and Tamil Nadu
Fire clay	Bihar and Gujarat
Fluorite	Gujarat and Rajasthan
Graphite	Orissa and Rajasthan
Gypsum	Rajasthan and Tamil Nadu
Kyanite	Bihar and Maharashtra
Limestone	Madhya Pradesh and Tamil Nadu
Magnetite	Tamil Nadu and Uttar Pradesh
Mica	Bihar and Andhra Pradesh
Pyrites	Bihar
Sulphur	Tamil Nadu
Quartz	Andhra Pradesh and Karnataka

Table 2.2

Metallic minerals	*State*
Bauxite	Bihar and Madhya Pradesh
Silver	Rajasthan and Bihar
Chromite	Orissa and Karnataka
Coal	Bihar and West Bengal
Copper	Bihar and Rajasthan
Diaspore	Uttar Pradesh and Madhya Pradesh
Gold	Karnataka and Andhra Pradesh
Iron	Goa and Madhya Pradesh
Lead	Rajasthan and Andhra Pradesh
Lignite	Tamil Nadu and Gujarat
Manganese	Orissa and Karnataka

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Table 2.3

Metallic minerals	*State*
Petroleum	Assam and Gujarat
Natural gas	Assam and Gujarat

2.4.2 Use and Exploitation

Minerals find use in a large number of ways in everyday use in domestic, agricultural, industrial and commercial sector and thus form a very important part of any nation's economy. The main uses of minerals are as follows:

- Development of industrial plants and machinery.
- Generation of energy, e.g. coal, lignite, uranium.
- Construction, housing, settlements.
- Defence equipments — weapons, armaments.
- Transportation means.
- Communication-telephone wires, cables, electronic devices.
- Medicinal system-particularly in Ayurvedic system.
- Formation of alloys for various purposes (e.g. phosphorite).
- Agriculture — as fertilizers, seed dressings and fungicides.
- Jewellery — gold, silver, platinum, diamond.

2.4.3 Conservation of Mineral Resources

As the mineral resources are limited in quantity and are being depleted very fast, the following steps are now being taken for the conservation of these resources:

- Minimising waste and developing technologies to recover the resources from waste.
- Developing technologies to recycle metals.
- Research is being carried out to substitute some metals like gold, silver, mercury and platinum etc. by man-made products.
- Development of alloys which will reduce the demand of some pure metal, e.g. alloys of magnesium are replacing steel and reducing the demand of copper, lead and tin.
- Alternatives to fossil fuels need to be found.
- Mining areas need to be reclaimed.
- A data bank on the availability and expenditure of mineral resources should be maintained so that their use is regulated.

2.4.4 Environmental Effect of Mineral Extraction and Use

The mining of mineral resources usually have a considerable effect on land, air, water and biological resources. Following are the some major environmental effect of mining operations:

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- Land degradation.
- Surface and groundwater water pollution due to the release of harmful trace elements such as cobalt, cadmium, lead by leaching.
- Adverse effect on the growth of vegetation.
- Defacing of landscape.
- Subsidence of land.
- Loss of fauna and flora, finally resulting in deforestation.
- Air pollution due to emission of harmful gases.
- Adverse effects on biological environment directly or indirectly by mining.
- Physical changes in the land, water, soil and air associated with mining.
- Rehabilitation problem of local inhabitant especially tribal people.
- Occupational health hazard.

2.4.5 Dereliction (Closing or Abandoning Mines)

Dereliction is a tendency to be negligent and uncaring. It results from the ruthless exploitation of natural resources without consideration for the future. In most of the cases, dereliction is the result of thoughtless and uncontrolled extraction of mineral resources. Dereliction arises because mining operators are not interested in the rehabilitation of local inhabitant especially tribal people because investment in rehabilitation programme will give them no financial return. Some of the adverse effects of dereliction are:

- Waste of valuable agricultural and industrial land.
- Health and accidental hazards.
- Old quarries may also be dangerous.
- Permanent damage to landscape.
- Wastes of human resources.
- Large number of litigation.

2.5. FOOD RESOURCES

Plant and animals are the main sources of human food. The main food resources include wheat, rice, maize, barely, oats, sweet potato, gram, pulse, millets, sugar-cane and large number of vegetables, fruits and dry fruits. A number of animal products such as milk, butter, ghee, egg and meat also supplement the food requirement of world. Rice, wheat and maize are the major staple diet of man. Due to climatic or topographic conditions, only 40% of the total area of the world can ever be used for cultivation of crop. Present day agricultural largely depend upon modern technological factors like the use of improved seeds, chemical fertilizer, pesticides and irrigation. Through modern technology have proved a boon to our agriculture and have increased the yield of crop manifold, they have created a number of problems.

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2.5.1 World Food Problems

During the last 50 years world grain production has increased almost three times, thereby increasing per capita production by about 50%. But, at the same time, population growth increased at such a rate in less developed countries that it outstripped food production. Every year 40 million people (50% of which are young children between 1 to 5 years) die of undernourishment and malnutrition.

Undernourishment is the lack of sufficient calories in available diet. According to FAO (Food and Agricultural Organization), the average minimum daily calorific requirement is 2500 calories per day. People taking less than its 90% daily requirement are said to be undernourished. In the condition of undernourishment, the living being does not have sufficient energy to lead an active and productive life. Consequently it has a little or no ability to work or move. Further, due to insufficient energy and nutrients, their body becomes susceptible to a number of infectious diseases.

One more severe condition of undernourishment is 'serious undernourishment' in which people take less than 80% of their daily calorific requirement. It leads to stunted growth, mental retardation and other types of disorders in the living beings.

Malnutrition is the lack or deficiency of specific constituents of food, such as proteins, vitamins or certain essential elements. It may also result from improper intake, as if person is taking full diet to satisfy his apetitite but not in proper proportion according to requirement. This condition is very common in richer countries. Otherwise, in poorer countries, it results due to economic reasons. The effects of malnourishment are long-term and result in number of diseases.

Indian scenario although India is the third largest producer of staple crops, an estimated 300 million Indians are still undernourished. India has only half as much land as USA, but it has nearly three times population to feed. Our food problem is directly related to population.

2.5.2 Impacts of Overgrazing and Agriculture

A. Impact of Overgrazing

- Land degradation.
- Increase in soil erosion as the plant cover is decreased.
- Decrease in the diversity of plant species.
- Decrease in the growth of vegetation.
- Dominance of plant species those are relatively undesirable to the livestock.
- Damage from the livestock trampling on the land.

B. Impact of Agriculture

- Deforestation.
- Soil erosion.
- Depletion of nutrients.
- Serious health disease, e.g. blue baby syndrome.

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- Eutrophication.
- Water logging and stalinization.
- Biological magnification of non-biodegradable pesticides.

2.5.3 Effects of Modern Agriculture

It makes use of hybrid seeds of selected and single crop variety, high-tech equipments and lots of energy subsidies in the form of fertilizers, pesticides and irrigation water. However, it also gave rise to several problematic off-shoots as discussed below:

- Impacts related to High Yielding Varieties (HYV).
- Fertilizer related problems.
- Micronutrient imbalance.
- Nitrate pollution.
- Eutrophication.
- Pesticides related problems.
- Creating resistance in pets and producing new pests (super pests—which have become immune to all types of pesticides).
- Death of non-target organisms.
- **Biological magnification:** Many of the pesticides are non-biodegradable and keep on accumulating in the food chain, a process called *biological magnification*.
- **Water logging:** Water logging occurs when the water table rises and eventually approaches the soil surface rendering the root zone unsuitable for crop growth. Excessive wetting and water logging are generally accompanied by oxygen deficiency because most pores are filled with water and the soil-air gets depleted.
- **Salinity problem:** This term is commonly used to refer to the soluble salt content of the soil. When soil salinity increases to harmful levels, plants are subject to reduce osmotic potential of the soil solution and to toxicity of specific ions such as chlorine and sodium.

2.6 ENERGY RESOURCES

Energy consumption of a nation is usually considered as an index of its development. Energy is vital for social and economic development. In fact, modern civilization is very much dependent on energy availability, and the whole infrastructure rests upon it. To meet the increasing energy demands, efforts are being made to improve existing technologies and to develop new approaches in conventional and non-conventional energy sources.

The first form of energy technology probably was the fire, which produced heat and the early man used it for cooking and heating purposes. Wind and hydropower have also been in use for the last 10,000 years. The invention of steam engines

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replaced the burning of wood by coal and coal was later replaced to a great extent by oil. This ultimately led to exploration and use of several alternate sources of energy.

2.6.1 Growing Energy Needs

Development in different sectors relies largely upon energy. Agriculture, industry, mining, transportation, lighting, cooling and heating in buildings, all needs energy. With the demands of growing population the world is facing further energy deficit. The fossil fuels like coal, oil and natural gas, which at present are supplying 95% of the commercial energy of the world, are not going to last for many more years. Our life style is changing very fast and from a simple way of life, we are shifting to a luxurious life style. If you just look at the number of electric gadgets, private cars and scooters in your locality you will realize that they have multiplied many folds and all of them consume energy.

Energy consumption is an index of advancement of a country. During the hunter gatherer stage of civilization, energy requirement per capita was only 2000-4000 kcal/day, which was obtained from food chain. Soon after 19th century, industrialisation increased rapidly which took the per capita energy utilisation to about 70,000 kcal, about 30% of the world's population, living in industrialised countries, consumes about 80% of global energy. In India, the per capita energy consumption is only 221 kg of oil equivalent/year, a very low rate compared with other developed countries.

Table 2.4

Countries	*Gross National Product (GNP)*	*Kg*
USA	19,840	7,655
Japan	21,020	3,306
Gemany	18,480	4,421
China	330	580
India	340	221

2.6.2 Renewable and Non-renewable Energy Sources

A source of energy is one that can provide adequate amount of energy in a usable form over a long period of time. These sources can be of two types:

A. Renewable energy sources which can be generated continuously in nature and are inexhaustible. They are also known as non-conventional sources of energy and can be used again and again in an endless manner.

1. Solar energy: Solar energy is the energy obtained from sun in the form of radiations. Sun is the source of an enormous amount of energy. It releases energy as a result of nuclear fusion reaction taking place in it. Solar energy may be trapped by two different types of processes: **thermal conversion**, involves direct heating, and **photo-conversion**, involves photosynthesis, photochemistry, photoelectron-chemistry and photovoltaics.

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2. Wind energy: Wind energy is one of the most potential sources of alternate energy, which is strangely influenced by geographical factors. Wind energy is harnessed by using wind mills. Wind mill is driven by the energy of sun. Making use of this energy, the blade of the wind mill keep on rotating due to the force of striking wind. Once the mill is turning due to force of wind, it can drive even a generator to get electricity. It is a non-polluting and sustainable source of energy but it is variable, unsteady, irregular, intermittent and erratic.

3. Hydropower energy: The water flowing in a river is collected by constructing a big dam where the water is stored and allowed to fall from a height. The blades of the turbine located at the bottom of the dam move with the fast moving water which in turn rotates the generator and produces electricity. Hydropower does not cause any pollution, it is renewable and normally the hydropower projects are multi-purpose projects helping in controlling floods, used for irrigation, navigation etc.

4. Ocean (tidal) energy: Oceans are the biggest water reservoirs and they constitute about 71% of the total earth's energy. Energy from ocean may be obtained in different ways: **Ocean Thermal Energy (OTE),** arising due to difference in temperature of water at the surface of tropical oceans and at deeper levels or **Tidal energy,** arising due to the tides (rise and fall of water) occurring in ocean.

5. Geothermal energy: Natural thermal energy produced during rock formation within the rocks and the fluids held during those formations is known as geothermal energy. It is produced by the fission of radioactive materials found in earth.

6. Biomass energy: Materials obtaining from the physiological activities is known as biomass. Biomass includes plant residues, wastes, herbarium plants, fresh water and marine algae and forest residue, etc. This biomass may be utilised for the generation of a number of energy system which are renewable source of energy.

7. Hydrogen: As hydrogen burns in air, it combines with oxygen to form water and a large amount of energy (150 kJ/gm) is released. Due to its high, rather the highest calorific value, hydrogen can serve as an excellent fuel. Production of hydrogen is possible by the thermal dissociation, photolysis or electrolysis of water:

(a) By thermal dissociation of water (at 3000 °C or above) hydrogen is produced.

(b) Hydrogen is produced by chemical reaction of water with some other chemicals in 2-3 cycles.

(c) Electrolytic method dissociates water into hydrogen and oxygen by making a current flow through it.

(d) Photolysis of water involves breakdown of water in the presence of sun light to release hydrogen.

(e) Hydrogen is highly inflammable and explosive in nature. Hence, safe handling is required for using hydrogen as fuel.

B. Non-Renewable energy sources which have accumulated in nature over a long span of time and can not be quickly replenished when exhausted.

1. Coal: Coal is the most abundant fossil fuel in the world. It is not only a source of energy but is also used as a raw material in industries. Formation of

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coal take place several hundred million year of time by the gradual conversion of buried matter of plants along the banks of the river. Depending upon the percentage of carbon present in it, coal may be of three types:

(a) Anthracite i.e., hard coal containing 90% carbon.
(b) Bituminous, i.e., soft coal containing 80% carbon.
(c) Lignite, i.e., brown coal containing 70% carbon.

As discussed above, coal is an important source of energy but on burning it produces a number of harmful gases responsible for polluting environment and also for global warming

2. Petroleum: Petroleum is perhaps the most widely used form of fuel for different purposes. It is a cleaner fuel as compared to coal as it burns completely leaving no residue. It is obtained by the fractional distillation, which is actually a complex mixture of hydrocarbons. One advantage of petroleum is that it can be transported very easily, which also adds to its increased use. One and most widely known use of petroleum is its use in domestic gas cylinders under the name Liquefied Petroleum Gas (LPG).

3. Natural gas: Natural gas is mainly composed of methane (95%) with small amount of propane and ethane. It is used in different ways:

(a) As domestic fuel.
(b) As industrial fuel.
(c) As fuel in thermal power plants for generation of electricity.
(d) As a source of hydrogen gas in fertiliser industry.
(e) As a source of carbon in tire industry.
(f) As industrial raw material in petro-chemical industry.

4. Nuclear energy: It is one of the main source of energy. A small quantity of radioactive material can produce an enormous amount of energy. It may be image by the fact that one ton of U^{235} provides as much energy as by 3 million tones of coal or 12 million barrels of oil. It is used as fuel for marine vessels, heat generation for chemical and food processing plants and for spacecrafts.

2.7 LAND RESOURCE

Land is a finite and valuable resource upon which we depend for our food, fiber and fuel wood, the basic amenities of life. Land is home to many unique plants and animals. They have developed here over millions of years in isolation. But we have already lost many species and could lose more without careful management.

The surface layer of the land is called 'soil'. Soil is the foundation for plant life on land. Soil is a non-renewable precious resource and need to be managed carefully so they remain productive now and in the future. It is continuously regenerated by natural process, through at a very slow rate. It takes thousands of years for rocks to weather into soils, and hundreds of

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years for rich organic matter to build up. Our welfare depends, to a large extent, on our soil and climate. Entire civilisations can rise and fall depending on their soil quality.

2.7.1 Land Degradation

Land degradation is the temporary or permanent lowering of the productive capacity of land (UNEP, 1992). It thus covers the various forms of soil degradation, adverse human impacts on water resources, deforestation and lowering of the productive capacity of rangelands.

This includes soil erosion by water and wind, deterioration in soil physical, chemical and biological properties, water logging and the build-up of toxicities, particularly salts, in the soil. Since soil productivity is intimately connected with water availability, lowering of the groundwater table is also noted. Land degradation has both on-site and off-site effects. On-site effects are the lowering of the productive capacity of the land, causing either reduced outputs (crop yields, livestock yields) or the need for increased inputs. Off-site effects of water erosion occur through changes in the water regime, including decline in river water quality and sedimentation of river beds and reservoirs. The main off-site effect of wind erosion is over blowing or sand deposition.

With increasing population growth the demands for arable land for producing food, fiber and fuel wood is also increasing. Hence, there is more and more pressure on the limited land resources which are getting degraded due to overexploitation. Soil degradation is the real cause of alarm because soil formation is an extremely slow process and the average annual erosion rate is 20-100 times more than the renewable rate.

The many and varied processes of land degradation have been grouped into different classes: water erosion, wind erosion, soil fertility decline, salinization, water logging, lowering of the water table, deforestation, forest degradation and rangeland degradation.

Water erosion covers all forms of soil erosion by water, including sheet and rill erosion and gullying. Human-induced intensification of landsliding, caused by vegetation clearance, road construction, etc., is also included.

Wind erosion refers to loss of soil by wind, occurring primarily in dry regions.

Soil fertility decline is used as a short-term to refer to what is more precisely described as deterioration in soil physical, chemical and biological properties. Whilst decline in fertility is indeed a major effect of erosion, the term is used here of cover effects of processes other than erosion. The main processes involved are:

- Lowering of soil organic master, with associated decline in soil biological activity;
- Degradation of soil's physical properties (structure, aeration, waterholding capacity), as brought about by reduced organic matter;

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- Adverse changes in soil nutrient resources, including reduction in availability of the major nutrients (nitrogen, phosphorus and potassium), onset of micronutrient deficiencies and development of nutrient imbalances.
- Buildup of toxicities, primarily acidification through incorrect fertiliser use.

Water logging is the lowering in land productivity through the rise in groundwater close to the soil surface. Also included under this heading is the severe form, termed ponding, where the water table rises above the surface. Water logging is linked with salinisation, both being brought about by incorrect irrigation management.

Salinisation is used in its broad sense, to refer to all types of soil degradation brought about by the increase of salts in the soil. It thus covers salinisation in its strict sense, the buildup of free salts; and codification (also called alkalisation) and the development of dominance of the exchange complex by sodium. As human-induced processes, these occur mainly through incorrect planning and management of irrigation schemes. Also covered is saline intrusion, the incursion of sea water into coastal soils arising from over-abstraction of groundwater.

Lowering of the water table is a self-explanatory form of land degradation, brought about through tubewell pumping of groundwater for irrigation exceeding the natural recharge capacity. This occurs in areas of non-saline ('sweet') groundwater. Pumping for urban and industrial use is a further cause.

Deforestation: The occurrence of deforestation is widespread and extremely serious in the region. It is not independently assessed here, in view of more detailed treatment in the current FAO Forest Resources Assessment 1990 project. Deforestation is also discussed as a cause of erosion.

Forest degradation: This is the reduction of biotic resources and lowering of productive capacity of forests through human activities. It is under review in a current survey (Banerjee and Grimes, in preparation).

Rangeland degradation: This is the lowering of the productive capacity of rangelands. It is considered in generalised terms, but no quantitative data have been identified.

2.7.2 Man Induced Landslide

Landslide refers to the downward sliding of huge quantities of landmass which occur along steep slopes of hills or mountains and may be sudden or slow. If a mass of earth moves along a definite plane or surface the failure is termed as landslide. There is large block known as a slump block moves during the landslide. The scar above a landslide is easily visible. They can occur along a slope where the internal resistance of the rocks are reduced or they loose their holding capacity.

There are several different types of landslides; some of these are mudslides, debris flows, rock falls, debris avalanches, debris slides, and earth flows. Landslides also can be grouped by the way in which they move. Landslide movement can be divided into four different types:

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- **Slides:** Slides are characterised by the downward movement of material along one or more failure surfaces.
- **Flows:** Flows are similar to slides but differ in the fact that they are characterised by high water content and move similar to fluids.
- **Lateral spreads:** Lateral spreads are usually associated with loose, sandy soils with high liquefaction potential. Lateral spreads can occur on even very gentle slopes.
- **Falls and topples:** Falls and topples are movements in which masses of rock or other material fall from cliffs or other steep slopes. Earthquakes commonly trigger this final type of movement.

