Centre for Distance & Online Education
(CDOE)

BACHELOR OF COMMERCE

EVS-201_L

ENVIRONMENTAL STUDIES

Guru Jambheshwar University of Science & Technology, Hisar – 125001

CONTENTS

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MULTIDISCIPLINARY NATURE OF ENVIRONMENTAL STUDIES

Structure

1.0 Learning Objectives

After studying this unit, you should be able to:

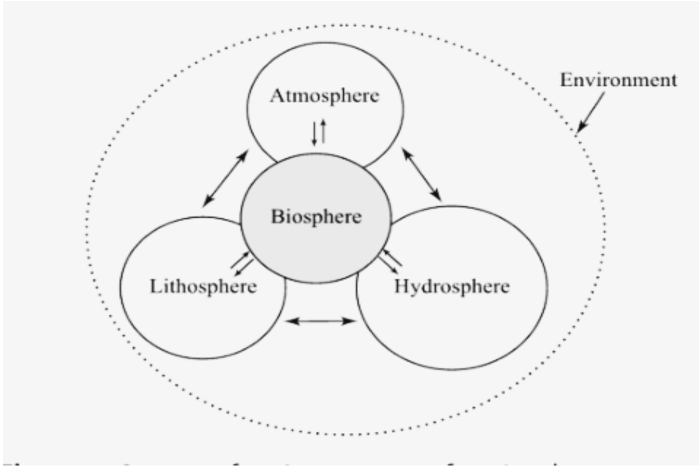
- *Explain the term environment.*
- *Describe multidisciplinary nature of environmental studies.*
- *Discuss the scope and importance of environmental studies.*
- *Explain the need of public awareness for protection of environment.*

1.1 Multidisciplinary Nature of Environmental Studies

- **Meaning of Environment**

The term 'environment' is originated from French word *environ* or *environner* which means 'to surround'. This means that environment includes things or events that surround something else. In other words, environment means the area in which something exists or lives. But this definition is not enough. This needs to be enlarged to include that there is interaction between objects and surrounding. **Environment** is defined as the social, cultural and physical conditions that surround, affect and influence the survival, growth and development of people, animals or plants. In other words environment is defined as "the sum total of water, air, land and the inter-relationships that exist among them and with the human beings, other living organisms and materials." Environment includes everything around us. It encompasses both the living (biotic) and nonliving (abiotic) components of the earth. The environment consists of four major components which are discussed below.

a) Atmosphere: It is the layer of air (gases) surrounding the earth.
b) Hydrosphere: It comprises of all forms of water bodies on earth including oceans, seas, rivers, lakes, ponds etc.
c) Lithosphere: It is outer shell of the earth and composed of the crust and the rigid outermost part of mantle.
d) Biosphere: It is the zone of earth that supports life. It includes all those places in soil, land, air and water where life is present.



Concept of environment as a functional system composed of organised, interacting and independent elements.

Environmental studies is the study of the interactions between the physical, chemical and biological components of the natural world, including their effects on all types of organisms and how humans impact their surroundings. Environment is everything that affects an organism during its lifetime. In turn, all organisms, including people, affect many components in their environment. The flora, fauna and micro-organisms as well as the man-made structures in our surroundings have a bidirectional interaction with us directly or indirectly.

- ## Multidisciplinary Nature of Environmental Studies

From a human point of view, environmental issues involve concerns about science, nature, health, employment, profits, law, politics, ethics, fine arts and economies. Environmental studies deal with working of earth, its life-support systems, its interactions, influences, its problems and solutions. Keeping in view the complex nature of environment, knowledge and information from various disciplines of science, social science, law and engineering have to be included in environmental studies to understand it completely. The multidisciplinary nature of environmental studies can be depicted as follows:

- Knowledge of basic concepts of physics, chemistry, atmospheric science, geography and geology is required to understand the physical and chemical structure of abiotic components of environment along with mass and energy transfers.

- Life sciences including botany, zoology, microbiology, genetics and biochemistry help in understanding the biotic components and their interactions. Genetics and biotechnology are emerging as useful tools for finding solutions to various environmental problems.
- Knowledge of subjects like economics, management and sociology is used to deal with the socio-economic aspects associated with various development activities.
- Subjects like civil engineering, chemical engineering, hydraulics and nanotechnology provide the technical solutions to environmental pollution control and waste treatment that are extremely important for the environment protection.
- Disciplines like mathematics, computer science and statistics serve as effective tools in environment modeling.
- The significant task disseminating environmental awareness is carried out by means of environmental education and mass communication.
- Environmental laws guides about legal measures for effective management and protection of the environment.
- Environmental ethics provide guidelines for a sustainable lifestyle.

1.2 Scope of Environmental Studies

The scope of environmental studies is so wide that it is related to every science and scientific aspects in general and biology in particular. The scope of environmental studies in numerous fields is given below:

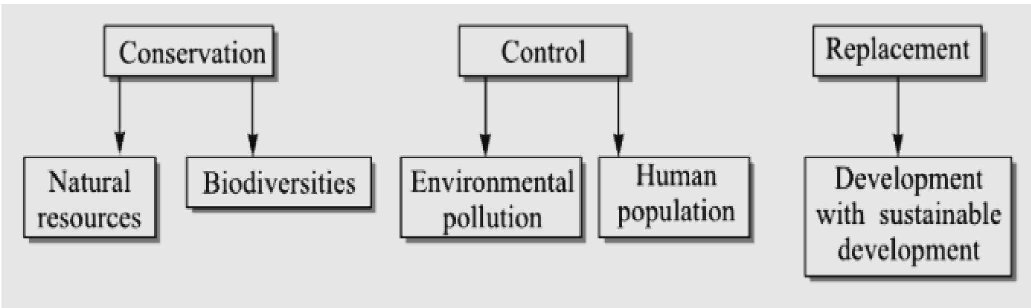
a. Conservation and management of natural resources (like forest resources, water resources etc.)
b. Conservation of biodiversities (genetic diversity, species diversity, ecosystem diversity, landscape diversity etc.)
c. Control of environmental pollutions (air pollution, water pollution, soil pollution etc.)
d. Control of human population
e. Replacement of development (urbanization, green revolution etc.), economic growth (industrialization etc.), with sustainable development.

These are the basic aspects of environmental studies which have a direct relevance to every section of the society. Environmental studies can also be highly specialized concentrating on more technical aspects like environmental science, environmental engineering or environmental management.

In the recent years, the scope of environmental studies has expanded dramatically the world over. Several career options have emerged in this field that are broadly categorized as:

1. **Research and Development (R & D) in environment:** The overall purpose of R & D activities in environment is to broaden the knowledge-base on environmental sciences leading to environment management and sustainable development. Skilled environmental scientists have an important role to play in examining various environmental problems in a scientific manner and carry out R & D activities for developing cleaner technologies and promoting sustainable development.
   There is a need for trained manpower at every level to deal with environmental issues. Environmental management and environmental engineering are emerging as new career opportunities for environmental protection and management. With the pollution control laws becoming more stringent, industries are finding it difficult to dispose off the wastes produced. In order to avoid expensive litigation, companies are now trying to adopt green technologies, which would reduce pollution.
   Investing in pollution control technologies will reduce pollution as well as cut on the costs for effluent treatment. Market for pollution control technology is increasing the world over. Cleaning up of the wastes produced is another potential market. It is estimated to be more than $ 100 billion per year for all American business. Germany and Japan having more stringent laws for many years have gained more experience in reducing effluents. Still there is a $ 200 billion market for cleaning up the former East Germany alone. In India also the Pollution Control Boards are seriously implementing pollution control laws and insisting on upgrading of effluents to meet the prescribed standards before they are discharging on land or into a water body. Many companies not complying with the orders have been closed or ordered to shift.

2. **Green marketing:** While ensuring the quality of products with ISO mark, there is an increasing emphasis on marketing the goods that are environmental friendly. Such products have ecomark or ISO 14000 certification. Environmental auditors and environmental managers would be in great demand in the coming years.
3. **Green advocacy:** With increasing emphasis on implementing various Acts and Laws related to environment, need for environmental lawyers has emerged, who should be able to plead the cases related to water and air pollution, forest, wildlife etc.
4. **Green media:** Environmental awareness can be spread amongst masses through mass media like television, radio, newspaper, magazines, hoardings, advertisements etc. for which environmentally educated persons are required.
5. **Environment consultancy:** Many non- government organizations (NGOs), industries and government bodies are engaging environmental consultants for systematically studying and tackling environment related problems.



Scope of environmental studies

1.3 Importance of Environmental Studies

The environment studies enlighten us, about the importance of protection and conservation of nature and warns us to immediately stop the indiscriminate release of pollutants into the environment. At present a great number of environment issues, have grown in size and complexity day by day, threatening the survival of mankind on earth. We study about these issues besides effective suggestions in the environmental studies. Environmental studies have become significant for the following reasons:

a) **Environment issues being of international importance**: It has been well recognized that environment issues like global warming and ozone depletion, acid rain, marine pollution and biodiversity are not merely national issues but are global issues and hence must be tackled with international efforts and cooperation.

b) **Problems cropped in the wake of development**: Development, in its wake gave birth to urbanization, industrial growth, transportation systems, agriculture and housing etc. However, it has become phased out in the developed world. The North, to cleanse their own environment has fact fully, managed to move ‘dirty’ factories of South. When the West developed, it did so perhaps in ignorance of the environmental impact of its activities. Evidently such a path is neither practicable nor desirable, even if developing world follows that.

c) **Explosively increase in pollution**: World census reflects that one in every six persons on this planet lives in India. Evidently with more than 17 percent of the world’s population and only 2.4 percent of its land area, there is a heavy pressure on the natural resources including land. Agricultural experts have recognized soils health problems like deficiency of micronutrients and organic matter, soil salinity and damage of soil structure.

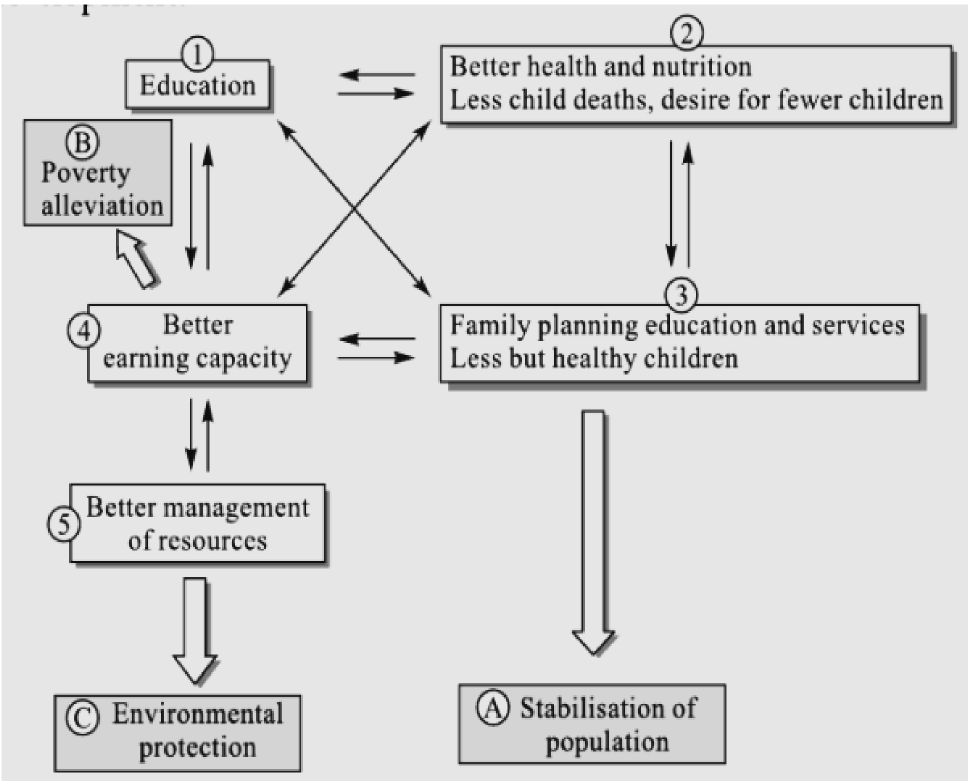
d) **Need to save humanity from extinction**: It is incumbent upon us to save the humanity from extinction, consequent to our activities constricting the environment and depleting the biosphere, in the name of development.

e) **Need for wise planning of development**: Our survival and sustenance depend. Resources withdraw, processing and use of the product have all to by synchronized with the ecological cycles in any plan of development our actions should be planned ecologically for the sustenance of the environment and development.

Environmental education is necessary for the survival of present and future generations. Following are some other important benefits of environmental studies:

- It directs attention towards the blind exploitation of nature by humans for greed or for the sake of development. Exploitation of nature has threatened the survival of all living organisms including humans.
- It generates concern for the changing environment, population explosion and throws light on the methods of solutions.

- It helps to understand different food chains and to find ways and means to maintain ecological balance.
- It helps in the maintenance of healthy life. With improvement in health status, productivity gets increased.
- It imparts knowledge about conservation of energy and reducing material dependence
  - by refusing to purchase things which are harming our environment
  - by reusing a product number of times
  - by encouraging recycling of recyclable products.
- It helps in developing social responsibility towards protection of environment and control of environmental pollution.
- It helps in appreciating and enjoying nature and working towards sustainable development.



Population stabilization, poverty alleviation and environmental protection are mutually supportive of and dependent on one other.

1.4 Need For Public Awareness

If we want to protect and sustain our earth, we have no other option but to make everyone environmentally educated. It is absolutely essential to create awareness about environment because we are facing various environmental challenges. It is essential to get the country acquainted with these challenges so that their acts may be eco-friendly. Some of these challenges are as under:

- **Growing population**: A population of over billion is growing at rate of more than 01 percent every year. Over 13 million people are added each year. It puts considerable pressure on its natural resources and reduces the gains of development. Hence, the greatest challenge before us is to limit the population growth.
- **Poverty**: India has often been described a rich land with poor people. The poverty and environmental degradation have a nexus between them. The vast majority of our people are directly dependent on the natural resources of the country for their basic needs of food, fuel, shelter and fodder. Environment degradation has adversely affected the poor who depend upon the resources of their immediate surroundings. Thus, the challenge of poverty and the challenge of environment degradation are two facets of the same challenge.
- **Agricultural growth**: The people must be acquainted with the methods to sustain and increase agricultural growth without damaging the environment. High yielding varieties have caused soil salinity and damage to physical structure of soil.
- **Need to restore groundwater**: It is essential to rationalize the use of groundwater. Factors like community wastes, industrial effluents and chemical fertilizers and pesticides have polluted our surface water and affected quality of the groundwater. It is essential to restore the water quality of our rivers and other water bodies like lakes. We need to find suitable strategies for conservation of water, provision of safe drinking water and keeping water bodies clean.
- **Development and forests**: Forests serve as catchments for the rivers. With increasing demands of water, plan to harness the mighty river through large irrigation projects were made. Certainly, these would submerge forests; displace local people, damage flora and

fauna. As such, the dams on the river Narmada, Bhagirathi and elsewhere have become areas of political and scientific debate.

- **Reorientation of institutions**: The people should be roused to reorient institutions, attitudes and infrastructures, to suit conditions and needs of today. The change has to be brought, keeping in view, India's traditions for resources use, management, education etc. Change should be brought in education, in attitudes, in administrative procedures and in institutions because it affects the way people see technology, resources and development.
- **Reduction of genetic diversity**: There is a need to take proper measures to conserve genetic diversity. At present most wild genetic stocks have been disappearing from nature. Wild species including the Asiatic Lion are facing threat of losing genetic diversity. The protected areas networks like sanctuaries, national parks, biosphere reserves are isolating populations. So, they are decreasing changes of one group breeding with another. Remedial steps need to be taken to check decreasing genetic diversity.
- **Evil consequences of urbanization**: Nearly 35 percent Indians live in urban areas. Urbanization and industrialization has given birth to a great number of environmental problems that need urgent attention. Over 30 percent of urban Indians live in slums where there are no sewerage and treatment facilities. Hence, coping with rapid urbanization is a major challenge.
- **Rapidly changing technologies lead to abandoned wastes**: In modern era of development there is greater inclination for adopting the latest product of technological advancement and discarding the older one as obsolete. People change their cars, mobile phones, computers, i-pads and electronic goods within a few years, thus adding to the vast e-waste stream.
- **Our fast and energy demanding lifestyle pollutes the environment**: To keep pace with fast and busy life, people have become increasingly dependent on machines to get the work done fast and make life more comfortable for us. But all these machines are energy demanding. Over-dependence on machines not only increases resource depletion and energy consumption, but also directly or indirectly affects our health. The electromagnetic radiations from mobile towers and cell phones, the toxic gases released from industries like carbon monoxide and nitrous oxides, noise produced by industrial activities, vehicles,

agricultural machinery, etc. and polluted water can seriously affect human health along with that of other animals and plants. People should know the impacts of all such anthropogenic activities.

- **Crazy consumerism leads to environmental degradation**: There is a sharp increase in consumerism. With increasing buying capacity people have started over-consumption. No doubt, it is good to have a good standard of living, which is achieved through technological development but the wasteful lifestyle of people leads to environmental degradation.

  It is important to make people aware about the harmful effects of environmental pollution on human health. At the same time, people should know how their activities influence the environment.

- **The earth has a definite capacity to tolerate pollutants and sustain populations**: Beyond that the earth cannot assimilate wastes and support life. How the earth's life support system works, what is the structure of its system and what are the principles on which it works are very important subjects that everyone should know.

  It is equally important to know what should be done to protect the earth and our environment. Thus environmental studies is a very important and the most fascinating subject that is directly concerned with everyone.

1.4.1 Our Cultural Heritage on Environmental Conservation

Indian culture is based on principles of environmental conservation. Our vedas have glorified every aspect of nature including sun, water, rivers, mountains, animals and plants as gods and goddesses, so that people have a feeling of reverence for nature. Our social customs and rituals make us care for flora and fauna. Our ancient teachings preach tolerance, contentment and helpfulness, which lead to sustainable life-style.

Religions like Buddhism and Jainism call for non-violence and use of minimal resources. There are innumerable examples and quotes that pint towards care for mother earth.

The teachings of the 15th century saint environmentalist Guru Jambheshwar Ji have remarkable significance for environmental conservation. He preached about conservation of biodiversity and a creed of Bishnois was created who followed his 29 commandments. In those time could forsee that if trees are protected, wildlife would be sustained and people would survive. There is an unparalleled example of sacrifice by 363 Bishnoi women and men who laid down their lives protecting the 'Khejri' trees in Rajasthan. The popular "Chipko Movement" of 1973 derived inspiration from those great sacrifices of 1730, led by Amrita Devi Bishnoi who laid her life saying *"If a tree is saved from being felling at the cost of one's head, it should be considered as a cheap bargaining".*

1.4.2 Environmentalists in Our Country

There are several internationally known environmentalists who have made landmark contributions. There have been a number of individuals who have been instrumental in shaping the environmental history in our country also. Some of the well-known names in recent times include environmentalists, scientists, administrators, legal experts, educationists and journalists.

- Salim Ali popularly known as 'Bird man of India' was our country's leading conservation scientist and influenced environmental policies in our country for over fifty years.
- Indira Gandhi, our late prime minister, was instrumental in introducing the concept of environmental protection in the Constitution of India as a fundamental duty.
- Justice Kuldeep Singh, popularly known as *the green judge* and Sh. M.C. Mehta, *the green advocate*, have immensely contributed to the cause of environment. In 1991, the Supreme Court of our country issued directives to make al curricula environment-oriented. This directive was, in fact in respond to a Public Interest Litigation (PIL) filed by *M.C. Mehta vs. Union of India (1988)* that prompted the apex court to give a mandate for creating environmental awareness among all citizens of India. Based on the judgment by Sh. Kuldeep Singh, environmental studies are now being taught as a compulsory subject to all students.
- Sh. Sunderlal Bahuguna is known for his 'Chipko Movement' and 'Tehri Bachao Andolan'.
- Smt. Medha Patekar and Ms. Arundhati Roy are known for their 'Narmada Bachao Andolan'.

- Mrs. Maneka Gandhi, former environment minister, has worked a lot for the cause of wildlife protection.
- Late Sh. Anil Aggarwal, the founder chairman of Centre for Science & Environment published the first citizens report on environment.
- The Magsaysay awardee Sh. Rajender Singh is known for his water conservation efforts and popularly known as ‘ Water Man of India’.
- Sh. G.D. Aggarwal, a reknowned scientist and civil engineer has been deeply involved in ‘Ganga Bachao Andolan’. The veteran technocrat is fighting to prevent building of hydroelectric dams on upstreams of Ganga. Fighting for this cause he got transformed as a saint and named as Swami Gyan Swaroop Sanand. The great man passed away on 111th day of his hunger fast in 2018 which was his final effort to make government pass a special act for restoring Ganga’s flow to its original nature of continuous and clear flow.

1.4.3 Environment Concern and Recognition At International Level

Environmental issues received international attention about 48 years back in Stockholm Conference, held on 5th June, 1972. Since then all over the world we celebrate World Environment Day on 5th June. At the United Nations Conference on Environment and Development held at Rio de Jeneiro, in 1992, popularly known as Earth Summit and ten years later, the World Summit on Sustainable Development, held at Johannesberg in 2002, key issues of global environmental concern were highlighted. Attention of general public was drawn towards the deteriorating environmental conditions all over the world.

Award of the Nobel Peace Prize (2004) to an environmentalist, for the first time, came as a landmark decision, showing increasing global concern towards environmental issues and recognition to efforts being made for environmental conservation and protection.

Nobel Peace Prize 2004 and 2007 for Environmentalists

The 2004 Nobel Peace Prize was awarded to Kenyan Environmentalist Wangari Maathai for her contribution to sustainable development, democracy and peace. This is the greatest recognition given to the cause of environment at international level. The Norwegian Nobel Committee, while awarding the prize, expressed the views "Peace on Earth depends on our ability to secure our living Environment".

Maathai, Kenya's Deputy Environment Minister is the founder of Kenya based Green Belt Movement. This movement comprising mainly of women has planted about 30 million trees across Africa. This has helped in slowing desertification, preserving forest habitats for wildlife and food for future generations and has helped combat poverty. Maathai has given a beautiful slogan "When we plant new trees, we plant the seeds of peace."

Nobel peace prize, 2007 was awarded jointly to Intergovernmental Panel on Climate Change (IPCC) headed by Indian Environmentalist Dr. R.K. Pachauri, and former US vice-president Al Gore. IPCC, the UN body comprising of 3,000 experts from various fields is an authority on global warming and its impacts. The award to IPCC is in appreciation of its efforts to build up and disseminate greater knowledge about man made climate change and to lay the foundation for the measures that are needed to counteract such change. Al Gore is "probably the single individual who has done most to create greater world-wide understanding to the measures that need to be adopted," observed the Norwegian Nobel Committee while naming the joint winner of the award.

1.4.4 Environmental Protection Efforts at National Level

- **Concept of ecomark:** In order to increase consumer awareness about environment, the Government of India has introduced a scheme of eco-labeling of consumer products as 'Ecomark' in 1991. It is an 'earthen pitcher' -a symbol of eco-friendliness and our traditional heritage. A product that is made, used or disposed off in a harmless manner is called eco-friendly and is awarded this eco-mark.
- **Eco-Clubs:** The Ministry of Forest and Climate Change has set up Eco-clubs in schools for involving school children in environmental protection activities like tree plantation and for awareness drives. Children are encouraged to participate in environmental awareness campaigns on Earth Day, World Environment Day and World Day for Water.
- **Eco-task force:** Army men are involved in various environment protection activities under the Eco-task force.

Whatever be the occupation or age of a person, he/she will be affected by the environment and also he/she will affect the environment by his/her deeds. That is why it becomes very necessary to make everyone aware and conscious about the importance of environment. There is an internationally observed environment calendar to mark some important aspect or issue of environment, so that people think, discuss, carryout campaigns and act for the cause of those environmental issues because environment belongs to all, influence all and is important to all.

World Wetland Day World Wildlife Day World Forest Day World Day for Water World Meteorological Day Earth Day International Biodiversity Day Anti-tobacco Day World Environment Day World Ocean Day World Population Day World Tiger Day Ozone Week Zero Emissions Day World Car-free Day Green Consumer Day World Farm Animal's Day World Habitat Day World Animal Welfare Day Wildlife Week World Conservation Day International Day for Natural Disaster reduction	February 02 March 03 March 21 March 22 March 23 April 22 May 22 May 31 June 05 June 08 July 11 July 29 September 16-23 September 21 September 22 September 28 October 02 October 03

International Day for Biological biodiversity	October 04 October 01-07 October 24 October 13 December 29

Ecomark of India

1.5 Check Your Progress

A. Fill in the blanks

1. World Day for Water is celebrated on …………… .
2. Smt. Medha Patekar is known for …………… Andolan.
3. In the year ……………, the supreme court of our country issued directives to make all curricula environment – oriented.
4. The 2007 Nobel Peace Prize was awarded jointly to Intergovernmental Panel on Climate Change (IPCC) headed by .... and ……………, the former US vice president.
5. The UN conference on Environment and Development was held at …………… .
6. ……………, the founder chairman of Centre for Science & Environment, published the first citizens report on environment.
7. …………… was the saint environmentalist of 15th century who founded Bishnoi creed.
8. Environment friendly products are given ISO …………… certification.
9. World Population Day is celebrated on …………… .
10. Wangari Mathaai was awarded Noble Prize for Peace due to her work on …………… Movement.