Anthropogenic (human) factors also influence landslide potential. The major human induced factors are mining, forestry practices, construction of highways, buildings, and railroads.

Considerable landslide modification accompanies urbanisation, and was a contributing factor in many of the landslides. In fact, 80 per cent of the landslides involved one or more of the human caused.

Diversion of excess water onto the slope was one of the most common human influences, contributing to well over 40 per cent of the landslides. The water most often came from roofs and paved areas, but sewers, water lines, culverts, ponds, and ditches were also sources.

Hillside excavations, primarily road cuts, but also those due to landscaping and construction activities, were a factor in more than 40 per cent of the landslides. In one case the excavation resulted in the immediate failure of a large mass of adjacent material, but most of these slides involved only a thin layer of surficial material resting upon an old, artificially steepened slope.

Artificial fills placed over impermeable deposits are often unstable. Even relatively small fill failures may cause substantial damage if they remove foundation support or if they slide into a structure below. Over 30 per cent of the landslides involved some artificial fill.

Finally, a few landslides (10 per cent) were the result of retaining wall failures, due to inadequate design, construction, or maintenance.

Prevention Measures

Slope: Retaining wall may be constructed against the slopes, which can prevents rolling down of material. Terracing of the slope is an effective measure.

Effect of water: Make proper drainage network for quick removal of percolating moisture or rain water by constructing ditches and water ways along the slope.

Geological structures: Weak planes or zones may covered or grouted to prevent percolation of water, this increases the compaction of loose material.

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2.7.3 Soil Erosion

Gravity, wind and water can wear away the soil surface and move soil far from where it was formed. This process is called *erosion*. Soil erosion is defined as the movement of soil components, especially surface-litter and top soil from one place to another. Soil erosion results in the loss of fertility because it is the top soil layer which is fertile. Erosion is a natural process, but people can greatly accelerate the rate of erosion by removing vegetation and using inappropriate land management practices. Good land management reduces erosion. Soil erosion is basically of two types based upon the cause of erosion:

Normal erosion or geologic erosion: Caused by the gradual removal of top soil by natural processes which bring equilibrium between physical, biological and hydrological activities and maintain a natural balance between erosion and renewal.

Accelerated erosion: Caused by anthropogenic (man-made) activities and the rate of erosion is much faster than the rate of formation of soil. Sometimes, the vegetation is removed intentionally (for example during logging, cultivating or grazing). Sometimes introduced pests remove it for us (possums, goats, rabbits, deer and pigs). Overgrazing, deforestation and mining are some important activities causing accelerated erosion.

There are two types of agents which cause soil erosion:

Climatic agents: Water and wind are the climatic agents of soil erosion. Water effects soil erosion in the form of torrential rains, rapid flow of water along slopes, run-off, wave action and melting and movement of snow. Water induced soil erosion is *Sheet erosion, Rill erosion, Gully erosion, Slip erosion and Stream bank erosion* while wind erosion is responsible for *Saltation, Suspension and Surface creep* type soil movement.

Biotic agents: Excessive grazing, mining and deforestation are the major biotic agents responsible for soil erosion. Due to these processes the top soil is disturbed or rendered devoid of vegetation cover.

The rate of soil erosion depends on the

- Type of soil.
- Climate.
- Vegetative cover.
- Topography (slope and aspect).
- Land management practices.

Effects of soil erosion

- It decreases the water clarity (less light for plants to photosynthesize) in water bodies.
- Fine sediments can suffocate fish and other aquatic life.
- Increased nutrients encourage undesirable plants and animals.
- Less habitat for kai moana (seafood).

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- Flooding problems upstream.
- Infilling of harbours restricting recreation.
- Changes in habitats.

The risk of erosion increases if land

- Has little vegetation on it.
- Is steep.
- Is on the bank of a river or lake.
- Is disturbed.
- Has erosion prone geology (for example mudstone or pumice).
- Is under pressure from high stock density or machinery.
- Is in an area of high and intensive rainfall.

Prevention of soil erosion: In order to prevent soil erosion and conserve the soil the following conservation practices are employed:

(a) Conservational till farming.
(b) Contour farming.
(c) Terracing.
(d) Strip cropping.
(e) Alley cropping – it is a form of intercropping in which crops are planted between rows of trees or shrubs.
(f) Wind breaks or shelterbelts.

2.7.4 Desertification

Desertification is a process whereby the productivity potential of arid or semi-arid lands falls by ten per cent or more and turns productive into non-productive desert as a result of poor land-management. Desertification occurs mainly in semi-arid areas (average annual rainfall less than 600 mm) bordering on deserts. In the Sahel, (the semi-arid area south of the Sahara Desert), for example, the desert moved 100 km southwards between 1950 and 1975. About one-third of the world's land surface is arid or semi-arid. It is predicted that global warming will increase the area of desert climates by 17% in the next century. The area at risk to desertification is thus large and likely to increase.

Worldwide, desertification is making approximately 12 million hectares useless for cultivation every year. This is equal to 10% of the total area of South Africa or 87% of the area of cultivated lands in our country.

In the early 1980s it was estimated that, worldwide, 61% of the 3257 million hectares of all productive drylands (lands where stock are grazed and crops grown, without irrigation) were moderately to very severely desertified. The problem is clearly enormous. It may be classified as follows:

- Moderate desertification is 10-25% drop in productivity.
- Severe desertification causes 25-50% drop.

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- Very severe desertification results in more than 50% drop in productivity and usually creates huge gullies and sand dunes.

Causes of Desertification: Desertification is caused by the combined effect of accelerated erosion by wind and water, woodland destruction, soil water logging, salinization and overgrazing in dryland environment. Desertification is characterised by devegetation and less of vegetal over, depletion of groundwater, salinisation and severe soil erosion. Desertification is not the literal invasion of desert into non-desert area.

- Overgrazing is the major cause of desertification worldwide. Plants of semi-arid areas are adapted to being eaten by sparsely scattered, large, grazing mammals which move in response to the patchy rainfall common to these regions. Early human pastoralists living in semi-arid areas copied this natural system. They moved their small groups of domestic animals in response to food and water availability. Such regular stock movement prevented overgrazing of the fragile plant cover.

  In modern times, the use of fences has prevented domestic and wild animals from moving in response to food availability and overgrazing has often resulted. However, when used correctly, fencing is a valuable tool of good veld management.

  The use of boreholes and windmills also allows livestock to stay all-year round in areas formerly grazed only during the rains when seasonal pans held water. Where not correctly planned and managed, provision of drinking water has contributed to the massive advance of deserts in recent years as animals gather around waterholes and overgraze the area.
- Cultivation of marginal lands, i.e. lands on which there is a high risk of crop failure and a very low economic return, for example, some parts of South Africa where maize is grown.
- Destruction of vegetation in arid regions, often for fuelwood.
- Poor grazing management after accidental burning of semi-arid vegetation.
- Incorrect irrigation practices in arid areas can cause salinisation (the build up of salts in the soil), which can restrict plant growth.

When the practices described above coincide with drought, the rate of desertification increases dramatically. Increasing human population and poverty contribute to desertification as poor people may be forced to overuse their environment in the short-term, without the ability to plan for the long-term effects of their actions. Where livestock has a social importance beyond food, people might be reluctant to reduce their stock numbers.

Effects of desertification: Desertification reduces the ability of land to support life, affecting wild species, domestic animals, agricultural crops and people. The reduction in plant cover that accompanies desertification leads to accelerated soil erosion by wind and water. South Africa losing approximately 300-400 million tons of topsoil every year. As vegetation cover and soil layer are reduced, rain drop impact and run-off increases.

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Water is lost off the land instead of soaking into the soil to provide moisture for plants. Even long-lived plants that would normally survive droughts die. A reduction in plant cover also results in a reduction in the quantity of humus and plant nutrients in the soil, and plant production drops further. As protective plant cover disappears, floods become more frequent and more severe. Desertification is self-reinforcing, i.e. once the process has started, and conditions are set for continual deterioration.

CASE STUDY

Desertification in Southern Africa

About half of southern Africa is semi-arid and thus at risk of desertification. The area already transformed into desert-like conditions is not accurately known because uncertainty surrounds the precise definition of a desert, and what the original state of the vegetation was in the semi-arid areas of southern Africa.

The areas which are known to have deteriorated this century are mainly on the edges of the southern Kalahari. The deterioration of the Karoo is less well-established. It is possible that desertification of the Karoo began in the last century, when sheep were first introduced, and before good records were available for the area.

In recent years the introduction of artificial water points into the Kalahari within Botswana, together with the widespread erection of veterinary fences, has led to the rapid desertification of huge areas. Similar schemes have had the same effect in the southern Kalahari within South Africa and Bophuthatswana.

Great Plains, United States

Desertification became well known in the 1930's, when parts of the Great Plains in the United States turned into the "Dust Bowl" as a result of drought and poor practices in farming, although the term itself was not used until almost 1950. During the dust bowl period, millions of people were forced to abandon their farms and livelihoods. Greatly improved methods of agriculture and land and water management in the Great Plains have prevented that disaster from recurring, but desertification presently affects millions of people in almost every continent.

People's Republic of China

Desertification is widespread in many areas of the People's Republic of China. The populations of rural areas have increased since 1949 for political reasons as more people have settled there. While there has been an increase in livestock, the land available for grazing has decreased. Also the importing of European cattle such as Friesian and Simmental, which have higher food intakes, has made things worse.

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Rio Puerco Basin, New Mexico

Overgrazing has made the Rio Puerco Basin of central New Mexico one of the most eroded river basins of the western United States and has increased the high sediment content of the river.

Waterberg Massif, South Africa

Overgrazing is also an issue with some regions of South Africa such as the Waterberg Massif, although restoration of native habitat and game has been pursued vigourously since about 1980.

2.8 ROLE OF AN INDIVIDUAL IN CONSERVATION OF RESOURCES

Various natural resources play key role in the development of a nation. Natural resources belong to each one of us and all of us have a duty to contribute towards the conservation of these resources. There is a strong need to conserve these natural resources.

Water conservation: Don't keep water taps running.

Install water-saving toilets that use not more than 4 litres per flush.

Check for water leaks in pipes and toilets and repair them promptly.

Use drip irrigation and sprinkling irrigation to improve irrigation efficiency and reduce evaporation.

Install a small system to capture rain water and collect normally wasted used water from sinks, cloth-washed, bath-tub etc. which can be used for watering the plants.

Build rain water harvesting system in your house.

Energy conservation: Turn off light, fans and other appliances when not in use.

Use solar cooker for cooking your food on sunny days which will be more nutritious and will cut down on your LPG expenses.

Grow deciduous tree and climbers at proper places out side your houses to cut-off intense heat of summer and get a cool breeze and shade.

Use public transportations whenever possible.

Add more insulation to your house.

Recycle and reuse glass, metal and paper.

Soil conservation

While constructing your house, don't uproot the trees as far as possible.

Grow different types of ornamental plants, herbs and trees in your garden.

Make compost from your kitchen waste and use it for your kitchen garden.

Use sprinkling irrigation.

Use green manure and mulch in the garden which will protect the soil.

Do not over-irrigate your fields with out proper drainage to prevent water logging and stalinisation.

Use mixed cropping so that some specific soil nutrients do not get depleted.

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2.9 EQUITABLE USE OF RESOURCES FOR SUSTAINABLE LIFE STYLE

Sustainable life styles and ways of working are central to overcoming poverty and conserving and protecting the natural resource base for all forms of life. Sustainable methods of production are needed in agriculture, forestry, fishing and manufacturing. Use of resources need to be minimised, and pollution and waste reduced.

Indeed there is a need to reduce the impacts of life style consumption habits on society and resources to ensure equitable availability of resources for all around the world. Education and training for sustainable production and consumption play an important role in achieving this by creating a more critical and responsible attitude towards consumerism in our everyday lives.

Likewise, there is a need to reduce the social and resource impacts of life style consumption habits to ensure the equitable availability of resources for all around the world.

The most serious global environment and development problems facing the world arise from a world economic order characterised by ever expanding consumption and production, which exhausts and contaminates our natural resources and creates and perpetuates gross inequalities between and within nations. We can no longer tolerate a situation which has brought us beyond the limits of the earth's carrying capacity and where twenty per cent of the people consume eighty per cent of the world's resources. We must act to balance ecological sustainability with equity between and within countries. It will be necessary to develop new cultural and ethical values, transform economic structures and reorient our lifestyles.

Consumption and production patterns which are equitable and ecologically sustainable are consistent with six basic principles which apply to consumers and producers. We must follow the following:

1. We must reawaken to the reality that quality of life is based on the development of human relationships, creativity, cultural and artistic expression, spirituality, reverence for the natural world and celebration of life and is not dependent upon increased consumption of non-basic material goods.
2. The economic system should be restructured away from production and consumption of non-basic goods for a few to focus on production of goods to meet basic human needs (e.g., water, food, clothing, shelter, education, health care) for all persons.
3. Macroeconomic systems should be restructured to include ecological and social costs in the prices for all goods and services, including work in the unpaid and informal sector.
4. Local communities must have full participation in the control and decision-making power over the management of the use of natural resources on which their economy depends to assure that these resources are used and consumed in an equitable and environmentally sustainable way.

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5. Continuation of the current economic order carries with it the threat of serious or irreversible environmental damage and associated social disruption. Therefore, lack of full scientific certainty regarding potential impacts of conversion should not be used as a reason to avoid immediate action.
6. Because the industrialised countries consume the vast proportion of the world's natural resources and create the majority of the global pollution, they must bear the primary responsibility for restoring the natural environment and compensating the victims of environmental degradation.
7. The concept of environmental space, whereby all people have the right to equitable shares of water, food, air, land and other resources within the carrying capacity of the earth, should be the basis for equitable production and consumption.
8. While overall population growth is a danger to the health of the planet, it must be recognised that population growth in the north, due to extremely high levels of per capita consumption, is a far greater immediate environmental threat than population growth in the south. Meeting basic needs is a prerequisite for stabilising population growth.
9. Overall consumption and production must be eased back to fit within the regenerative carrying capacity of the earth. Given the ecological and development crisis, this transition must be completed within a few decades in order to avoid irreversible damage to life on earth.
10. The use of energy, especially fossil fuels, must be reduced significantly.
11. Renewable sources which are less environmentally damaging should be promoted.
12. Due to their destructive social and environmental impacts, production and use of military goods and weapons are not an acceptable part of an equitable and environmentally sustainable society.
13. Production and consumption of products with built-in obsolescence should be stopped; consumption of products which are transported over long distances should be reduced; and production processes which create toxic, hazardous, or radioactive wastes should be halted.
14. Reduction in consumption should have priority over reuse or recycling of products.
15. Goods should be produced in closed cycles, whereby substances are continually reused to the greatest extent.
16. Goods should be produced to have the least impact on the environment, with long durability, high efficiency and simple repairability.
17. After reduction, reuse of goods should have priority over recycling.
18. Industries and government must take full responsibility for proper treatment throughout the life cycle of the production process. If there are waste products, they should be treated where they are produced and not transported across national boundaries.

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19. Local decentralised recycling units should be a priority over large-scale centralized recycling units due to their greater employment creation and lower use of energy and transport.
20. Incineration of waste should not be considered as an alternative to recycling.

SUMMARY

Any material from nature or component of the natural environment that can be utilized by man to promote his welfare is considered a natural resource. A natural resource can be a substance, an energy unit or a natural process or phenomena. The major natural resources are Forest resource, Water resource, Mineral resource, Food resource, Land resource and Energy resource.

Depending upon the availability and abundance, natural resources are of two types: renewable and non-renewable. Renewable resources are those which are inexhaustive and can be regenerated within a given span of time while Non-renewable sources can not be regenerated, once we exhaust these reserves, the same cannot be replenished.

Forests are one of the most important natural resources on this earth. Covering the earth like a green blanket these forests not only produce innumerable material goods, but also provide several environmental services which are essential for life. There are three major types of forests, classed according to latitude: Tropical, Temperate and Boreal forest. The diverse functions of forests can be categorized as **production functions, protective functions and regulative functions.** Since time immemorial, humans have depended heavily on forests for food, medicine, shelter, wood and fuel. With growing civilization the demands for raw material the forest cover area is decreasing very rapidly.

Deforestation is the permanent destruction of indigenous (original) forests and woodlands. Deforestation is defined as the complete cleaning of tree formation and their replacement by using land for other purpose. Due to deforestation, there is change in natural phenomenon like rise in temperature, low rain fall, accelerated soil erosion, loss of habitat and species.

Water is indispensable natural resources, on which all life depends. Water is needed for daily use by organisms, for irrigation, navigation, industrial use, electricity production and domestic use. The water we use keeps on cycling endlessly through the environment, which we call as Hydrological cycle. Water moves from one reservoir to another by way of processes like evaporation, condensation, precipitation, deposition, runoff, infiltration, sublimation, transpiration, melting, and groundwater flow.

Due to its unique properties, water is of multiple uses for all living organisms. Water is used for drinking, irrigation and transportation, washing and waste disposal for industries and used as a coolant for thermal power plants. Water shapes the earth's surface and regulates our climate.

Overuse of groundwater for drinking, irrigation and domestic purposes has resulted in rapid depletion of ground water in various regions leading to drying of wells and lowering of water table which may damage wetlands, cause ground subsidence, and induce salt-water intrusion in coastal aquifers.

Apart from its benefits however, due to heavy rains or sudden snow melts, the quantity of water in streams exceeds from their capacity and water overflows the banks and causes inundation of surrounding land. This condition is called flood. To control flood, DAMS are made to restrict water for other beneficial purposes.

Minerals are naturally occurring inorganic, crystalline solid having a definite chemical composition and characteristic physical properties and can be grouped into (i) fuel minerals, (ii) metallic minerals and (iii) non-metallic minerals. The mining of mineral resources usually have a considerable effect on land, air, water and biological resources by degrading land, polluting surface and groundwater water and causes rehabilitation problem for local inhabitant.

Plant and animals are the main sources of human food. The main food resources include wheat, rice, maize, barely, oats, sweet potato, gram, pulse, millets, sugar cane, and large number of

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vegetables, fruits and dry fruits. During the last 50 years, world grain production has increased almost three times, thereby increasing per capita production by about 50% due to which there are food problems of undernourishment and malnutrition.

Energy consumption of a nation is usually considered as an index of its development and considered as a major resource. These sources can be of two types: **Renewable energy sources** which can be generated continuously in nature and are inexhaustible. They are also known as non-conventional sources of energy and can be used again and again in an endless manner and **Non-Renewable energy sources** which have accumulated in nature over a long span of time and can not be quickly replenished when exhausted.

Land is a finite and valuable resource upon which we depend for our food, fiber and fuel wood, the basic amenities of life. Land degradation is the temporary or permanent lowering of the productive capacity of land. The many and varied processes of land degradation have been grouped into different classes: water erosion, wind erosion, soil fertility decline, salinization, water logging, lowering of the water table, deforestation, forest degradation and rangeland degradation.

Gravity, wind and water can wear away the soil surface and move soil far from where it was formed. This process is called erosion. Soil erosion is defined as the movement of soil components, especially surface-litter and top soil from one place to another.

Desertification is a process whereby the productivity potential of arid or semi arid lands falls by ten percent or more and turns productive into non- productive desert as a result of poor land-management. Desertification occurs mainly in semi-arid areas (average annual rainfall less than 600 mm) bordering on deserts.

DESCRIPTIVE TYPE QUESTIONS

1. Discuss briefly the impact of over utilization of water on ground and surface water. **[5 Marks](UPTU 2005)**
2. Define natural resources. How will you classify natural resources? Explain major reasons of the resource depletion.
3. How individual efforts are helpful for resource conservation? What are the major causes of deforestation? Briefly explain the effects of deforestation on environment.
4. What do you mean by deforestation? Explain its causes and ill-effects. **[5 Marks](UPTU 2005)**
5. What are the alternative energy resources? Differentiate between renewable and non-renewable natural resource. **[5 Marks](UPTU 2005)**
6. Name and discuss the major world food problems. **[5 Marks](UPTU 2005)**
7. Discuss the energy scenario in Indian Context. **[5 Marks](UPTU 2005)**
8. Discuss the environmental effects of extracting and using mineral resources. **[5 Marks](UPTU 2005)**
9. Define scope and importance of environmental studies.
10. Explain the need for public awareness and role of an individual in conservation of natural resources.
11. What are the different types of materials? Describe the effects of mineral extraction on environment. **[5 Marks](UPTU 2006)**
12. Name and explain in brief, the various ways in which, energy from oceans can be obtained. **[5 Marks](UPTU 2006)**
13. What is Geothermal Energy? Discuss its merits and limitations. **[5 Marks](UPTU 2006)**
14. Explain causes of soil erosion and enumerate the methods of prevention of soil erosion. **[5 Marks](UPTU 2006)**

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15. Explain the equitable use of resources for sustainable life style. [5 Marks](UPTU 200
16. Identify and explain the core causes of water crisis in the world. (UPTU 200
17. Discuss the productive, consumptive and protective functions of forest. What are the maj causes of deforestation and it's after effects?
18. Give a brief account of non-conventional resources of energy?
19. Discuss the various uses of forests.
20. Give your views on 'Dams a boon or bane to human civilization'.
21. 'Water could be the source of the world's next big conflicts'. Explain.
22. Discuss the benefits and problems of dams.
23. Write an explanatory note on mineral resource of India.
24. Discuss the changes caused by agriculture and overgrazing
25. Name the various unconventional renewable energy resources and briefly discuss each o them.
26. Discuss the causes of desertification.
27. What do you understand by soil erosion? What are the different factors those are responsible for increasing the rate of erosion.
28. Describe the various kinds of energy resources. Distinguish between renewable and non-renewable energy resources.
29. Describe various alternative energy sources and their use.
30. Land is a natural resource. Justify.
31. Enumerate the various causes of land degradation. Discuss the causes and effects of (a) soil erosion (b) desertification and (c) man induced landslide.
32. How can an individual play a role in conserving the natural resources?
33. Discuss equitable use of resources for sustainable lifestyle.

SHORT QUESTIONS WITH ANSWERS

Q. 1. What is meant by resources?

Ans. The resource means a source of supply or support that is generally held in reserves. A resource can be a substance, an energy unit or a natural process or phenomenon, that can be utilized by man to promote his welfare, e.g., water, air, soil, mineral, cop and wildlife.

Q. 2. How can mineral resources be conserved?

Ans. mineral sources can be conserved by

- Minimizing waste and developing technologies to recover the resource from waste.
- Developing the allows which will reduce the demand of pure metal.
- Finding the alternatives to fossil fuel
- Reclamaining the mining areas.

Q. 3. What are the various sources of food?

Ans. The main food resource includes wheat, rice, maize, pulse, vegetables, fruits and dry fruits. A huge number of animal products like milk, butter, ghee and meat are supplementing the food requirement of world.

Q. 4. Write a short note on 'Mineral Resources of India'. [5 Marks](UPTU 2006)

Ans. Minerals are naturally occurring inorganic, crystalline solid having a definite chemical composition and characteristic physical properties. There are thousands of minerals occurring in different parts of the world. India has a thriving mining industry with mineral sector contributing about 3% of gross domestic product. The number of minerals mined in India

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is more than 80 and can be grouped into (i) fuel minerals like coal, petroleum (ii) metallic minerals like iron ore, bauxite and (iii) non-metallic minerals like lime stone, clay etc.

Q. 5. List the environmental problems associated with: **[5 Marks](UPTU 2006)**
(i) Chemical fertilizers and (ii) Pesticides

Ans. Effects of

(a) **Pesticides** have been found to pollute virtually every lake, river and stream. Pesticide runoff has been found to be highly lethal to amphibians The use of pesticides also decreases biodiversity in the soil and decreses the water retention capacity her soil qualitywith the additional effect that more life in the soil allows for higher. There are also health effects of pesticide such as abdominal pain, dizziness, headaches, nausea, vomiting, as well as skin and eye problems and long-term health problems such as respiratory problems, memory disorders, dermatologic conditions, cancer, depression, neurologic deficits, miscarriages, and birth defects.

(b) Over-application of chemical **fertilizers**, or application of chemical fertilizers at a time when the ground is waterlogged or the crop is not able to use the chemicals, can lead to surface runoff (particularly phosphorus) or leaching into groundwater (particularly nitrates). One of the adverse effects of excess fertilizer in lacustrine systems are algal blooms, which can lead to excessive mortality rates for fish and other aquatic organisms. When prolonged algae blooms occur over many years, the effect is a process called eutrophication Excessive nitrogen fertilizer applications can lead to pest problems by increasing the birth rate, longevity and overall fitness of certain pests and excessive use of organic fertilizers also provide increased physical and biological storage mechanisms to soils.Storage and application of some fertilizers in some weather or soil conditions can cause emissions of the greenhouse gas. Besides supplying nitrogen, ammonia can also increase soil acidity.

Q. 6. Write the short notes on the following: **[5 Marks](UPTU 2006)**
(i) Environment Movement in India.
(ii) Environment related acts.

Ans. Short notes

(i) India's environmental movement began indisputably in the early seventies. However, a critical understanding of the text 'Nectar in a Sieve' published in 1954 by Kamala Markandaya implies that it had its ideological moorings from the first decade of India's independence. If one may borrow the expression of Madhav Gadgil and Ramachandra Guha, Kamala Markandaya's lament over destruction of landscape, her voice for preservation of nature may earn her the epithet 'Invisible environmentalist'. Markandaya is strongly convinced that growth of industry is not a signpost of everlasting happiness for majority of people eking out their livelihoods in the villages.

(ii) The different statutes / legislations enacted in India exclusively for environment protection are

- The Water (Prevention and Control of Pollution) Act, 1974
- The Air (Prevention and Control of Pollution) Act, 1981
- The Environment Protection Act, 1986
- The Forest Conservation Act, 1980
- The Wildlife Protection Act, 1972

There are three key policies relating to environmental protection in India. They are:

- The National Forest Policy, 1988
- Policy statement for Abatement of Pollution, 1992
- National Conservation Strategy and Policy Statement on Environment and Development, 1992

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Q. 7. Differentiate between renewable and non-renewable natural resources

Ans. Renewable natural resources which are in-exhaustive and can be regenerated within a given span of time e.g. forests, wildlife, solar energy whereas Non-renewable natural sources not be regenerated once exhaust, the same can not be replenished e.g. fossil fuel like coal, petroleum; etc.

Q. 8. Write short notes on the following problems of modern agriculture:

(a) Fertilizers (b) Pesticides (c) Water logging (d) Salination

Ans. Short notes

(i) Over-application of chemical **fertilizers**, or application of chemical fertilizers at a time when the ground is waterlogged or the crop is not able to use the chemicals, can lead to surface runoff (particularly phosphorus) or leaching into groundwater (particularly nitrates). One of the adverse effects of excess fertilizer in lacustrine systems is algal blooms, which can lead to excessive mortality rates for fish and other aquatic organisms. When prolonged algae blooms occur over many years, the effect is a process called eutrophication Excessive nitrogen fertilizer applications can lead to pest problems by increasing the birth rate, longevity and overall fitness of certain pests and excessive use of organic fertilizers also provide increased physical and biological storage mechanisms to soils. Storage and application of some fertilizers in some weather of soil conditions can cause emissions of the greenhouse gas. Besides supplying nitrogen, ammonia can also increase soil acidity.

(ii) **Pesticides** have been found to pollute virtually every lake, river and stream. Pesticide runoff has been found to be highly lethal to amphibians. The use of pesticides also decreases biodiversity in the soil and decreases the water retention capacity her soil quality with the additional effect that more life in the soil allows for higher. There are also health effects of pesticide such as abdominal pain, dizziness, headaches, nausea, vomiting, as well as skin and eye problems and long-term health problems such as respiratory problems, memory disorders, dermatologic condition, cancer, depression, neurologic deficits, miscarriages, and birth defects.

(iii) Water logging – the raised water table results in the soil becoming water logged. It occurs on areas that are poorly drained topography and having impermeable clay layer below the soil. When soil are waterlogged, airspace in the soil are filled with water and plant root lacks oxygen and it results damage soil structure.

(iv) Salinization – this term is commonly used to refer to the soluble salt content of the soil. When soil salinity increases to harmful level, plants are subject to reduce osmotic potential of the soil solution and so toxicity of specific ions such as chlorine and sodium.

Q. 9. Write detailed notes on:

(a) Floods (b) Droughts

Ans. Short notes

(i) **Floods** are the most common and wide spread of all natural disasters except fire. When due to heavy rains or sudden snow melts, the quantity of water in streams exceeds their capacity and water overflows the banks and causes inundation of surrounding land. This condition is called flood. Deforestation, overgrazing, mining, rapid industrialization, global warming etc. have also contributed largely to a sharp rise in the incidence of floods, which otherwise is a natural disaster.

(ii) The term 'drought' is generally applied when the country receives less of long term average rainfall. Drought is a meteological phenomenon but due to several anthropogenic causes like over grazing, deforestation, mining etc. there is spreading of the deserts tending to convert more areas to drought affected areas. Erroneous and intensive cropping and increased exploitation of water through well or canal irrigation to get high productivity has converted drought-prone areas into desert.

Q. 10. What are the impacts of overgrazing on agriculture?

Ans. Overgrazing causes land degradation, soil erosion, decreases the diversity of plant species

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and growth of vegetation and causes the dominance of plant species those are relatively undesirable to the livestock.

Q. 11. Distinguish between the following:
(a) Afforestation and agroforestry
(b) Deforestation and desertification

Ans. Differentiate the following

(a) **Afforestation** is the program that is carried out to increase the forest cover area by plant more trees in the forest while in **Agroforestry** different agricultural crops are planted to increase the productivity/yield and to improve the soil quality.

(b) **Deforestation** is the permanent destruction of indigenous (original) forests and woodlands and defined as the complete cleaning of tree formation and their replacement by using land for other purpose whereas **Desertification** is a process whereby the productivity potential of arid or semi arid lands falls by ten percent or more and turns productive into non- productive desert as a result of poor land-management.

Q. 12. What do you understand by man induced land slide?

Ans. Landslide refers to the downward sliding of huge quantities of land mass which occur along steep slopes of hills or mountains and may be sudden or slow. If a mass of earth moves along a definite plane or surface the failure is termed as Landslide. The major causes of human-induced landslide are mining, forestry practices, and construction of highways, buildings, and railroads.

Q. 13. Write short notes on:
(a) Wind energy (b) Bio-energy
(c) Hydro-energy

Ans. Short notes

- **Wind energy** is one of the most potential sources of alternate energy, which is strongely influenced by geographical factors. Wind energy is harnessed by using wind mills. Wind mill is driven by the energy of sun. Making use of this energy, the blade of the wind mill keep on rotating due to the force of striking wind. Once the mill is turning due to force of wind, it cans even a generator to get electricity. It is a non-polluting and sustainable source of energy but it is variable, unsteady, irregular, intermittent and erratic.
- **Hydropower energy** – the water flowing in a river is collected by constructing a big dam where the water is stored and allowed to fall from a height. The blades of the turbine located at the bottom of the dam move with the fast moving water which in turn rotates the generator and produces electricity. Hydropower does not cause any pollution, it is renewable and normally the hydro power projects are multi-purpose projects helping in controlling floods, used for irrigation, navigation etc.
- **Biomass energy** – materials obtaining from the physiological activities is known as biomass. Biomass includes plant residues, wastes, herbarium plants, fresh water and marine algae and forest residue, etc. this biomass may be utilized for the generation of a number of energy system which are renewable source of energy.

Q. 14. What is desertification?

Ans. **Desertification** is a process whereby the productivity potential of arid or semi arid lands falls by ten percent or more and turns productive into non-productive desert as a result of poor land-management.

Q. 15. What are the different methods of conserving water resources?

Ans. Conserving water can help preserve our natural resources. Conserving water means more water is available to serve additional water needs, as well as for wildlife and recreation. Water conservation practices can result in lower wastewater discharges which can mean an improvement in overall water quality. Decreasing run-off losses- can be reduced by allowing most of the water to infiltrate into the soil. This can be achieved by using contour cultivation, terrace farming, water spreading, chemical treatment or improver water storage. Water can be conserved by reducing evaporation losses, storing water in soil, reducing irrigation losses and reuse of water.

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Q. 16. Explain the significance of biogas energy

Ans. **Biogas energy–** Materials obtaining from the physiological activities is known as biomass. Biomass includes plant residues, wastes, herbarium plants, fresh water and marine algae and forest residue, etc. this biomass may be utilized for the generation of a number of energy system which are renewable source of energy.

Q. 17. Write short notes on:

(i) Causes and effects of deforestation

(ii) Effects of mining on environment

(iii) Darns-benefits and problems

(iv) Advantages and limitations of non-conventional sources of energy.

Ans. Short notes

(i) **Deforestation** is the permanent destruction of indigenous (original) forests and wood-lands and defined as the complete cleaning of tree formation and their replacement by using land for other purpose.

(ii) The extraction of metals is a violent process which inevitably has a great impact on the environment. It involves the following:

- Construction of infrastructure - roads, mining installations, housing for miners, power plants and dams.
- stripping of large areas of topsoil and of all flora and fauna in addition to manmade constructions;
- Digging up chemically-reactive minerals which are harmless when underground, but when extracted react spontaneously with oxygen and water. The extraction of sulphide ores inevitably produces sulphric acids and metal ions. This emission known as 'acid mine drainage', occurs in active mines and in places where waist is stored, and remains a risk even after the mine has closed, sometimes even centuries after the closure of a mine;.
- Adding potentially toxic chemicals, such as cyanide, to the ore to extract the metal, which increases the toxicity level of the waste;
- Using large amounts of energy and water, which are often scarce; mining is responsible for about 10 percent of the world's energy consumption;
- Conflicts over resources. Mining usually involves the destruction of resources which people rely on such as agricultural land, drinking or fishing waters, hunting grounds, religious or recreational areas as well as even their homes themselves.

(iii) Dams are made to fulfill the following purposes and benefits:

- For irrigation
- To generate electricity
- For flood control
- For industrial and domestic supply
- For fish farming
- Navigation

Dams have serious consequences on the living conditions and culture and population especially indigenous people, losses forest and wildlife habitat and degrade upstream catchments areas, losses of aquatic biodiversity, effects water quality, natural flooding, sedimentation and water logging problems.

Non-conventional energy sources are present in huge amount and resources are free of cost but their recovery is seasonal and installation cost is high.

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MULTIPLE CHOICE QUESTIONS

1. Common energy source in Indian villages is
   (a) Electricity (b) Coal
   (c) Sun (d) Wood and anima dung
2. Fossil fuel and metallic minerals are
   (a) Renewable resource (b) Inexhaustible resources
   (c) Non-renewable resources (d) None of these
3. Which of the following statements about the forest is not correct?
   (a) Forest reduces soil erosion (b) Provides recreational opportunities
   (c) Provides economic development (d) None of the above
4. In our country the percentage of land under forest is about
   (a) 20% (b) 19%
   (c) 25% (d) 30%
5. Forest and wild life are
   (a) Renewable resource (b) Non-renewable resources
   (c) Inexhaustible resources (d) None of these
6. Which of the following is not true about deforestation
   (a) Population explosion is one of the reasons for deforestation.
   (b) Cleaning of forest for agriculture causes deforestation.
   (c) Deforestation is taking place only in developing courtiers
   (d) Cash crop economy of third world is a cause of deforestation
7. Both power and manure is provided by
   (a) Nuclear plants (b) Thermal plants
   (c) Biogas plants (d) Hydroelectric plant
8. "The value of forest is often higher when it is left standing than it could be worth when it is harvested." Which of the following factors is most supportive of the above statement?
   (a) Increase in timber value (b) Increase in wildlife
   (c) Increase in ecotourism (d) Increase in forest produce
9. Which of the following is a non-renewable resource?
   (a) Coal (b) Forests
   (c) Water (d) Wildlife
10. How do dams affect deforestation?
    (a) Open up previously inaccessible forest to public
    (b) Submerges forest
    (c) Damages downstream ecosystem
    (d) all of the above
11. Deforestation generally decreases
    (a) Rainfall (b) Soil erosion
    (c) Draught (d) Global warming
12. Which of the following is not a viable protection against deforestation?
    (a) Reduce the consumption of forest and related products
    (b) Boycott products of companies involve in deforestation
    (c) Privatization of forest land
    (d) Environmental education
13. Extensive planting of trees to increase cover is called
    (a) Afforestation (b) Agroforestation
    (c) deforestation (d) Social forestry

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14. Soil conservation is a process in which
    (a) Soil is aerated
    (b) Soil erosion is allowed
    (c) Sterile soil is made fertile
    (d) Soil is protected against loss
15. Soil erosion can be prevented by
    (a) Over grazing
    (b) Removal of vegetation
    (c) Afforestation
    (d) Deforestation
16. Chipko movement was started to conserve
    (a) Forests
    (b) Grasslands
    (c) Deserts
    (d) Soil
17. Major purpose of the most of the dams around the world is
    (a) Power generation
    (b) Irrigation
    (c) Drinking water supply
    (d) Flood control
18. Which of the following could be the most important socio-economic impact of dams?
    (a) Loss of biodiversity
    (b) Poorly managed involuntary displacement and loss of livelihood
    (c) loss of forests and wildlife habitat
    (d) Water-logging
19. Couvery water dispute is in between
    (a) India and Pakistan
    (b) Punjab and Haryana
    (c) Utter Pradesh and Madhya Pradesh
    (d) Karnataka and Tamil Nadu
20. Which of the following is not an ideal solution for tracking the water crisis?
    (a) Drilling large number of deep bore wells
    (b) Population growth control
    (c) Water conservation in irrigation
    (d) water pollution control
21. Khetri (Rajasthan) is famous for
    (a) Coal mines
    (b) Copper mines
    (c) Granite stone
    (d) Marble stone
22. Which of the following is not a necessary condition for ensuring food security
    (a) Availability of food
    (b) Access of food
    (c) Self sufficiency in the production of food within a country
    (d) Must fulfill nutritional requirement
23. Which of the following is an adverse effect of modern agriculture
    (a) Water logging
    (b) Water pollution
    (c) Water scarcity
    (d) all of the above
24. Out of the following nutrients in fertilizer, which one causes minimum water pollution
    (a) Nitrogen
    (b) Phosphorus
    (c) Potassium
    (d) Organic matter
25. Identify the non-renewable energy resource from the following
    (a) Coal
    (b) Fuel cells
    (c) Wind power
    (d) Wave power
26. Which of the following is a disadvantage of most of the renewable energy sources
    (a) Highly polluting
    (b) High waste disposal cost
    (c) Unreliable supply
    (d) High running cost
27. Which of the following forms of land degradation is more prevalent in India?
    (a) Desertification
    (b) Soil erosion
    (c) Land slide
    (d) Soil subsidence

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Match the Following Terms

Match the terms of Column I with the appropriate terms of Column II

Column I	Column II
(i) Solar energy	(a) Methane and carbon dioxide
(ii) Mineral	(b) Agro-forestry
(iii) Taungya system	(c) Mining
(iv) Derilect land	(d) Inexhaustible
(v) Biogas	(e) Exhaustible

Fill in the Blanks

1. Most biotic resources are .....
2. The practices of felling and burning of forests followed by cultivation of crop for few years is called .....
3. The first movement against tree felling fought by a Bisnoi woman of Khajarili village named .....
4. Chipko movement in Tihri Garhwal region was initiated by .....
5. In Karnataka, Chipko movement is known as .....