B. Choose the correct answer

1. Ecomark of our country is
   a) Earthen lamp
   b) Earthen pitcher
   c) Earthen mug
   d) Earthen cup
2. The scientist turned saint who fought for protection of river Ganga was
   a) G.D. Aggarwal
   b) Anil Aggarwal
   c) Arundhati Roy
   d) Kuldeep Singh
3. …………… is popularly known as ‘Bird Man of India’.
   a) Sunder Lal Bahuguna
   b) Rajender Singh
   c) Salim Ali
   d) M.C. Mehta
4. …………… is popularly known as ‘the green judge’.
   a) Kuldeep Singh
   b) R.K. Pachauri
   c) M.C. Meht
   d) M S Swaminathan
5. Noble Peace Prize of 2004 was awarded to
   a) Al Gor
   b) R.K. Pachauri
   c) Wangari Mathaai
   d) Rajender Singh
6. International Day for Biological Diversity is celebrated on …………… .
   a) Sept. 28
   b) July 11
   c) May 31

   d) Dec. 29

7. Chipko Movement took place in the year …………… .
   a) 1730
   b) 1965
   c) 1835
   d) 1973
8. Sunder Lal Bahuguna is known for his Chipko Movement and …………… .
   a) Narmada Bachao Andolan
   b) Tehri Bachao Andolan
   c) Ganga Bachao Andolan
   d) Kaveri Bachao Andolan
9. World Environment Day is celebrated on 5th June every year, on this day in 1972 …..…… conference was held which was a beginning of international conferences on environmental issues.
   a) Stockholm
   b) Rio de Jeneiro
   c) Johannesberg
   d) Copenhagen
10. Key issues of global environmental concern were highlighted in the World Summit on Sustainable Development, held at …………… in 2002.
    a) Copenhagen
    b) Rio de Jeneiro
    c) Johannesberg
    d) United Nations, New York

1.6 Summary

- *Environmental studies is the study of the interactions between the physical, chemical and biological components of the natural world, including their effects on all types of organisms and how humans impact their surroundings.*

- *Keeping in view the complex nature of environment, knowledge and information from various disciplines of science, social science, law and engineering have to be included in environmental studies to understand it completely.*
- *Conservation and management of natural resources, conservation of biodiversities, control of environmental pollutions, control of human population, replacement of development, economic growth with sustainable development are the basic aspects of environmental studies which have a direct relevance to every section of the society.*
- *Research and Development (R & D) in environment, Green marketing, Green advocacy, Green media and Environment consultancy are some of the career options have emerged in the field of environmental studies.*
- *It is essential to make the public aware of the formidable consequences of the Environmental Degradation, if not retorted and reformative measures undertaken would result in the extinction of life.*

1.7 Key Words

- **Environment:** The sum total of water, air, land and the inter-relationships that exist among them and with the human beings, other living organisms and materials.
- **Atmosphere:** It is the layer of air (gases) surrounding the earth.
- **Hydrosphere:** It comprises of all forms of water bodies on earth including oceans, seas, rivers, lakes, ponds etc.
- **Lithosphere:** It is outer shell of the earth and composed of the crust and the rigid outermost part of mantle.
- **Biosphere:** It is the zone of earth that supports life. It includes all those places in soil, land, air and water where life is present.

1.8 Self-Assessment Test

1. Define environment.
2. Describe the multi-disciplinary nature of environmental studies.
3. What is the scope of environmental studies?
4. Describe the importance of environmental studies.

5. Explain the need of public awareness about the environment and its degradation.

1.9 Answers to Check Your Progress

A. Fill in the blanks

1. March 22 2. Narmada Bachao 3. 1991 4. Dr. R.K. Pachauri, Al Gore 5. Rio de Jeneiro

6. Anil Aggarwal 7. Guru Jambheshwar Ji Maharaj 8. 14000 9. July 11 10. Green Belt

B. Choose the correct answer

1. b) 2. a) 3. c) 4. a) 5. c) 6. d) 7. d) 8. b) 9. a) 10. b)

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Lesson No. 2	Author: Mr. Dayanand
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NATURAL RESOURCES AND THEIR ASSOCIATED PROBLEMS: FOREST RESOURCES, WATER RESOURCES, MINERAL RESOURCES, FOOD RESOURCES, ENERGY RESOURCES, LAND RESOURCES AND DESERTIFICATAION

Structure

2.0 Learning Objectives

After studying this unit you should be able to

- *Understand the concept of renewable and non-renewable resources.*
- *Describe the impacts of overutilization of underground and surface water.*
- *Discuss the measures to conserve to water.*
- *Explain how various human activities in agriculture and industry have led to degradation of land and water resources.*
- *Describe the effects of mineral extraction on environment.*
- *Explain the necessity of conserving of mineral resources.*
- *Describe significance of forest as a resource.*
- *Explain the causes and ill effects of deforestation.*
- *Understand the present day food problems at international level.*
- *Describe measures required for conserving forest wealth.*
- *Discuss the role of energy as a resource in economic growth.*
- *Explain the management of energy with switching over to renewable sources.*
- *Describe the application of solar energy in modern days.*
- *Explain the techniques of using various conventional and non-conventional energy sources and their related merits and demerits.*

2.1 Natural Resources

We learnt about the concept of environment in the previous chapter. Our environment supplies us with various essential resources that are necessary for sustenance of life. **Natural resources** can be defined as 'variety of goods and services provided by nature which are necessary for our day-to-day lives'. Example: Plants, animals and microbes (living or biotic part), Air, water, soil, minerals, climate and solar energy (non- living or abiotic part). They are essential for the fulfillment of physiological, social, economic and cultural needs at the individual and community levels.

There are two types of natural resources namely renewable and non-renewable resources.

1. **Renewable resources:** The resources that can be replenished through rapid natural cycles are known as renewable resource. These resources are able to increase their abundance through reproduction and utilization of simple substances. Ex: Plants, (crops and forests) and animals.

   Some examples of renewable resources though they do not have life cycle but can be recycled are Wood and wood-products, pulp products, natural rubber, fibers (Cotton, jute, animal wool, silk and synthetic fibers) and leather.

   In addition to these resources, water and soil are also classified as renewable resources. Solar energy is also a renewable resource as it is an inexhaustible source of energy.

2. **Non-renewable resources:** The resources that cannot be replenished through natural processes are known as non-renewable resources. These are available in limited amounts, which cannot be increased. These resources include fossil fuels (petrol, coal etc.), metals (iron, copper, gold, silver, lead, zinc etc.), minerals and salts (carbonates, phosphates, nitrates etc.). Once a non-renewable resource is consumed, it is gone forever.

   Natural resources meet most of our requirements regarding food, clothing, building, dams and vehicles. Human beings have exploited natural resources since the beginning of civilization. Trends reflecting the exploitation of natural resources at the rates much higher than the rates at which these resources are replenished through processes are evident all over the world. Population explosion, considerable increase in per capita resource demand and continuous industrial development are widening the gap between exploitation and replenishment. All these have led to the disruption of the functioning of natural environment.

   The natural environment, which includes forests, grasslands, deserts, rivers, lakes, oceans is the habitat for different communities of plants and animals. The interaction between biotic and abiotic components of nature is the basis of various types of ecosystems. A number of organisms are our food resources.

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. For example, if a species is exploited so much that its population size declines below the threshold level then it is not able to sustain itself and gradually the species becomes endangered or extinct. It is very important to protect and conserve our natural resources and use them in a judicious manner so that we do not exhaust them. It does not mean that we should stop using most of the natural resources. Rather, we should use the resources in such a way that we always save enough of them for our future generations.

2.1.1 Water Resources

Water is one of the most essential components of life. Our water resources are limited though apparently water is available in an abundant quantity. There is scarcity of usable quantity of water in large parts of the world. Human survival, since ages has depended on the relationship societies had with land and water resources. This relationship has been evolving ever since riverbanks and river valleys influenced the early human settlements. Many early civilizations have flourished on the riverbanks and perished in the river floods – some probably due to the faulty watershed/river basin management. However, eventually human beings had come to understand the cyclical relationship of water with land. This understanding led to the creation of tanks using highly developed engineering techniques.

Freshwater is one of the most important substances required for sustaining human life. Considered as one of the important five elements – earth, fire, air, space and water – it was revered and worshiped and treated by all with respect. This is because a mere one percent of all water on the planet is readily accessible to us for use. Of this amount, about 73 percent goes to agriculture, 20 percent to industry and the rest is used for domestic and recreational needs such as drinking and other non-potable uses.

The global distribution of water resources reveals that less than 3% of the total quantity is fresh water. A break up of the total fresh water among various resources and its availability is shown in table below:

Types of Fresh Water	% of total fresh water	% of available fresh water
1) Frozen	80.00	
2) Liquid	20.00	
Lakes	0.2	1.0
Soil	0.04	0.2
Rivers	0.02	0.1
Atmosphere	0.02	0.1
Biological (Metabolic)	0.001	0.005
Ground water	19.7	98.4

Global distribution of fresh water

It is evident from the above table that only one fifth of the fresh water is available in the liquid form. This limited amount is replenishable and therefore, has been relied upon for recurrent use by human being. More than 90% of this scarce commodity is in the form of ground water, while only 1% is in the lakes and ponds. The soil profile carries only 0.2%, but double the amount is held either by rivers or atmosphere. India, in terms of total annual rainfall is very fortunate. It receives an average rainfall of 400 m ham (million hectare metres) out of which 185 m ham is available as surface water, 50 m ham is stored as underground water and 165 m ham is stored in soil.

The total amount of fresh water is more than enough to meet the present and future needs of human kind. But due to its uneven distribution, wide seasonal as well as yearly fluctuations, water shortage is a chronic problem in many parts of the world. Thus we can see that the water which is required for various purposes like irrigation, navigation, generation of hydroelectricity and domestic and industrial needs is rather scarce. It is, therefore, necessary that water resources should be utilized judiciously.

2.1.1.1 Hydrological Cycle:

The movement of water on the earth is continuous and forms many complex inter- related loops Cycling of water involves atmosphere, sea, earth and the entire living biota. The circulation of water is highly dynamic and global in extent. However, for the sake of convenience it is divided into different categories:

a) **Precipitation:** Precipitation includes all forms in which atmospheric moisture descends to earth: rain, snow, hail, sleet and dew. The moisture that enters the atmosphere by the vaporization of water condenses either into liquid (rain) or solid (snow, hail and sleet) before it can fall. Water returns to the land and the sea from the atmosphere by means of condensation, deposition and precipitation.

   Condensation is defined as the process by which water changes from vapour phase to a liquid state (in the form of dew droplets). **Deposition** is the process by which water changes directly from a vapour into a solid (ice crystals) phase. In the atmosphere tiny droplets of water and ice crystals produced through condensation and deposition form clouds. The major amount of water on earth, is received as rainfall.

   The water cycle in nature is sustained by energy from the sun. Solar energy evaporates water from the sea and the land. Water vapours condense in the atmosphere to form clouds which are transported to long distance by wind currents. Rainfall and melted snow replenish water in rivers, which carry it back to the sea.

b) **Run off:** Some of the rainfall is soaked into the soil and excess water flows over the land surface along the natural slope of the area. Run off is the main source of water for lakes and rivers which ultimately drain into the sea. The flowing water acts as an agent of soil erosion and weathering of the underlying rock. Excessive run off during the rainy season causes flood in many parts of our country.

c) **Sublimation:** It is the process by which solid water changes directly to vapour phase without passing through the intervening liquid phase. The gradual disappearance of flakes of ice during the periods when the temperature remains well below freezing is an example of sublimation.

d) **Evaporation:** It is the process by which liquid water changes into vapour at ambient temperature. Water evaporates from all aquatic bodies as well as from wet surfaces. Evaporation from the ocean surface is by far the largest source of atmospheric water vapour.

e) **Transpiration:** It refers to the loss of water in vapour form from plant leaves. On land, transpiration is considerable. For example, the loss of water through transpiration alone by one hectare (2.5 acres) of corn approximately amounts to 35,000 litres (8800 gallons) of water each day.

2.1.1.2 Forms of Water:

Water exists on land in three forms viz: fresh water, brackish water and marine water.

Fresh water

Water, a universal solvent, invariably contains many soluble salts. In fresh water the total salt content remains under 1.5 percent. Different types of soluble salts released by weathering of rocks, soil erosion and decay of organic matter, readily dissolve in water. Dissolved salts have particular significance for floating aquatic vegetation and phytoplankton.

Brackish water

The content of dissolved salts in brackish water is higher than the fresh water and ranges between 0.5 and 3.5%. These waters of intermediate salinity range are distinct from fresh or marine waters. In an estuary which represents the tail end of a river, mixing of fresh water with sea water results in brackish water.

Marine Water

The sea water is highly saline. The average salinity of sea water remains almost constant at 35 parts of salt per 1000 parts of water by weight and is written as 3.5%. Some salt lakes may also have salinity levels up to and above 35%. The biotic activity in such habitats is greatly restricted.

2.1.1.3 Over Exploitation of Surface and Groundwater:

Water which falls in the form of precipitation moves down into soil and through rocks and gets accumulated as **ground water.** The layer of rock through which it percolates down is known as **aquifer** and water can be utilized by digging out wells. Ground water can be found in two layers of the soil. The **zone of aeration,** where gaps in the soil are filled both with air and water. Further down there is a **zone of saturation** where in the gaps are filled up completely with water. Water table is the boundary between the saturated zone and unsaturated zone in rock and it rises and drops drown with increase or decrease in the amount of ground water. Ground water provides a constant supply to us for different purposes and this is not likely to dry up under natural conditions. The surface water includes the streams, ponds, lakes, human-made reservoirs and canals and freshwater wetlands. As part of water cycle the surface water bodies are considered renewable resources though they are dependent on other parts of water cycle. Agriculture is by far the biggest consumer of water. Almost 70% of available water is consumed every year in agricultural production worldwide. In Asia, it accounts for 86% of total annual water withdrawal, compared with 49% in North and Central America and 38% in Europe. The Green Revolution in India ushered in an era of energy and resource intensive agriculture. Water was a critical input to the Green Revolution, through irrigation, flood control and drainage and it has contributed most to the growth in wheat and rice production for the past 40 years.

Implications for future agricultural production are to develop water efficient measures giving more productivity per unit of water input. This would require efficient operation of irrigation systems; technologies that reduce water consumption, appropriate soil and water conservation measures, changes in cropping patterns and the ways in which crops are grown, so as to use water more efficiently.

Similar standards would need to be set and enforced for industries to cut down on water use and prevent them for discharging polluting effluents into water bodies.

2.1.1.4 Degradation of Water Sources:

The depletion of water resources and their contamination making them unfit as a source of water for human consumption. It is a major problem today. Most of our water bodies like rivers, lakes, oceans, estuaries and ground water bodies are facing severe pollution due to intensive agriculture, urbanization, industrialization and deforestation. Siltation of rivers and lakes due to soil erosion progressively reduces their water holding capacity resulting in ravaging floods year after year. Today we are faced with the paradoxical situation of lack of safe drinking water in above-average rainfall areas and regions having abundant water bodies.

Discharge of sewage and industrial effluents into water bodies not only pollute water but often lead to an increase in the growth of aquatic plants and algal blooms in water bodies, ultimately causing them to disappear. This may also cause the decay and destruction of various organisms in water, example: fish.

2.1.1.5 Floods and Droughts:

Floods are the most common of all natural calamities. Floods regularly claim over 20 thousand lives and adversely affect 75 million people annually worldwide. Bangladesh alone accounts for about two-third of global loss of life due to floods. India accounts one fifth of global death count and loss of Rs. 600 million every year on an average. More than the loss of life and damage to property, millions of people are displaced every year due to floods in the South Asian countries.

A flood is the discharge of water that exceeds the canal capacity of the river. Floods are caused by different factors that includes:

Heavy rainfall often causes floods in the low lying coastal areas. Prolonged downpour can also cause the over flowing of lakes and rivers resulting into floods. Anthropogenic activities like deforestation, overgrazing, mining, rapid urbanization, global warming etc. have contributed largely to a sharp rise in the incidence of floods, which otherwise is a natural disaster.

It is possible to reduce the adverse effects of floods by: construction of dams and reservoirs at appropriate places; strengthening the embankments on rivers and canals; improving the carrying capacities of rivers, canals and reservoirs by periodical desilting and deepening operations; diversion of flood waters from a river or a channel into other canals and channels; introducing flood plain management techniques; and preparing ponds, reservoirs, tanks and leading channels by removing obstructions and avoiding constructions.

It is now easy to predict or forecast onset of floods beforehand by the advancement in science and technology. The damage to property and loss of life or displacement of people can be reduced if only the concerned agencies coordinate their activities and act in time to address the calamity.

Like flood, a **'drought'** can be defined as a prolonged period of unusually dry weather, with little rainfall, in a region where rains are normally expected. As such a drought differs from a dry climate which is usually associated with a region that is normally or seasonally dry. Droughts often last for years. Drought is a creeping calamity because it develops slowly and has a prolonged existence. Droughts are not confined to any particular tectonic or topographic setting and their impact often extends over large areas and regions. The impact of drought affects the developing countries more severely than the developed countries. Crop losses, hunger and malnutrition cause immense misery to the poor people.

Though climate is usually the prime trigger of drought, the situation is often made worse by the way people use the water resources. Felling trees for firewood, denuding the forest for agricultural or housing purpose, mining, unscientific farming methods and indiscriminate drawing of ground water cause drought. It is argued that serious droughts in developing countries are more a function of global developmental policies than climatic conditions.

Droughts produce series of direct and indirect impacts that usually extend far beyond the area that is experiencing the actual water shortage. These may be classified as:

Economic – Loss of crop, dairy, livestock, fishery produce;

Environmental – Damage to plant and animal species, erosion of soils; and

Social – Food shortage, damage to health, conflicts between water users. It is possible to take precautions in drought prone areas by constructing reservoirs, educating people for water conservation, scientific farming and optimal use of ground water resources. Since many parts of India are prone to drought, government agencies maintain a stock of food grain to meet the scarcity to crop failures.

Water Harvesting Measures: One of the effective measures to combat drought and resulting water shortage is to adopt rain water harvesting measures. Water harvesting can be undertaken through variety of ways by capturing runoff from rooftops; capturing runoff from catchments; capturing seasonal floodwaters from local streams in ponds and reservoirs; and conserving water through watershed management.

These techniques can serve the following purpose: Provide drinking water, provide water for irrigation, increase groundwater recharge, reduce storm water discharges, urban floods and overloading of sewage treatment plants, reduce seawater ingress in coastal areas.

At the local level, several water management strategies are in use today, that offer practical and sometimes superior alternatives to the large-scale centralized, capital-intensive approaches to water management. They can also complement wider reaching water management approaches.

Several methods are being used in the traditional system of water harvesting in different regions of the country. For example, *johads*, *talaabs* as surface water bodies and *kunds* (underground tanks) are in vogue in many parts of the country. In the North-eastern Hills bamboo drip irrigation is practiced to conserve water.

In a cold desert area like Spiti in Himachal Pradesh, *kul* irrigation is practiced since ancient times. *Kuls* are diversion channels made to carry water from glaciers to villages. The *kuls* often span long distances, some being 10 km long and run down precipitous mountain slopes. Several methods are being followed by individuals and communities in urban as well as rural areas to harvest rain water. One such scheme is operational in the Rashtrapati Bhavan. In Rashtrapati Bhavan an underground tank of 1 lakh litre capacity has been constructed to store water for low quality use. Rainwater from the northern side of roof and paved areas surrounding Rashtrapati Bhavan is diverted to it. Two dugwells are used to store overflow from the 1 lakh litre rainwater storage tank. Another dry open well is recharged with rainwater from the southern side of the roof and runoff from the staff residential area. A desilting tank is used to remove pollutants from the water passing into the recharge well.

2.1.1.6 Dams- Benefits and Problems

Positive Impacts of Dams

- **Ecological Impacts:** i) Flood control-Dams help in controlling river flow and flooding.

ii) Ecosystem services-Some dams help in creating new wetlands which are actually new opportunities for fishing and recreation in the reservoirs.

- **Socioeconomic Impacts:** i) Hydroelectricity generation-Dams are useful for generation of electricity.

  ii) Helps in solving problems of hunger and starvation- About 16% of world's food comes from land irrigated from dam reservoirs.

  iii) Water supply-Dams ensure a year round water supply.

Negative Impacts of Dams

- **Ecological Impacts:** i) Seismic tremors-The hydraulic pressures generated by deep reservoirs is sufficient to change the seismicity of the region.

  ii) Evaporation losses-The reservoir of the dam provides more surface area for evaporation. The loss of water due to evaporation is very high. As salt does not evaporate, the remaining water becomes more saline.

  iii) Salinization of the soil-Use of saline water from dams for irrigation increases the rate of salinization of the soil.

  iv) Landslides-The rise in water level can destabilize the geodynamic situation leading to substantial landslips.

  v) Silting-Generally, a turbulent stream feeds the reservoir of a dam. A rapid stream always carries some soil particle in suspension because of much up and down movement of water. However the water in the reservoir is calm and slow moving. As a result, most of the sediment that enters that enters the run off that feeds it, settles at the bottom at the rate of 10 cm per year. At such a rate, the lakes behind high dams can last upto hundreds of years, though not forever.

- **Socioeconomic Impacts:** i) Increase in water related disease- Water impoundments for dams may provide breeding sites for the vectors. This leads to transmission of malaria and schistosomiasis and spread of onchocerciasis in populations living near dam spillways.

  ii) Low efficiency-most of the world's large dams have been unable to achieve the social, technical and economic objectives for which they were designed.

2.1.1.7 Conservation and Management of Water Resources:

Water is increasingly becoming a scarce commodity. Its scarcity threatens us all - jeopardizing our livelihoods and sometimes endangering our lives. For many millions of people, freshwater scarcity is defined as much by *poor quality* as by *insufficient quantity*. As reported in 2001 by the United Nations Population Fund (UNFPA), within the next 25 years, one-third of the world's population will experience severe water scarcity. Right now, more than 1 billion people lack access to safe drinking water and 3 billion people (half of the Earth's population) lack access to basic sewage systems. More than 90 % of all the sewage produced in the developing countries returns untreated to land and water. Unless water resources are managed properly, we will keep facing paradoxical situations like lack of drinking water due to pollution even in above- average rainfall areas.

As populations increase and economic development intensifies, critical policy decisions would need to be taken on a long-term basis for **regenerating, regulating**, **allocating** and **using** water resources. In future, conflicting demands will increasingly be felt between the needs for safe drinking water and sanitation as well as industrial and agricultural activities.

Management of water resources means a programme to provide an adequate supply of good quality of water for various uses without endangering the life of the source or the reserve of water. In other words, efforts should be made to see that: (i) water of the right quality is available for all kind of uses and (ii) there is no misuse or wastage of this precious resource.

Water management includes recharging the reserves of groundwater and diverting supply from an area of surplus to the region of scarcity.

Recharging of groundwater is the most important aspect of the water management. In the mountains and hills, the watersheds are covered with vegetation. The litter-covered soil of the watershed allows infiltration of rain water, which finds its way to the aquifers.

In urban and rural areas, storm water, used water or domestic drains can be fed into pits, trenches, or any depression, where it can filter underground.

Flood water can be injected into aquifers through a series of deep pits or it can be spread on the fields through a network of ditches.

The excess flow of normal as well as flood water can be diverted to areas where there is scarcity of water. This will not only remove the danger of damage caused by floods but will also benefit the regions of scarcity.

By proper treatment of the domestic and municipal waste water, one can obtain a supply fit for many industrial and agricultural purposes. The treatment of waste water involves removal of pollutants, germs and toxic elements.

Desalination of sea water and brackish water

Sea water can be distilled by using solar energy, thus fresh water of good quality can be obtained. A number of technologies have been developed for desalination of sea water or brackish ground water like reverse osmosis (RO), distillation, electrodialysis and vacuum freezing. This is being used in our country at places like Bhavnagar in Gujarat and Churu in Rajasthan.

Reducing over consumption

Using more water than necessary is an unpardonable waste of the precious and scarce resource. In our country, a lot of water is wasted due to leaking taps and bad plumbing. There is also need for a check on excessive irrigation.

Waste water

Domestic and municipal waste water is rich in organic nutrients. If this kind of water is made free from disease carrying germs and poisonous elements, it can be used for irrigation of farms, gardens and other vegetation. For the removal of germs and toxic elements, the waste water or sewage is treated in a tank or in ponds for several days. In doing so, the heavy particles settle down to the bottom by themselves, while the finer particles are made to settle down by adding alum and caustic soda. The clear liquid is then allowed to pass through filters or sand or earth and finally air is blown through it. This treatment not only removes carbon dioxide and hydrogen sulphide which is generally dissolved in waste water, but also adds oxygen to the filtered water, thus helping in purification. Treatment of water with appropriate doses of chlorine, known as chlorination, kills all the harmful germs and makes water usable. Growing of algae or water hyacinth, a wild plant that grows in floating masses in rivers and lakes serves a double purpose.

It cleans the water of pollutants like phosphates and nitrates that act as nutrients for these plants and these plants can also be utilised for the production of biogas.

2.1.2 Energy Resources

Modern industrial societies are characterized by the intensive use of energy. Energy has been a crucial factor in the current model of development. There is a close relationship between energy consumption and economic growth as measured in terms of the growth of Gross Domestic Product (GDP) in any country. It is now argued that the cost and availability of energy are two major factors in promoting economic growth of society or country as a whole.

The demand for energy doubles every 14 years and is taken as one of the indicators of development of a country. India, with 16% of the world's population consumes roughly 3% of the total energy produced in the world, in comparison of USA which has 6.25% of the world's population and utilizes 30% of the energy produced. Despite continuous increase in energy use, per capita consumption in India is still very low compared with other countries. Even today, about 80% of our population continues to depend on fuel wood, dung and agricultural wastes. We know that non-renewable sources of energy such as fossil fuels, coal and petroleum, are not going to last for long. Forests are also being depleted at the alarming rate due to indiscriminate felling of trees. It has become, therefore, necessary to think of alternative, non- conventional sources of energy.

Energy needs in India are met by harnessing two categories of energy sources as mentioned below.

- **Renewable Resources** which can be generated continuously in nature and are inexhaustible e.g. Oil (fossil fuels), Natural gas, Coal, Hydropower, Nuclear energy, etc. They are also known as non-conventional sources of energy and they can be used again and again in an endless manner.
- **Non-renewable Resources** which have accumulated in nature over a long span of time and cannot be quickly replenished when exhausted e.g. Biomass energy, Solar energy, Ocean Thermal Energy (OTE), Geothermal energy, Wind energy, etc.

2.1.2.1 Non-Conventional Sources:

There are various non-conventional sources of energy which we will deliberate here.

1. **Biomass energy**

This is a renewable energy source derived from plant resources, animal waste and the waste of various human activities. It is also derived from the by-products of the timber industry, agricultural crops, raw material from the forest, major parts of household wastes and wood. Biomass is an important source of energy and the most important fuel worldwide after coal, oil and natural gas. There are three ways to use biomass. It can be burned to produce heat and electricity, changed to a gas-like fuel such as methane, or changed to a liquid fuel.

Liquid fuels, also called biofuels, include two forms of alcohol: ethanol and methanol. Biofuels can be obtained by fermenting biomass that produces alcohols like ethanol and methanol. Ethanol can be easily produced from carbohydrate rich substances like sugarcane, corn and sorghum (Jowar). It burns clean and is non-polluting. However, as compared to petrol its calorific value is less and therefore, produces much less heat than petrol. It is also considered to be an excellent substitute for kerosene and its combustion is as clean as LPG. Ethanol is obtained from grain-based or sugar-containing plants like maize, cereals or even organic wastes.