ANSWERS

Multiple Choice Questions

1. (d)	**2.** (c)	**3.** (d)	**4.** (b)	**5.** (a)	**6.** (c)	**7.** (c)
8. (c)	**9.** (a)	**10.** (d)	**11.** (a)	**12.** (c)	**13.** (a)	**14.** (d)
15. (c)	**16.** (a)	**17.** (b)	**18.** (b)	**19.** (d)	**20.** (a)	**21.** (b)
22. (c)	**23.** (d)	**24.** (c)	**25.** (a)	**26.** (c)	**27.** (b)	

Match the Following Terms

(i) d (ii) e (iii) b (iv) c (v) a

Fill in the Blank

1. Renewable
2. Shift cultivation
3. Amrita Devi
4. Sunder Lal Bahugana
5. Appiko movement.

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3 Chapter

Ecosystem

Inside This Chapter

3.1 Concept of Ecosystem
3.2 Ecosystem Characteristics
3.3 Energy Flow in Ecosystem
3.4 Primary and Secondary Production
3.5 Ecosystem Regulation
3.6 Nutrient Cycling
3.7 Ecological Succession
3.8 Food Chain
3.9 Food Web
3.10 Ecological Pyramids
3.11 Types of Ecosystem

3.1 CONCEPT OF ECOSYSTEM

The term ecology was coined by Eaenst Haeckel in 1869. It is derived from the Greek words *Oikos*- home + *logos*- study. So ecology deals with the study of organism in their natural home interacting with their surroundings. An ecosystem includes a group of biotic communities of species interacting with one another in an area, plus their surroundings, plus all the ways in which they interact with each other and exchanging energy and matter. Now ecology is often defined as 'the study of ecosystem.'

An ecosystem was defined as a dynamic entity composed of a biological community and its associated abiotic environment. Often the dynamic interactions that occur within an ecosystem are numerous and complex. Ecosystems are also always undergoing alterations to their biotic and abiotic components.

3.2 ECOSYSTEM CHARACTERISTICS

Ecosystems show large variations in their size, structure, composition etc. however, all the ecosystems are characterised by certain basic structural and functional features which are common.

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3.2.1 Structural Features

Ecosystems are composed of a variety of abiotic and biotic components that function in an interrelated fashion. Some of the more important components are:

Abiotic structure: The physical and chemical components of an ecosystem constitute its abiotic structure. It includes climatic factors, soil factors, geographical factors, energy, nutrients and toxic substances.

Physical factors and climatic regime: The sunlight and shade, intensity of solar flux, duration of sun hours, average temperature, annual rainfall, wind, latitude and altitude, soil type, water availability etc. are some of the important physical features which have a strong influence on the ecosystem.

Soils are much more complex than simple sediments. They contain a mixture of weathered rock fragments, highly altered soil mineral particles, organic matter, and living organisms. Soils provide nutrients, water, a home and a structural growing medium for organisms. The vegetation found growing on top of a soil is closely linked to this component of an ecosystem through nutrient cycling.

The ***atmosphere*** provides organisms found within ecosystems with carbon dioxide for photosynthesis and oxygen for respiration. The processes of evaporation, transpiration and precipitation cycle water between the atmosphere and the earth's surface.

Solar radiation is used in ecosystems to heat the atmosphere and to evaporate and transpire water into the atmosphere. Sunlight is also necessary for photosynthesis. Photosynthesis provides the energy for plant growth and metabolism and the organic food for other forms of life.

Most living tissue is composed of a very high percentage of *water*, up to and even exceeding 90%. The protoplasm of a very few cells can survive if their water content drops below 10% and most are killed if it is less than 30-50%. Water is the medium by which mineral nutrients enter and are translocated in plants. It is also necessary for the maintenance of leaf turgidity and is required for photosynthetic chemical reactions. Plants and animals receive their water from the earth's surface and soil. The original source of this water is precipitation from the atmosphere.

Chemical factors: Inorganic substances or the major essential nutrients like carbon, nitrogen, phosphorus, potassium, hydrogen, oxygen and sulphur which involve in the cycling of materials in the ecosystem and organic substances like protein, carbohydrates, lipids, humic substances etc., which largely form the living body and link the abiotic and biotic components. These chemical factors includes toxic substances, salt causing salinity and various organic substances present in the soil or water largely influence the functioning of the ecosystem.

Biotic structure: Ecosystems are composed of a variety of *living organisms*. The plants, animal and microorganisms present in an ecosystem form the biotic components. These organisms have different nutritional behaviour and status in the ecosystems and are accordingly known as producers, consumers, based on how they get their food:

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Producers or autotrophs are organisms that can manufacture the organic compounds. Producers or energy transducers convert solar energy into chemical energy with the help of inorganic substances such as water and CO_2 and organic substances such as enzymes. These producers are *autotrophic* (auto-self, tropic-nourishing) organisms, largely green plants (trees, grasses, tiny phytoplankton etc.). Most producers are green plants that can manufacture their food through the process of photosynthesis. They possess a green pigment called chlorophyll, which transducts solar energy. These autotrophs are called *photoautotrophs* because they utilise light energy. There are other type of autotrophs, called *chemoautotrophs*, which use energy generated in an oxidation-reduction process, but their importance in the ecosystem as producers is minimal.

Consumers or *heterotrophic* organism get their energy and nutrients by feeding directly or indirectly on producers. All the organisms that can not make their own food (and need producers) are called heterotrophs (hetro-other, tropic-nourishing). In an ecosystem heterotrophs are called consumers because they depend on others. They obtain food by eating other organisms. There are different levels of consumers. Those that feed directly from producers, i.e. organisms that eat plant or plant products are called primary consumers.

Organisms that feed on primary consumers are called secondary consumers. Those who feed on secondary consumers are tertiary consumers. Some organisms, like the squirrel are at different levels. When the squirrel eats acorns or fruits (which are plant product), it is a primary consumer; however, when it eats insects or nestling birds, is it is a tertiary consumer. Consumers are also classified depending on what they eat.

1. **Herbivores** are those that eat only plants or plant products. Examples are grasshoppers, mice, rabbits, deer, beavers, moose, cows, sheep, goats and groundhogs.
2. **Carnivores,** on the other hand, are those that eat only other animals. Examples of carnivores are foxes, frogs, snakes, hawks, and spiders.
3. **Omnivores** are the last type and eat both plants (acting a primary consumers) and meat (acting as secondary or tertiary consumers). Examples of omnivores are:
   - *Bears:* They eat insects, fish, moose, elk, deer, sheep as well as honey, grass, and sedges.
   - *Turtles:* They eat snails, crayfish, crickets, earthworms, but also lettuce, small plants, and algae.
   - *Squirrels:* They eat insects, moths, bird eggs and nestling birds and also seeds, fruits, acorns, and nuts.
   - Human

Plants and animals supply organic matter to the soil system through shed tissues and death. Consumer organisms that feed on this organic matter, or detritus, are known as **Detritivores** or **Decomposers**. Decomposers are also heterotrophic organisms but depend upon dead organic matter for their food and that organic matter is eventually converted back into inorganic nutrients in the soil. They are

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chiefly microorganisms like bacteria, actinomycetes and fungi. Some invertebrate animals like protozoa, oligochaetes such as earthworms use the dead organic matter for their food. When producers, consumers and decomposers die, the decomposers recycle the nutrients tied up in dead bodies. Usually these nutrients end up back in the soil, and they are once again available to plants.

The following graphical model describes the major ecosystem components and their interrelationships

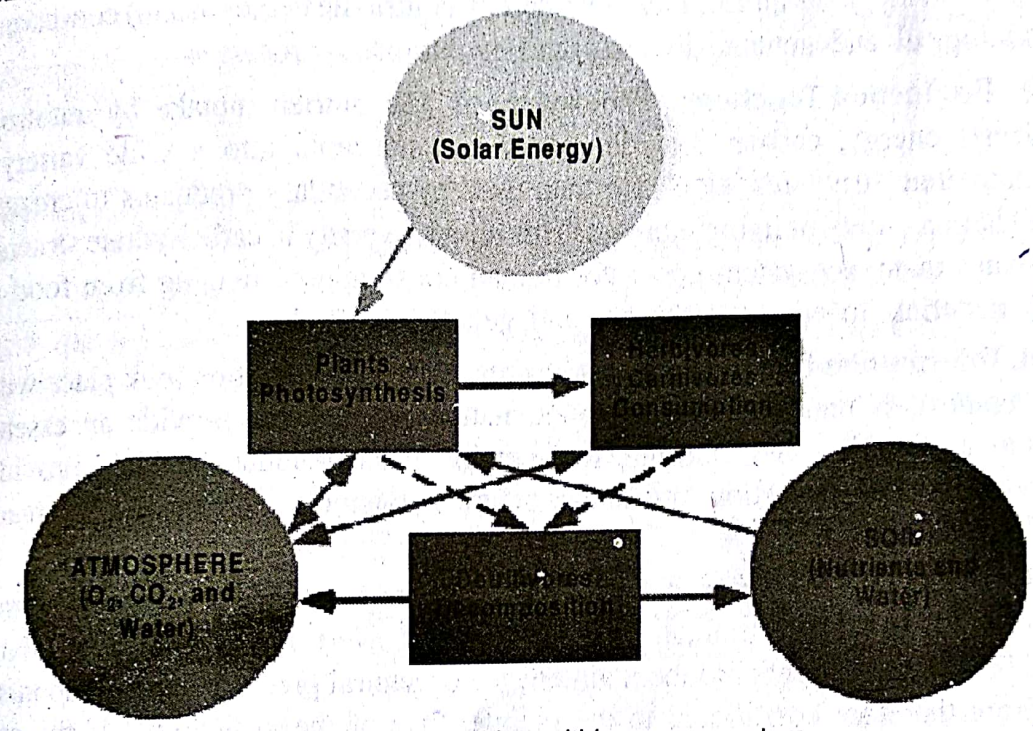

Fig. 3.1 Relationships within an ecosystem

Table 3.1

Abiotic Components	*Biotic Components*
Sunlight Temperature Precipitation Water or moisture Soil or water chemistry (e.g., P, NH_4^+)	Primary producers Herbivores Carnivores Omnivores Detritivores
All of these vary over space/time	

3.2.2 Functional Attributes

Every ecosystem performs under natural conditions in a systematic way. From the operational point of view, the abiotic and biotic components of an ecosystem are so interwoven into the fabric of nature that their separation from each other becomes particularly very difficult.

Although a wide range of ecosystem functions and their associated goods and services are grouped into four primary categories (De Groot *et al*, 2000):

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1. Regulation functions: This group of functions relates to the capacity of natural and semi-natural ecosystems to regulate essential ecological processes and life support systems through bio-geochemical cycles and other biospheric processes. In addition to maintaining ecosystem (and biosphere) health, these regulation functions provide many services, which have direct and indirect benefits to humans (such as clean air, water and soil, and biological control services).

2. Habitat functions: Natural ecosystems provide refuge and reproduction habitat to wild plants and animals and thereby contribute to the (in situ) conservation of biological and genetic diversity and evolutionary processes.

3. Production functions: Photosynthesis and nutrient uptake by autotrophs converts energy, carbon dioxide, water and nutrients into a wide variety of carbohydrate structures which are then used by secondary producers to create an even larger variety of living biomass. This broad diversity in carbohydrate structures provides many ecosystem goods for human consumption, ranging from food and raw materials to energy resources and genetic material.

4. Information functions: Because most of human evolution took place within the context of undomesticated habitat, natural ecosystems provide an essential 'reference function' and contribute to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, recreation and aesthetic experience.

Although the rank-order of the function categories is somewhat arbitrary, there is an underlying logic in their ordering. The first two function-groups (regulation and habitat) are essential to the maintenance of natural processes and components, and are therefore conditional to the maintenance of the availability of the other two function-groups.

Table 3.2 provides an overview of the main functions, goods and services that can be attributed to natural ecosystems, and their associated ecological structures and processes.

Table 3.2

Functions	*Ecosystem Processes and Components*	*Goods and Services (examples)*
Regulation Functions	*Maintenance of essential ecological process and life support systems*	
1. Gas regulation	Role of ecosystems in biogeochemical Cycles (e.g. CO_2/O_2 balance, ozone layer, etc.).	UV-protection by O_3 (preventing disease); Maintenance of (good) air quality; Influence on climate.
2. Climate regulation	Influence of land cover and biol. mediated processes (e.g. DMS production) on climate.	Maintenance of a favourable climate (temp., precipitation, etc.) for example, human habitation, health, cultivation.

(Contd.)

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Functions	*Ecosystem Processes and Components*	*Goods and Services (examples)*
3. Disturbance prevention	Influence of ecosystem structure on dampening environmental disturbances.	Storm protection (e.g. by coral reefs). Flood prevention (e.g. by wetlands and forests).
4. Water regulation	Role of land cover in regulating runoff and river discharge.	Drainage and natural irrigation; Medium for transport.
5. Water supply	Filtering, retention and storage of fresh water (e.g. in aquifers).	Provision of water for consumptive use (e.g. drinking, irrigation and industrial use).
6. Soil retention	Role of vegetation root matrix and soil biota in soil retention.	Maintenance of arable land; Prevention of damage from erosion /siltation.
7. Soil formation	Weathering of rock, accumulation of organic matter.	Maintenance of productivity on arable land; Maintenance of natural productive soils.
8. Nutrient regulation	Role of biota in storage and recycling of nutrients (eg. N, P&S)	Maintenance of healthy soils and productive ecosystems.
9. Waste treatment	Role of vegetation and biota in removal or breakdown of xenic nutrients and compounds.	Pollution control/detoxification; Filtering of dust particles; Abatement of noise pollution.
10. Pollination	Role of biota in movement of floral gametes.	Pollination of wild plant species; Pollination of crops.
11. Biological control	Population control through Trophic – dynamic relations.	Control of pests and diseases; Reduction of herbivory (crop damage).
Habitat Functions	*Providing habitat (suitable living space) for wild plant and animal species*	
12. Refugium function	Suitable living space for wild plants and animals.	Maintenance of biological and genetic diversity (and thus the basis for most other functions).
13. Nursery function	Suitable reproduction habitat.	Maintenance of commercially harvested species.
Production Functions	*Provision of natural resources*	
14. Food	Conversion of solar energy into edible plants and animals.	Hunting, gathering of fish, game, fruits, etc.; Small-scale subsistence farming and aquaculture.

(Contd.)

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Functions	Ecosystem Processes and Components	Goods and Services (examples)
15. Raw materials	Conversion of solar energy into biomass for human construction and other uses.	Building and Manufacturing (e.g. lumber, skins); Fuel and energy (e.g. fuel wood, organic matter); Fodder and fertilizer (e.g. krill, leaves, litter).
16. Genetic resources	Genetic material and evolution in wild plants and animals.	Improve crop resistance to pathogens and pests; Other applications (e.g. health care).
17. Medicinal resources	Variety in (bio)chemical substances in, and other medicinal uses of natural biota.	Drugs and pharmaceuticals; Chemical models and tools; Test- and essay organisms.
18. Ornamental resources	Variety of biota in natural ecosystems with (potential) ornamental use.	Resources for fashion, handicraft, jewellery, pets, worship, decoration and souvenirs (e.g. furs, feathers, ivory, orchids, butterflies, aquarium fish, shells, etc.).
Information Functions	*Providing opportunities for cognitive development*	
19. Aesthetic information	Attractive landscape features.	Enjoyment of scenery (scenic roads, housing, etc.).
20. Recreation	Variety in landscapes with (potential) recreational uses.	Travel to natural ecosystems for eco-tourism, out door spots, etc.
21. Cultural and artistic information	Variety in natural features with cultural and artistic value.	Use of nature as motive in books, film, painting, folklore, national symbols, architect, advertising, etc.
22. Spiritual and historic information	Variety in natural features with spiritual and historic value.	Use of nature for religious or historic purposes (i.e. heritage value of natural ecosystems and features).
23. Science and education	Variety in nature with scientific and educational value.	Use of natural systems for school excursions, etc. Use of nature for scientific research.

Source: Adapted from Costanza *et al*, (1997), de Groot, de Groot *et al*, (2000).

3.3 ENERGY FLOW IN ECOSYSTEM

Most of the important relationships between living organisms and the environment are controlled ultimately by the amount of available incoming energy received at the earth's surface from the sun. It is this energy which helps to drive biotic

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systems. The sun's energy allows plants to convert inorganic chemicals into organic compounds.

Only a very small proportion of the sunlight received at the earth's surface is transformed into biochemical form. Several studies have been carried out to determine this amount. Most ecosystems fix less than 1% of the sunlight available for photosynthesis.

Living organisms can use energy in basically two forms: radiant or fixed. *Radiant energy* exists in the form of electromagnetic energy, such as light. *Fixed energy* is the potential chemical energy found in organic substances. This energy can be released through respiration. Organisms that can take energy from inorganic sources and fix it into energy rich organic molecules are called autotrophs. If this energy comes from light then these organisms are called photosynthetic autotrophs. In most ecosystems plants are the dominant photosynthetic autotroph.

Organisms that require fixed energy found in organic molecules for their survival are called heterotrophs. Heterotrophs who obtain their energy from living organisms are called consumers.

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 or one way flow. Unlike the nutrients which move in a cyclic manner and are reused by the producers after flowing through the food chain, energy is not reused in the food chain.

Energy flow models: The flow of energy through various trophic levels in an ecosystem can be explained with the help of various energy flow models.

Universal energy flow model – energy flow through an ecosystem was explained by E.P. Odum as the universal energy flow model. As the flow of energy takes place, there is a gradual loss of energy at every level, thereby resulting in less energy available at next tropic level as indicated by narrower pipes (energy flow) and smaller boxes (stored energy in biomass). The loss of energy is mainly the energy not utilised (NU). Fig. 3.2 (Universal energy flow model)

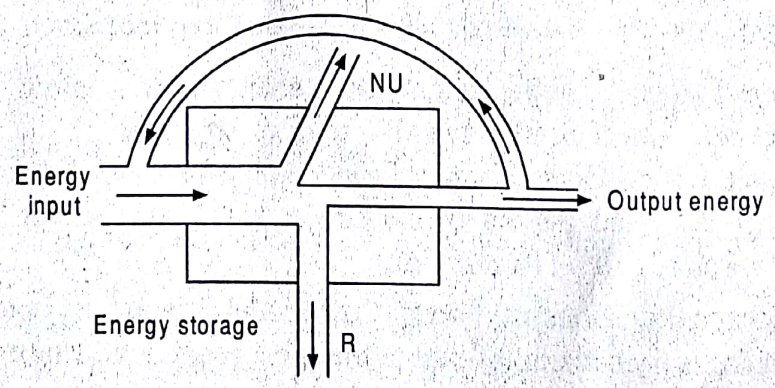

Fig. 3.2 Universal energy model

Single channel energy flow model – the flow of energy takes place in a single channel of green plants or producers to herbivores and carnivores. Figure 3.3 depicts such a model and illustrated the gradual decline the energy level due to loss of energy at each successive trophic level in a grazing food chain.