Methanol is very useful since it burns at a lower temperature than gasoline or diesel. Thus the bulky radiator may be substituted by sleek designs in our cars. Methanol too is a clean, non-polluting fuel. Methanol can be easily obtained from woody plants.

Gasohol is a common fuel used in Brazil and Zimbabwe for running cars and buses. In India too gasohol is planned to be used on trial basis in some parts of the country, to start with in Kanpur. Gasohol is a mixture of ethanol and gasoline.

In the United States, biofuel is now being produced from soybean oil. Researchers are also developing algae that produce oils, which can be converted to biodiesel and new ways have been found to produce ethanol from grasses, trees, bark, sawdust, paper and farming wastes.

Biomass does not add net carbon dioxide to the atmosphere as it absorbs the same amount of carbon in growing as it releases when consumed as fuel. Its advantage is that it can be used to generate electricity with the same equipment or power plants that are now burning fossil fuels. Biomass fuels used in India account for about one third of the total fuel used in the country. Over 90% of the rural households and about 15% of the urban households use biomass fuels (e.g. wood, cowdung cakes, crop residues and sawdust). The inefficient burning of such fuels in traditional chulhas is causing a serious problem of indoor air pollution and consequent health hazards. Moreover, the unsustainable level of consumption of fuel wood leads to deforestation and desertification, which degrades the environment. Thus proper management of biomass as a resource is very essential. Note that like any fuel, biomass creates some pollutants, including carbon dioxide, when burned or converted into energy. In terms of air pollutants, biomass generate less relative to fossil fuels. Biomass is naturally low in sulphur and therefore, when burned, generates low sulphur dioxide emissions. However, if burned in the open air, some biomass feedstocks would emit relatively high levels of nitrous oxides (given the high nitrogen content of plant material), carbon monoxide and particulates.

In this context, technological solutions, institutional arrangements, financial support and training schemes for ensuring adequate and affordable clean energy systems and services using biomass assume great significance.

An initiative in this direction has come from the Ministry of Non-conventional Energy Sources (MNES). It has been promoting indigenously developed technologies for efficient utilization of biomass fuels with a focus on extraction of more energy, reduction of household consumption of firewood, generation of employment and improvement in the living standards of rural population.

It has been found to be more practical to compress biomass into briquettes (small hard blocks of different shapes used as fuel) and thereby improve its utility and convenience of use. In the dense briquetted form, biomass can either be used directly as fuel instead of coal in the traditional chulhas and furnaces or in the gasified.

2. **Biogas**

You may have heard of the use of cattle dung for production of biogas which is a source of energy used for cooking. Through a simple process cattle dung is used to produce a gas that contains 55-70% inflammable methane gas and is clear and efficient fuel for use in rural areas. Water weeds like water hyacinth, water lettuce, salvinia, hydrilla, duck weeds and algae are found to be useful supplement to cattle dung. The fibrous waste of the sugar industry is the world's largest potential source of biomass energy. Biogas can also be used to raise steam, which in turn may be used for running engines or machines in factories or for running turbines to generate electricity. Ethanol produced from sugarcane molasses is a good automobile fuel and is now used in a third of the vehicles in Brazil. It has been found that large biogas plants can supply the needs of a number of families or even small villages. The residual dung or the digested slurry left after generating, biogas can be used as manure for agricultural purposes. This is an economical way of obtaining energy from organic wastes. In China and India, great efforts are being made to install tens of thousands of biogas plants in rural areas.

3. **Hydrogen as a Fuel**

As hydrogen burns in air, it combines with oxygen to form water and a large amount of energy (150 kilojoules per gram) is released. Due to its high, rather the highest calorific value, hydrogen can serve as an excellent fuel. Moreover, it is non-polluting and can be easily produced. Production of hydrogen is possible by thermal dissociation, photolysis or electrolysis of water:

a) By thermal dissociation of water (at 3000 K or above) hydrogen (H_2) is produced.
b) Thermochemically, hydrogen is produced by chemical reaction of water with some other chemicals in 2-3 cycles so that we do not need the high temperatures as in direct thermal method and ultimately H_2 is produced.
c) Electrolytic method dissociates water into hydrogen (H_2) and oxygen by making a current flow through it.
d) Photolysis of water involves breakdown of water in the presence of sunlight to release hydrogen. Green plants and micro-algae also carry out photolysis of water

during photosynthesis. Efforts are underway to trap the hydrogen molecule which is produced during photosynthesis. Hydrogen generated by microbial systems is called biohydrogens.

However, hydrogen is highly inflammable and explosive in nature. Hence, safe handling is required for using H_2 as a fuel. Also, it is difficult to store and transport. And being very light, it would have to be stored in bulk.

Presently, H_2 is used in the form of liquid hydrogen as a fuel in spaceships. H_2 can be used in fuel cell to generate electricity. In fuel cell hydrogen is burnt in air or oxygen in the pressure of an electrolyte to produce electricity.

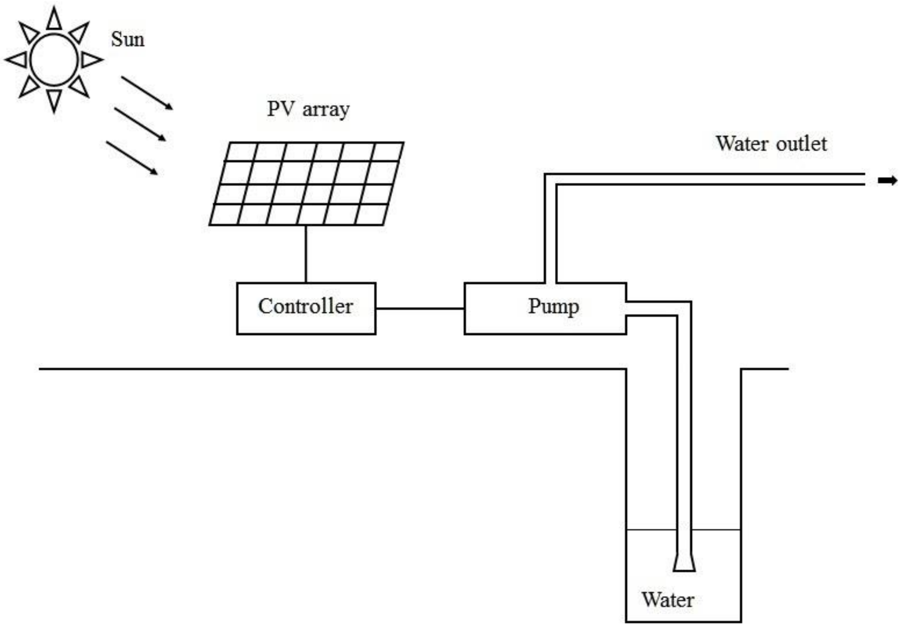
4. Solar energy

Solar energy is the most readily available abundant source of energy. It is free as it does not belong to anybody. It is a non-polluting energy source. The energy we get today from the fossil fuels like coal is in reality sun's energy, trapped in plants millions of years ago. Plants make their food and grow by using solar energy for photosynthesis. Millions of years ago, huge forests got buried in the earth's crust and they got transformed into coal and oil under great pressure and temperature therefore coal and oil are called fossil fuels.

Nowadays, we have learnt to harness solar energy for various purposes. Some important solar energy harvesting devices are discussed here.

a) **Solar heat collectors:** These can be passive or active in nature. Passive solar heat collectors are natural materials like stones, bricks etc. or material like glass which absorb heat during the day time and release it slowly at night. Active solar collectors pump a heat absorbing medium (air or water) through a small collector which is normally placed on the top of the building.

b) **Photovoltaic cells (Solar cells)** for direct conversion of solar radiations into electrical energy: Solar cell or PV cell is made of thin wafers of semiconductor material like silicon and gallium. When solar radiations fall on them, a potential difference is produced which causes flow of electrons and produces electricity. Silicon can be obtained from silica or sand, which is abundantly available and inexpensive. By using gallium arsenide, cadmium sulphide or boron, efficiency of the PV cells can be improved. The potential difference produced by a single PV cell of 4 cm^2 size is about 0.4-.0.5 volts and produces a current of 60 milli amperes.



A solar pump run by electricity produced by solar cells

A group of solar cells joined together in a definite pattern form a solar panel which can harness a large amount of solar energy and can produce electricity enough to run street-light, irrigation water pump etc. Solar cells are widely used in calculators, electronic watches, radios, street lighting, traffic signals, water pumps etc. They are also used in artificial satellites for electricity generation. Solar cells are used for running radio and television also. They are more in use in remote areas where conventional electricity supply is a problem.

c) **Solar cooker:** Solar cookers make use of solar heat by reflecting the solar radiations using a mirror directly on to a glass sheet which covers the black insulated box within which the raw food is kept. A new design of solar cooker is now available which involves a spherical reflector (concave or parabolic reflector) instead of plane mirror that has more heating effect and hence greater efficiency.

The food cooked in solar cookers is more nutritious due to slow heating. However, it has the limitation that it cannot be used at night or on cloudy days. Moreover, the direction of the cooker has to be adjusted according to the direction of the sun rays.

d) **Solar water heater:** It consists of an insulated box painted black from inside and having a glass lid to receive and store solar heat. Inside the box it has black painted copper coil through which cold water is made to flow in, which gets heated and flows out into a storage tank. The hot water from the storage tank fitted on roof top is then supplied through pipes into buildings like hotels and hospitals.

e) **Solar furnace:** Here thousands of small plane mirrors are arranged in concave reflectors, all of which collect the solar heat and produce as high a temperature as 3000°C.

f) **Solar power plant:** Solar energy is harnessed on a large scale by using concave reflectors which cause boiling of water to produce steam. The steam turbine drives a generator to produce electricity.

5. Wave and Tidal Energy

The earth's surface is 70% water. By warming the water, the sun, creates ocean currents and wind that produces waves. It is estimated that the solar energy absorbed by the tropical oceans in a week could equal the entire oil reserves of the world – 1 trillion barrels of oil. The energy of waves in the sea that crash on the land of all the continents is estimated at 2 to 3 million megawatts of energy.

From the 1970s several countries have been experimenting with technology to harness the kinetic energy of the ocean to generate electricity. Tidal power is tapped by placing a barrage across an estuary and forcing the tidal flow to pass through turbines. In a one-way system the incoming tide is allowed to fill the basin through a sluice and the water so collected is used to produce electricity during the low tide. In a two way system power is generated from both the incoming as well as the outgoing tide. In India, the first wave energy project with a capacity of 150 KW, has been set up at Vizhinjam near Thiruvanathapurm. A major tidal wave power project of 50 MW capacity is proposed to be set up in the Hanthal Creek in the Gulf of Kachchh in Gujarat.

Drawbacks: Tidal power stations bring about major ecological changes in the sensitive ecosystem of coastal regions and can destroy the habitats and nesting places of water birds and interfere with fisheries. A tidal power station at the mouth of a river blocks the flow of polluted water into the sea, thereby creating health and pollution hazards in the estuary. Other drawbacks include offshore energy devices posing navigational hazards. Residual drift current could affect spawning of some fish, whose larvae would be carried away from spawning grounds. They may also affect the migration patterns of surface swimming fish.

6. **Geothermal Energy**

Volcanoes, hot springs and geysers and methane under the water in the oceans and seas are sources of geothermal energy. Geothermal means heat from the earth. In some countries, such as in the USA, water is pumped from underground hot water deposits and used to heat people's houses. Hot water and superheated steam of hot springs can be used to generate electricity. In our country there are about 46 hydrothermal areas where the temperature of the spring water exceeds 150°C. The thermal energy of hot springs can be used for generating electricity, heating buildings and homes glass-houses in colder areas for growing vegetables. In India, the North-western Himalayas and the western coast are considered geothermal areas. Satellites like the IRS-1 have played an important role, through infrared photographs of the ground, in locating geothermal areas. The Geological Survey of India has already identified more than 350 hot spring sites, which can be explored as areas to tap geothermal energy. An experimental 1 KW generation project in the Puga valley in the Ladakh region is being used for poultry farming, mushroom cultivation and pashmina-wool processing, all of which need higher temperature.

Geothermal energy is as cheap as hydropower and will thus be increasingly utilised in future. However, water from geothermal reservoirs often contains minerals that are corrosive and polluting. Geothermal fluids are a problem which must be treated before disposal.

7. **Wind Energy**

Wind Energy has been used for hundreds of years for sailing, grinding grain and for irrigation. Wind energy systems convert the kinetic energy associated with the movement of air to more useful forms of power. Wind turbines transform the energy in the wind into mechanical power, which can then be used directly for grinding, lifting water or to generate electricity. Wind turbines can be used singly or in clusters called ‘wind farms’. At present, India is the third largest wind energy producer in the world. The power in wind is a function of the wind speed and therefore the average wind speed of an area is an important determinant of economically feasible power. Wind speed increases with height. At a given turbine site, the power available 30 meters above ground is typically 60 percent greater than at 10 meters.

Over the past two decades, a great deal of technical progress has been made in the design, siting, installation, operation and maintenance of power-producing wind mills (turbines). These improvements have led to higher wind conversion efficiencies and lower electricity production costs.

Environmental Impacts: Wind power has few environmental impacts, as there are virtually no air or water emissions, or radiation, or solid waste production. The principal problems are bird kills, noise, effect on TV reception and aesthetic objections to the sheer number of wind turbines that are required to meet electricity needs. Although large areas of land are required for setting up wind farms, the amount used by the turbine bases, the foundations and the access roads is less than 1% of the total area covered by the wind farm. The rest of the area can also be used for agricultural purposes or for grazing.

Siting windmills offshore reduces their demand for land and visual impact. Siting windmills offshore reduces their demand for land and visual impact. Wind is an intermittent source and the intermittency of wind depends on the geographic distribution of wind. Wind therefore cannot be used as the sole resource for electricity and requires some other backup or stand-by electricity source.

8. **Ocean Thermal Energy (OTE)**

The energy available due to the difference in temperature of water at the surface of the tropical oceans and at deeper levels is called Ocean Thermal Energy.

A difference of 20℃ or more is required between surface water and deep water of ocean for operating OTEC (Ocean Thermal Energy Conversion) power plants. The warm surface water of ocean is used to boil a liquid like ammonia. The high pressure vapours of the liquid formed by boiling are then used to turn the turbine of a generator and produce electricity. The colder water from the deeper oceans is pumped to cool and condense the vapours into liquid. Thus the process keeps on going continuously for 24 hours a day.

India has tremendous potential in non-conventional sources of energy. Our diverse geographical settings help in promotion of non-conventional energy sources of energy namely solar, wind and tidal. Looking at the future potential in generating solar energy, the International Solar Alliance was established in the year 2015. Major initiatives were taken by India for the establishment of this alliance. This would help us in developing clean and green energy that would address the problems emerging due to the use of conventional sources of energy like coal, petroleum and radio-active minerals. Therefore we can say these above mentioned non-conventional sources are the energy of future.

But, today our major energy sources are coal, fossil fuel, natural gas, hydro- power and atomic energy. These sources of energy are known as conventional sources of energy. Let us discuss these sources in detail in the following section.

2.1.2.2 Conventional Energy Sources:

The power production through conventional sources like oil, gas, coal and hydel lags far behind the current demand driven by growth in agriculture industry and the population. India's electricity sector currently faces problems of capacity, distribution losses, poor reliability and frequent blackouts. Indian industry cites power supply as one of the biggest limitations on progress. One government estimate projects 8-10% annual growth in energy demand over the next 15 years if the economy grows as expected in the 7-8% per year range. The shortfall implies greater dependence on international markets.

1. **Oil (Fossil fuel)**

   Petroleum is the lifeline of global economy and is cleaner than coal. There are 13 countries in the world having 67% of the petroleum reserves which together form the OPEC (Organization of Petroleum Exporting Countries). About 1/4th of the oil reserves are in Saudi Arabia.

   At the present rate of usage, the world's crude oil reserves are estimated to get exhausted in just 40 years. Some optimists, however, believe that there are some yet undiscovered reserves. Even then the crude oil reserves will last for another 40 years or so. Crude petroleum is a complex mixture of alkane hydrocarbons. Hence, it has to be purified and refined by the process of fractional distillation, during which process different constituents separate out at different temperatures. We get a large variety of products from this, namely, petroleum gas, kerosene, petrol, diesel, fuel oil, lubricating oil, paraffin wax, asphalt, plastic etc.

Basic steps in harnessing energy from petroleum include exploration of oil resources, drilling of wells, production, storage and transport of crude oil, refining of crude oil, storage and transportation of products. During refining of crude oil, several products are obtained that are used in domestic, transport, industrial and electric power sectors.

Petroleum is a cleaner fuel as compared to coal as it burns completely and leaves no residue. It is also easier to transport and use. That is the reason why petroleum is preferred amongst all the fossil fuels.

Liquefied Petroleum Gas (LPG): The main component of petroleum is butane, the other being propane and ethane. The petroleum gas is easily converted to liquid form under pressure as LPG. It is odourless, but the LPG in our domestic gas cylinders gives a foul smell. This is, in fact, due to ethyl mercaptan, a foul smelling gas, added to LPG so that any leakage of LPG from the cylinder can be detected instantaneously.

Oil fields in India are located at Digboi (Assam), Gujarat Plains and Bombay High, offshore areas in deltaic coasts of Godavari, Krishna, Kaveri and Mahanadi. Oil supplies nearly 30% of India’s energy. Oil consumption in the country was approximately 1.93 million barrels per day (bpd) in 1999 and was about 4.7 million bpd in 2017. In 2017, India imported about 198 million tonnes of crude oil and its products. India draws most of its imports of oil from the Bombay High, Upper Assam, Cambay, Krishna-Godavari and Cauvery basins. Oil reserves are estimated at 4.7 billion barrels. The Bombay High Field, India’s largest producing field, generated 250,000 b/d in 1998 and 210,000 b/d in 1999.

Consumption of petroleum products rose from 57 million tonnes in 1991-1992 to 196 million tonnes in 2016. The India Hydrocarbon Vision 2025 report estimates future refinery demand at 368 million tons by 2025. Thus, India is becoming a major global market for petroleum products.

2. **Natural Gas**

It is mainly composed of methane (95%) with small amounts of propane and ethane. It is a fossil fuel. Natural gas deposits mostly accompany oil deposits because it has been formed by decomposing remains of dead animals and plants buried under the earth. Natural gas is the cleanest fossil fuel. It can be easily transported through pipelines. It has a high calorific value of about 50 kJ/g and burns without any smoke. Currently, the amount of natural gas deposits in the world are of the order of 80,450 g/m^3 . Russia has maximum reserves (40%), followed by Iran (14%) and USA (7%). Natural gas reserves are found in association with all the oil fields in India. Some new gas fields have been found in Tripura, Jaisalmer, off-shore area of Mumbai and the Krishna-Godavari Delta.

Natural gas is used as a domestic and industrial fuel. It is used as a fuel in thermal power plants for generating electricity. It is used as a source of hydrogen gas in fertilizer industry and as a source of carbon in tyre industry.

- **Compressed Natural Gas (CNG):** It is being used as an alternative to petrol and diesel for transport of vehicles. Delhi has totally switched over to CNG where buses and auto-rickshaws run on this new fuel. CNG use has greatly reduced vehicular pollution in the city.
- **Synthetic Natural Gas (SNG):** It is a mixture of carbon monoxide and hydrogen. It is a connecting link between a fossil fuel and substituted natural gas. Low grade coal is initially transformed into synthetic gas by gasification followed by catalytic conversion to methane.

About 7% of India’s energy needs are met by natural gas especially in power generation, fertilizers and petrochemicals production. Natural gas can serve to reduce dependence on foreign oil. Absence of sulphur dioxide and reduced levels of carbon dioxide and nitrogen oxide are major environmental benefits of using natural gas. Currently, India’s natural gas consumption is 50 billion cubic metres (bcm) and is mostly met by domestic production. In 2017, India imported 27,570 million cubic metres of natural gas.

3. **Coal (Fossil Fuel)**

India depends on coal for more than half of its total energy needs. Nearly three quarters of the country’s electricity and 63% of commercial energy comes from coal. India has huge coal reserves accounting for 8% of the world's total. It is the third leading coal producer in the world after China and the United States. Most of its coal demand is satisfied through domestic production with the only exception being coking coal that is in short supply. Despite India's wealth in coal reserves, only about 3% is coking coal so India's steel industry must import coking coal to meet about 25% of its annual needs.

Coal and its environmental impacts: Coal is the world's single largest contributor of greenhouse gases and is one of the most important causes of global warming. Many coal-based power generation plants are not fitted with devices such as electrostatic precipitators to reduce emissions of suspended particulate matter (SPM) which is a major contributor to air pollution. Burning coal also produces oxides of sulphur and nitrogen which, combined with water vapour, lead to 'acid rain'. This kills forest vegetation and damages architectural heritage sites, pollutes water and affects human health. Thermal power stations that use coal produce waste in the form of 'fly ash'. Large dumps are required to dispose off this waste material, while efforts have been made to use it for making bricks. The transport of large quantities of fly ash and its eventual dumping are costs that have to be included in calculating the cost-benefits of thermal power.

4. **Hydro Power**

Hydro power is the cheapest and cleanest and, hence, regarded the best source of energy. This uses water flowing down a natural gradient to turn turbines to generate electricity known as 'hydroelectric power' by constructing dams across rivers. Between 1950 and 1970, hydropower generation worldwide increased seven times. The long life of hydropower plants, the renewable nature of the energy source, very low operating and maintenance costs and absence of inflationary pressures as in fossil fuels, are some of its advantages. However, obtaining electricity from mega dams has given rise to many controversies in recent times and small hydro power plants are emerging as viable alternatives. These plants serve the energy needs of remote and rural areas where the grid supply is not available.

Drawbacks: Although hydroelectric power has led to economic progress around the world, it has created serious ecological problems.

- To produce hydroelectric power, large areas of forest and agricultural lands are submerged. These lands traditionally provided livelihood for local tribal people and farmers. Conflicts over land use are inevitable.
- Silting of the reservoirs (especially as a result of deforestation) reduces the life of the hydroelectric power installations. Water is required for many other purposes besides power generation. These include domestic requirements, growing agricultural crops and for industry. This gives rise to conflicts.
- The use of rivers for navigation and fisheries becomes difficult once the water is dammed for generation of electricity.
- Resettlement of displaced persons is a problem for which there is no ready solution. The opposition to many large hydroelectric schemes is growing as most dam projects have been unable to resettle people that were affected and displaced.
- In certain regions large dams can induce seismic activity which will result in earthquakes. There is a great possibility of this occurring around the Tehri dam in the Himalayan foothills. Shri Sunderlal Bahuguna, the initiator of the Chipko Movement has fought against the Tehri Dam for several years. With large dams causing social problems has been a trend to develop small hydroelectric generation units. Multiple small dams have less impact on the environment. China has the largest number of these - 60,000, generating 13,250 megawatts, i.e. 30% of China’s electricity. Sweden, the US, Italy and France also have developed small dams for electrical power generation. The development of small hydroelectric power units could become a very important resource in India, which has steeply falling rivers and the economic capability and technical resources to exploit them.

5. **Nuclear Energy**

In 1938 two German scientists Otto Hahn and Fritz Strassman demonstrated nuclear fission. They found they could split the nucleus of a uranium atom by bombarding it with neutrons. As the nucleus split, some mass was converted to energy. The nuclear power industry however was born in the late 1950s. The first large-scale nuclear power plant in the world became operational in 1957 in Pennsylvania, US. Dr. Homi Bhabha was the father of Nuclear Power development in India. The Bhabha Atomic Research Center in

Mumbai studies and develops modern nuclear technology. India has 22 nuclear reactors at 7 nuclear power stations that produce 3.22% of India's electricity. These are located in Maharashtra (Tarapur), Rajasthan, Karnataka (Kaiga), Uttar Pradesh, Gujarat and Tamil Nadu. India gets uranium from mines in Bihar. There are deposits of thorium in Kerala and Tamil Nadu. The nuclear reactors use Uranium 235 to produce electricity. Energy released from 1kg of Uranium 235 is equivalent to that produced by burning 3,000 tons of coal. U235 is made into rods which are fitted into a nuclear reactor. The control rods absorb neutrons and thus adjust the fission which releases energy due to the chain reaction in a reactor unit. The heat energy produced in the reaction is used to heat water and produce steam, which drives turbines that produce electricity.

The drawback is that the rods need to be changed periodically. This has impacts on the environment due to disposal of nuclear waste. The reaction releases very hot waste water that damages aquatic ecosystems, even though it is cooled by a water system before it is released. The disposal of nuclear waste is becoming an increasingly serious issue. The cost of Nuclear Power generation must include the high cost of disposal of its waste and the decommissioning of old plants. These have high economic as well as ecological costs that are not taken into account when developing new nuclear installations.

Although the conventional environmental impacts from nuclear power are negligible, what overshadows all the other types of energy sources is that an accident can be devastating and the effects last for long periods of time. While it does not pollute air or water routinely like oil or biomass, a single accident can kill thousands of people, make many others seriously ill and destroy an area for decades by its radioactivity which leads to death, cancer and genetic deformities. Land, water, vegetation are destroyed for long periods of time. Management, storage and disposal of radioactive wastes resulting from nuclear power generation are the biggest expenses of the nuclear power industry. There have been nuclear accidents at Chernobyl in USSR and at the Three Mile Island in USA. The radioactivity unleashed by such an accident can affect mankind for generations.

2.1.2.3 Future Energy Needs and Conservation:

Energy is an essential input for industrial development. Energy is produced from commercial sources like coal, petroleum, hydroelectric schemes as well as from non-commercial sources like cow dung, fuel wood and agricultural wastes. Per capita consumption of commercial energy is sometimes used as an index of the economic advancement that a country has attained. India's per capita consumption of commercial energy, however, is very low. It is only one eighth of the world average.

Commercial energy accounts for a little over half of the total energy used in the country, the rest coming from non-commercial sources. Share of agriculture in commercial energy consumption has risen rapidly over the past two-and-a-half decades. Industry consumed about 78 percent of the coal and 62 percent of the electrical energy in the country in 1985-86. The transport sector accounted for 56 percent of the total oil consumption during the year 1989. The energy consumption of these sectors as well as the household sector are increasing rapidly. The energy strategy, therefore, has to plan not only for an increase in indigenous availability but also aim at its efficient utilization.

Environmental Conservation and Energy:

Energy generation and environmental conservation are the twin issues arising from exploitative interaction of humans with natural resources. Excessive utilisation of coal and oil for generation of electricity leads to the multiple problems of acid rain and rising carbon dioxide levels in the atmosphere. Huge dams can make substantial contributions to economic development in electricity in developing countries like India, but as in any large-scale electricity generating option, there are trade-offs. Reservoirs inundate forests, farmland and wildlife habitats and uproot entire communities of indigenous people.