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There are certain relationships to understand the above-mentioned things:

Table 3.3

1.	Solar energy assimilated by photoautrophs	=	NPP (chemical energy).	+	R (heat energy of respiration)
2.	NPP eaten by heterotrophs (herbivores)	=	Chemical energy of assimilated by herbivores.	+	Chemical energy of faeces produced by herbivores
3.	Chemical energy of assimilated by herbivores	=	Chemical energy of secondary production of herbivores (growth and reproduction)	+	Metabolic energy loss by herbivores
4.	Chemical energy of secondary production of herbivores (growth and reproduction)	=	Chemical energy assimilated by carnivores	+	Chemical energy of faeces of carnivores
5.	Chemical energy assimilated by carnivores	=	Chemical energy of sec. production (growth and reproduction) of carnivores	+	Metabolic energy loss by carnivores
6.	Consumption	=	Assimilation	+	Egesta, faeces and urine
7.	Assimilation	=	Production	+	Respiration
8.	Production	=	Elimination (the biomass of individuals that have died or been killed)	+	Change in biomass (growth and reproduction)

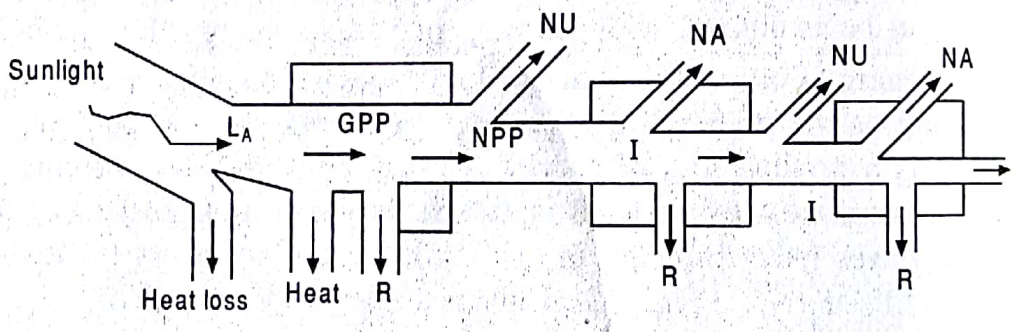

Fig. 3.3 Single channel energy flow model.

The above Figure 3.3 shows a simplified energy flow diagram depicting three tropic levels in a linear food chain. I – total energy input; L_A – light absorbed by plant cover. GPP – Gross Primary Production; NPP – Net Primary Production; NU – energy not used (stored or exported); NA – energy not assimilated by consumers (egested); R – Respiration.

Double channel or Y-shaped energy flow model – in nature, both grazing food chain and detritus food chain operate in the same ecosystem. However, sometimes it is the grazing food chain which predominates. It happens in marine ecosystem where primary production in the open sea is limited and a major portion of it is eaten by herbivorous marine animals. On the other hand, in a forest ecosystem the huge quantity of biomass produced can not be all consumed by herbivores. Rather, a large proportion of the live biomass enters into detritus (dead) compartment in the form of litter. Hence the detritus food chain is more important there.

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The two channels or Y shaped model of energy flow shows the passage of energy through both food chain i.e. grazing and detritus food chain, which separated in time and space.

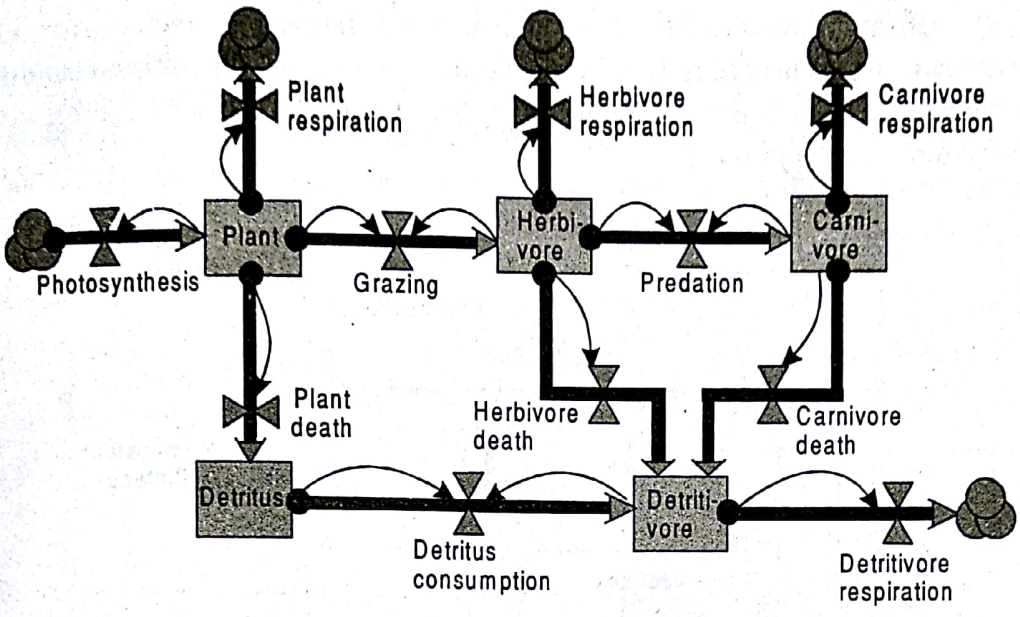

Fig. 3.4

3.4 PRIMARY AND SECONDARY PRODUCTION

Primary productivity of an ecosystem is defined as the rate at which rediant energy is converted into organic substances by photosynthesis or chemosynthesis by the primary producers. Respiratory loss of energy is must because it is required for the maintenance of the organism. The producers are left with a little less organic matter than what was actually produced by them. This is known as the Net Primary Production (NPP) and the respiratory loss (R) added to it gives the Gross Primary Production (GPP).

$$NPP = GPP - R$$

The energy stored at consumer level for use by next trophic level is thus defined as secondary production.

3.5 ECOSYSTEM REGULATION

All ecosystems regulate themselves and maintain themselves under a set of environmental conditions. Any environmental stress tries to disturb the normal ecosystem functions. However, the ecosystem, by itself, tries to resist the change and maintain itself in equilibrium with the environment due to a property known as **homeostasis. Homeostasis is the inherent property of all living system to resist changes.** However, the system can show this tolerance or resistance only within a maximum and a minimum range, which is its range of tolerance known as ***homeostasis plateau.*** **Within this range, if stress tries to cause a deviation, then the system has its own mechanism to counteract these deviations which are known**

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as **negative feedback mechanisms. So negative feedback mechanisms are deviation counteracting mechanisms which try to bring the system back to its ideal conditions.** But, if the stress is too high and beyond the range of homeostatic plateau, then other type of mechanisms, known as **positive feedback mechanisms come into effect. So the positive feedback mechanisms add to stress conditions and tend to take the system away form the optimal conditions.** Human being should not contribute to positive feedback mechanism otherwise the ecosystem will collapse.

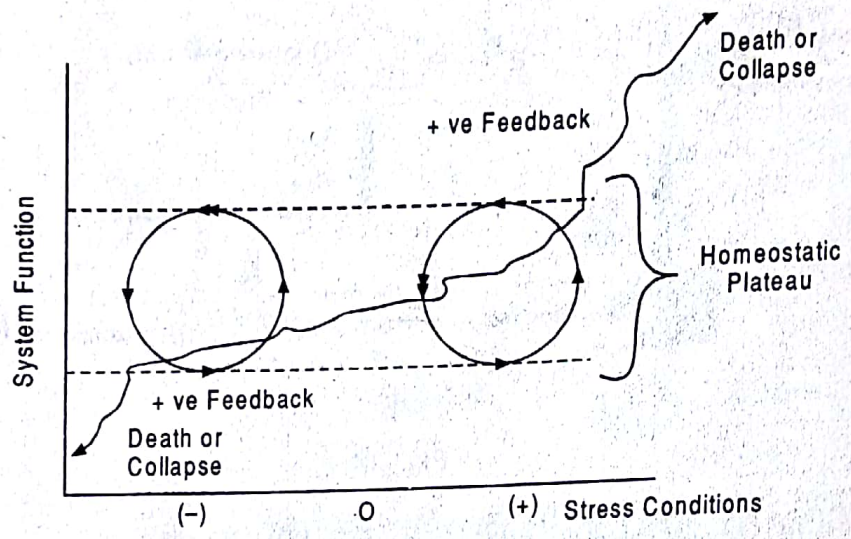

Fig. 3.5

3.6 NUTRIENT CYCLING

Recycling nutrients in the ecosystem is important because only plants can create new nutrients by combining molecules from the soil or air. Not all of the building blocks required by plants are readily available, and they must be carefully conserved within the ecosystem. Other members of the food chains reuse the nutrients assembled by plants.

Nutrients like carbon, nitrogen, sulphur, oxygen, hydrogen, phosphorus etc. move in circular path through biotic and abiotic components are therefore known as biogeochemical cycles. Water also moves in a cycle, known as hydrological cycle.

- **Nitrogen cycle:** Nitrogen is the most important essential element required for the metabolism, growth, development and reproduction of all living organisms. The atmospheric air is a great reservoir of the gas. It constitutes about 78% v/v of the atmosphere. However, atmospheric nitrogen is chemically inert and cannot be directly utilized by most of the living organisms. They need it in the form of soluble nitrogen compounds such as nitrate (NO_3), nitrite (NO_2) and ammonia (NH_3) and amino acids. In fact the elemental nitrogen is converted into usable forms by the process of nitrogen fixation and added to the soil. Nitrogen fixation is possible by the activity of physical (lightening) and biological (microorganism) agencies. Thus plants obtain

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their nitrogen supply from the soil and convert them into essential biomolecules needed for their healthy growth and development. On the other hand animal obtain their nitrogen requirements from plants. After the death of plants and animal nitrogen compounds again reach to the soil. The nitrogenous organic compounds in the soil undergo microbial decomposition by the process of ammonification and nitrification, These compounds are again absorbed by the plant root or get converted into free nitrogen through denitrification process. Thus a biogeochemical cycle exists and is called as nitrogen cycle.

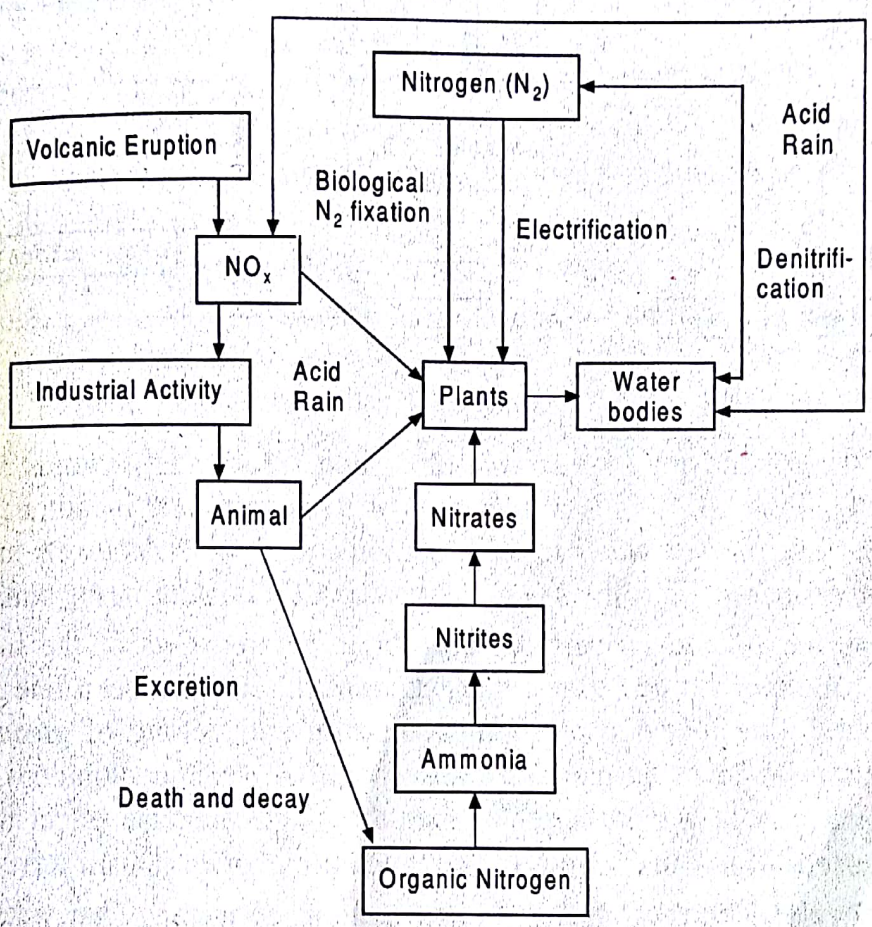

Fig. 3.6

- **Carbon cycle:** Carbon is the basic building element of all the living organisms. By volume, carbon dioxide in the atmosphere is very low i.e. about 0.03% v/v. It is absorbed by the plant in the form of CO_2 from the atmosphere. It is absolutely essential for the synthesis of carbohydrates and fat through photosynthesis in the presence of sunlight in green plants (producers). Later on, the carbohydrates and fats formed in green plants are utilised by consumers (herbivores and carnivores) and thus compound again digested and converted into other forms. From both the producer and consumer carbon is returned back to the atmosphere during respiration. After the death of producer and consumer certain decomposition agents (like bacteria and fungi) decompose and degrade the complex organic compounds (carbohydrate, fat etc.) in their simplest forms (carbon, hydrogen, oxygen, nitrogen etc.), which are then available for other cycles. Some of the organic carbon becomes incorporated into the earth's crust in the form of coal, natural gas, petroleum etc. These

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fossils (coal, natural gas, petroleum etc.) form the most important sources of energy. CO_2 is also released due to the combustion of these fossil fuels. Thus carbon cycle is mainly maintained by the process of photosynthesis, respiration, decomposition and combustion of fossil fuels.

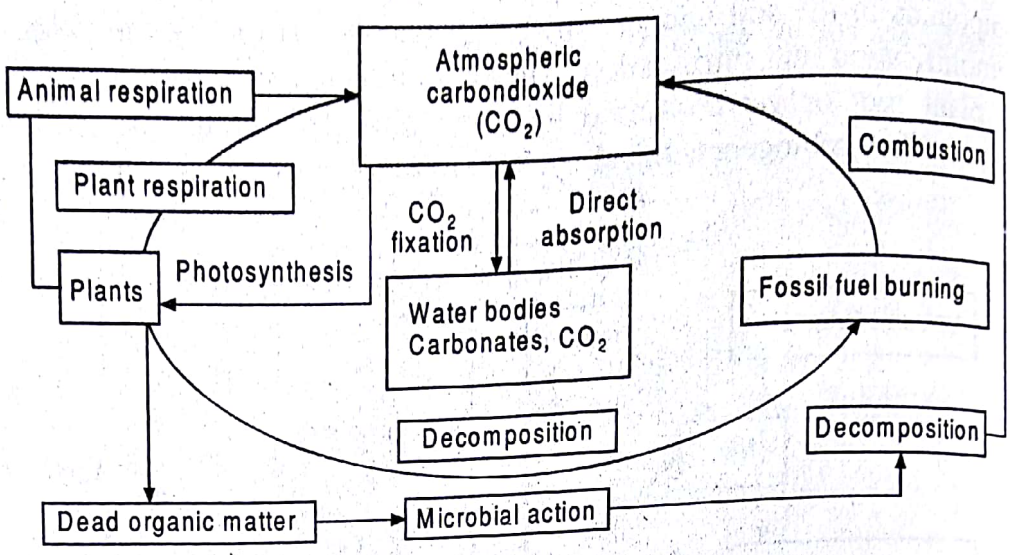

Fig. 3.7

Sea is the second major reservoir of carbon. Sea water contains 50 times mare CO_2 than air. This is in the form of carbonates and bicarbonates. The CO_2 dissolves in sea water to form carbonic acid which converts carbonate into bicarbonates. Thus the sea regulates the CO_2 content in the atmosphere. CO_2 has the unique property of absorbing infrared rays of the sum, thus keeping the earth warm. But a huge amount of CO_2 has been released into atmosphere due to extensive industrialisation and cutting of green plants. This has resulted in an excessive absorption of infrared radiations leading to an increase in atmospheric temperature. A greenhouse effect has been experienced which had effected the functioning of organism adversely.

- **Water cycle:** The earth has a limited amount of water. That water keeps going around and around and in what we call the "Water Cycle".

This cycle is made up of a few main parts:

1. Condensation
2. Precipitation
3. Infiltration
4. Runoff
5. Evaporation (and transpiration)

The process begins with **condensation**, when water vapour condenses in the atmosphere to form clouds. Condensation occurs when the temperature of the air or earth changes. Water changes states when temperatures fluctuate. So when the air cools enough, water vapor has to condense on particles in the air to form clouds. This process is very noticeable on plants as they dew in the morning. As clouds form, winds move them across the globe, spreading out the water vapour. When

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eventually the clouds can't hold the moisture, they release it in the form of precipitation, which can be snow, rain, hail, etc.

Precipitation is made up of any type of water that falls to the earth like snow, hail, mist, or rain. Precipitation occurs when water vapour in the atmosphere condenses into clouds and falls to the earth. About 300 cu km (about 70 cu mi) of precipitation falls on the land each day. Almost two-thirds of this precipitation re-evaporates into the atmosphere, while the rest flows down rivers to the oceans. Individual storms can produce enormous amounts of precipitation.

The next three stages: infiltration, runoff, and evaporation occur simultaneously. Infiltration depends a lot on the permeability of the ground. Infiltration happens when water soaks into the soil from the ground level. It moves underground and moves between the soil and rocks. Some of the water will be soaked up by roots to help plants grow. The plant's leaves eventually release the water into the air through the plant's pores.

Some of the water keeps moving down into the soil to a level that is filled with water, called groundwater. Groundwater is simply water under the ground where the soil is completely filled or saturated with water. This water is also called an "*aquifer*." Groundwater moves underground from areas where the elevation is high, like a hilltop, to places that are lowland areas. Water movement is slow and might move anywhere from less than a millimetre up to a mile in a day. The very top of this layer filled with ground water is called the water table. The Water Table is found underground where the rock and soil begin to be filled or "saturated" with water. It also marks the very top of the groundwater layer.

Where the water table meets the land surface, a spring might bubble up or seep from the ground and flow into a lake, stream woodland, or the ocean. When groundwater meets the land surface, it flows out and helps keep rivers, streams, lakes and wetlands filled with water. Permeability is the measure of how easily something flows through a substance. The more permeable, the more precipitation seeps into the ground.

If precipitation occurs faster than it can infiltrate the ground, it becomes **runoff**. Runoff remains on the surface and flows into streams, rivers, and eventually large bodies such as lakes or the ocean. Infiltrated groundwater moves similarly as it recharges rivers and heads towards large bodies of water.

As both of these processes are happening, warmth from the sun causes water from lakes, streams, ice, and soils to turn into water vapour in the air by causing **evaporation**. Evaporation is the change of liquid water to a vapour. Sunlight aids this process as it raises the temperature of liquid water in oceans and lakes. As the liquid heats, molecules are released and change into a gas. Almost all of the precipitated water (80 per cent) goes right back into the air because of evaporation. The rest runs off the land or soaks into the ground to become groundwater. Transpiration happens when plants give off water vapour through tiny pores in their leaves. This is the plant's way of getting rid of waste, just like people and animals sweat when they're hot! This water vapor evaporates into the air and is stored in the atmosphere until it becomes clouds or precipitation or involved in condensation.