The answer to the country's energy needs can only lie in adopting non- conventional sources of energy. A beginning is being made by Government of India to give the same type of resources and support to developing alternative sources of energy as have so far been extended to the development of conventional energy sources.

Following are some of the important means of energy conservation through the incorporation of innovative and imaginative alternatives within conventional rural agricultural technologies.

(a) Improved Chullahas: In developing countries like India, the energy needs of rural poor are mostly met with by burning firewood. Traditional methods of cooking are very unhealthy for the cook, as they emit a lot of smoke. Also the heat released in burning is not efficiently utilised. Indian energy scientists have come up with smokeless stoves (chulhas) specially designed for Indian conditions. These ‘Chulhas’ are smokeless, permit shorter cooking time and there is also saving of fuel. The improved ‘chulha’ has invoked tremendous response and positive action from all concerned. Nearly 3,000 villages have been rendered ‘smokeless’ in the sense that in each house of these villages, either an improved ‘chulha’ or a biogas plant is used for cooking food. A trained work force of more than 50,000 persons, mainly women, was created to work as master craftsmen for constructing the improved chulhas.

In India, the overall renewable energy capacity targets have been raised from 35,776 MW in 2015 to 1,75,000 MW by 2022 (MOEF & CC, 2015). This comprises of 1,00,000 MW solar, 60,000 MW wind, 10,000 MW Biomass and 50,000 MW.

(b) Energy from City Sewage: The city sewage treatment plants use anaerobic digestion units for extracting methane from human night soil which is in the form of a sludge. The gas generated from the sludge is called sludge gas, which like biogas consists largely of methane. The Department of Non-Conventional Energy Sources has supported setting up sewage based biogas plants in Uttar Pradesh, MadhyaPradesh and Delhi.

One large size urban waste recycling plant is already operating at Okhla, Delhi. The gas is being supplied to about 800 households over an area of four kilometers. The gas is about 50 percent cheaper than the LPG gas. Another such project has been commissioned, recently at Pandraune in UP. Plants are under construction at Ayodhya in UP, Eshaopur in Delhi and at Bhopal in MP. In Jabalpur, Municipal Corporation is setting up a garbage-based power plant to generate 7 MW electricity daily.

Many bio-organic wastes are released as by-products by distilleries in India. A new technology for waste recycling and disposal has been introduced for the first time in the country by a distillery in Gujarat. The technology, simultaneous with the treatment of 45,000 litres of waste, will generate energy equivalent to that given by 10 tonnes of coal every day. The fuel is generated from the waste after fermenting the ash with yeast in a suitable culture medium. The 10 million litre capacity distillery can get 50 percent of its fuel requirement from recycling its own waste. If all the 150 distilleries in the country adopt the technology there could be a saving of Rs 30 crores or 5,00,000 tonnes of coal annually. This will also result in an environmentally safe disposal of wastes.

(c) Solar Energy: Biogas is a cheap and efficient fuel and its feedstock is renewable. More recently, other renewable sources for energy generation are being explored. Systematic efforts are being made to tap solar energy for meeting the demands of our rural poor. It is a decentralised energy system, which can be used to meet versatile needs of the Indian masses. Solar cooking, water heating, water desalination, space heating, crop drying, etc. are some of the modes of thermal conversion. Efforts are onto economically develop solar collectors for high temperature applications. More than 380 solar water heating systems are operating in the country. More than 1,000 large capacity water heating systems are under installation.

Solar energy can also be converted into electrical energy. This electricity can be used to run pumps, streetlighting system or even refrigerators. More than 160 solar photovoltaic pumps have been installed in the rural areas providing water for drinking and irrigation. Solar photovoltaic street lighting systems have been provided by Government of India in more than 150 villages on experimental basis. Installed in the remote villages, also known as Urjagrams, far from power lines, solar energy makes electricity available to people who would otherwise not be able to dream of thermal or hydel electrical energy.

(d) Wind Energy: Another renewable alternative source of energy is wind energy. Wind energy holds promise for systematic utilization. It can be converted into mechanical and electrical energies and would be particularly useful in remote areas. Wind energy can be made to run turbine to generate electricity. At present this energy is being used to upwell ground water at four locations of Ajmer in Rajasthan.

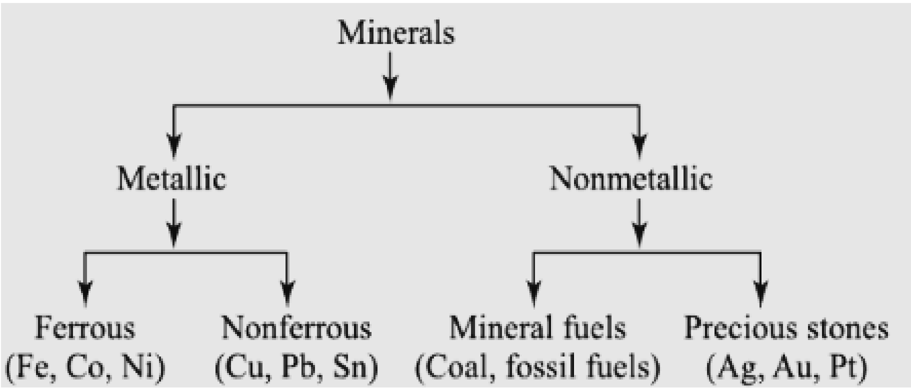
DNES has installed 924 wind pumps throughout the country. Wind electricity generators at appropriate locations (like Ladakh) are envisaged with aggregate capacity of 2 MW, for lighting and pumping water in addition to devising charging of batteries.

It is easy to waste energy but cheaper to save it than generate it. We can conserve energy by preventing or reducing waste of energy and by using resources more efficiently. People waste energy because government subsidises it. If the real cost was levied, people would not be able to afford to waste it carelessly.

2.1.3 Mineral Resources

A mineral is a naturally occurring substance of definite chemical composition and identifiable physical properties. An ore is a mineral or combination of minerals from which a useful substance, such as a metal, can be extracted and used to manufacture a useful product.

Minerals are formed over a period of millions of years in the earth's crust. Iron, aluminum, zinc, manganese and copper are important raw materials for industrial use. Important non-metal resources include coal, salt, clay, cement and silica. Stone used for building material, such as granite, marble, limestone, constitute another category of minerals. Minerals with special properties that humans value for their aesthetic and ornamental value are gems such as diamonds, emeralds, rubies. The luster of gold, silver and platinum is used for ornaments. Minerals in the form of oil, gas and coal were formed when ancient plants and animals were converted into underground fossil fuels.



Classification of Minerals

2.1.3.1 Mineral Resource of India

India produces and works with roughly 100 minerals, which are an important source for earning foreign exchange as well as satisfying domestic needs.

We import mercury, graphite, cobalt etc. and export iron ore, granite, bauxite, titanium manganese etc. The distribution of minerals in the country is uneven and mineral density varies from region to region.

Coal, iron ore, manganese, mica, bauxite, copper etc. are found in the North-Eastern peninsular belt located in Chhotanagpur Plateau and the Orissa Plateau covering the state of Jharkhand, West Bengal and Orissa. These regions are called the mineral heartland of India.

Gems, marble, coal, mica, graphite, manganese etc. exist in large quantities in Central Belt located in Chhatisgarh andhra Pradesh, Madhya Pradesh and Maharashtra. The central belt is the second largest mineral belt in the country.

2.1.3.2 Mineral Extraction

Minerals and their ores need to be extracted from the earth's interior so that they can be used. This process is known as mining. Mining operations generally progress through four stages:

a) Prospecting: Searching for minerals.
b) Exploration: Assessing the size, shape, location and economic value of the deposit.
c) Development: Work of preparing access to the deposit so that the minerals can be extracted from it.
d) Exploitation: Extracting the minerals from the mines.

In the past, mineral deposits were discovered by prospectors in areas where mineral deposits in the form of veins were exposed on the surface. Today, however, prospecting and exploration is done by teams of geologists, mining engineers, geophysicists and geochemists who work together to discover new deposits. Modern prospecting methods include the use of sophisticated instruments like GIS to survey and study the geology of the area.

The method of mining has to be determined depending on whether the ore or mineral deposit is nearer the surface or deep within the earth. The topography of the region and the physical nature of the ore deposit is studied.

Mines are of two types – surface (open cut or strip mines) or deep or shaft mines. Coal, metals and non-metalliferous minerals are all mined differently depending on the above criteria. The method chosen for mining will ultimately depend on how maximum yield may be obtained under existing conditions at a minimum cost, with the least danger to the mining personnel.

Most minerals need to be processed before they become usable. Thus 'technology' is dependent on both the presence of resources and the energy necessary to make them 'usable'.

2.1.3.3 Mine safety:

Mining is a hazardous occupation and the safety of mine workers is an important environmental consideration of the industry. Surface mining is less hazardous than underground mining. Metal mining is less hazardous than coal mining. In all underground mines, rock and roof falls, flooding and inadequate ventilation are the greatest hazards. Large explosions have occurred in coal mines, killing many miners. More miners have suffered from disasters due to the use of explosives in metal mines.

Mining poses several long-term occupational hazards to the miners. Dust produced during mining operations is injurious to health and causes a lung disease known as black lung, or pneumoconiosis. Fumes generated by incomplete dynamite explosions are extremely poisonous. Methane gas, emanating from coal strata, is hazardous to health although not poisonous in the concentrations usually encountered in mine air. Radiation is a hazard in uranium mines.

2.1.3.4 Environmental Problems:

Mining operations are considered one of the main sources of environmental degradation. The extraction of all these products from the lithosphere has a variety of side effects. Depletion of available land due to mining, waste from industries, conversion of land to industry and pollution of land, water and air by industrial wastes, are environmental side effects of the use of these non-renewable resources. Public awareness of this problem is of a global nature and government actions to stem the damage to the natural environment have led to numerous international agreements and laws directed toward the prevention of activities and events that may adversely affect the environment.

2.1.4 Forest Resources

Forests are our treasures which provide us a wide variety of commodities such as timber, fuel wood, fodder, fibers, fruits, herbal drugs, cosmetics and many types of raw materials used by the industries. A great variety of mammals and birds which live in the forests, serve as useful living resources. Forests play a great role in soil formation, water conservation and regenerating of oxygen. Trees fix CO_2 in their biomass and through transpiration (loss of moisture to atmosphere) they moderate the climate. Can you imagine what would happen if forest does not exist in the world. As mentioned above, it performs certain functions which can be directly observed. But there are certain functions which cannot be directly observed like purification of air, carbon sink etc. Broadly, all the above mentioned functions performed by the forest can be categorized under three major headings: economic, ecological and social.

- **Economic Significance:** Forest is one of the largest available renewable resources on the planet earth. It provides a wide variety of goods and services which include food, fodder and fuel. Wood is used for making houses, furniture, matches, ploughs, bridges and boats. Forest products such as tannins, gums, spices, waxes, honey, musk and hides are all provided by the flora and fauna of forests. Fruits, leaves, roots and tubers of plants form the food of forest tribes. Wood and bamboo pulp are used for manufacturing paper and rayon. The flora and fauna of the forest also holds the key to numerous life sustaining products such as pharmaceuticals, insecticides and pesticides. These substances should be harvested sustainably so that it could enhance the long term resource value of the forest.
- **Ecological Significance:** As mentioned above forest performs certain function like moderation of global climate, supporting natural ecological systems and processes. Let us discuss them in detail:

  - Moderation of global climate**:** Forests stabilize global climate in a significant manner by influencing natural cycles such as hydrological and carbon cycles. You might have read about these cycles when you were in school. As you know, spatial as well as temporal patterns of rainfall are greatly influenced by forest. How much of water is retained in the soil and how much flows away, sometime causing floods, also depends on tree cover. Similarly forest can also influence the atmospheric carbon dioxide level. Tree biomass holds carbon dioxide in a fixed state. Therefore, forest acts as a major source of carbon sink i.e. ability to absorb carbon dioxide from the atmosphere. In other words, a carbon sink is a natural or artificial reservoir that accumulates and stores some carbon-containing chemical compound for an indefinite period. When wood is burnt CO_2 is released in the atmosphere. This has a direct impact on the extent of greenhouse effect and global warming. In other words, more forests lead to greater removal of atmospheric carbon dioxide during photosynthesis resulting reduction of the greenhouse gases in the atmosphere. Therefore, large-scale afforestation has been adopted as a measure to reduce greenhouse effect.

- Protection of biodiversity**:** Forests are the greatest repository of biodiversity on the land as they provide ideal conditions for the survival and growth of living organisms. The number of species per unit area is much greater in a forest than in any other terrestrial ecosystem. For example, the tropical rainforest covers less than 7% of the earth's land surface but accounts for more than 50% of all known species. About 62% of all known plants are found in these rainforests. That is why there has been a growing campaign for saving the rain forest in Amazon and Nile basin. The growing awareness about the importance and necessity to conserve biodiversity is helping human being to realise the significance of forest. Do you think this awareness or campaign is sufficient to protect rain forest? Think about it.
- Supporting natural ecological systems and processes**:** As mentioned earlier forests perform certain activities which are crucial for supporting ecological systems and processes directly. Some of these functions and processes are as follows:

  Forests check the soil erosion by preventing the action of winds and water thereby preserves the fertile top soil.

  - It prevents landslides and reduces the intensity of cyclones and floods.
  - By preventing soil erosion, forests reduce silting of water bodies including reservoirs.
  - Forest improves air quality by absorbing toxic gases and particulate matter.
  - It protect watersheds and ensure perennial supplies of fresh water.

- **Socio-cultural significance**: As mentioned in the introduction, forests have been part of our social and cultural ethos since the inception of civilization. We find signs of such cultural bonds even in today's modern and materialistic life. This is largely because forests have significant aesthetic, recreational and spiritual value.

2.1.4.1 Deforestation- Causes and Consequences

Deforestation refers to the permanent removal or destruction of indigenous forests. Today, it has been roughly estimated that the indigenous forest cover constitutes 21% of the earth's land surface. According to the World Resources Institute, deforestation is regarded as one of the world's most pressing land- use problems. Another major concern is the rate at which deforestation is occurring. Currently, 12 million hectares of forests are cleared annually.

Almost all of this deforestation occurs in the moist forests and open woodlands of the tropics. It has been predicted that if deforestation continues at this rate then all the moist tropical forest could be lost by the year 2050, except for isolated areas in the Amazon and the Zaire basin, as well as a few protected areas within reserves and parks.

In India, forests cover 24.39 percent of the total geographical area. However, it is assessed that the country needs 33% of its area under forests to meet the ecological and economic needs.

Causes of Deforestation

Let us discuss some of the major causes of deforestation all over the world in general and India in specific.

- Population Explosion: Increasing human population is one of the major causes of deforestation. It poses a major threat to the environment. Vast areas of forest land are cleared to reclaim land for expansion of farming land, mining activities, creation of new and expansion of existing human settlements and development of infrastructure like roads and railway tracks. Growth of population increases the demand for forest products like timber, firewood, paper and other valuable products of importance, all necessitating felling of trees.
- Forest Fires: This is also another major cause of deforestation. Forest fires occur either naturally or are human induced. Some of the major causes of forest fires are as follows:
- Dry humus and organic matter forming a thick cover over the forest floor provides ideal condition for ground or carelessly surface fires. Throwing burning cigarette stubs on dried foliage can light a fire.
- Crown fire takes place in densely populated forests where tree tops may catch fire by heat produced by the constant rubbing against each other.

- Fire destroys fully grown trees, results in killing and scorching of the seeds, humus, ground flora and animal life.
- Overgrazing**:** Trampling of the forest soil in the course of overgrazing by livestock has far reaching effects such as loss of porosity of soil, soil erosion and desertification reduced productivity of the previously fertile forest area.
- Shifting cultivation: There are an estimated 300 million people living as shifting cultivators who practice slash and burn agriculture and are supposed to clear more than 5 lakh ha of forests for shifting cultivation annually. In India, we have this practice in North-east and to some extent in Andhra Pradesh, Bihar and M.P. which contribute to nearly half of the forest clearing annually.
- Raw material for industrial use: Wood for making boxes, furniture, railway-sleepers, plywood, match-boxes, pulp for paper industry etc. have exerted tremendous pressure on forests. Plywood is in great demand for packing tea for Tea industry of Assam while fir tree wood is exploited greatly for packing apples in J&K.
- Development Projects: Massive destruction of forests occurs for various development projects like hydroelectric projects, big dams, mining etc.
- Pest Attacks: Pests destroy trees by eating up the leaves, boring into shoots and by spreading diseases.

Consequences of Deforestation

Forests are closely related with climate, biological diversity, wild animals, crops and medicinal plants. Large scale deforestation has far-reaching consequences:

- Habitat destruction of wild animals. Tree-using animals are deprived of food and shelter.
- Increased soil erosion due to reduction of vegetation cover.
- Reduction in the oxygen liberated by plants through photosynthesis.
- Increase in pollution due to burning of wood and due to reduction in carbon dioxide fixation by plants.
- Decrease in availability of forest products.
- Loss of plant, animal and microbial diversity.

- Scarcity of fuel wood and deterioration in economy and quality of life of people residing near forests.
- Lowering of the water table due to more run-off and resultant increased use of the underground water.
- Rise in carbon dioxide level in the air due to burning of vegetation has caused global warming resulting in melting of ice caps and glaciers and consequent flooding of coastal areas.

2.1.4.2 Impact of mining and dam building on environment, forest and biodiversity

Timber extraction, mining and construction of dams are invariably parts of the needs of a developing country like India. Unfortunately forests are located in areas where there are rich mineral resources. Mineral based industries like iron and steel, alumina refineries etc. are also located in these areas. Out of the top mineral producing districts in the country, almost half of the districts are predominantly tribal dominated. The average forest cover in these districts is 28 percent, much more than the national average of 20.9 percent (Centre for Science and Environment, 2008). Forests also cover the steep embankments of river valleys, which are ideally suited to develop hydel and irrigation projects. Thus, there is a constant conflict of interest between conservation and development. What needs to be understood is that long-term ecological gains cannot be sacrificed for short-term economic gains that unfortunately lead to deforestation. These forests where development projects are planned can displace thousands of tribal people who lose their homes when these plans are executed.

Floods, droughts and landslides become more prevalent in such areas. Forests are the repositories of invaluable gifts of nature in the form of biodiversity and by destroying them, we are going to lose these species even before knowing their significance as well as benefits. These species could be having marvelous economic or medicinal value and deforestation results in loss of this storehouse of species which have evolved over millions of years in a single stroke.

2.1.4.3 Effect on tribal population and their rights

Poverty amidst plenty, nature is bountiful but tribals are poor. This statement explains the conditions of majority of tribal population in our country. Tribal dominated areas of the country have rich forest cover, mineral bearing areas and significant number of watersheds of key rivers. Forest provides food, medicine and other products needed for tribal people and plays a vital role in the life and economy of tribes living in the forest. As mentioned in the previous section, due to developmental activities like construction of dams, mining, establishment of mineral based industries etc. alienated tribal people from their own land. This alienation deprived them from their livelihoods. Most of them are dependent upon natural resources based informal economy. Their natural resource based informal economy is mostly dependent on agriculture, both settled and jhum methods and on the other non-timber forest product (NTFP) such as medicinal herbs, edible flowers, leaves and fruits. They also get their small timber and firewood from the forest. Hence development is bound to affect their agricultural and forest land which is the primary source of their livelihood. The development process pushes them from an informal to a formal economy that is new to them without any preparation. They had depended on agricultural land and forests, both of which they loose to the project. When they receive compensation it is monetary with which most communities living in the informal economy are nor familiar. As mentioned above in most cases the Common Property Resources are not compensated. Therefore, there was a need to address these problems. Government of India passed an act in the Parliament titled 'The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006' to address this anomaly.

2.1.4.4 Conservation and management of forest resources

As a result of increased exploitation of forests for timber, firewood and other forest products, without putting in adequate efforts to regenerate them, the forests are known to be fast disappearing. This has caused an environmental imbalance. For example, most of the rainwater is lost as runoff which flows over the mountain slopes unchecked often causing floods. The excessive washing away of top soil results in low fertility and reduces crop yields. It is because of these consequences of deforestation, a strong forest policy has been adopted by our Indian Government to protect forests and to plant more trees. Some of the conservation measures practiced in India and other parts of the world are as follows:

1. **Increase in area of forest plantation:** The Tree plantation can be raised in vacant or unused lands and waste, degraded and marginal lands, especially on road side, along railway tracts, on contours and on land not suited for agricultural production. Planting trees outside forest areas will reduce pressure on forests for timber, fodder and fuel wood. Apart from this, the deforested areas need to be reforested.
2. **Developing alternative sources and promoting the substitutes:** It has become necessary to find alternative fuels as well as raw materials to manufacture paper, sports goods, packing cases, furniture and beams used in buildings. Research is going on to develop alternate sources; in some cases, plastics and composite materials have been successful in replacing the use of timber.
3. **Increase the area of forest permanently reserved for timber production:** The most serious impediment to sustainable forest management is the lack of dedicated forests specifically set aside for timber production. If the forest does not have a dedicated long-term tenure for timber production then there is no incentive to care for the long- term interests of the forest. FAO (2001) found that 89 percent of forests in industrialized countries were under some form of management but only about six percent were in developing countries. If 20 percent could be set aside, not only could timber demand be sustainably met but buffer zones could be established to consolidate the protected areas.
4. **Adoption and promotion of sustainable management of forest:** Achieving ecological sustainability means that the ecological values of the forest must not be degraded and if possible they should be improved.
5. This means that **silviculture** and management should not reduce biodiversity, soil erosion should be controlled, soil fertility should not be lost, water quality on and off site should be maintained and that forest health and vitality should be safeguarded. However, management for environmental services alone is not economically and socially sustainable. It will not happen until or unless the developing nations have reached a stage of development and affluence so that they can accommodate the costs of doing so. There are vast areas of

unused land some of which is degraded and of low fertility. Technological advances are being made to bring this land back into production. This should be a major priority since a significant proportion of cleared tropical forest will eventually end up as degraded land of low fertility.

6. **Developing a reliable mechanism of information base and regular monitoring**: Knowledge of how much forest, where it is and what it is comprised of seems to be straightforward. However, surprisingly, this most basic information is not always available. It is not possible to properly manage a forest ecosystem without first understanding it. Remote sensing technologies make it feasible and affordable to identify hotspots of deforestation. The international community could undertake monitoring efforts that would have immediate payoffs. The priority is to fund and coordinate basic monitoring on the rate, location and causes of global deforestation and forest poverty along with the impacts of project and policy interventions.
7. **Establishing an effective system of fighting forest fires:** In order to save forests from fire, it is necessary to adopt latest techniques of fire fighting. Some of the fire suppression techniques are to develop three meter wide fire lanes around the periphery of the fire, back fires, arrangement of water spray, fire retardant chemicals should be sprayed from back tank and if possible by helicopters. There must be trained staff of fire fighters to control the fire.
8. **Strictly enforcing laws to deal with unauthorized cutting of trees:** In many countries the contrast between what forestry law prescribes and what actually happens on the ground is both stark and obvious. Even where the law is strong, illegal behavior by both public and private actors often continues. Some explanations for this are that forest departments lack the financial and human resources to monitor and control forest activities, which often take place in very remote areas; government officials entrusted with enforcing the law may be under immense pressure to condone violations, or engage in violations themselves; court systems are backlogged or bankrupt; the difficulties of daily life for the rural poor may overwhelm any likely risks associated with violating the law; etc.
9. **Promoting agro-forestry and social forestry**: Rural people partly meet their needs for fire wood and small timber by growing fast growing trees planted within the limits of their

village, along the footpaths, roadsides, alongside railway tracks, side roads or canals and streams, boundaries of fields and empty spaces. The aim of social forestry is to meet the needs of fuel, fodder, fruits, timber and other requirements of local people.

10. **Participatory forest management and rights:** All stakeholders with an interest in the fate of the forest should be involved in planning, management and benefit sharing. The balance of rights can be tilted strongly toward society in the form of publicly owned strictly protected areas. State ownership and management can be retained but with sustainable timber extraction allowed. As of now much of the world's tropical forest are state owned but community participation in forest ownership and management needs to be encouraged. Land reform is essential in order to address the problem of deforestation. However an enduring shift in favour of the peasants is also needed for such reforms to endure. Moreover the rights of indigenous forest dwellers and others who depend on intact forests must be upheld. Therefore, the recognition of traditional laws of the indigenous peoples as indigenous rights will address the conflicts between customary and statutory laws and regulations related to forest ownership and natural resource use while ensuring conservation of forest resources. Keeping this in view various state governments in India has been implementing Joint Forest Management Programme after successful implementation in West Bengal and Haryana in 1970's.

2.1.5 Food Resources

Today our food comes almost entirely from agriculture, animal husbandry and fishing. Although India is self-sufficient in food production, it is only because of modern patterns of agriculture that are unsustainable and which pollute our environment with excessive use of fertilizers and pesticides.

The FAO defines sustainable agriculture as that which conserves land, water and plant and animal genetic resources, does not degrade the environment and is economically viable and socially acceptable. Most of our large farms grow single crops (monoculture). If this crop is hit by a pest, the entire crop can be devastated, leaving the farmer with no income during the year. On the other hand, if the farmer uses traditional varieties and grows several different crops, the chance of complete failure is lowered considerably. Many studies have shown that one can use alternatives to inorganic fertilizer and pesticides. This is known as Integrated Crop Management.

2.1.5.1 World Food Problems

In many developing countries where populations are expanding rapidly, the production of food is unable to keep pace with the growing demand. Food production in 64 of the 105 developing countries is lagging behind their population growth levels. These countries are unable to produce more food, or do not have the financial means to import it. India is one of the countries that have been able to produce enough food by cultivating a large proportion of its arable land through irrigation. The Green Revolution of the 60's reduced starvation in the country. However many of the technologies we have used to achieve this are now being questioned.

- Our fertile soils are being exploited faster than they can recuperate.
- Forests, grasslands and wetlands have been converted to agricultural use, which has led to serious ecological questions.
- Our fish resources, both marine and inland, show evidence of exhaustion.
- There are great disparities in the availability of nutritious food. Some communities such as tribal people still face serious food problems leading to malnutrition especially among women and children.

These issues bring in new questions as to how demands will be met in future even with a slowing of population growth. Today the world is seeing a changing trend in dietary habits. As living standards are improving, people are eating more non-vegetarian food. As people change from eating grain to meat, the world's demand for feed for livestock based on agriculture increases as well. This uses more land per unit of food produced and the result is that the world's poor do not get enough to eat.

Women play an extremely vital role in food production as well as cooking the meal and feeding children. In most rural communities they have the least exposure to technical training and to health workers trained in teaching/learning on issues related to nutritional aspects.

Women and girls frequently receive less food than the men. These disparities need to be corrected.

In India there is a shortage of cultivable productive land. Thus farm sizes are too small to support a family on farm produce alone. With each generation, farms are being subdivided further.

Poor environmental agricultural practices such as slash and burn, shifting cultivation, or ‘rab’ (wood ash) cultivation degrade forests.

Globally, 5 to 7 million hectares of farmland is degraded each year. Loss of nutrients and overuse of agricultural chemicals are major factors in land degradation. Water scarcity is an important aspect of poor agricultural outputs. Salinization and water logging has affected a large amount of agricultural land worldwide.

Loss of genetic diversity in crop plants is another issue that is leading to a fall in agricultural pro- duce. Rice, wheat and corn are the staple foods of two thirds of the world’s people. As wild relatives of crop plants in the world’s grasslands, wetlands and other natural habitats are being lost, the ability to enhance traits that are resistant to diseases, salinity, etc. is lost. Genetic engineering is an untried and risky alternative to traditional cross breeding.

2.1.5.2 Food Security

It is estimated that 18 million people worldwide, most of whom are children, die each year due to starvation or malnutrition and many others suffer a variety of dietary deficiencies.

The earth can only supply a limited amount of food. If the world’s carrying capacity to produce food cannot meet the needs of a growing population, anarchy and conflict will follow. Thus food security is closely linked with population control through the family welfare program. It is also linked to the availability of water for farming. Food security is only possible if food is equitably distributed to all. Many of us waste a large amount of food carelessly. This eventually places great stress on our environmental resources.

A major concern is the support needed for small farmers so that they remain farmers rather than shifting to urban centers as unskilled industrial workers. International trade policies in regard to an improved flow of food across national borders from those who have surplus to those who have a deficit in the developing world is another issue that is a concern for planners who deal with International trade concerns. 'Dumping' of underpriced foodstuffs produced in the developed world, onto markets in undeveloped countries undermines prices and forces farmers there to adopt unsustainable practices to compete.

2.1.5.3 Fisheries

Fish is an important protein food in many parts of the world. This includes marine and fresh water fish. While the supply of food from fisheries increased phenomenally between 1950 and 1990, in several parts of the world fish catch has since dropped due to overfishing. In 1995 FAO reported that 44% of the world's fisheries are fully or heavily exploited, 16% are already overexploited, 6% are depleted and only 3% are gradually recovering. Canada had to virtually close down cod fishing in the 1990s due to depletion of fish reserves.

Modern fishing technologies using mechanized trawlers and small meshed nets lead directly to overexploitation, which is not sustainable. It is evident that fish have to breed successfully and need to have time to grow if the yield has to be used sustainably. The worst hit are the small traditional fishermen who are no match for organized trawlers.

2.1.5.4 Loss of Genetic diversity

There are 50,000 known edible plants documented worldwide. Of these only 15 varieties produce 90% of the world's food. Modern agricultural practices have resulted in a serious loss of genetic variability of crops. India's distinctive traditional varieties of rice alone are said to have numbered between 30 and 50 thousand. Most of these have been lost to the farmer during the last few decades as multinational seed companies push a few commercial types. This creates a risk to our food security, as farmers can loose all their produce due to a rapidly spreading disease. A cereal that has multiple varieties growing in different locations does not permit the rapid spread of a disease.

The most effective method to introduce desirable traits into crops is by using characteristics found in the wild relatives of crop plants. As the wilderness shrinks, these varieties are rapidly disappearing. Once they are lost, their desirable characteristics cannot be introduced when found necessary in future. Ensuring long-term food security may depend on conserving wild relatives of crop plants in National Parks and Wildlife Sanctuaries.

If plant genetic losses worldwide are not slowed down, some estimates show that as many as 60,000 plant species, which accounts for 25% of the world's total, will be lost by the year 2025. The most economical way to prevent this is by expanding the network and coverage of our Protected Areas. Collections in germplasm, seed banks and tissue culture facilities, are other possible ways to prevent extinction but are extremely expensive.

Scientists now believe that the world will soon need a second green revolution to meet our future demands of food based on a new ethic of land and water management that must be based on values which include environmental sensitivity, equity, biodiversity conservation of cultivars and in-situ preservation of wild relatives of crop plants. This must not only provide food for all, but also work out more equitable distribution of both food and water, reduce agricultural dependence on the use of fertilizers and pesticides (which have long term ill effects on human wellbeing) and provide an increasing support for preserving wild relatives of crop plants in Protected Areas. Pollution of water sources, land degradation and desertification must be rapidly reversed. Adopting soil conservation measures, using appropriate farming techniques, especially on hill slopes, enhancing the soil with organic matter, rotating crops and managing watersheds at the micro level are a key to agricultural production to meet future needs. Most importantly food supply is closely linked to the effectiveness of population control programs worldwide. The world needs better and sustainable methods of food production which is an important aspect of landuse management.

2.1.5.5 Alternate Food Sources

Food can be innovatively produced if we break out of the current agricultural patterns. This includes working on new avenues to produce food, such as using forests for their multiple non-wood forest products, which can be used for food if harvested sustainably. This includes fruit, mush- rooms, sap, gum, etc. This takes time, as people must develop a taste for these new foods. Medicines, both traditional and modern, can be harvested sustainably from forests.

Madagascar's Rosy Periwinkle used for childhood leukemia and *Taxol from western Yew of the American Northwest* as an anticancer drug are examples of forest products used extensively in modern medicine. Without care, commercial exploitation can lead to early extinction of such plants.

Using unfamiliar crops such as Nagli, which are grown on poor soil on hill slopes is another option. This crop grown in the Western Ghats now has no market and is thus rarely grown. Only local people use this nutritious crop themselves. It is thus not as extensively cultivated as in the past. Popularizing this crop could add to food availability from marginal lands. Several crops can be grown in urban settings, including vegetables and fruit which can be grown on waste household water and fertilizers from vermicomposting pits.

Several foods can be popularized from yet unused seafood products such as seaweed as long as this is done at sustainable levels. Educating women about nutrition, who are more closely involved with feeding the family, is an important aspect of supporting the food needs of many developing countries.

Integrated Pest Management includes preserving pest predators, using pest resistant seed varieties and reducing the use of chemical fertilizers.

2.1.6 Land Resources

Land is a basic resource for us. It is, in fact, the foundation on which the entire ecological system rests and it is the living ground (habitat) for all terrestrial plants and animals. The capability of land to support life and various activities of man and animals is dependent both on its biological productivity and load bearing capacity of the soil and rocks. Landforms such as hills, valleys, plains, river basins and wetlands include different resource generating areas that the people living in them depend on. If land is utilized carefully it can be considered a renewable resource.

Land is under great pressure due to increase in population. Our land mass which was, in 1901, inhabited by 238 million people, is now shared by more than 1200 million people. Mismanagement of the land resource as a result of indiscriminate cutting of trees or deforestation has caused considerable damage to the quality of the soil and landscapes.

Soil, which forms the uppermost layer of the land, is the most precious of all resources, because it supports the whole life system, provides food and fodder in the form of vegetation and stores water essential for life. It contains sand, silt and clays, mixed with air and moisture. It possesses rich organic and mineral nutrients.

The type of soil varies from place to place. Those soils which are rich in organic matter are fertile. Fertility is also dependent on the capacity of the soil to retain water and oxygen.

2.1.6.1 Major Types of Soil in India

1. Red soil is found on plateau and lowland areas of eastern Bihar, Madhya Pradesh, Jharkhand, Chhatisgarh, Odisha, Kerala, Karnataka and Andhra Pradesh, where rainfall is between 100-300 cm/year and temperature remains above 22°C. The soil supports rain forests and grasslands and is good for cultivation of potatoes, bananas, pineapples and rubber.
2. The type of soil found on the Deccan and Malwa plateau of western and central India has a cover of clay and is loamy and black. It is very fertile and supports mixed grasslands, forests, crops of sugarcane, groundnut, soyabean, cotton and rice.
3. The soils of the desert region of western and north-western India are low in organic matter and generally considered to have low fertility. However, if water is provided they can be made very fertile.
4. Another type of soil forms part of the Indo-Gangetic plains extending in the delta regions on the coasts of Bengal, Odisha andhra Pradesh, Tamil Nadu, Kerala and Gujarat. This soil is characterised by loamy texture, dry composition and variability of thickness from place to place. The soil is highly productive and supports crops of all kind.
5. The soil that forms part of the low-lying wetlands or marshy land in the deltas of Ganga, Godavari, Krishna, Kaveri and in the river basins of Kerala, contains rich organic matter such as decomposed farmyard manure (dung) and plant material (wood peat) and as such is very fertile.
6. The soil found on the mountainous Himalayan region, which is ash grey to pale yellow-brown in colour, has low fertility and supports oak and coniferous plants such as pines and deodar.

2.1.6.2 Changes Caused by Agriculture and Overgrazing

The changes in environment caused by man through his agro-pastoral activities can be divided into two types for the sake of simplicity: (a) changes brought about by traditional agriculture; (b) changes brought about by modern agriculture. The characteristics of traditional agriculture include defacement of land, deforestation coupled with loss of soil structure, soil erosion and depletion of soil nutrients. Overgrazing, is also a bye-product of efforts to exploit the land resources for maximum livestock production. While modern agriculture continues to share the disruptive effects of traditional agriculture on environment. It also affects certain changes in environment characteristic only of modern agricultural practices. For example, excessive irrigation causes twin problems of salinization and water logging resulting from rise in water table apart from causing depletion of ground water resources. Similarly, addition of chemical fertilizers increases the rate of depletion of micronutrients from soils and eutrophication of water. The use of plant protection chemicals poisons the food products and sometimes kills non-target friendly organisms. Likewise, use of high yielding varieties makes the agriculture market-oriented, encourages monoculture causing eruption of epidemics and depletion of genetic diversity.

2.1.6.3 Land Degradation

Land degradation refers to the process of deterioration in the quality of land. In a general way, it has been defined as a reduction in the capacity of the soil to produce in terms of quality, quantity, goods and services. Human activities which result in land degradation include deforestation, farming, damming of rivers, industrialization, mining, developmental works such as human settlements, roads and highways and networks for transport and communication. Natural disasters, such as droughts, floods, landslides and earthquakes also contribute to land degradation. Land use has undergone tremendous change as human societies evolved through the ages. However, in the pre-industrial era, nature’s restorative ability could take care of these changes. In recent times, the over exploitative use of land and soil degradation have assumed alarming proportions. Farmland is under threat due to more and more intense utilization. Every year, between 5 to 7 million hectares of land worldwide is added to the existing degraded farmland. As urban centers grow and industrial expansion occurs, the agricultural land and forests shrink. This is a serious loss and has long term ill effects on human civilization.

In India, between 30 and 50 percent of private and common land is estimated to be ecologically degraded to varying degrees and is generally referred to as “wasteland”, that is land not producing its potential of biomass due to ecological degradation, over exploitation or the absence of a clear management system.

Wasteland development involves regenerating the land through a variety of soil and water management practices, planting appropriate plant species, protecting them and sharing the benefits. The following programmes are being implemented currently as part of the national effort towards wasteland development: Integrated Wastelands Development Project (IWDP) scheme, Technology development extension and training scheme, Support to NGOs/Voluntary agencies (grant-in-aid) scheme, Investment promotional schemes (IPS), Wastelands development task force (WDTF).

The Society of Promotion of Wasteland Development (SPWD) has undertaken Charagah development in Rajasthan as one of its major activities. Charagahs are common lands allotted for cattle grazing in a village. In dry land areas like Rajasthan, the role of common lands is crucial in the maintenance of cattle population. Small farmers depend on Charagahs as fodder availability on their own lands is poor especially in the months when no fodder is available at all. Thus, the development of Charagahs assumes importance.

Many traditional farming societies had ways of preserving areas from which they used resources. For instance, in the ‘sacred groves’ of the Western Ghats, requests to the spirit of the Grove for permission to cut a tree, or extract a resource, were accompanied by simple rituals. The outcome of a chance fall on one side or the other of a stone balanced on a rock gave or withheld permission. The request could not be repeated for a specified period.

2.1.6.4 Soil Erosion

It is the process in which the top layers of soil are removed and carried away from one place to another by wind or water. In this process, mineral particles, organic matter and nutrients from the soil are removed, reducing its thickness and water-holding capacity. Eroded soil may then become a pollutant in streams and reservoirs. The process is more evident in areas where deforestation has led to erosion on steep hill slopes as in the Himalayas and in the Western

Ghats. These areas are called ‘ecologically sensitive areas’ or ESAs. The time required to form new soil is so long that from human viewpoint, soil lost through erosion is lost forever. To prevent the loss of millions of tons of valuable soil every year, it is essential to preserve what remains of our natural forest cover. It is equally important to reforest denuded areas. The linkage between the existence of forests and the presence of soil is greater than the forest’s physical soil binding function alone. The soil is enriched by the leaf litter of the forest. This detritus is broken down by soil micro-organisms, fungi, worms and insects, which help to recycle nutrients in the system. Further losses of our soil wealth will impoverish our country and reduce its capacity to grow enough food in future.

A host of practices such as bunding, mulching and soil moisture conservation needs to be adopted at a large scale to prevent soil erosion. One way of achieving and maintaining a fertile soil is to apply organic material in the form of green manures, straw or as manure which has already undergone a high degree of fermentation. This improves the cohesiveness of the soil, increases its water retention capacity and promotes a stable aggregate structure.

In arid and semi-arid regions, too much or too little irrigation can lead to an increase in soluble salts, rendering the soil saline or alkaline and thus unfavourable for plant growth. As water evaporates from the soil, salts such as chlorides, sulfates and bicarbonates of sodium, calcium and magnesium accumulate in it.

The most effective treatment of alkaline soils is to apply gypsum. A good drainage system must also be provided to assist with washing out the sodium from saline soils. Only the most salt-tolerant species can be grown in areas with severe soil salinity.

2.1.6.5 Land Use Planning and Management

Land is an exhaustible resource and is very sensitive to changes in climate and physical processes. It should be used according to its suitability and capability. Suitability and capability of land is assessed in terms of its load bearing ability and fertility. Since food for an increasing population requires more land for cultivation, the encroachment of fertile agricultural lands for non-agricultural purposes like construction of roads and buildings should be reduced to the minimum. Extreme care should be taken in selecting sites for development of industries, construction of dams and water reservoirs and mining so that the environment and socio- economic conditions of the people living in that area are not disturbed.

Hill areas, as far as possible, should be put under forest cover because forests serve as a resource for fuel, fodder and timber and provide space for animal farming. Besides, forests help in increasing the ground water, since they impede the free surface run-off, thus allowing water to be absorbed by the ground. In this process, soil erosion is minimized and flooding can be avoided.

- **Soil Management**

  As we have said before, soil is a precious resource which takes millions of years to form and hence proper management of soil is very necessary. The management of the soil is two-fold i.e. (a) to minimize or check soil erosion and (b) restore productivity of the soil.

a) **Control of Soil Erosion:** The most significant measures for control of soil erosion are: growth of grasses, shrubs and trees on soils i.e; construction of a drainage system which can prevent free, uncontrolled flow of water. Water flow causes formation of narrow channels or gullies and leads to development of deep narrow valleys leading to ravine land. The famous Chambal ravines have been formed as a result of deep soil erosion and the process is still continuing. This can be controlled by constructing a series of check dams which prevent the flow of running water and widening of gullies. Formation of a broad wall of stone along the coasts of Maharashtra, Kerala andhra Pradesh and Odisha has proved to be very effective in controlling erosion by sea waves and currents. Movement of sand by gusts of wind in the deserts and sandy coasts can be prevented by putting barriers of trees and shrubs across the path of wind. In the mountain and hilly areas, planting of stems and branches of self-propagating trees and shrubs, not only strengthens the slope of the terrace but also provides fuel wood and fodder to the farmers.

   On the vulnerable slopes, a cover of vegetation is provided and in the beginning, seeds are covered with coir netting pegged firmly to the ground. Netting checks erosion, holds the soil material together and adds nutrients. The quick growth of grass stabilizes the soil.

b) **Treatment of soil sickness:** Due to overuse without rest, soil becomes deficient in the requisite nutrients and loses its fertility. Rotation of vegetables, such as peas and beans, helps to remove the deficiency of nutrients. Legume plants such as peas add nitrogen to the soil and thus increase its binding property as well as productivity. The roots and off-shoots of the crops and their remains are left in the field for a certain period of time to protect the soil from erosion.

It is found that excessive irrigation causes complete saturation or water logging of the soil, which consequently loses productivity, partially or completely. As a result of over irrigation in some areas, salinity and alkalinity of the soil increases, making it “sick”. This kind of soil sickness can be controlled by, first of all, sealing off all points of leakage canals, reservoirs, tanks and ponds and use of only the required amount of water.

2.2 Desertification

Desertification is a process whereby the productive potential of arid or semi-arid lands falls by ten percent or more.

Moderate desertification is 10-25% drop in productivity, severe desertification causes 25-50% drop while very severe desertification results in more than 50% drop in productivity and usually creates huge gullies and sand dunes. Desertification leads to the conversion of rangelands or irrigated croplands to desert like conditions in which agricultural productivity falls. Desertification is characterized by devegetation and loss of vegetal over, depletion of groundwater, salinization and severe soil erosion. Desertification is not the literal invasion of desert into non-desert area. It includes degradation of the ecosystems within as well as outside the natural deserts. The Sonoran and Chihuahuan deserts are about a million years old, yet they have become more barren during the last 100 years. So, further desertification has taken place within desert.

Causes of Desertification: Formation of deserts may take place due to natural phenomena like climate change or may be due to abusive use of land. Even the climate change is linked in many ways to human activities. The major anthropogenic activities responsible for desertification are as follows:

a) **Deforestation:** The process of denuding and degrading a forested land initiates a desert producing cycle that feeds on itself. Since there is no vegetation to hold back the surface run-off, water drains off quickly before it can soak into the soil to nourish the plants or to replenish the groundwater. This increases soil erosion, loss of water fertility and loss of water.

b) **Overgrazing:** The regions most seriously affected by desertification are the cattle producing areas of the world. This is because the increasing cattle population heavily graze in grasslands or forests and as a result denude the land area. When the earth is denuded, the microclimate near the ground becomes inhospitable to seed germination. The dry barren land becomes loose and more prone to soil erosion. The top fertile layer is also lost and thus plant growth is badly hampered in such soils. The dry barren land reflects more of the sun's heat, changing wind patterns, driving away moisture laden clouds leading to further desertification.

c) **Mining and quarrying:** These activities are also responsible for loss of vegetal cover and denudation of extensive land areas leading to desertification. Deserts are found to occur in the arid and semi-arid areas of all the continents. During the last 50 years about 900 million hectares of land have undergone desertification over the world. This problem is especially severe in Sahel region, just south of the Sahara in Africa. It is further estimated that if desertification continues at the present rate, then within a few years, it will affect such lands which are presently occupied by 20% of the human population.

Amongst the most badly affected areas are the sub-Saharan Africa, the Middle East, Western Asia, parts of Central and South America, Australia and the western half of the United States.

It is estimated that in the last 50 years, human activities have been responsible for desertification of land area equal to the size of Brazil. The United Nations Environment Programme (UNEP) estimates suggest that if we don't make sincere efforts now then very soon 63% of rangelands, 60% of rain-fed croplands and 30% of irrigated croplands will suffer from desertification on a worldwide scale, adding 60,000 km^2 of deserts every year.

2.3 Role of An Individual In Conservation of Natural Resources

We have learnt about the depletion of natural resources, degradation of land, deforestation and pollution of air, water and land. With the progress of human civilization, man started altering the natural environment in pursuit of creating an economic, social and cultural environment of his own choice. This slowly resulted in depletion of natural resources and degradation of the environment. Further, with increased human population rapid industrialization and urbanization and developing projects have placed a lot of strain on natural resources and environment. Now the situation is deteriorating so fast, especially in the last few decades, that environmental problems are posing threats to human health and his very existence.

We must that each one of us is individually responsible for maintaining the quality of the environment. The actions of individuals determine the quality of life for everyone. It is extremely necessary that each individual should only be aware of the various environment issues and the consequences of their actions, but also make firm resolve to develop environmentally ethical lifestyle. Following are some of the guidelines that individuals should follow:

- Develop respect for all forms of life.
- Try to plant trees wherever you can and, more importantly, take care of them. Trees reduce atmospheric pollution.
- Wherever possible, reduce the use of wood and paper products. Try to recycle paper products and use recycled paper wherever possible.
- Join an afforestation programme.
- Advocate organic farming by asking your grocery store to stock organically grown vegetables and fruits. This will spare you from the risk of pesticides.
- Reduce the use of fossil fuels and air pollution either by walking or using bicycle for short distances and by using carpool or public transport for long distances.
- Switch off the lights and fans when not needed.
- Do not pour paints, pesticides, solvents, oil or other products containing harmful chemicals down the drain.
- Buy consumer goods in refillable glass containers instead of can or throw away bottles.
- Use rechargeable batteries.
- Say No to plastic bags. Buy your vegetables and groceries in your own cloth bag.
- Do not use disposal papers or plastic plates when reusable versions are available.
- Recycle newspapers, aluminium and other items accepted for recycling in your area.
- Setup a composed bin your garden and use it to produce manure from your plant wastes. Do not use chemical fertilizers.
- Join any of the several NGOs that exist in your area or become a volunteer to work for environment protection.

- Do not use leaded petrol in your vehicles.
- Use catalytic converters in the exhaust system of your vehicles.
- Discard the vehicles that are more than 15 years old.
- Do not burn garbage.
- Do not discharge municipal waste on land or into water bodies.
- Conserve water. It is a precious material and should be used carefully avoiding any waste.
- Use pressure cooker for cooking.
- Soak lentils before cooking.
- Keeping the vessel covered with a lid during cooking helps to cook faster, thus saving energy.
- Use energy efficient LED bulbs and other electrical equipments which are rated as energy efficient.

2.4 Equitable Use of Resources for Sustainable Lifestyle

Reduction of the unsustainable and unequal use of resources and control of our population growth are essential for the survival of our nation and indeed of human kind everywhere. Our environment provides us with a variety of goods and services necessary for our day-to-day lives, but the soil, water, climate and solar energy which form the ‘abiotic’ support that we derive from nature, are in themselves not distributed evenly throughout the world or within countries. A new economic order at the global and at national levels must be based on the ability to distribute benefits of natural resources by sharing them more equally among the countries as well as among communities within countries such as our own. It is at the local level where people subsist by the sale of locally collected resources, that the disparity is greatest. ‘Development’ has not reached them and they are often unjustly accused of ‘exploiting’ natural resources. They must be adequately compensated for the removal of the sources to distant regions and thus develop a greater stake in protecting natural resources.

There are several principles that each of us can adopt to bring about sustainable lifestyles. This primarily comes from caring for our Mother Earth in all respects. A love and respect for Nature is the greatest sentiment that helps bring about a feeling for looking at how we use natural resources in a new and sensitive way. Think of the beauty of a wilderness, a natural forest in all its magnificence, the expanse of a green grassland, the clean water of a lake that supports so much life, the crystal clear water of a hill stream, or the magnificent power of the oceans and we cannot help but support the conservation of nature's wealth. If we respect this we cannot commit acts that will deplete our life supporting systems.

2.5 Check Your Progress

A. Fill in the blanks

1. ……..…. refers to the process of deterioration in the quality of land.
2. Forests and wildlife are essential to maintain .... of an area.
3. Wood, rubber, fibers, leather, soil, water, solar energy are examples of …………… resources.
4. Even our renewable resources can become non-renewable if we exploit them to such extent that their rate of…………… exceeds their rate of regeneration.
5. …………… includes all forms in which atmospheric moisture descends to earth: rain, snow, hail, sleet and dew.
6. …………… is the process by which solid water changes directly to vapour phase without passing through the intervening liquid phase.
7. ……………of rivers and lakes due to soil erosion progressively reduces their water holding capacity resulting in ravaging floods year after year.
8. The demand for energy doubles every……. years and is taken as one of the indicators of …………… of a country.
9. Gasohol is a mixture of …………… and gasoline.
10. Hydrogen generated by microbial systems is called …………….. .
11. Solar cell or PV cell is made of thin wafers of ………….. material
12. Wind turbines can be used singly or in clusters called …………….
13. The energy available due to the difference in temperature of water at the surface of the tropical oceans and at deeper levels is called …………….
14. The 13 countries in the world having 67% of the petroleum reserves together form …………….
15. Natural Gas is mainly composed of ………….. with small amounts of propane and ethane.
16. …………….is the cheapest and cleanest and, hence, regarded the best source of energy.

17. ……………..are the greatest repository of biodiversity on the land as they provide ideal conditions for the survival and growth of living organisms.
18. Integrated Pest Management includes preserving ………….., using pest resistant seed varieties and reducing the use of ……………. .
19. Those soils which are rich in ……… matter are fertile.
20. Land is an ………… resource and is very sensitive to changes in climate and physical processes.