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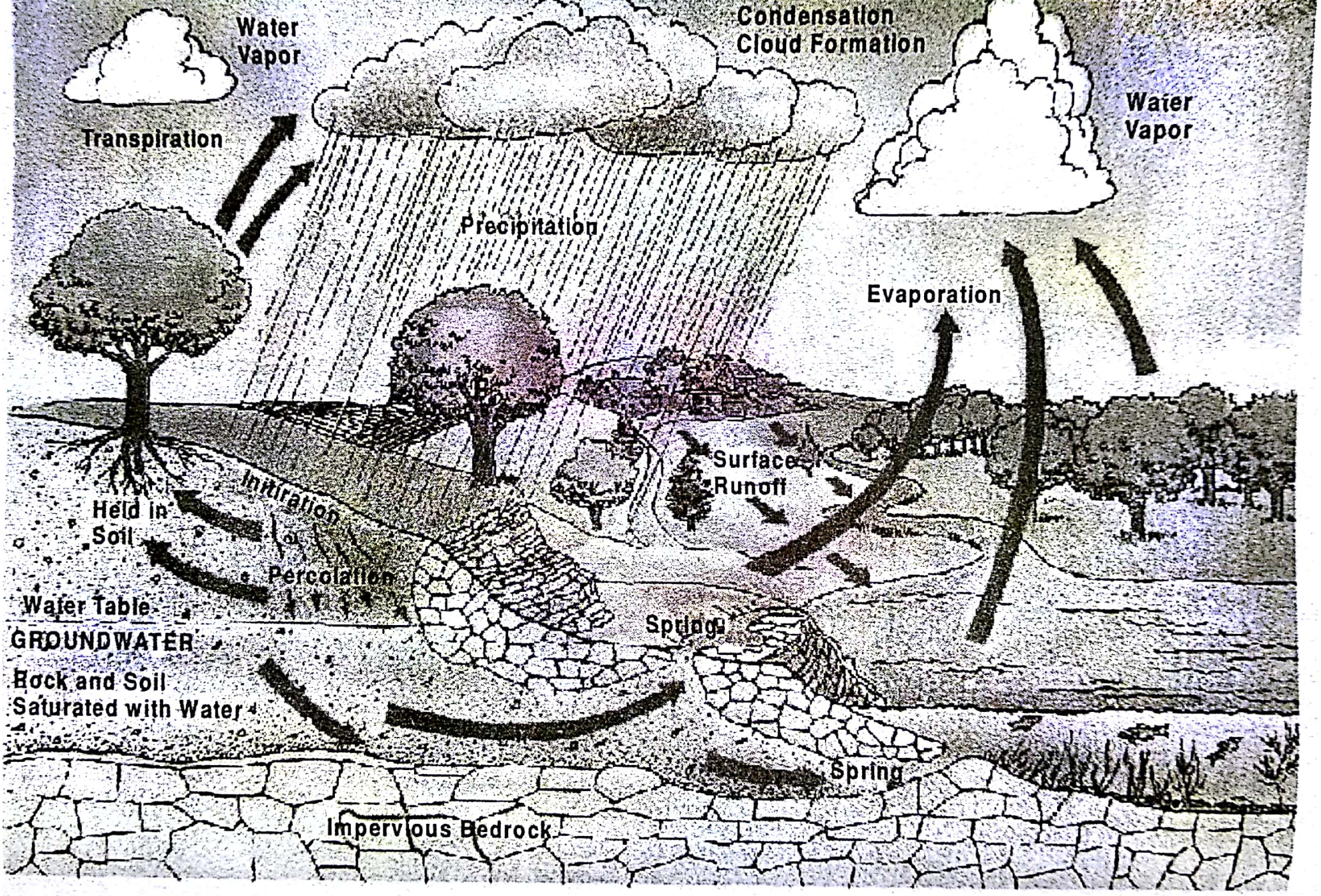

Fig. 3.8 The Water Cycle

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3.7 ECOLOGICAL SUCCESSION

A group of similar individuals able to breed among themselves constitute a species. A group of individuals of a particular species occupying a definite space is referred as population. Many mutually adjusted populations of plants inhabiting a particular habitat make plant community. The community is not stable but a dynamic system. The gradual replacement of one type of plant community by the other is called plant succession. According to E.P. Odum (1971), "it is an orderly process of community change in a unit area". He prefers to call this orderly process as ecosystem development rather then the more often known as ecological succession.

D.B. Sutton and N.P. Harmon (1973), define ecological succession as "the dynamic process by which ecosystem change in order to develop greater stability over the course of time."

Ecological succession is defined as an orderly process of changes in the community structure and function with time mediated through modifications in the physical environment and ultimately culminating in a stabilised ecosystem known as climax.

3.7.1 Characteristics of Ecological Succession

1. It tends to progress from unstable biotic community to stable biotic community, i.e., complete adjustment with the environment.
2. Its seral stages are so regular and directional that an ecologist can often predict the sequence of future community.
3. In successive seral stages there is tendency towards increase in species diversity, total biomass, niche specialisation and humus content of the soil.
4. It tends to progress from simple food chain to complex food chain.
5. The habitat tends to modify from aquatic or dry conditions to moderate wet conditions.
6. Succession of plant and animal communities occurs side-by-side. However, plant succession is easily visible.

3.7.2 Causes of Succession

A variety of factors, biotic and abiotic, may be involved at different stages of the successional process. These factors are summarised below:

1. Biotic factors: It include the influences of living organisms of a particular habitat on plant life of that habitat, many biotic agencies (plant and animals) affect the vegetation in several ways. The grazing animals damage young shoot and plants, destroy water absorbing litter of the ground by their hoof and disturb the soil.

Man is capable of destroying the whole of vegetation community of a given habitat within no time through his destructive activities such as by cutting, clearing, harvesting, cultivation and deforestation etc.

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Vegetation may also be damaged by the attack of insects, pests and fungi. The competition among plants for space, light, nutrient, water also affect plant community in a specific habitat.

2. Abiotic factors: The development of plant community is affected and controlled by following abiotic factors:

Climatic factors: Temperature, sunlight, lightening, wind velocity, soil moisture, humidity, snowfall, hails etc.

Edaphic factors: Soil texture, soil structure, nutrient content of soils, soil reaction, soil temperature, soil erosion and soil organisms.

Physiographic factors: It include nature of the ground, mountains, plains, plateau, altitude, slope, depth etc.

Fire factors: Fire is very much involved in regulating the plant comities. The fire includes both natural forest fires through lightening and man caused forest fires due to deliberate actions.

3.7.3 Types of Succession

A Sere (the transitional series of communities) always starts on a bare area such as rock, sand, clay-gravel and water body. Depending upon the nature of bare area on which it develops, F.E. Clements (1916) has divided succession of plant community in two types:

Primary succession begins on extremely bare area or on the primitive substratum on which there was no previous existence of vegetation. Such areas or sites may be newly exposed rocks due to melting of ice from the glacial areas, newly formed sand dunes, flood plains formed by recent alluvia, heaps of debris, newly formed pond, newly formed sea floor, cooled and solidified basaltic surface due to recent lava flows, exposed lake bed due to drying of water etc. where the conditions of existence may be favourable initially. The rate of succession is very slow in such type of newly formed bare habitat.

Secondary succession refers to community development on the secondary bare area which was once occupied by vegetation but now have been rendered nude or bare due to destruction of vegetation either by natural forces such as sudden change in climatic conditions, prolonged drought, glaciation, lava flow, severe storms, natural forest fires etc. or by human interference such as over-grazing, deforestation, massive land use changes, intentional burning of vegetation, jhuming cultivation etc. It is important to note that such bare habitat still contain mature soil hence the secondary succession is comparatively more rapid.

Depending upon the nature of environment *i.e.* moisture present in substrata and staring on different types of areas or **ecological successions** is named differently as follows:

Hydrarch or Hydrosere – starting in watery area like pond, swamp, bog.

Mesarch – starting in an area of adequate moisture.

Xerarch or Xerosere – starting in a dry area with little moisture. They can be the following types:

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Lithosere	:	Starting on a bare rock
Psammosere	:	Starting on sand
Halosere	:	Starting on saline soil

3.7.4 Process of Succession

The process of succession takes place in a systematic order of sequential steps as follows:

Nudation: It is the development of a bare area without any life form. The bare area may be caused due to topographic factor (land slide/volcanic eruption), climatic factor (drought) or biotic factor (overgrazing).

Invasion: It is the successful establishment of one or more species on a bare area through dispersal or migration, followed by species or establishment. As growth and reproduction starts, these pioneer species increase in number and form groups or aggregations.

Competition and coaction: As the number of individuals grows there is competition, both inter-specific and intra-specific, for space, water and nutrients. They influence each other in a number of ways, known as coaction

Reaction: The living organisms grow, use water and nutrients from the substratum, and in turn, they have a strong influence on the environment which is modified to a large extent and this is known as reaction.

Stabilisation: The succession ultimately culminates in a more or less stable community called climax which is in equilibrium with the environment.

3.7.5 Importance of Succession

1. It provides information, which helps to have a controlled growth of one or more species in a forest by preventing the invasion of other species in the area.
2. Pastures can be maintained by not allowing biotic succession to proceed through grazing or fire.
3. It also helps in reforestation and forest management programmes.

Table 3.4 Trends of Changes in the Ecosystem's Characteristics during Succession

Ecosystem attribute/characteristics	*Seral stages*	*Climax stage*
Community Structure		
(i) Size of individual	Small	Large
(ii) Ecological niches	Few, generalised	Many, specialised
(iii) Community organisation	Simple	complex
Community Functions		
(i) Food chains and food web	Simple	Complex
(ii) Efficiency of energy use	Low	High
(iii) Nutrient conservation	Low	High

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3.8 FOOD CHAIN

Within an ecosystem, nutrients are recycled as living things go about their daily business of eating food and excreting waste products. All living things exist as part of a nutrient recycling chain—an enormous chain defined by what eats what. This is called the **food chain.** Food chains are the pathways along which nutrients pass through an ecosystem. Food chains require constant supplies of new energy to make up for the continual losses.

The transfer of food energy from the producers through a series of organism (herbivores to carnivores to decomposers) constitutes food chain. **The sequence of eating and being eaten in an ecosystem is known as food chain.** All organisms, living or dead, are potential food for some other organism and thus, there is essential no waste in the functioning of a natural ecosystem. Each organism in the ecosystem is assigned a feeding level or trophic level depending on its nutritional status.

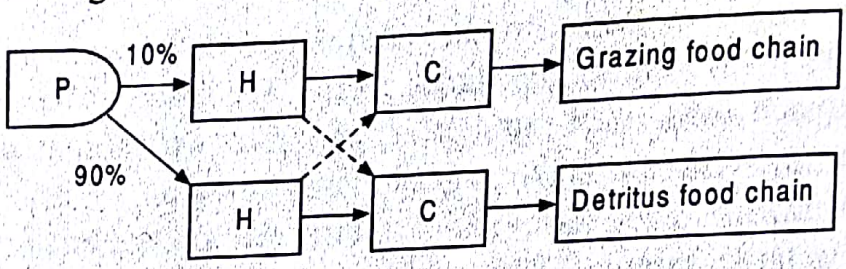

Fig. 3.9

Three basic types of food chains are found in a typical ecosystem through which energy assimilated by plants can flow:

Grazing food chain: It starts with green plants (primary producers) and via herbivores culminates in carnivores. It may be terrestrial and aquatic type. For example:

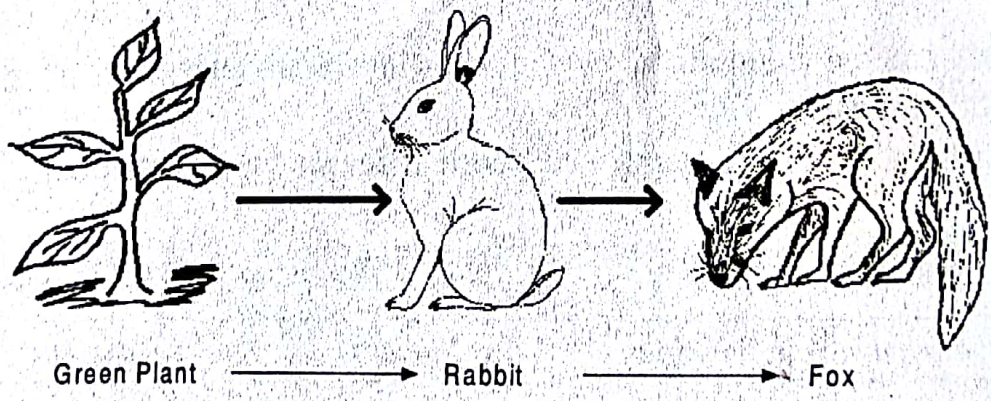

Fig. 3.10 Grazing Food Chain

Detritus food chain: Disintegrated dead bodies of plants is called **detritus.** A group of minute organism for which detritus serves as a source of energy are called **detritivores.** The food chain so formed is called detritus food chain. Millipedes, earthworms, fungi, moluscs etc. are the examples of detritivores. The detritus food chain is more common in terrestrial ecosystem than in aquatic ecosystem. It starts with dead organic matter and the detritivores and decomposers consume.

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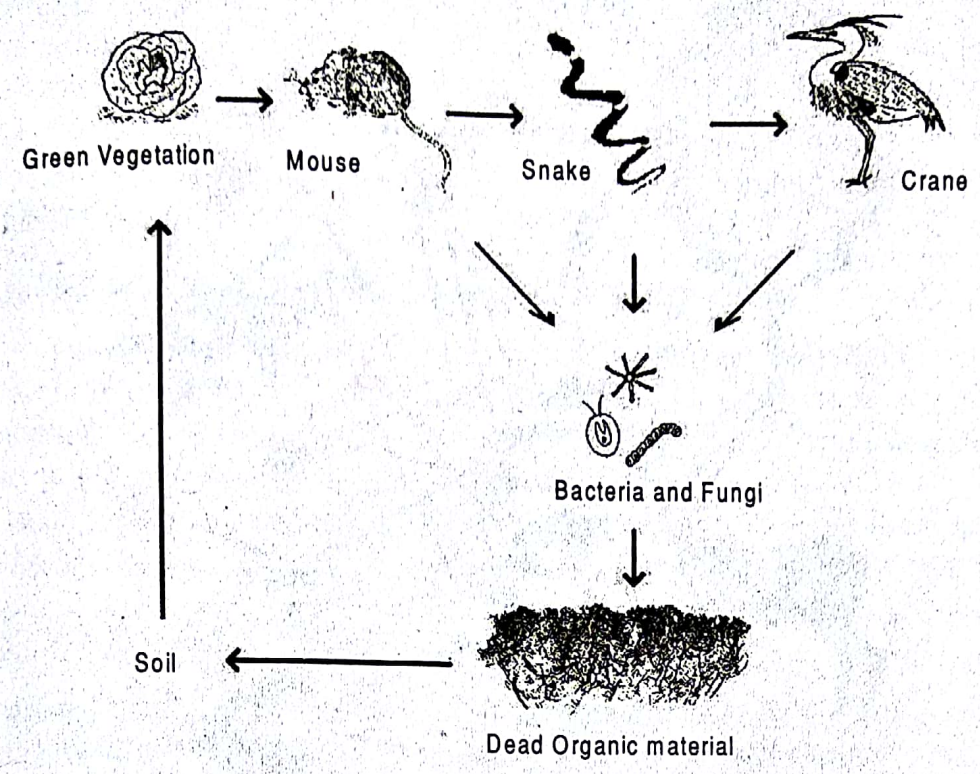

Fig. 3.11 Detritus Food Chain

Parasitic food chain: In parasitic food chain either the producer or the consumer is parasitized and therefore the food passes to smaller organism.

Tress (Producer) → Fruit eating birds (Herbivores) → Lice and Bugs (Parasite on Herbivores) → Bacteria and Fungi (Hyperparasite on lice and bugs)

Terrestrial food chains

1. Vegetation → Grasshopper → Shrew → Hawk
2. Vegetation → Rabbit → Fox → Wolf → Tiger
3. Vegetation → Frog → Snake → Peacock
4. Plant → Butterfly → Frog → Snake → Hawk

Aquatic food chain

1. Phytoplankton → Zooplankton → Small Crustaceans → Predator Insects → Small Fish → Stork/KingFisher → Crocodile
2. Phytoplankton → Zooplankton → Small Fish → Large Fish → Shark
3. Phytoplankton → Zooplankton → Fish → Crane → Hawk

3.9 FOOD WEB

Feed web is a network of food chains where different types of organisms are connected at different trophic levels, so that there are a number of options of eating and being eaten at each trophic level.

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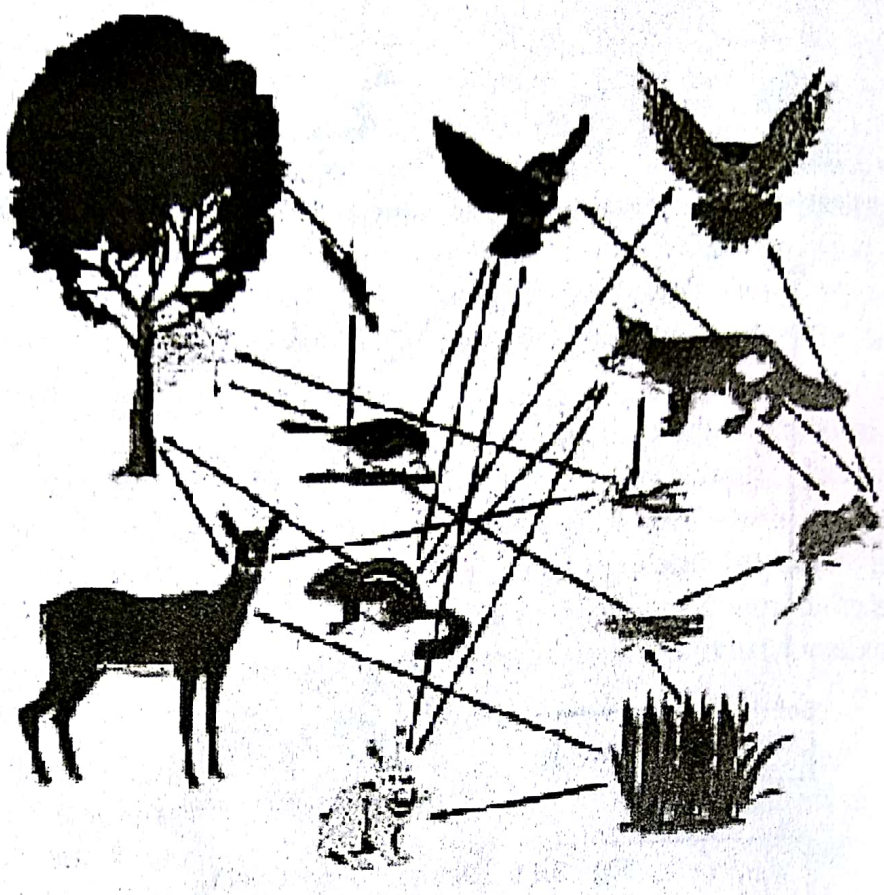

Fig. 3.12 Terrestrial Food Web

Food web is a set of interconnected food chains by which energy and materials circulate within an ecosystem. The food web is divided into two broad categories: the grazing web, which typically begins with green plants, algae, or photosynthesising plankton, and the detrital web, which begins with organic debris. These webs are made up of individual food chains. In a grazing web, materials typically pass from plants to plant eaters (herbivores) to flesh eaters (carnivores). In a detrital web, materials pass from plant and animal matter to bacteria and fungi (decomposers), then to detrital feeders (detritivores), and then to their predators (carnivores).