B. Choose the correct answer

1) Ground subsidence occurs due to
   a) Withdrawal of more groundwater than its recharge
   b) More recharge of groundwater than its withdrawal
   c) Equal rates of recharge and withdrawal
   d) None of the above
2) Per capita use of water is highest in :
   a) USA b) India c) Kuwait d) Indonesia
3) Major causes of deforestation are
   a) Shifting cultivation
   b) Fuel requirements
   c) Raw material for industries
   d) All of these
4) Forests prevent soil erosion by binding soil particles in their
   a) Stems b) Leaves c) Roots d) Buds
5) Which of the following dreams to become the water super power in the middle east countries
   a) Kuwait b) Syria c) Jordan d) Turkey

6) Over grazing results in

   a) Produce soils

   b) Soil erosion

   c) Retention of useful species

   d) All of these

7) Natural geysers which operate due to geothermal energy are present in

   a) Manikaran in Kullu

   b) Sohana in Haryana

   c) None of these

   d) Both of these

8) The minimum time needed for the formation of one inch of top soil is

   a) 10 years b) 50 years c) 100 years d) 200 years

9) Which of the following is responsible for desertification?

   a) Deforestation

   b) Overgrazing

   c) Mining

   d) All of these

10) Nuclear energy can be generated by

   a) Nuclear fission

   b) Nuclear fusion

   c) Both of these

   d) None of the above

2.6 <u>Summary</u>

- *Water is renewable resource whereas land is a non-renewable resource.*
- *Degradation in physical resources such as land and water results mainly due to exploitative activates of humans in the fields of agriculture, industry and urbanization.*
- *Conservation in agriculture can be affected by changes in land use pattern, conservation of irrigation water, minimizing use of pesticides and fertilizers and implementation of innovative and environmentally sound agricultural techniques.*
- *Functions performed by the forest as a resource can be categorized under three major headings: economic, ecological and social. Ecological functions include stabilizing global climate, protect biodiversity and support global ecological system and processes. Forest has also socio-cultural significance in terms of providing ethical, spiritual, recreational and tourist value.*
- *There are various causes responsible for deforestation. Some of the immediate or explicit causes are logging for wood, land use and land cover change, forest fire and pest attack. Indirect or implicit cause is increasing population.*
- *Mainly there are two sources of energy viz i) Non-conventional sources such as biomass, solar, fuel cell, geothermal, Co-generation and wind energy, ii) Conventional sources of energy like natural oil energy, gas, coal and hydro power energy.*
- *The amount of energy consumed per person each year is a useful measure of standard of living.*
- *Energy demand of developing countries is increasing due to population growth and industrialization.*
- *Switching to clean, renewable energy will bring us cleaner air and water while improving human health and increasing energy security.*
- *Conservation of energy sources is urgently required as its excessive consumption is not only costly but also leads to multiple problems. Moreover, dependence of modern human on innovative and non- conventional sources of energy has become the only alternative.*

2.7 Keywords

- **Renewable resources:** The resources that can be replenished through rapid natural cycles are known as renewable resource.
- **Non-renewable resources:** The resources that cannot be replenished through natural processes are known as non-renewable resources.
- **Precipitation:** Precipitation includes all forms in which atmospheric moisture descends to earth: rain, snow, hail, sleet and dew.
- **Sublimation:** It is the process by which solid water changes directly to vapour phase without passing through the intervening liquid phase.
- **Mining:** Minerals and their ores need to be extracted from the earth's interior so that they can be used. This process is known as mining.
- **Land degradation:** It refers to the process of deterioration in the quality of land. In a general way, it has been defined as a reduction in the capacity of the soil to produce in terms of quality, quantity, goods and services.
- **Soil Erosion:** It is the process in which the top layers of soil are removed and carried away from one place to another by wind or water. In this process, mineral particles, organic matter and nutrients from the soil are removed, reducing its thickness and water-holding capacity.
- **Desertification:** It is a process whereby the productive potential of arid or semi-arid lands falls by ten percent or more.

2.8 Self-Assessment Test

1. What are the differences between conventional and non-conventional sources of energy?
2. Explain the functions of forests in detail with suitable examples.
3. Discuss the major causes and consequences of deforestation.
4. Why is there a constant conflict of interest between conservation and development? Explain with suitable examples.
5. Discuss the various ways of water conservation.
6. Describe the essential components of land management.
7. How is biogas helpful in meeting the energy crisis of people living in rural areas?

8. Discuss any two non-conventional means of generating energy.
9. What are the merits and demerits of building big dams?
10. How can you as an individual conserve different natural resources?

2.9 Answers to check your progress

A. Fill in the blanks

1. Land Degradation 2. Biodiversity 3. Renewable 4. Consumption

5. Precipitation 6. Sublimation 7. Siltation 8. 14, development 9. Ethanol 10. Biohydrogen 11. Semiconductor 12. wind farms 13.Ocean Thermal Energy 14. OPEC (Organization of Petroleum Exporting Countries) 15. Methane 16. Hydro power 17. Forest 18. pest predators, chemical fertilizers 19. Organic 20. exhaustible

B. Choose the correct answer

1.a) 2.a) 3.d) 4.c) 5.d) 6.b) 7.d) 8.d) 9.d) 10.c)

2.10 References / Suggested readings:

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ECOSYSTEM: STRUCTURE, FUNCTION, SUCCESSION AND TYPES OF ECOSYSTEM

Structure

3.0 Learning Objectives

After studying this lesson, you will be able to:

- *explain the concept of ecosystem*
- *describe ecosystem components*
- *learn about ecosystem functions*
- *understand the concept of food chains and food web*

- *explain energy flow through food chain*
- *nutrient cycling in an ecosystem*
- *understand the concept of ecological pyramids*
- *learn about different types of ecological pyramids*
- *explain various examples of ecological pyramids in different ecosystems*
- *understand the concept of ecological succession*
- *understand ecosystem development*
- *know about homeostasis and feedback mechanisms in an ecosystem*
- *know about various types of ecosystem*

3.1 Ecosystem

The interactions in nature are studied in a branch of science termed as 'Ecology'. Have you ever pondered that why the forest area is covered by huge lush green trees and besides these, what more is present in a forest? Why there is a difference in forest types along the physical gradients? Why the plants and animals in a pond differ from an ocean? How the availability of water and temperature could mark a difference in vegetation of a desert and a tundra region? How the animals affect water and nutrient availability in the soil? How does fire affect the amount of food available in grasslands? All these questions find answers in the study of ecology and ecosystems.

The term 'Ecology' was first coined by the German biologist Ernst Haeckel in 1869. Haeckel defined ecology as 'the study of natural environment including the relations of organisms to one another and to their surroundings.' It is derived from two Greek words - "*oikos*" meaning home and "*logos*" meaning study. Thus literally, ecology is the study of life at home with main emphasis on pattern of relations between organisms and their surrounding environment.

In simple words, it deals with the intricate web of relationships between living organisms and their non-living surroundings. The surroundings consist of other living organisms and non-living environment such as water, air, soil, etc. Ecologists mainly focus on the distribution, life processes and adaptations among the organisms, which further are associated with the analysis of flow of energy and nutrients.

Ecology can also be considered in terms of concept of levels of organization. The entire biological spectrum can at the best be divided into ten levels of organization including atom, cell, organ and organ system. The ecologists study interactions within and among six of these levels – organisms, populations, communities, ecosystems, biomes and the biosphere. Now, let us understand the concept of ecosystem.

In nature, the living organisms (plants, animals and microorganisms) and nonliving environment (e.g. water, air, soil, etc.) are inseparably interrelated and interact with each other. No living organism can exist by itself, or without an environment. Every organism uses energy, nutrients and water from its surrounding environment in various life activities.

1. The plants obtain the energy directly from the sun and, in case of animals and microorganisms, energy is taken from other organisms through feeding on plants, predation, parasitism and/or decomposition.
2. The terrestrial plants obtain water mainly from soil, while animals get it from free standing water in the environment or from their food.
3. The plants obtain most of their nutrients from the soil or water, while animals get nutrients from plants or other organisms. Microorganisms are the most versatile, obtaining nutrients from soil, water, food, or other organisms.

As a result, the organisms interact with one another and with their environment in a number of ways. These fundamental interactions among organisms and their non-living/physico-chemical environment constitute an interrelating and interdependent ever-changing system known as an ecological system or ecosystem. The ecosystem has been considered as the basic functional unit of ecology and ecology as study of ecosystems.

However, the term 'Ecosystem' was first coined in 1935 by the British ecologist Sir Arthur G. Tansley as part of a debate over the nature of biological communities: "Our natural human prejudices force us to consider the organisms as the most important parts of these systems, but certainly the inorganic "factors" are also parts - could be no systems without them and there is a constant interchange of the most various kinds within each system, not only between the organisms but between the organic and the inorganic. These ecosystems, as we may call them, are of the most various kinds and sizes."

Tansley described the most fundamental nature of ecosystems – as a system in which biotic and abiotic components of environment are interrelated. The main focus is on the organisms in the definition and the nature of the "constant interchange of the most various kinds" is not made clear.

The great ecologist, E. P. Odum (1971) defined ecosystem as "Any unit that includes all of the organisms (i.e. the "community") in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity and material cycles (i.e. exchange of materials between living and nonliving parts) within the system is an ecological system or ecosystem" Thus, Odum describes explicitly that ecosystem is a geographical unit and energy flow plays a central role in defining structural and functional features of the ecosystem.

Various other ecologists defined ecosystem in their own terms at different times. Though there may be differences in the definitions given by different authors, all have three common characteristics – biotic component, abiotic environment and interactions between these two. The biotic component of ecosystem generally consists of communities of organisms and abiotic component includes the physico-chemical environment surrounding them. Interactions may be numerous including food webs, trophic dynamics, nutrients cycling, flow of energy, etc. It has held a central position in modern ecology and environmental sciences. Modern ecology is now defined as "the study of structure and functions of ecosystems." Now a day, most of the environmental management strategies include recognition of ecosystems as a way of ordering our perception of nature.

Ecosystems differ greatly in their composition - in the number and kind of species, the type and relative proportions of non-living constituents and in the degree of variations in time and space. A forest, a grassland, a pond, a coral reef, a part of any field and a laboratory culture can be some examples of ecosystem. The size of ecosystems varies tremendously. An ecosystem could be an entire rain forest, covering a large geographical area, or it could be a single tree inhabiting a large no. of birds and/or microorganisms in its leaf litter. It could be a termite's gut, a lake or the biosphere as a whole with an entire intertwined environment of earth. The number of ecosystems on earth is countless and each ecosystem is distinct. All ecosystems have the following common characteristics as given by Smith (1966):

1) The ecosystem is the major structural and functional unit of ecology.
2) The structure of an ecosystem is related to its species diversity; the more complex ecosystems have high species diversity.
3) The function of ecosystem is related to energy flow and material cycling through and within the system.
4) The relative amount of energy needed to maintain an ecosystem depends on its structure. The more complex the structure, the lesser the energy it needs to maintain itself.
5) Ecosystems mature by passing from less complex to more complex stages. Early stages of such succession have an excess of potential energy and a relatively high energy flow per unit biomass. Later (mature) stages have less energy accumulation and its flow through more diverse components.
6) Both the environment and energy fixation in any given ecosystem are limited and cannot be exceeded without causing serious undesirable effects.
7) Alterations in the environment represent selective pressures upon the population to which it must adjust. Organisms which are unable to adjust to the changed environment disappear ultimately.

All ecosystems have a feeding hierarchy which starts with an energy source (e.g. the sun) and then followed by producers, consumers and decomposers. These components are dependent on one another. One of the important features is presence of grazing or detritus food chain and webs which become the lifeline of ecosystems. In grazing food chain and webs, green plants (i.e. producers) synthesize food from non-living nutrients with the help of the sunlight in the process of photosynthesis. Animals (i.e. consumers) consume plants and other animals to get the nutrients. When plants and animals die and decay or when animals excrete waste, bacteria and fungi (i.e. decomposers) feed on the dead or waste materials and release the nutrients back into water and/or soil for reuse by the producers. In a detritus food chain or web, the energy comes from dead organic matter (i.e. detritus) instead of green producers. One example of a detritus food web is the ecosystem of a deciduous forest floor. Ecosystems are sustained by the presence of biodiversity. Each organism in an ecosystem has a purpose (i.e. niche), as a result, the loss of one species can alter both the size and stability of ecosystems. In a whole, the ecosystems are open systems – depicting that things are entering and leaving the system, even though the general appearance and basic functions may remain constant for long periods of time.

3.2 Ecosystem Structure

The ecosystem is largely divided into two components - Abiotic and Biotic components. Ecosystem structure is created due to interaction between abiotic and biotic components, varying over space and time.

Abiotic Components

The abiotic components of an ecosystem refer to the physical environment or the non-living factors. The organisms cannot live or survive without their abiotic components. They mainly include:

a) Inorganic substances required by organisms such as carbon dioxide, water, nitrogen, calcium, phosphorus, etc. that are involved in material cycles. The amount of these inorganic substances present at any given time in ecosystem is called as standing state or standing quality of ecosystem.

b) Organic compounds like proteins, carbohydrates, amino acids, lipids, humic substances and others are synthesized by the biotic counterpart of an ecosystem. They make biochemical structure of ecosystem.

c) Climatic factors including mainly rain, light, temperature, humidity, wind and air and edaphic and other factors such as minerals, soil, topography, pH, etc. greatly determine the functions, distribution, structure, behavior and inter-relationship of organisms in a habitat.

Biotic Components

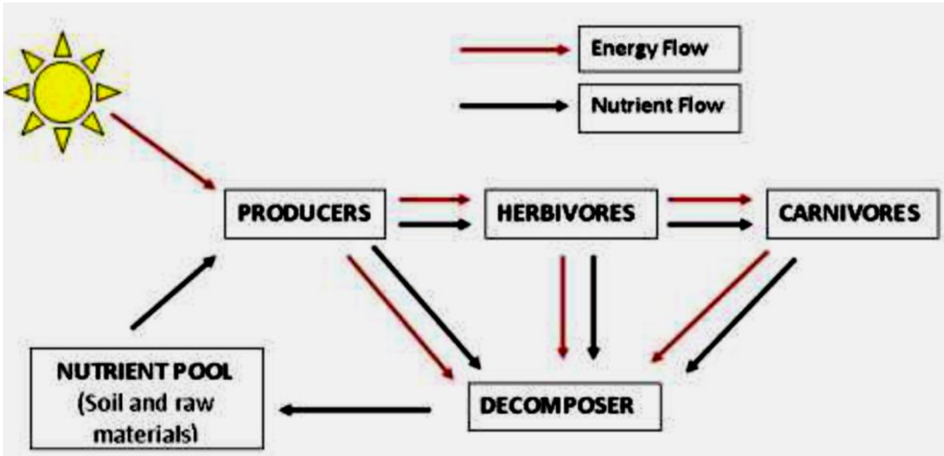
The biotic components of the ecosystems are the living organisms including plants, animals and microorganisms. Based on their nutritional requirement, i.e. how they get their food, they are categorized into three groups –

a) Producers are mainly the green plants with chlorophyll which gives them the ability to use solar energy to manufacture their own food using simple inorganic abiotic substances, through the process of photosynthesis. They are also called as photoautotrophs (photo-light, auto-self, troph-nutrition). This group is mainly constituted by green plants, herbs, shrubs, trees, phytoplanktons, algae, mosses, etc. There are some chemosynthetic bacteria (sulphur bacteria) deap beneath in the ocean which can synthesize their food in absence of sunlight, thus known as chemoautotrophs (chemo-chemical, auto-self, troph-nutrition).

b) **Consumers** lack chlorophyll, so they depend on producers for food. They are also known as heterotrophs. They mainly include herbivorous (feed on plants), carnivorous (feed on other animals), omnivorous (feed on both plants and animals) and detritivorus organisms (feed on dead parts, waste, remains, etc. of plants and animals).

c) **Decomposers** (saprotrophs) are the microorganisms, bacteria and fungi, which breakdown complex dead organic matter into simple inorganic forms, absorb some of the decomposition products and release inorganic nutrients that are reused by the producers. All ecosystems have their own set of producers, consumers and decomposers which are specific to that ecosystem.

The nutritional and energy relationship among different biotic components of an ecosystem is shown below.



Nutritional relationship among different biotic components of an ecosystem

3.3 Ecosystem Functions

Ecosystem functions are the physical, biological and geochemical processes that take place or occur within an ecosystem. Or simply, we can say ecosystem functions relate to the structural components of an ecosystem (e.g. plants, water, soil, air and other living organisms) and how they interact with each other, within ecosystem and across ecosystems. Every ecosystem performs under natural conditions in a systematic way. It receives energy from sun and passes it on through various biotic components and in fact, all life depends upon this flow of energy. Besides energy, various nutrients and water are also required for life processes which are exchanged by the biotic components within themselves and with their abiotic components within or outside the ecosystem. The biotic components also regulate themselves in a very systematic manner and show mechanisms to encounter some degree of environmental stress.

The structure and function of ecosystems are very closely related and influence each other so intimately that they need to be studied together. Despite the broad spectrum and great variety of functions in nature, the simple autotroph–heterotroph–decomposer classification is a good working arrangement for describing the ecological structure of a biotic community. Production, consumption and decomposition are useful terms for describing overall functions. These and other ecological categories pertain to functions and not necessarily to species as such, because a particular species population may be involved in more than one basic function. For example, individual species of bacteria, fungi, protozoa and algae may be quite specialized metabolically, but collectively these lower phyla organisms are extremely versatile and can perform numerous biochemical transformations. Table below represents various structural and functional aspects of an ecosystem.

Structural and Functional aspects of an Ecosystem

Structural Aspects	Functional Aspects
a) Biotic components Producers, consumers and decomposers. **b) Abiotic components** Inorganic substances (C, H, O, N, P, S, etc.), organic compounds (proteins, amino acids, lipids, carbohydrates, humic substances, etc.), climate and its components (temperature, humidity, moisture, sunlight, rainfall, wind, air etc.), edaphic and other factors (minerals, soil, topography, pH, etc.)	**a) Food chains and food webs** **b) Energy flow** **c) Nutrient cycling** **d) Ecosystem processes to explain interactions among the components of ecosystem** **e) Ecosystem development** **f) Ecosystem regulation and stability** **g) Ecosystem services**

3.3.1 Food Chains and Food Webs

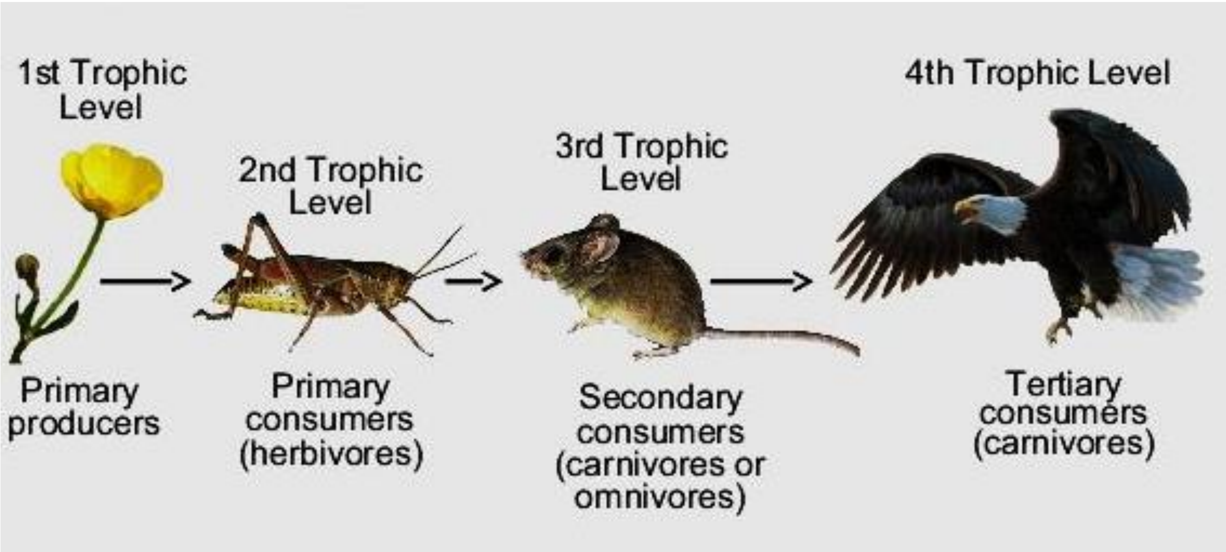
The flow of energy is mediated through a series of feeding relationships in a definite sequence or pattern i.e. from producers to primary consumers to secondary consumers and to tertiary consumers. Nutrients too move in along this food chain. The sequence of eating and being eaten in an ecosystem is known as food chain. All organisms, living or dead are potential food for some other organism and thus, there is essentially no waste in the functioning of a natural ecosystem. Some common examples of food chains are:

Grass → Grasshopper → Frog → Snake → Hawk (Grassland ecosystem)

Plants → Deer → Lion (Forest ecosystem)

Phytoplanktons → Zooplanktons → Small fish → Large fish (Pond ecosystem)

Each organism in the ecosystem is assigned a feeding level or trophic level depending on its nutritional status as shown in figure below. Thus, in grassland food chain, grass occupies 1st trophic level, grasshopper the 2nd, frog the 3rd, snake the 4th and hawk 5th trophic level. At each trophic level some energy is lost as heat and respiration, as a result available energy decreases moving away from the first trophic level. Therefore, the number of trophic levels in a food chain is limited. The decomposers consume the dead organic matter of all these trophic levels.



T1	T2	T3	T4
(Grass,Plants,Trees, Phytoplanktons)	(Insects,Grasshopper, Deer,Giraffe)	(Frog,Lizard,Snake Crabs)	(Eagle,Tigers,Sea otters, Crocodiles)

<u>Trophic Levels (T) of a food chain</u>

The food chains can be of two types –

1. **Grazing food chain:** The food chain that starts from green plants and ends in a consumer. Some examples are:

   Grass → Insect → Sparrow → Eagle

   Tree → Bird → Snake → Hawk

   Plants → Deer → Tiger

2. **Detritus food chain:** In many cases, the principal energy input is not green plants but dead organic matter. These are called detritus food chains. The detritus food chains are commonly found in forest floors, salt marshes and the ocean floors in very deep areas. Example of detritus food chain is as follows:

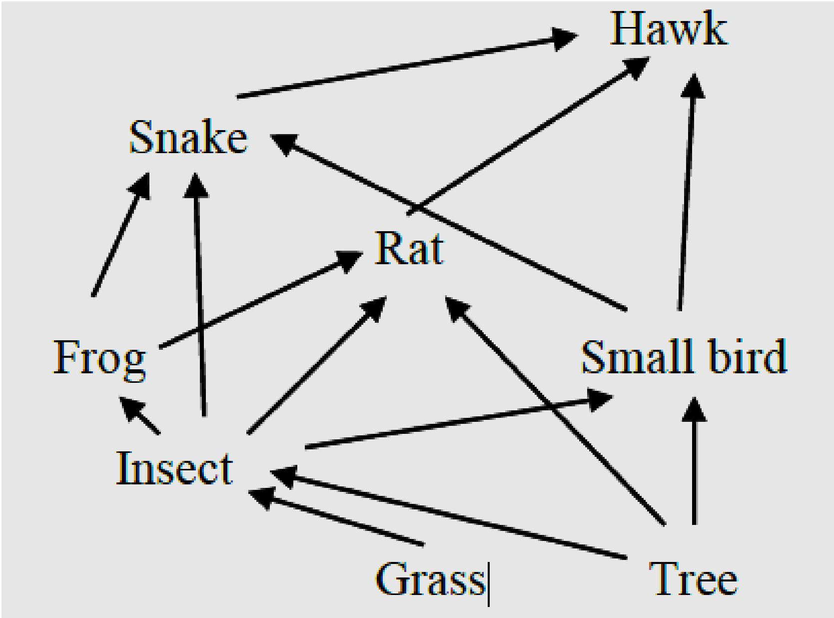
Leaf litter → Bacteria → Protozoa → Small fish → Large fish

It is very important to know about the food chains, because certain animals eat only particular type of animals or plants. A balance is maintained in the entire ecosystem through these feeding relationships. The food chains keep a check on the population size of organisms. If in a grassland ecosystem, the deer population increases, grass reduces; but when grass reduces, the deer that feed on it will also be checked in their population size. So, the grass and other plants will get time to grow again.

The food chains also exhibit the property of **biomagnification** or biological magnification. Certain chemicals, heavy metals or pesticide are either slowly degradable or non-biodegradable in nature. As they enter the food chain in low concentrations, they tend to accumulate at each trophic level and as a result, an increase in their concentrations is exhibited with increase in trophic level of a food chain. In this way, the top trophic level is worse affected due to high accumulation of the chemicals in organisms.

The real world is more complicated than a simple food chain. While many organisms specialize in

their diets (e.g. anteaters), other organisms do not. Hawks don’t limit their diets to snakes, snakes eat things other than mice, mice eat grass as well as grasshoppers. A more realistic representation of who eats whom is called a **food web**. A food web is defined as a network of interwoven food chains with numerous producers, consumers and decomposers operating simultaneously at each trophic level so that there are a number of options of eating and being eaten at each trophic level.



A Food Web

Food webs can get quite complex with several interconnected food chains. They give greater stability to an ecosystem. In a linear food chain, if one species become extinct or one species suffers, then the species in the subsequent trophic levels are also affected. In a food web, on the other hand, there are a number of options available at each trophic level. So if one species is affected, it does not affect other trophic levels so seriously.

Significance of studying food chains and food webs:

1. They play a very significant role in the ecosystem because the two most important functions of energy flow and nutrient cycling takes place through them.
2. Food chains also help in maintaining and regulating the population size of different animals and thus, help maintain the ecological balance.
3. Food chains show the unique property of biological magnification of some chemicals.

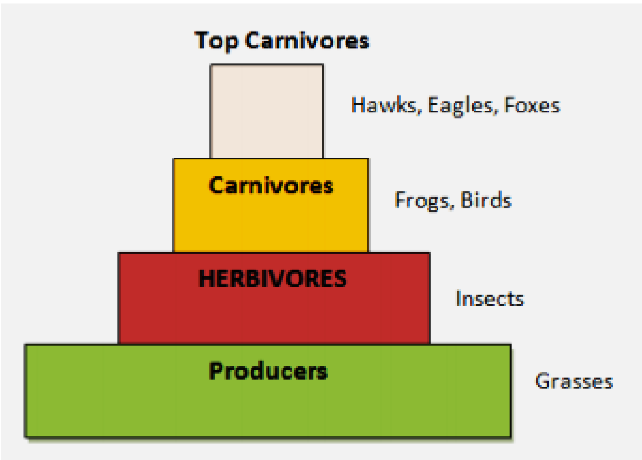
3.3.2 Ecological pyramid

Ecological pyramids are the graphic representations of trophic levels in an ecosystem. They are pyramidal in shape and they are of three types. The producers make the base of the pyramid and the subsequent tiers of the pyramid represent herbivore, carnivore and top carnivore levels.

1) **Pyramid of number**

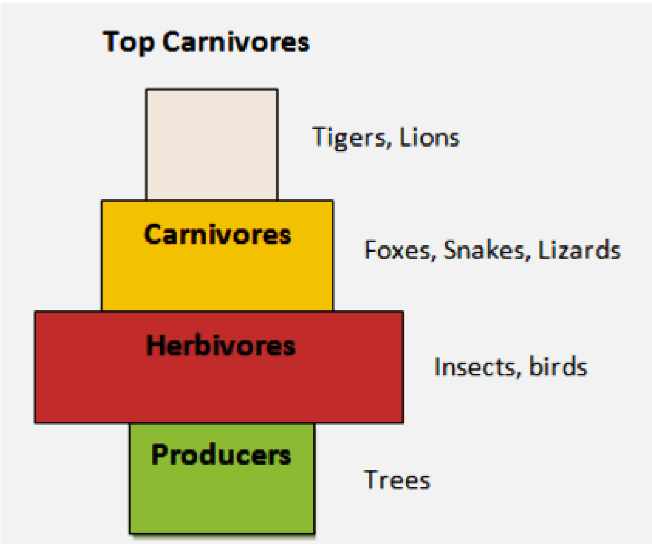
   Pyramid of numbers may be defined as graphical representation of number of individual organisms per unit area at each trophic level arranged stepwise with producers at the base and top carnivores at the top. The shape of pyramid of numbers may vary from one ecosystem to another ecosystem.