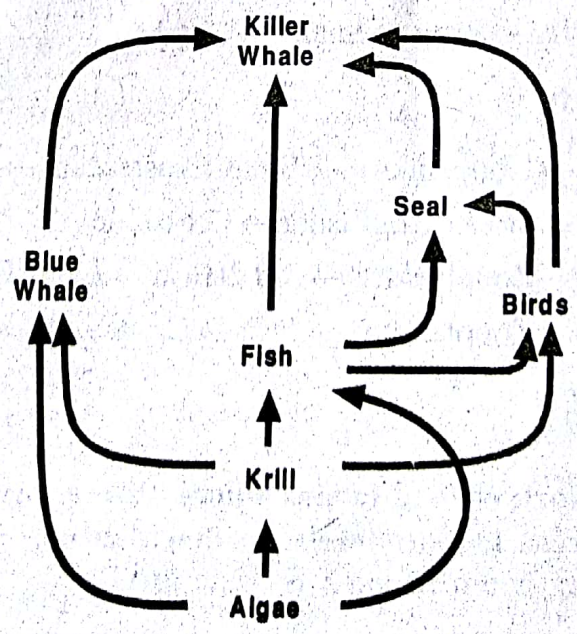

Fig. 3.13 Aquatic Food Web

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Generally, many interconnections exist within food webs. For example, the fungi that decompose matter in a detrital web may sprout mushrooms that are consumed by squirrels, mice, and deer in a grazing web. Robins are omnivores, that is, consumers of both plants and animals, and thus are in both detrital and grazing webs. Robins typically feed on earthworms, which are detritivores that feed upon decaying leaves.

3.9.1 Significance of Food Chains and Food Webs

- The energy flow and nutrient cycling take place through them.
- Help in maintaining the ecological balance.
- Helps to understand the feeding relationships and the interaction between organisms in any ecosystem.
- Food chains show a unique property of biological magnification* of some chemicals.

3.10 ECOLOGICAL PYRAMIDS

Graphical representation of trophic structure and function of an ecosystem, starting with producers at the base and successive trophic levels forming the apex is knows as an ecological pyramid. Ecological pyramids are of three types:

3.10.1 Pyramid of Number

It shows the relationships among the number of producers (irrespective to taxonomic position), primary consumers (herbivores), secondary consumers (carnivores) and so on in any ecosystem. It also represents the number of individual organisms per unit area at each tropical level. We may have upright (grassland/pond ecosystem) or inverted pyramid (parasitic ecosystem) of number, depending upon the type of ecosystem and food chain.

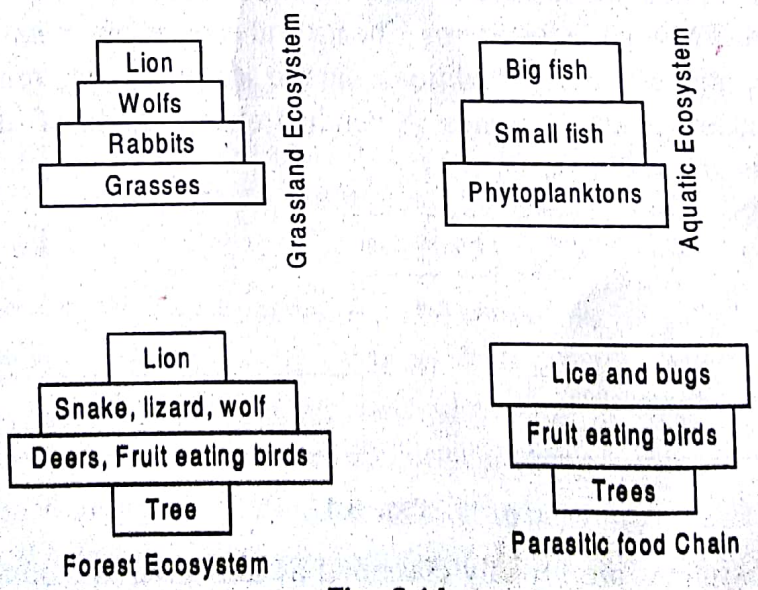

Fig. 3.14

*Some metallic pollutants and pesticides are not biodegradable and are not easily excreted. These are deposited in higher concentration in the body of organisms of higher trophic levels through food chain.

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3.10.2 Pyramid of Biomass

It is based upon the total biomass (dry matter) at each trophic level in a food chain. The pyramid of biomass can also be upright (grassland ecosystem) or inverted (pond ecosystem).

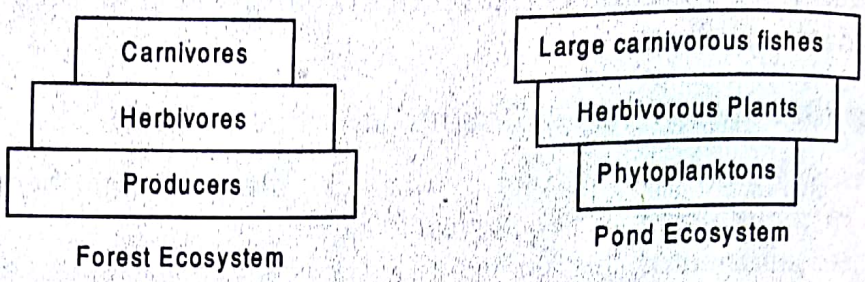

Fig. 3.15

3.10.3 Pyramid of Energy

The amount of energy present at each trophic level is considered for this type of pyramid. Pyramid of energy gives the best representation of the trophic relationship. According to Lindman (1942), only 10% of energy is converted at each trophic level. For example in case of pond ecosystem, each 1000 calory of energy produced in producers (algae etc.), 100 calories may be converted in primary consumers (zooplanktons), 10 calories by secondary consumer and 1 calory by tertiary consumers (top consumers). Thus the amount of energy gradually decreases at successive trophic levels and it is always upright.

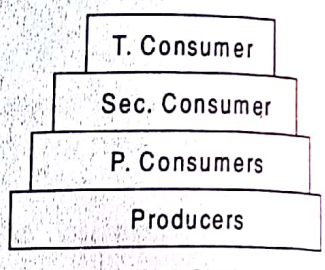

Fig. 3.16

3.11 TYPES OF ECOSYSTEM

Several kinds of ecosystems operate in biosphere. They are, broadly, grouped into natural and artificial type ecosystems. The natural ecosystem operates automatically under the activities of natural conditions, but the artificial ecosystems are controlled and manipulated by human beings. A detailed classification of different types of ecosystems is shown in figure 3.17:

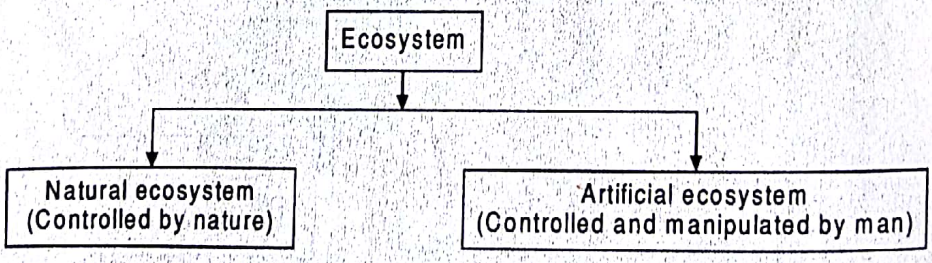

Fig. 3.17

Natural ecosystems are broadly classified as terrestrial and aquatic ecosystem. Terrestrial ecosystems are known by the type of main vegetation in them. For example, if the main vegetation in an ecosystem is grass, then the terrestrial ecosystem will be known as grassland ecosystem. Aquatic ecosystems are another

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category on the basis of type of habitat. They may be fresh water or marine type water.

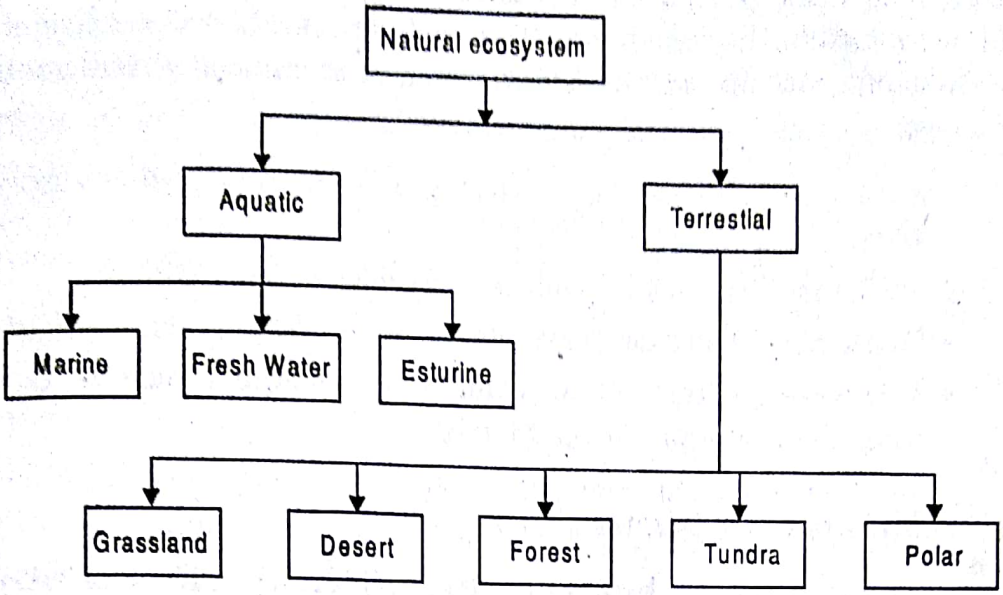

Fig. 3.18

The fresh water ecosystems are lentic and lotic type. Pond and lakes etc. are the example of standing fresh water ecosystem (lentic ecosystem) while river springs etc. are examples of running fresh water (lotic ecosystem)

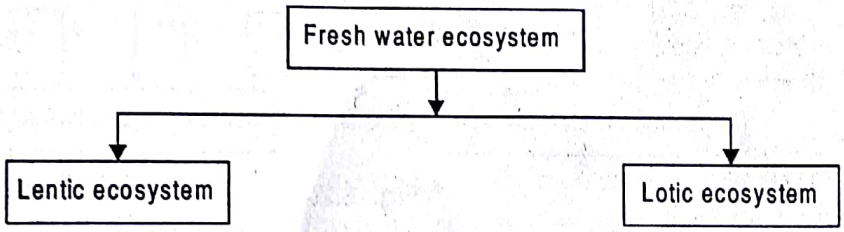

Fig. 3.19

3.11.1 Functions of Natural Ecosystem

Natural ecosystems function themselves under natural conditions and they are not influenced by man-made activities. Some characteristics and functions of ecosystems are the following:

- The industrial and automobile generated air pollutants are trapped by leaves of the trees and convert into harmless compounds.
- The industrial waste, sewage and domestic waste water gets filtered through the natural soil and are thus made drinkable.
- The type of vegetation influences the climate and the soil structure. For example, if there is almost no vegetation. The climate will be very dry and of desert type.
- In natural ecosystems, there is a continued and rapid exchange of O_2, CO_2 and H_2O. The concentration of these compounds varies from season to season and also throughout the year.

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3.11.2 Functions of Artificial Ecosystem

Such ecosystems are creations of human beings. They do so for their convenience in order to fulfill certain needs. The kinds of species and the size of artificial ecosystems may vary widely. A few examples of artificial ecosystems may be as follows:

- A water-filtration tank/pond which purifies the water before supplying it for drinking.
- A cooling water spray pond in a thermal power station.
- Closed ecosystem created in scientific bottles with in the research laboratories.
- A home-acquairium or an exhibition acquairium such as Taraporewala acquairium, Marine Drive, Mumbai.

3.11.3 Forest Ecosystem

The 40% land is covered by forest. In India 1/10th area of the total land is covered by forest. They are classified as:

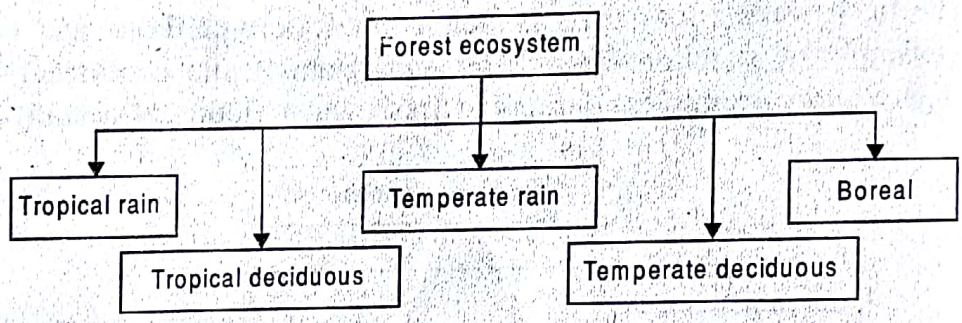

Fig. 3.20

Tropical rain forest: Such forests are located in equatorial regions of earth such as in Congo river basin of Africa, Central America where av. rainfall is high (<150 cm/year) and av. annual temperature exceeds 18°C. These forests characterised by warm and humid climate, high diversity of trees species, broad leaved and tall plants, high diverse animal life and abundance of insects and invertebrates.

Tropical deciduous forest: In the continental regions of the tropics where av. rainfall range 100-120 cm/year, the rainfall is not evenly distributed but is restricted to a few months with prolonged dry season and are less luxuriant.

Temperate rain forest: Occurs in the region which are comparatively very cold and have winter rainfall, the summer are hot and dry.

Temperate deciduous forest: Occurs in very cold climate, the annual temperature is in between 7-15°C. The summer is hot and winter is very cold. These forest characteristic by tall deciduous trees, abundance of insects and birds and dominance of hard wood trees which are suitable for quality furniture and building purpose.

Boreal forest: Such forests are found across east-west band of North Europe, North Asia and North America and in close vicinity below 60°N latitude to where the climate is cold. The annual rainfall varies from 100 mm to 350 mm and annual temperature ranges between 6° in winter to 20° in summer.

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The major components of forest ecosystem are as follows:

Abiotic components: It constitute the organic and inorganic substances present in the soil and the atmosphere. The different types of minerals are found in forests. Other components are dead organic debris and eitter accumulation. The light conditions are different due to complex stratification of plant communities.

Biotic components: The order of food chain in forest ecosystem among living organism is as under:

Producers: There are mainly trees with greater degree of stratification and much species diversity. The trees are of different kinds depending upon the kinds of forest formation developing in that climate. The shrubs and ground vegetation are also present in that area.

Consumers

Primary consumers: These are herbivores that include the animal feeding on tree leaves, shoots or fruit of producer like ants, bugs, spider, mice, squirrel, deer, giraffes, elephant etc.

Secondary consumers: There are the carnivores like snake, birds, lizards, fox and wolf etc. feeding on herbivores.

Tertiary Consumers: There are top level carnivores like lion, tiger etc. which depend upon or eat secondary consumers.

Decomposers: A wide variety of decomposers are also present in forest ecosystem like fungi, bacteria and actinonycetes etc.

3.11.4 Functions of Forest Ecosystem

Forest ecosystem enhances water resources in both quality and quantity, because of their capacity and ecological cleansing action. The hydrological cycle depends upon forest ecosystem and encourages absorption rather than runoff on precipitation. Forests give shelter to wildlife and fish.

Forest ecosystem considered as a pathway for the exchange and regulation of atmospheric gases, water and trace elements. The forest biomass above ground efficiently intercepts atmospheric particles and aerosols. The atmospheric pollutants move through leaves into the forest ecosystem, which are very important to the balance of life on earth.

3.11.5 Grassland Ecosystem

It is a type of terrestrial ecosystem. They may be of following types:

- Tropical grassland
- Temperate grassland
- Polar grassland

It occupies a comparatively small area and comprises following components:

Abiotic components: These are the nutrients present in soil and the aerial

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environment. The CO_2, H_2O, NO_3^- , PO_4^{4-} and SO_4^{2-} etc. supply C, H, O, N, P, S etc. from air and soil of the area. Some trace elements are also present in the soil.

Biotic components: These are categorized as under:

Producers: These are mainly grasses like species of Dichanthium, Cynodon, Desmodium, Digiteria, Setaria, sporobolus etc., some shrubs and fords also contributes to producers.

Consumers: These are mainly herbivores (cows, buffaloes, deers, sheep, rabbit, mouse and some insects and Termites and Millipeds) and carnivores (fox, jackals, snakes, frogs, lizards, birds, hawks).

Decomposers: These are microbes which decay the dead organic matter of different forms of higher life are fungi like Mucor, Aspergillus, Penicillum, Cladosporium etc. and some bacteria and actinomycetes. They bring about mineral back to the soil for use of producers.

3.11.6 Desert Ecosystem

About 17% of land is covered by desert. The species composition of such ecosystem is much more varied and typical due to extremes of both, temperature and water factors. The various biotic components of a desert ecosystem are:

Producer: These are shrubs specially bushes, some grasses and a few trees. The shrubs have widespread, branched root system with their stem and branches variously modified. Sometimes a few succulents like cactus or lower plants like lichens and xerophytes mosses may also be present.

Consumer: The animals like reptiles and insects are able to live under these desert conditions. Some nocturnal rodents and birds are also found. The camels 'ship of desert' feed on tender shoot of plants.

Decomposer: These are very few, as due to poor vegetation the amount of dead organic matter is correspondingly less. They are some fungi and bacteria. Most of them are thermophilic in nature.

3.11.7 Aquatic Ecosystem

Pond Ecosystem: The pond can be defined as a body of shallow standing water characterized by relatively quiet waters and abundant vegetation with thousands of microorganisms, large plant and animals. The important components of pond ecosystem are as follows:

Abiotic components: These include basic inorganic and organic compounds such as water, CO_2, O_2, Ca, N and P and their compounds as amino acid and humic acids etc. Amounts of various organic compounds like carbohydrates, proteins, lipids etc. are also estimated for biomass determination.

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Biotic components

Producers: These are autotrophic, green plants and some photosynthetic bacteria. The producers fix radiant energy and with the help of minerals derived from the water and mud, they manufacture complex organic substances like carbohydrates, proteins, lipids etc. They are mainly macrophytes (rooted hydrophytes, e.g. Trapa, Salvinia etc.) and phytoplanktons (minute lower plants, e.g. Spirogyra etc.).

Consumers: These are nutritionally dependent on producers, the green plants. Most of the consumers are herbivores. They are mainly Zooplanktons—primary consumers (Euglene, Lecane etc.) secondary consumers (insects, small fishes and water beetles) and tertiary consumers (big fishes).

Decomposers: These are also known as micro-consumers because they absorb only a fraction of the decomposed organic matter. They bring about the decomposition of complex dead organic matter of both producers as well as the macro-consumers to simple form. They play an important role in the return of mineral elements again to the medium of the pond.

Ocean (marine) ecosystem: Approximately 70% of the earth's surface is covered by major oceans of the world. Each ocean represents a very large and stable ecosystem. The marine environment as compared with fresh water, appears to the more stable in their chemical composition due to being seine and moreover others physico-chemical factors as dissolved oxygen content, light and temperature are also different. The *biotic components* of an ocean ecosystem as following:

Producers: These are autotrophs, responsible for trapping the radiant energy of sum with the help of their pigments. Producers are mainly the phytoplanktons, such as diatoms, dinoflagellates and some microscopic algae and brown and red algae.

Consumers: These are dependent on primary producers for their nutrition. They are basically primary consumers (crustaceans, mollusks, fish etc.), secondary consumers (herring, shad, mackeral etc.) and tertiary consumers (cod, haddock, halibut etc.).

Decomposers: The microbes active in the decay of dead organic matter of producers and macro-consumers are chiefly bacteria and some fungi.

SUMMARY

An ecosystem includes a group of biotic communities of species interacting with one another in an area, plus their surroundings, plus all the ways in which they interact with each other and exchanging energy and matter. Ecosystem show large variations in their size, structure, composition etc. however, all the ecosystems are characterized by certain basic structural and functional features which are common.

Ecosystems are composed of a variety of abiotic and biotic components that function in an interrelated fashion. The physical and chemical components of an ecosystem constitute its abiotic structure. The plants, animal and microorganisms present in an ecosystem form the biotic components. These organisms have different nutritional behavior and status in the ecosystems and are accordingly known as Producers, Consumers and Decomposers. Consumers are also classified depending on what they eat as **Herbivores, Carnivores** and **Omnivores.**

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Every ecosystem performs under natural conditions in a systematic way. Although there are a wide range of ecosystem functions and are grouped into four primary categories as ***Regulation functions, Habitat functions, Production functions*** and ***Information functions.***

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 or one way flow unlike the nutrients which move in a cyclic manner.

Primary productivity of an ecosystem is defined as the rate at which radiant energy is converted into organic substances by photosynthesis or chemo-synthesis by the primary producers. The producers are left with a little less organic matter than what was actually produced by them, is known as the net primary production (NPP) and the respiratory loss (R) added to it gives the gross primary production (GPP).

Any environmental stress tries to disturb the normal ecosystem functions. However, the ecosystem, by itself, tries to resist the change and maintain itself in equilibrium with the environment due to a property known as **homeostasis**.

Nutrients like carbon, nitrogen, sulphur, oxygen, hydrogen, phosphorus etc. move in circular path through biotic and abiotic components are therefore known as biogeochemical cycles. Water also moves in a cycle, known as hydrological cycle.

A group of similar individuals able to breed among themselves constitute to species. A group of individuals of a particular species occupying a definite space is referred as population. Many mutually adjusted populations of plants inhabiting a particular habitat make plant community. The community is not stable but a dynamic system and process of community change in a unit area is more often known as ecological succession.

A variety of factors, biotic and abiotic, may be involved at different stages of the successional process. A Sere (the transitional series of communities) always starts on a bare area such as rock, sand, clay-gravel and water body. Succession of plant community in two types: **Primary succession** begins on extremely bare area or on the primitive substratum on which there was no previous existence of vegetation. **Secondary succession** refers to community development on the secondary bare area which was once occupied by vegetation but now has been rendered nude or bare due to destruction of vegetation either by natural forces or by human interference. The process of succession takes place in a systematic order of sequential steps as Nudation, Invasion, Competition and coaction, Reaction and Stabilization.

Food chains are the pathways along which nutrients pass through an ecosystem. Three basic types of food chains are found in a typical ecosystem through which energy assimilated by plants can flow. They are grazing food chain, detritus food chain and parasitic food chain.

Feed web is a network of food chains where different types of organisms are connected at different trophic levels, so that there are a number of options of eating and being eaten at each trophic level. Food Web is a set of interconnected food chains by which energy and materials circulate within an ecosystem.

Graphical representation of trophic structure and function of an ecosystem, starting with producers at the base and successive trophic levels forming the apex is knows as an ecological pyramid. Ecological pyramids are of three types: Pyramid of number, Pyramid of Biomass and Pyramid of Energy.

Several kinds of ecosystems operate in biosphere. They are, broadly, grouped into natural and artificial type ecosystems. The natural ecosystem operates automatically under the activities of natural conditions, but the artificial ecosystems are controlled and manipulated by human beings.

Natural ecosystems are broadly classified as terrestrial and aquatic ecosystem. Terrestrial ecosystems are known by the type of main vegetation in them like forest, desert, grassland, polar and tundra whereas Aquatic ecosystems are another category on the basis of type of habitat like marine, fresh water and esturine.

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DESCRIPTIVE TYPE QUESTIONS

1. What is an ecosystem? Describe briefly the forest ecosystem and aquatic ecosystem. **[10 Marks](UPTU 2005)**
2. Describe food chain. Name and explain various types of food chain with suitable example. **[10 Marks](UPTU 2005)**
3. What is the significance of food chain and food web in any ecosystem?
4. What are the main factors, which influence the food chain?
5. What do you understand by ecological pyramids? Explain various types of pyramids with suitable example.
6. What is ecological succession? Describe the causes and basic types of ecological succession. **[10 Marks](UPTU 2005)**
7. What is ecosystem? With the help of the suitable models explain the energy flow in the ecosystem.
8. Explain the types, characteristic features and functions of forest ecosystem.
9. Define ecosystem. Explain the types, characteristic features, structure and functions of aquatic ecosystem
10. What is food chain and food web? Explain with the help of suitable examples.
11. What is ecosystem? Discuss the biotic and abiotic components of an ecosystem.
12. What are food chains and food webs? Explain with the help of examples.
13. Discuss the models of energy flow in ecosystem
14. What is biogeochemical cycling? Explain the water cycle with the help of the diagram.
15. What is meant by ecological succession? Discuss the process of succession with the help of hydrosere.
16. Explain the concept of an ecosystem. Enumerate different types of ecosystem and briefly explain each of them.
17. Discuss the structure and function of an ecosystem in detail.
18. Explain in detail about producers, consumers and decomposers.
19. Depict diagrammatically a terrestrial food web and oceanic food web. **(UPTU 2006)**
20. Show diagrammatically a terrestrial food web in an ecosystem. Depict different food chains in this food web.
21. What are the biogeochemical cycles? How nitrogen circulation does occurs in nature.
22. Depict diagrammatically the carbon cycle.
23. Define ecological succession. Give an account of process of ecological succession in nature.
24. Explain the flow of energy through the various components of the ecosystem.
25. 'The flow of energy is unidirectional and continuous in an ecosystem.' Comment on this statement. **[10 Marks](UPTU 2006)**
26. Describe the structure, silent features and functions of grassland ecosystem.
27. Define ecology and ecosystem. Explain the role of producers, consumers and decomposers in an ecosystem. **[10 Marks](UPTU 2006)**
28. With a neat sketch, explain how the elementai carbon is recycled in nature **[10 Marks](UPTU 2006)**

SHORT QUESTIONS WITH ANSWERS

Q. 1. Define Ecology and Ecosystem.

Ans. **Ecology** deals with the study of organism in their natural home interacting with their surroundings. The term Ecology was coined by Eaenst Haeckel in 1869. It is derived from the Greek words *Oikos*- home + *logos*- study. Now ecology is often defined as 'the study of ecosystem.'

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Q. 2. Define biomagnification.

Ans. Some metallic pollutants and pesticides are not biodegradable and are not easily excreted. These are deposited in higher concentration in the body of organisms of higher trophic levels through food chain, this process is known as **Biological magnification.**

Q. 3. Differentiate between biome and ecosystem.

Ans. Within the biosphere, living things form ecological communities based on the physical surroundings of an area. These communities are referred to as **biomes.** A biome is made up of the total of all biological communities interacting within a single life zone where the climate is similar. Deserts, grasslands, and tropical rainforests are three of the many types of biomes that exist within the biosphere whereas an **ecosystem** includes a group of biotic communities of species interacting with one another in an area, plus their surroundings, plus all the ways in which they interact with each other and exchanging energy and matter.

Q. 4. Explain food web with suitable example.

Ans. **Feed web** is a network of food chains where different types of organisms are connected at different trophic levels. Generally, many interconnections exist within food webs. For example, the fungi that decompose matter in a detrital web may sprout mushrooms that are consumed by squirrels, mice, and deer in a grazing web. Robins, typically feed on earthworms, are omnivores, that is, consumers of both plants and animals.

Q. 5. Why are decomposers called 'micro-consumers'?

Ans. Decomposers like bacteria, actinomycetes and fungi, are heterotrophic organisms feed on organic compounds of dead or living protoplasm of plants and animals for their food and energy. They absorb some of the decomposition products as their food, so also known as **micro-consumers**.

Q. 6. What roles do autotrophs and heterotrophs play in the ecosystem?

Ans. **Autotrophs** (auto-self, tropic-nourishing) are organisms that can manufacture the organic compounds by converting solar energy into chemical energy with the help of inorganic substances such as water and CO_2 and organic substances such as enzymes and contribute to build up of organic matter in an ecosystem. **Heterotrophs** get their energy and nutrients by feeding directly or indirectly on producers and are a part of food chain, food web and ecosystem.

Q. 7. "The pyramid of energy always takes a true upright shape." Why?

Ans. The amount of energy present at each trophic level is considered for energy pyramid. **Pyramid of energy** gives the best representation of the trophic relationship. According to Lindman (1942) only 10% of energy is converted at each trophic level. Thus the amount of energy gradually decreases at successive trophic levels and makes a shape of upright pyramid.

Q. 8. Write the short notes on

(i) Ecological pyramids
(ii) Ecological succession
(iii) Food Chain and food web

Ans. Short notes

(i) Graphical representation of trophic structure and function of an ecosystem, starting with producers at the base and successive trophic levels forming the apex is knows as an **ecological pyramid**. Ecological pyramids are of three types: Pyramid of number, Pyramid of biomass and pyramid of energy.

(ii) **Ecological succession** is defined as an orderly process of changes in the community structure and function with time mediated through modifications in the physical environment and ultimately culminating in a stabilized ecosystem known as climax.

(iii) The transfer of food energy from the producers through a series of organism (herbivores to carnivores to decomposers) constitutes **food chain**. The sequence of eating and being eaten in an ecosystem is known as food chain. Food Web is a set of interconnected food chains by which energy and materials circulate within an ecosystem. The **food web** is divided into two broad categories: the grazing web, which typically begins with green plants, algae, or photosynthesizing plankton, and the detrital web, which begins with organic debris.

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Q. 9. Write short note on the following: **[10 Marks](UPTU 2006)**

(i) Grassland Ecosystem

(ii) Desert Ecosystem

Ans. Short notes:

(i) **Grassland ecosystem** is a type of terrestrial ecosystem. They may be of following types: Tropical grassland, Temperate grassland and Polar grassland.

(ii) About 17% of land is covered by desert. The species composition of such ecosystem is much more varied and typical due to extremes of both, temperature and water factors. The various biotic components of a **desert ecosystem** are: producer (Lichens and xerophytes mosses), consumer (some reptiles and insects, nocturnal rodents and birds and camels) and decomposer (fungi and bacteria).

Q. 10. Describe the structure and function of: **[10 Marks](UPTU 2006)**

(i) Forest Ecosystem

(ii) Lake Ecosystem

Ans. Some characteristics and functions of forest ecosystem are the following-

(i) The industrial and automobile generated air pollutants are trapped by leaves of the trees and convert into harmless compounds.

(ii) The industrial, sewage and domestic waste water gets filtered through the natural soil and are thus made drinkable.

(iii) The type of vegetation influences the climate and the soil structure. For example, if there is almost no vegetation. The climate will be very dry and of desert type.

(iv) In forest ecosystems, there is a continued and rapid exchange of O_2, CO_2 and H_2O. The concentration of these compounds varies from season to season and also throughout the year.

Q. 11. Describe the organization of desert ecosystem.

Ans. About 17% of land is covered by desert. The species composition of the such ecosystem is much more varied and typical due to extremes of both, temperature and water factors. The various biotic components of a **desert ecosystem** are: Lichens and xerophytes mosses (producer), some reptiles and insects, nocturnal rodents and birds and camels (consumer) and fungi and bacteria (decomposer).

Q. 12. Write short note on

(a) Tropic level (b) Position of man on the food chain

(c) Bio-magnification

Ans. Short notes:

(a) A trophic level of an organism is its position in a food chain. Levels are numbered according to how far particular organisms are along the chain from the primary producers [plants] at level 1, to herbivores (level 2), to predators (level 3), to carnivores or top carnivores (level 4 or 5). It is determined by the number of energy-transfer steps to that level.

(b) Every living thing has its place in the food chain. Human beings are at the top of the food chain. When something is at the top of the food chain, it means there are few, if any, *natural predators* that naturally hunt and eat it.

(c) Some metallic pollutants and pesticides are not biodegradable and are not easily excreted. These are deposited in higher concentration in the body of organisms of higher trophic levels through food chain, this process is known as **Biological magnification.**

Q. 13. List the stages of primary succession. Which stage takes the longest time and which stage will have the greatest diversity of species?

Ans. The process of succession takes place in a systematic order of sequential stages as follows: Nudation, Invasion, Competition, Reaction and Stabilization (Climax). Climax takes the longest time and competition stage has greatest diversity of species.

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Q. 14. Distinguish between the following:

(a) Biotic and abiotic components of ecosystem
(b) Food chain and food web
(c) Grazing food chain and detritus food chain
(d) Primary succession and secondary succession
(e) Gross primary productivity and net primary productivity
(f) Autotrophs and heterotrophs

Ans. Distinguish between the following:

(a) **Abiotic components** are nonliving chemical and physical factors in the environment. Often, these are described as light, temperature, water, atmospheric gases, wind as well as soil while **Biotic components** are composed of a variety of *living organisms*. The plants, animal and microorganisms present in an ecosystem form the biotic components. These organisms have different nutritional behavior and status in the ecosystems.

(b) The transfer of food energy from the producers through a series of organism (herbivores to carnivores to decomposers) constitutes **food chain.** The sequence of eating and being eaten in an ecosystem is known as food chain. Food Web is a set of interconnected food chains by which energy and materials circulate within an ecosystem. The food web is divided into two broad categories: the grazing web, which typically begins with green plants, algae, or photosynthesizing plankton, and the detrital web, which begins with organic debris.

(c) Grazing food chain starts with green plants (primary producers) and via herbivores culminates in carnivores. It may be terrestrial and aquatic type. The food chain formed by **detritus** is called detritus food chain. The detritus food chain is more common in terrestrial ecosystem than in aquatic ecosystem. It starts with dead organic matter and the detritivores and decomposers consume.

(d) **Primary succession** begins on extremely bare area or on the primitive substratum on which there was no previous existence of vegetation. **Secondary succession** refers to community development on the secondary bare areas which was once occupied by vegetation but now has been rendered nude or bare due to destruction of vegetation either by natural forces or by human interference.

(e) The producers are left with a little less organic matter than what was actually produced by them due to certain losses. This is known as the net primary production (NPP) and the respiratory loss (R) added to it gives the gross primary production (GPP).

(f) **Autotrophs** (auto-self, tropic-nourishing) are organisms that can manufacture the organic compounds by converting solar energy into chemical energy with the help of inorganic substances such as water and CO_2 and organic substances such as enzymes and contribute to build up of organic matter in an ecosystem. **Heterotrophs** get their energy and nutrients by feeding directly or indirectly on producers and are a part of food chain, food web and ecosystem.

MULTIPLE CHOICE QUESTIONS

1. The study of interactions between living and non-living organisms and environment is called as
   (a) Ecosystem
   (b) Ecology
   (c) Phyto-geography
   (d) Phytosociology
2. The term ecology was introduced by
   (a) Haekel
   (b) Odum
   (c) Tansely
   (d) Ramdeo Mishra

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3. An ecosystem consist of
   (a) Green plants and animals (b) Green plants and decomposers
   (c) Producers and consumers
   (d) Green plants, animals, decomposers and abiotic enyironment
4. In a food chain animals constitute the
   (a) First trophic level (b) Second trophic level
   (c) Intermediate trophic level (d) Ultimate trophic level
5. Which ecological pyramid is always upright
   (a) Pyramid of number (b) Pyramid of biomass
   (c) Pyramid of energy (d) Pyramid of number and biomass
6. Which of the following statements is not true
   (a) Inorganic nutrients are recycled in an ecosystem
   (b) Energy flows through the ecosystem in the form of C-C bonds
   (c) Energy is recycled in an ecosystem
   (d) Respiration process releases energy
7. Which one of the following is an abiotic component of the ecosystem
   (a) Bacteria (b) Plants
   (c) Humus (d) Fungi
8. The primary producers in a forest ecosystem are
   (a) Chlorophyll containing trees and plants
   (b) Herbivores
   (c) Carnivores (d) Bacteria and other micro-organism
9. A trophic level refers to
   (a) Area in the tropics. (b) An organism's portion in a food chain.
   (c) An organism's position in an ecosystem.
   (d) An organism's position in a biome.
10. The food chain in which micro-organisms breakdown dead producers is called
   (a) Consumer food chain. (b) Predator food chain.
   (c) Parasitic food chain. (d) Detritus food chain.
11. A food web consists of
   (a) Interlocking food chains. (b) Producers, consumers and decomposers
   (c) A portion of a food chain. (d) A set of similar consumers.
12. Tendency of pollutants to become concentrated in successive trophic levels is known as
   (a) Biomagnification (b) Biorhythm
   (c) Bioremediation (d) Biopiracy
13. Eutrophication is
   (a) An improved water quality status of lakes.
   (b) The result of accumulation of plant nutrients in water bodies.
   (c) A process in the carbon cycle.
   (d) A water purification technique.
14. Increase in fauna and decrease in flora would be harmful due to increase in
   (a) Diseases (b) CO_2
   (c) O_2 (d) Radioactive pollution
15. Tropical rainforest occur in India in
   (a) Jammu and Kashmir (b) Rajasthan
   (c) Kerala and Assam (d) No where
16. Most stable ecosystem is
   (a) Forest (b) Desert
   (c) Ocean (d) Mountain
17. A primary succession on bare rock starts with
   (a) Lichens (b) Herbs
   (c) Trees (d) Animals

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18. Which of the following is a possible producer in an ecosystem?
(a) Plants (b) Animals
(c) Human beings (d) Fish

19. The largest reservoir of nitrogen an our planet is
(a) Ocean (b) Atmosphere
(c) Biosphere (d) Fossil fuels

Match the Following Terms

Match the terms of Column I with the appropriate terms of Column II

Column I	Column II
(i) Tropical rain forest	(a) Cacti
(ii) Temperate broad leaf forest	(b) Pine and deodar
(iii) Coniferous forest	(c) Dipterocarpus
(iv) Deserts	(d) Cynodon
(v) Grasslands	(e) Oaks

Fill in The Blanks

(a) The term 'ecology' was coined by.....
(b) The study of reciprocal relationship between organisms and their environment is called.....
(c) Herbivores are .....consumers.
(d) Every food chain starts with a .....
(e) Each step in a food chain represent a .....
(f) Autotrophic planktons are called .....
(g) The pyramid of .....is always upright.
(h) Dead plant parts and animal remains are called .....
(i) The ecological factors related to soil and substratum is called ..... factors.

ANSWERS

Multiple Choice Questions

1. (b)	2. (a)	3. (d)	4. (c)	5. (c)	6. (c)	7. (c)
8. (a)	9. (c)	10. (d)	11. (a)	12. (a)	13. (b)	14. (b)
15. (c)	16. (c)	17. (a)	18. (a)	19. (b)		

Match the Following Terms

(i) c (ii) e (iii) b (iv) a (v) d

Fill in the Blanks

(a) Eaenst Haeckel (b) Ecology (c) Primary
(d) Producers (e) Trophic level (f) Phytoplankton
(g) Energy (h) Detritus (i) Edaphic

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