- In grassland and aquatic ecosystems, pyramid of number is upright. The producers in the grassland are the grasses and in aquatic ecosystems are phytoplanktons (algae etc.) which are small in size and large in number per unit area. So the producers form a broad base in the pyramid. The herbivores in the grassland are the insects; carnivores are frogs, birds, etc. and top carnivores are hawk, eagle, foxes etc. which are gradually less and less in number and so the pyramid apex becomes gradually narrower forming an upright and erect pyramid. Similar is the case with herbivores (zooplanktons, etc.), carnivores (small fishes, etc.) and top carnivores (large fishes, crocodile, etc.) in aquatic ecosystems (pond, lake or marine ecosystem) which decreases in number at higher trophic levels, thus forming an upright pyramid of numbers.



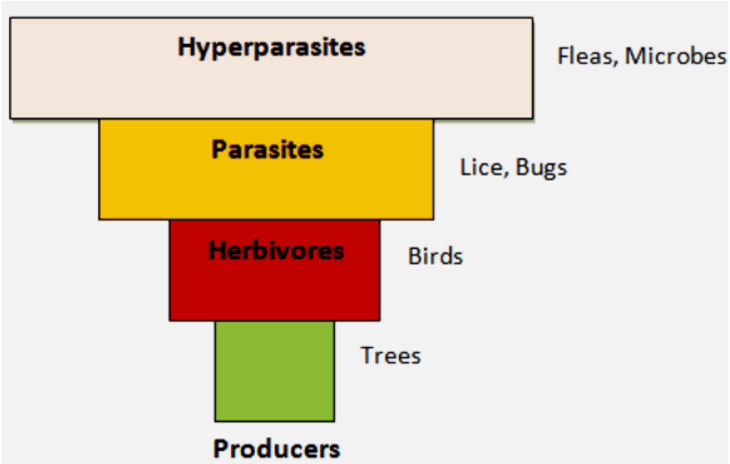
Pyramid of Numbers in Grassland Ecosystem (Upright)

- In a forest ecosystem, large sized trees are the producers, which are less in number and so form a narrow base. The trees support large number of herbivores like insects, birds, frogs, etc. including several species of animals that feed upon leaves, fruits, flowers, bark, etc. of the trees. They are large in number than trees and hence form a middle broad level. The secondary consumers like predatory birds (hawks, eagle, etc.), foxes, snakes, lizards, etc. are less in number than herbivores while top carnivores like lion, tiger, etc. are still smaller in number making the pyramid gradually narrow towards apex. So the pyramid assumes a spindle shape with narrow on both sides and broader in the middle.



Pyramid of Numbers in Forest Ecosystem (Spindle shaped)

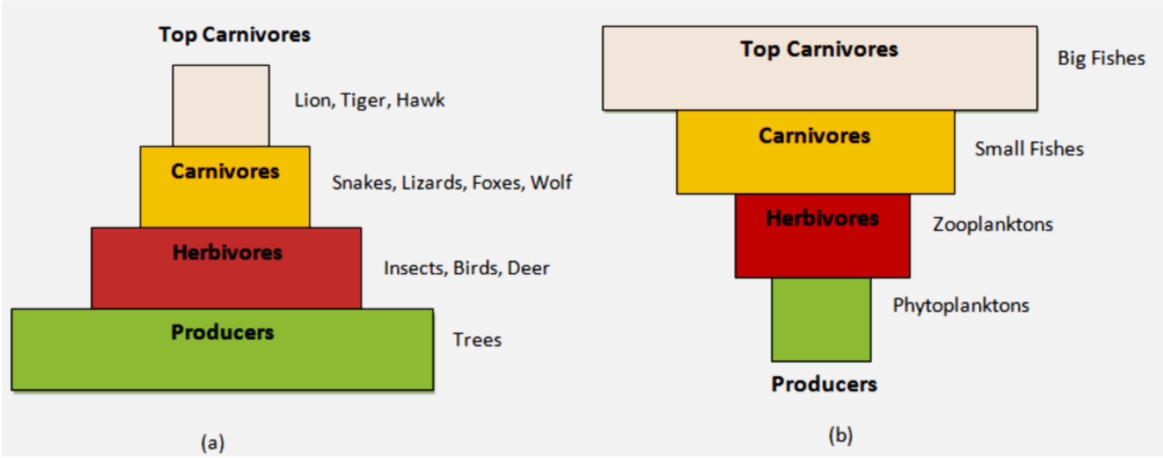
- In a parasitic food chain, for example, the producers like a few big trees offers food to quite a lot of frugivorous birds which are the herbivores and more in number than trees. The birds harbor and sustain a good number of ecto-parasites like lice, bugs, etc., while a greater number of hyperparasites like bugs, fleas, microbes, etc. feed upon them. This when graphically represented form an inverted pyramid.



Pyramid of Numbers in a Parasitic Food Chain (Inverted)

2) Pyramid of biomass

A pyramid of biomass shows the relationship between biomass and trophic level by quantifying the biomass present at each trophic level at a particular time. It is a graphical representation of biomass (total amount of living organic matter in an ecosystem) present in unit area at a particular time in different tropic levels. The pyramid of biomass may be upright or inverted. For example, in a forest ecosystem, the plants and trees (primary producers) make up a large percentage of the biomass, with gradually lessening of biomass present at herbivores, carnivores and top carnivores level respectively per unit area at a particular time. Therefore, the pyramid of biomass in a forest ecosystem is upright with producers forming the broad base and consumers forming narrow top. In contrast, in a pond ecosystem, the pyramid of biomass is inverted as the **standing crop** of phytoplanktons, the major producers, at any given time make up less biomass than the consumers, such as fishes and insects. Standing crop biomass is the amount of the living matter at any given time. As with inverted pyramids of numbers, the inverted biomass pyramid is not due to a lack of productivity from the primary producers, but results from the high turnover rate of the phytoplankton. The phytoplanktons are consumed rapidly by the primary consumers, which minimizes their biomass at any particular point in time. However, since phytoplanktons reproduce quickly, they are able to support the rest of the ecosystem. One problem with pyramids of biomass is that they can make a trophic level appear to contain more energy than it actually does. For example, all birds have beaks and skeletons, which despite having mass are not typically digested by the next trophic level.

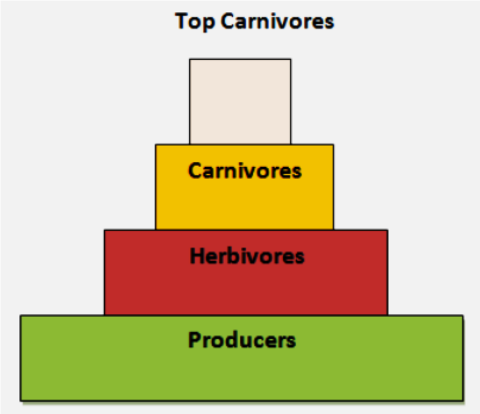


(a) Pyramid of Biomass in a Forest Ecosystem (Upright)

(b) Pyramid of Biomass in a Pond Ecosystem (Inverted)

3) Pyramid of Energy

The pyramid of energy is by far the most practical of all the three ecological pyramids as it depicts the actual functional relationships between trophic levels. It represents the amount of energy present at each trophic level. Likewise it starts with the producers and ends with consumers at higher trophic levels. It is also called as **pyramid of productivity**. Since the productivity or energy flow is expressed per unit time basis, this pyramid is always and for all the ecosystems is an upright position. For ecosystem to be self sustaining, lower trophic levels should have more amount of energy than the higher trophic levels. This helps the organisms at lower levels to maintain a stable population, but also to transfer energy up the pyramid. As per the second law of thermodynamics, energy flow declines from producer level to successive trophic levels. When energy is transferred to next trophic levels, only about 10% of it is utilized to assemble body mass and become stored energy. Remaining 90% is lost in metabolic activities. For instance, if the producers make up 100 Kcal energy, only 10 Kcal is passed on to herbivores, then about 1 Kcal of herbivores is transferred to carnivores and then only 0.1 Kcal energy passes on to top carnivores level. This decline in energy at subsequent level is referred to as Lindeman's data or 10% law. Therefore, pyramid of energy is always upright.



Pyramid of Energy

3.3.3 Ecological Efficiency

It is clear from the trophic structure of an ecosystem that the amount of energy decreases at each subsequent trophic level. This is due to two reasons:

1. At each trophic a part of the available energy is lost in respiration or used up in metabolism.
2. A part of energy is lost at each transformation, i.e. when it moves from lower to higher trophic
   level as heat.

The ratio of the amount of energy acquired from the lower trophic level and the amount of energy transferred from higher trophic level is called ecological efficiency. Lindman in 1942, defined these ecological efficiencies for the first time and proposed 10% rule e.g. if autotrophs produce 100 cal, herbivores will be able to store 10 cal. and carnivores 1cal. However, there may be slight variations in different ecosystems and ecological efficiencies may range from 5 to 35%. Ecological efficiency (also called Lindman's efficiency) can be represented as:

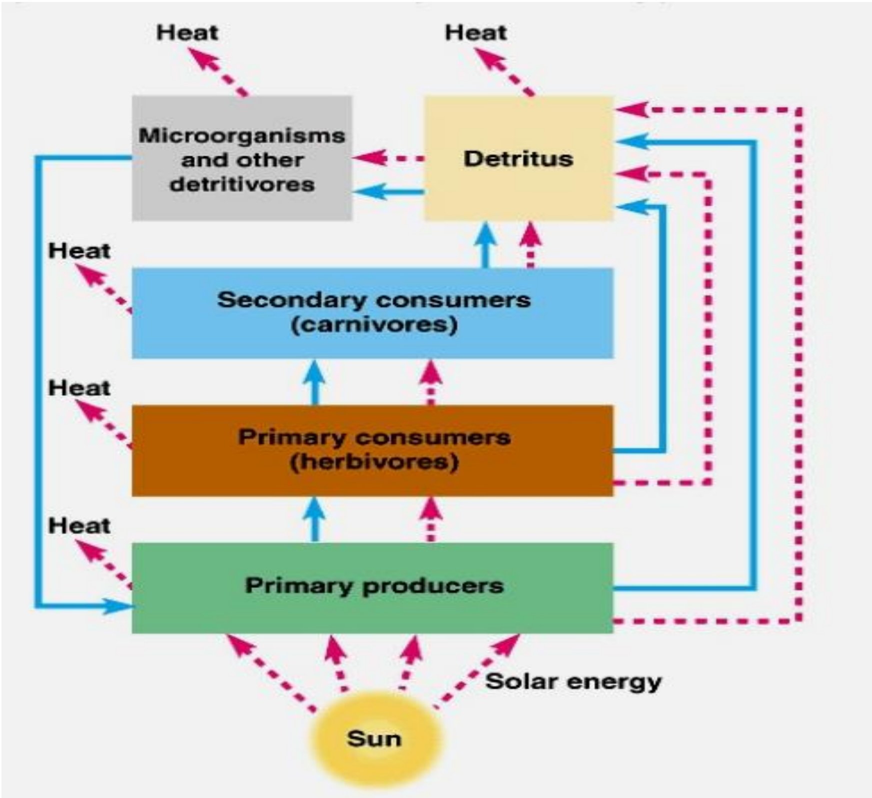
$$\frac{I_t \times 100}{I_t - 1} = \frac{\text{Ingestion at trophic level}_t \times 100}{\text{Ingestion at previous trophic level} - 1}$$

3.3.4 Energy Flow

Everything that organisms do in ecosystems (breathing, running, burrowing, growing) all require

Energy. So, how do they get it? In an ecosystem, there is a continuous interaction between plants, animals and their environment to produce and exchange materials. The energy needed for this material cycling comes from the sun. Sun is the ultimate source of energy, directly or indirectly, for all other forms. The green plants capture the solar energy and convert it through the process of photosynthesis into chemical energy of food (organic matter) and store it into their body. This process is called as **primary production**. The rate of total organic matter production by green plants (primary producers) is known as **gross primary productivity**. The green plants use some of the energy in the process of respiration. Rest amount of energy is called as **net primary production**, the amount of energy left for the heterotrophic organisms. In this stored form, other organisms take the energy and pass it on further to other organisms. During this process, a reasonable proportion of energy is lost out of the living system. At the consumer level, the rate of assimilation of energy is called **secondary productivity**. The whole process is called as **flow of energy**. The most important feature of this energy flow is unidirectional or one-way or non-cyclic flow. It flows from producer to herbivores to carnivores organisms; it is never reused back in the food chain unlike the nutrients which move in a cycle. As the flow of energy takes place, there is a gradual loss of energy at each level.

Primary productivity of an ecosystem depends upon the solar radiations, availability of water, nutrients and upon the plants and their chlorophyll content. Productivity of tropical rainforest and estuaries is highest. The greater productivity of tropical rainforests to a large extent is due to the favourable combination of high incident solar radiation, warm temperatures, abundant rainfall and rich diversity of species. These factors result into longer, almost year-round growing season. In estuaries, the natural wave currents bring lots of nutrients with them congenial for growth. On the other hand, desert ecosystems have limitations of adequate water supply while tundra ecosystems have low water temperature as limiting factor and hence show low primary production.



-------- *Heat* ***Unidirectional Flow of Energy and Nutrients Cycling In an Ecosystem***

—— *Nutrients*

3.3.4.1 Ecosystem Thermodynamics

The flow of energy in the ecosystems follows the two laws of thermodynamics-

a) **The first law of thermodynamics**, also known as energy-mass conservation law, states that neither energy nor matter can be created or destroyed, but it can be transformed from one form to another; rather, the amount of energy lost in a steady state process cannot be greater than the amount of energy gained. For instance, the solar energy is converted into chemical energy in the process of photosynthesis. The conversion must be balanced, as expressed in Odum's model, such that the sum of all outputs is equal to the sum of inputs.

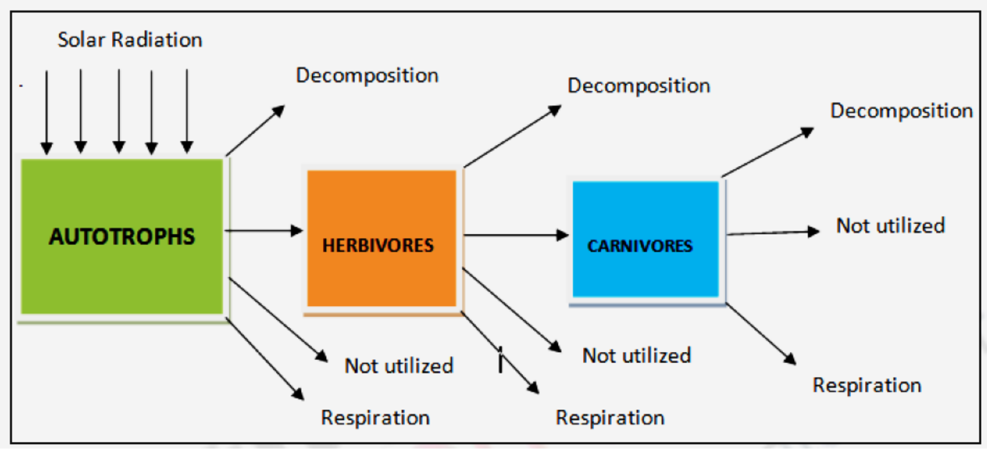
b) **The second law of thermodynamics**, also known as law of entropy, states that energy dissipates as it is used or it is converted from a more concentrated form to dispersed form. Any change of energy from one form to another implies an irreversible loss of useful energy in form of heat, which increases the entropy or disorder of the universe. In some systems, entropy remains constant but never decreases; only irreversible processes produce entropy. An example of the second law of thermodynamics in ecology is metabolism, in which a set of chemical reactions in an individual transforms organic matter into a more useful component. However, the cost of this conversion includes respiration, which is the energy unavailable neither to individual nor to others in the food web. This shows that as the energy flows through the food chain, there occurs dissipation of energy at every trophic level. The loss of energy takes place through respiration, loss of energy in locomotion, running, hunting and other activities. At every level there is about 90% loss of energy and the energy transferred from one trophic level to the other is only about 10%.

3.3.4.2 Models of Energy Flow

Various models depicting energy flow in ecosystems are described below:

Single Channel Energy Flow Model

The flow of energy in an ecosystem takes place through the food chain and it is this energy flow which keeps the system going. The most common feature of this energy flow is that it is unidirectional or one-way flow or single channel flow. Unlike the nutrients (carbon, nitrogen, phosphorus, sulphur etc.) which move in a cyclic manner and are reused by the producers after moving through the food chain, energy is not reused in the food chain. It flows from producers to herbivores to carnivores and so on.



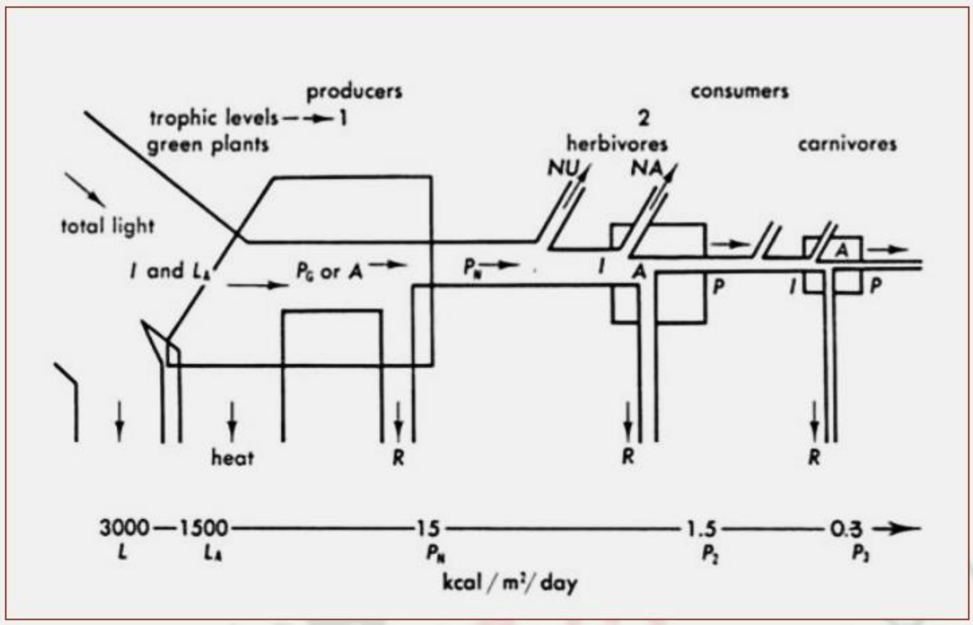
Simplified Single Channel Energy Flow Diagram

Two things are clear from the diagram above: Firstly, the flow of energy is unidirectional and non-cyclic. The green plants obtain energy from the sun and it is transformed into chemical energy by the process of photosynthesis. This energy is stored in plant tissues and transformed into heat energy during metabolic activities which then passes to next trophic level in the food chain. The solar energy captured by green plants (autotrophs) never revert back to sun, however, it passes to herbivores and that which passes to herbivores does not go back to autotrophs but passes to consumers. Thus, in biological systems, the energy flows from the sun to green plants and then to all heterotrophic organisms. Due to unidirectional flow of energy, the entire system would collapse if primary source of energy were cut off.

Secondly, at each tropic level there is progressive decrease in energy as heat in the metabolic reactions and also some of the energy is utilized at each tropic level.

Figure below show the energy flow in three trophic levels in a linear food chain. Here the boxes represent the trophic levels (producers, herbivores and carnivores) and the pipelines depict the energy flow in and out of each trophic level. Size of the box shows energy stored in the form of biomass at that trophic level. There is loss of energy (represented as pipes getting narrower) at every successive trophic level, there is also a corresponding decline in energy stored in standing crop or biomass (represented as decreased size of box) at successive trophic level. Energy inflows in the system balance the energy outflows as required by the first law of thermodynamics and each energy transfer is accompanied by loss of energy in the form of unavailable heat energy (i.e. respiration) as stated second law of thermodynamics.

The energy flow is significantly reduced at each successive trophic level from producers to herbivores to carnivores. Thus, at each transfer of energy from one trophic level to another trophic level, major part of energy is lost in the form of heat or other form. There is successive reduction in the energy flow whether we consider it in term of total flow (I+A) or secondary productivity and respiration component.



Single Channel Energy flow model depicting three trophic levels

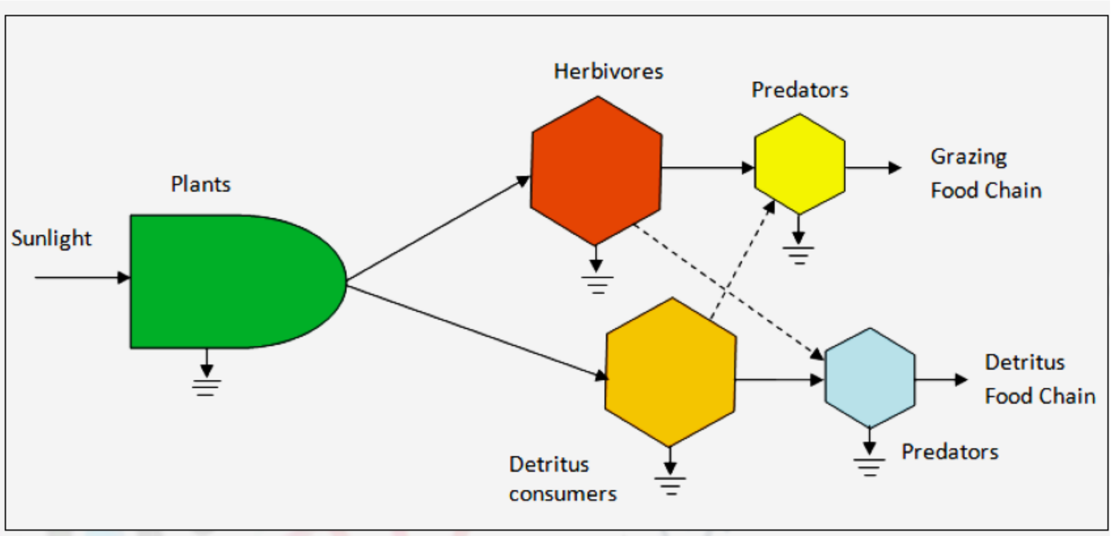
(box 1, 2 and 3) in a linear food chain

[I- total energy input, LA – light absorbed by plant cover, PG – gross primary production, A – total assimilation, PN – net primary production, P – Secondary production, NU – Energy not used (stored), NA – Energy not assimilated by consumers (egested), R – respiration. Bottom line in the diagram shows the order of the magnitude of energy losses expected at major transfer points, starting with a solar input of 3,000 Kcal per square meter per day.

Thus, of the 3000 Kcal of total light falling upon green plants, approximately 50% is absorbed (1500 Kcal), 1% is converted at first trophic level (15 Kcal). Thus net primary production (PN) is 15 Kcal only. Secondary productivity (P2 and P3) tends to be about 10% at successive consumer level, i.e. herbivores and carnivores, although efficiency may be sometimes up to 20% at the carnivores level (as shown in diagram P3 = 0.3 Kcal). There is a successive reduction in energy flow at successive trophic levels. Thus shorter the food chain, greater would be the energy available at higher trophic levels.

Double Channel or Y-Shaped Energy Flow Model

The double channel or Y-Shaped energy flow model depicts the simultaneous working of grazing an detritus food chains in an ecosystem. In nature, both grazing and detritus food chains are interconnected in the same ecosystem. For example, dead bodies of small animals that were once part of grazing food chain become incorporated in the detritus food chain as do the faeces of grazing food animals. Functionally, the distinction between the two is of time lag between the direct consumption of living plants and ultimate utilization of dead organic matter. The importance of two food chains may differ in different ecosystems, in some cases, grazing is more important and in others, detritus is more important. It happens in marine ecosystems where primary production at open sea is limited and a major portion of it is eaten by herbivores marine animals. Therefore, very little primary production is left to be passed onto the detritus pathways. On the other hand, in a forest ecosystem, the huge quantity of biomass produced cannot be all consumed by herbivores and a large part of it enters into detritus compartment in the form of litter. Hence the detritus food chain is more important there. As an example, in a lake open water zone, grazing food chain predominates as phytoplanktons are eaten upon by zooplanktons and other organisms. On the other hand, in the lake bottom, dead organisms are deposited and they are acted upon by detritus feeders and decomposers.



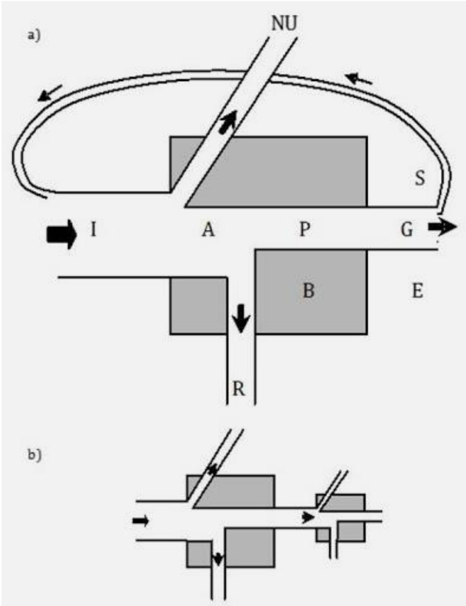
<u>Double Channel or Y-shaped Energy Flow Model</u>

The two arms differ fundamentally in the way they can influence primary producers. In grazing food chain, herbivores feed on living plants, therefore they directly affect the plant population. Whatever they do not eat is available to the decomposers after death. As a result, decomposers are not able to directly influence the rate of supply of their food. Further, the amount of net production energy that flows down the two pathways varies in different kind of ecosystems and often in the same ecosystem; it may vary seasonally or annually. In heavily grazed grassland, 50% or more of the net production may pass down the grazing pathway. But aquatic systems like marshes or forests operate as detritus systems, for, over 90% of primary production is not consumed by heterotrophs until plant parts die and reach water, sediments and soils. This delay in consumption of primary production increases structural complexity of the ecosystem. Since all the food is not assimilated by the grazers, some is diverted to the detritus route. So the impact of grazers on the community depends on the rate of removal of living plants and the amount of energy in the food that is assimilated. Marine zooplanktons commonly graze more phytoplanktons than they can assimilate, the excess being egested to the detritus food chain. Thus energy flow along different path is dependent on the rate of removal of living plant material by herbivores as well as on the rate of assimilation in their bodies.

Universal Energy Flow Model

E.P. Odum (1968) gave Universal Energy Flow Model which represents the basis for a general explanation of ecosystem trophic flows. The model can be applied to any living component, whether it is plant, animal, microorganism, individual, population or trophic group. Such a model may depict food chain as already shown in previous models or the bioenergetics of an entire ecosystem. In the figure, the living structure or biomass of the component is represented as the shaded box. Further, I - is the ingested energy which is solar radiation in case of autotrophs and ingested food in case of heterotrophs. Since not all the energy supplied is utilized, the lost part is called as energy not utilized (NU). The assimilated energy (A) is known as gross production.

Part of A is used for system structural maintenance, that is the respiration (R) and the other part is transformed into organic matter (P), known as net production. P is the energy available for other individuals or trophic levels. Individuals use part of the net production for growth (G) or, in the case of populations or trophic levels, for biomass accumulation (B). A part of net production can be stored (S) to at individual level in the form of organic compounds of higher energetic content (lipids) or, at ecosystem level, as a nutrients deposit or detritus. Some production can be excreted by individuals or, analogously, exported from the ecosystem (E).



Universal Energy Flow Model

[I- Input solar radiations or ingestion of food; A- Assimilated energy; P-net production; G-Growth and Reproduction; B- Standing crop Biomass; R-Respiration; S-Stored energy; E-Excreted energy; NU-energy not utilized]

The universal energy flow, can be used in two ways: i) The model can represent a species population in which case the appropriate energy inputs and links with other species would be shown as a conventional species oriented food web diagram or ii) the model can represent a discrete energy level in which case the biomass and energy channels represent all or parts of many population supported by the same energy source. Foxes, for example, usually obtain part of their food by eating plants (fruits etc.) and part by eating herbivores (rabbit, field mice model etc.).

Energy partitioning between P and R is of vital importance to the individual and species. Different organisms have different patterns of energy consumption. Large organisms require more maintenance energy as they have more biomass to maintain. The warm blooded animals (birds and mammals) require more energy than the cold blooded animals. Predators use a large part of assimilated energy in respiration than herbivore, to find and overcoming the prey. The species adapted to unstable, recently derived or under populated area, generally allocate a large portion of their energy to reproduction. The species adapted to stable and more favorable habitats, allocate little energy to reproduction.

3.3.5 Nutrient Cycling

We have already seen that while energy does not recycle through an ecosystem, nutrients do. Since the inorganic elements move through both the biological and geological world, we call them biogeochemical cycles. Of the 30 to 40 elements necessary to life, six rank as the most important: carbon, hydrogen, oxygen, nitrogen, sulphur and phosphorus. These nutrients move from non-living to the living and back to the non-living again in a cyclic manner.

Each element has its own unique cycle, but all the cycles do have some things in common. **Reservoirs** are those parts of the cycle where the chemical is held in large quantities for long periods of time. In **exchange pools** the chemical is held for only a short time. The length of time a chemical is held in an exchange pool or a reservoir is known as **residence time**. The oceans are the reservoir for water, while a cloud is an exchange pool. Water may reside in an ocean for thousands of years, but in a cloud for a few days only. The biotic community includes all living organisms. This community may serve as an exchange pool and serve to move chemicals from one stage of the cycle to another. For example, the trees of the tropical rain forest bring water up from the forest floor to be evaporated into the atmosphere. The energy from most of the transportation of chemicals from one place to another is provided either by the sun or by the heat released from the mantle and core of the earth.

The biogeochemical cycles are of two basic types: – i) gaseous cycles - such as nitrogen and carbon,

the reservoir is in the atmosphere or hydrosphere (ocean); ii) sedimentary cycles – such as phosphorus cycle, the reservoir is in the lithosphere.

The nutrients are first taken up by the producers, bound in the organic compounds (carbohydrates, proteins, lipids, etc.) and move along the food chain to heterotrophic level and ultimately from all trophic levels, with the detritus, to the decomposers. The decomposers break down the complex organic compounds and release the nutrients back to the soil from where they are again taken up by the plants, thus making the cycle complete. These biogeochemical cycles give an insight in how human activities lead to eutrophication in water bodies and global climate change.

3.3.5.1 Carbon cycle

The source of all carbon is carbon dioxide present in the atmosphere. It is highly soluble in water; therefore, oceans also contain large quantities of dissolved carbon dioxide. The global carbon cycle consists of following steps-

- **Photosynthesis**

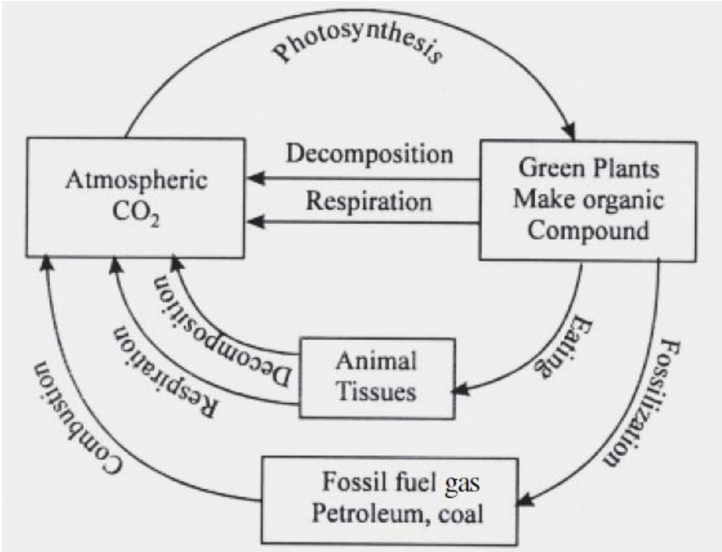
  Green plants in the presence of sunlight utilize CO_2 in the process of photosynthesis and convert the inorganic carbon into organic matter (food) and release oxygen. A part of the food made through photosynthesis is used by plants for their own metabolism and the rest is stored as their biomass which is available to various herbivores, heterotrophs, including human beings and microorganisms as food. Annually 4-9 x 10^{13} kg of CO_2 is fixed by green plants of the entire biosphere. Forests acts as reservoirs of CO_2 as carbon fixed by the trees remain stored in them for long due to their long life cycles. A very large amount of CO_2 is released through forest fires.

- **Respiration**

  Respiration is carried out by all living organisms. It is a metabolic process where food is oxidized to liberate energy, CO_2 and water. The energy released from respiration is used for carrying out life processes by living organism (plants, animals, decomposers etc.). Thus CO_2 is released into of the atmosphere through this process.

- **Decomposition**

  All the food assimilated by animals or synthesized by plant is not metabolized by them completely. A major part is retained by them as their own biomass which becomes available to decomposers on their death. The dead organic matter is decomposed by microorganisms and CO_2 is released into the atmosphere by decomposers.



Carbon Cycle

- **Combustion**

  Burning of biomass releases carbon dioxide into the atmosphere.

- **Impact of human activities**

  The global carbon cycle has been increasingly disturbed by human activities particularly since the beginning of industrial era. Large scale deforestation and ever growing consumption of fossil fuels by growing numbers of industries, power plants and automobiles are primarily responsible for increasing emission of carbon dioxide. Carbon dioxide has been continuously increasing in the atmosphere due to human activities such as industrialization, urbanization and increasing use and number of automobiles. This is leading to increase concentration of CO_2 in the atmosphere, which is a major cause of global warming.

3.3.5.2 Nitrogen cycle

Nitrogen is an essential component of protein and required by all living organisms including human beings. Our atmosphere contains nearly 79% of nitrogen but it can not be used directly by the majority of living organisms. Broadly like corbondioxide, nitrogen also cycles from gaseous phase to solid phase then back to gaseous phase through the activity of a wide variety of organisms. Cycling of nitrogen is vitally important for all living organisms. There are five main processes which essential for nitrogen cycle are elaborated below.

a) Nitrogen fixation: This process involves conversion of gaseous nitrogen into Ammonia, a form in which it can be used by plants. Atmospheric nitrogen can be fixed by the following three methods:-

   a. Atmospheric fixation: Lightening, combustion and volcanic activity help in the fixation of nitrogen.

   b. Industrial fixation: At high temperature (400℃) and high pressure (200 atm.), molecular nitrogen is broken into atomic nitrogen which then combines with hydrogen to form ammonia.

   c. Bacterial fixation: There are two types of bacteria-

      (i) Symbiotic bacteria e.g. Rhizobium in the root nodules of leguminous plants.

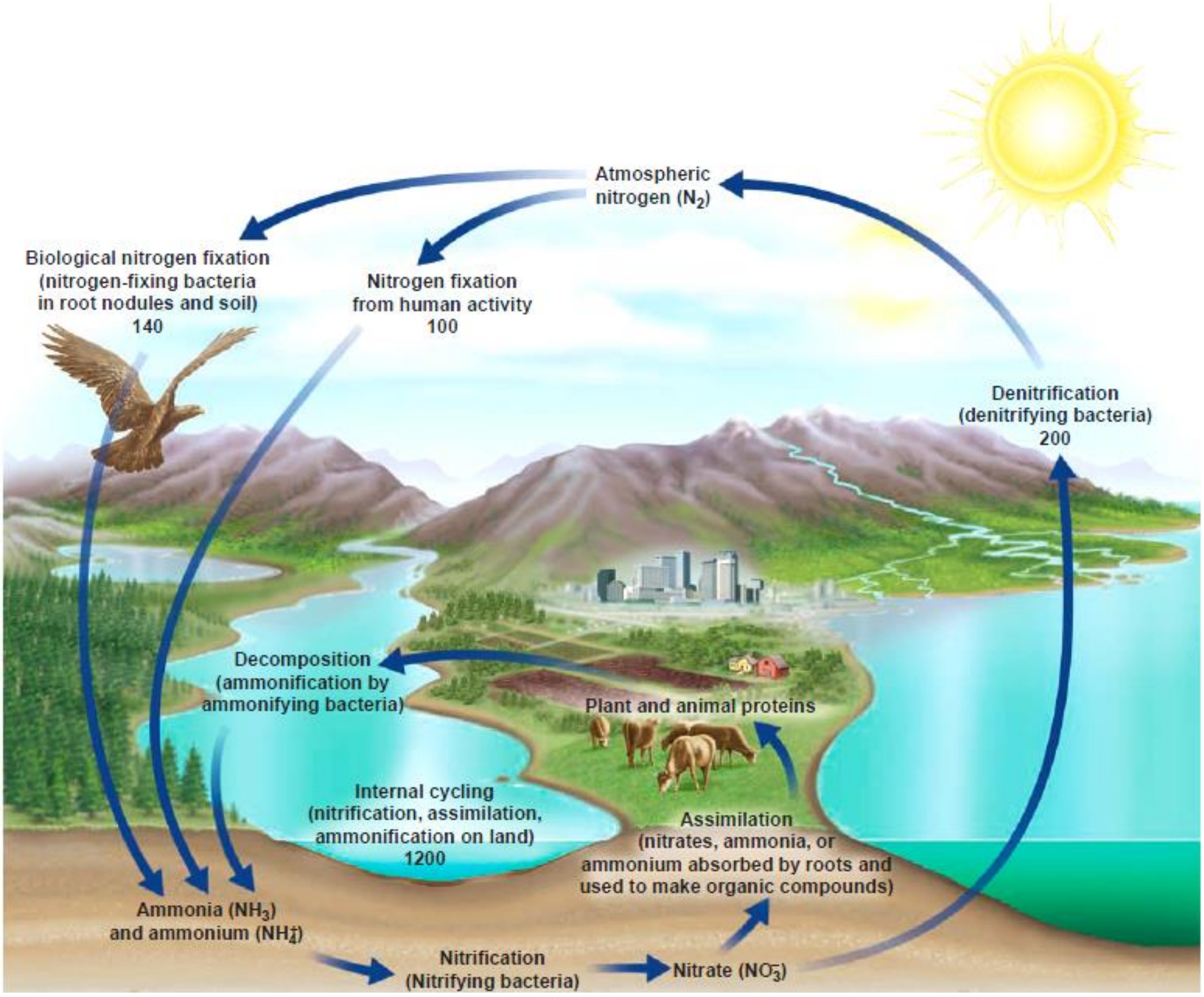
      (ii) Freeliving or symbiotic e.g. Nostoc, Azobacter and Cyanobacteria can combine atmospheric or dissolved nitrogen with hydrogen to form ammonia.

b) Nitrification: It is a process by which ammonia is converted into nitrates or nitrites by Nitrosomonas and Nitrococcus bacteria respectively. Another soil bacteria Nitrobacter can covert nitrate into nitrite.

c) Assimilation: In this process nitrogen fixed by plants is converted into organic molecules such as proteins, DNA, RNA etc. These molecules make the plant and animal tissue.

d) Ammonification : Living organisms produce nitrogenous waste products such as urea and uric acid. These waste products as well as dead remains of organisms are converted back into inorganic ammonia by the bacteria this process is called ammonification. Ammonifying bacteria help in this process.

e) Denitrification: Conversion of nitrates back into gaseous nitrogen is called denitrification. Denitrifying bacteria live deep in soil near the water table as they like to live in oxygen free medium. Denitrification is reverse of nitrogen fixation.



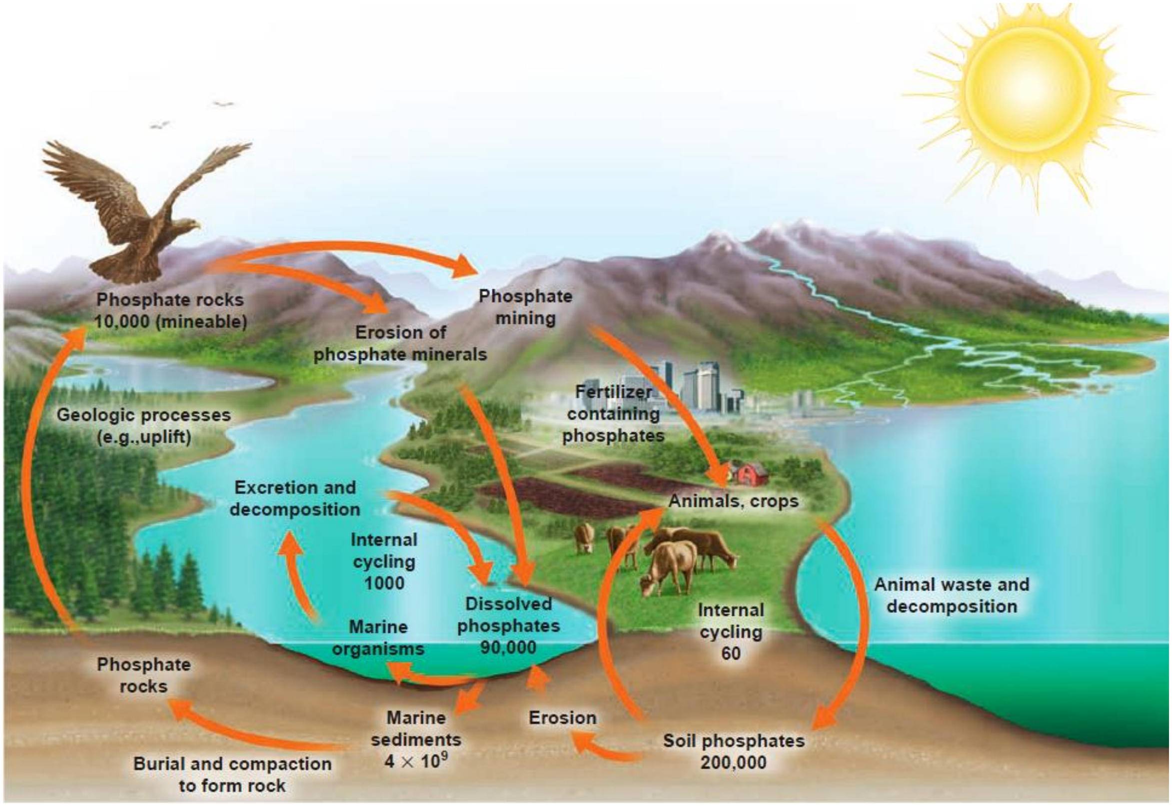
Nitrogen Cycle

3.3.5.3 Phosphorus Cycle

Phosphorus does not form compounds in the gaseous phase and does not appreciably enter the atmosphere (except during dust storms). In the phosphorus cycle, phosphorus cycles from the land to sediments in the ocean and back to the land. As water runs over apatite (group of phosphate-containing minerals that are often found as small green, yellow, or blue crystals in rocks) and other minerals containing phosphorus, it gradually wears away the surface and carries off inorganic phosphate (PO_4^{-3}) molecules. The erosion of phosphorus-containing minerals releases phosphorus into the soil, where plant roots absorb it in the form of inorganic phosphates. Once in cells, phosphates are incorporated into biological molecules such as nucleic acids and ATP (adenosine triphosphate, an organic compound important in energy transfer reactions in cells). Animals obtain most of their required phosphate from the food they eat, although in some localities drinking water contains a substantial amount of inorganic phosphate. Phosphorus released by decomposers becomes part of the soil's pool of inorganic phosphate for plants to reuse. Like carbon, nitrogen and other biogeochemical cycles, phosphorus moves through the food web as one organism consumes another.

Phosphorus cycles through aquatic communities in much the same way that it does through terrestrial communities. Dissolved phosphorus enters aquatic communities through absorption and assimilation by algae and plants, which are then consumed by plankton and larger organisms. A variety of fishes and mollusks eat these in turn. Ultimately, decomposers that break down wastes and dead organisms release inorganic phosphorus into the water, where it is available for aquatic producers to use again.

Phosphate can be lost from biological cycles. Streams and rivers carry some phosphate from the land to the ocean, where it can be deposited on the seafloor and remain for millions of years. The geologic process of uplift may someday expose these seafloor sediments as new land surfaces, from which phosphate will once again erode. A small portion of the phosphate in the aquatic food web finds its way back to the land. Sea birds that eat fishes and other marine animals may defecate on land where they roost. Guano, the manure of sea birds, contains large amounts of phosphate and nitrate. Once on land, these minerals are available for the roots of plants to absorb. The phosphate contained in guano may enter terrestrial food webs in this way, although the amounts involved are quite small.



Phosphorus Cycle

3.3.5.4 Water Cycle

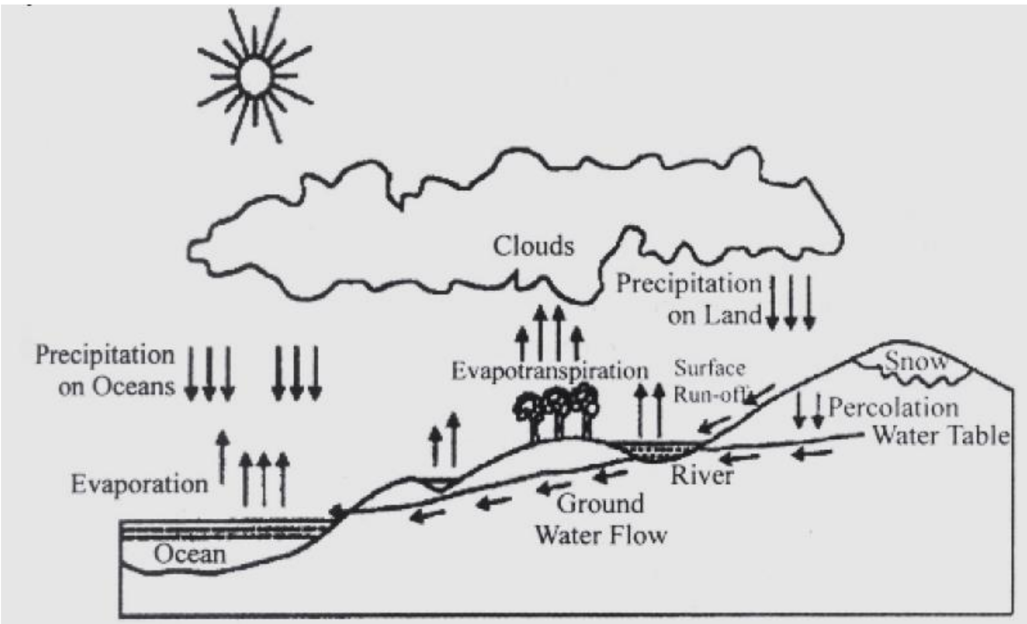
Water is essential for life. No organism can survive without water. Precipitation (rain, snow, slush dew etc.) is the only source of water on the earth. Water received from the atmosphere on the earth returns back to the atmosphere as water vapour resulting from direct evaporation and through evapotranspiration the continuous movement of water in the biosphere is called water cycle (hydrological cycle). Earth is a watery planet of the solar system, about 2/3rd of earth surface is covered with water. However, a very small fraction of this is available to animals and plants.

Water is not evenly distributed throughout the surface of the earth. Almost 95 % of the total water on the earth is chemically bound to rocks and does not cycle. Out of the remaining 5%, nearly 97.3% is in the oceans and 2.1% exists as polar ice caps. Thus only 0.6% is present as fresh water in the form of atmospheric water vapours, ground and soil water.

The driving forces for water cycle are 1) solar radiation 2) gravity. Evaporation and precipitation are two main processes involved in water cycle. These two processes alternate with each other. Water from oceans, lakes, ponds, rivers and streams evaporates by sun's heat energy.

Plants also transpire huge amounts of water. Water remains in the vapour state in air and forms clouds which drift with wind. Clouds meet with the cold air in the mountainous regions above the forests and condense to form rain precipitate which comes down due to gravity.

On an average 84% of the water is lost from the surface of the through oceans by evaporation. While 77% is gained by it from precipitation. Water run off from lands through rivers to oceans makes up 7% which balances the evaporation deficit of the ocean. On land, evaporation is 16% and precipitation is 23%.



Water Cycle

3.3.6 Ecosystem Development

An ecosystem is not static in nature. It grows and changes in its structure and function with time. These changes are very orderly and can be predicted, the process known as ecological succession. The **ecological succession** is defined as an orderly process of changes in the biotic community structure and function with time, mediated through modifications in the physical environment ultimately culminating into a stable community known as climax. Clements (1916) while studying plant communities defined succession as “the natural process by which the same locality becomes successively colonized by different groups or communities of plants.” Odum (1969) preferred to call this process as ecosystem development. Ecosystem development may further be defined in terms of following parameters:

1. It is an orderly process of community development that involves changes in species structure with time. It is a directional process and thus predictable.
2. The succession is a community controlled process even though physical environment determines the patterns, rates of change and development.
3. It culminates in a stabilized ecosystem in which maximum biomass is maintained per unit of energy flow.

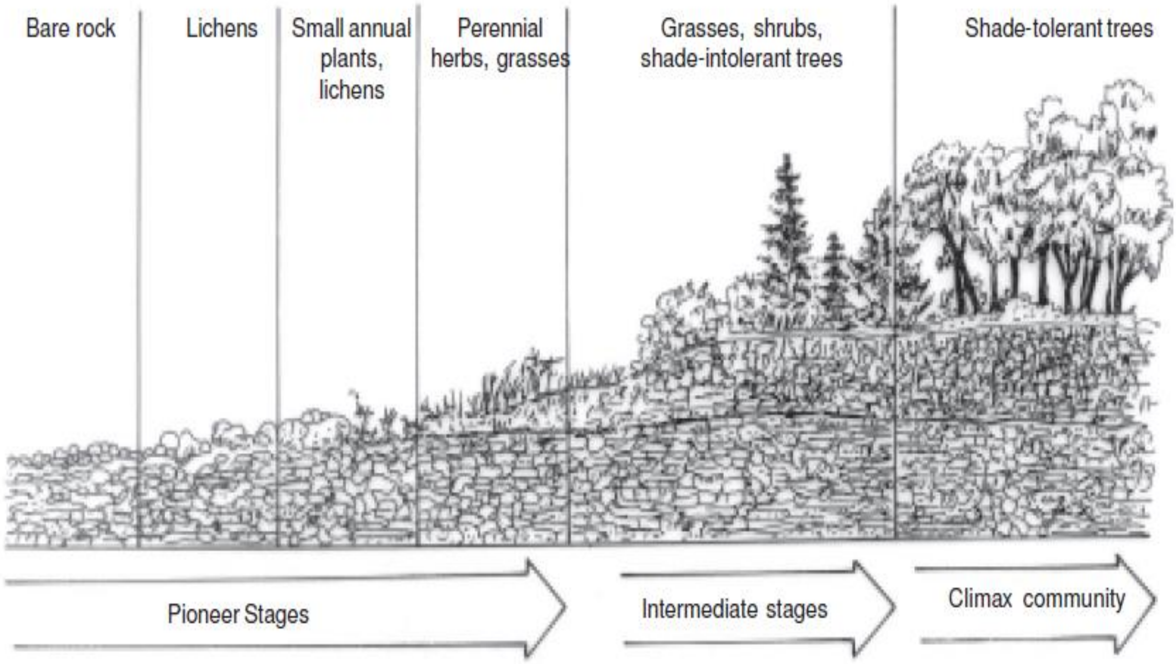
Both the biotic and abiotic components are involved in this change. This change is brought about both by the activities of the communities as well as by the physical environment in that particular area. The physical environment often influences the nature, direction, rate and optimal limit of changes. During succession both the plant and animal communities undergo change. There are two types of successions (i) Primary succession and (ii) Secondary succession.

Primary Succession

Primary succession takes place an over a bare or unoccupied areas such as rocks outcrop, newly formed deltas and sand dunes, emerging volcano islands and lava flows as well as glacial moraines (muddy area exposed by a retreating glacier) where no community has existed previously. The plants that invade first bare land, where soil is initially absent are called **pioneer species**. The assemblage of pioneer plants is collectively called pioneer community. A pioneer species generally show high growth rate but short life span.

Primary succession is much more difficult to observe than secondary succession because there are relatively very few places on earth that do not already have communities of organisms. Furthermore, primary succession takes a very long time as compared to secondary succession as the soil is to be formed during primary succession while secondary succession starts in an area where soil is already present.

The community that initially inhabits a bare area is called **pioneer community**. The pioneer community after some time gets replaced by another community with different species combination. This second community gets replaced by a third community. This process continues sequence-wise in which a community replaced previous by another community. Each transitional (temporary) community that is formed and replaced during succession is called a stage in succession or a **seral community**. The terminal (final) stage of succession forms the community which is called as **climax community**. A climax community is stable, mature, more complex and long lasting. The entire sequence of communities in a given area, succeeding each other, during the course of succession is termed **sere**.



The orderly sequence of primary succession

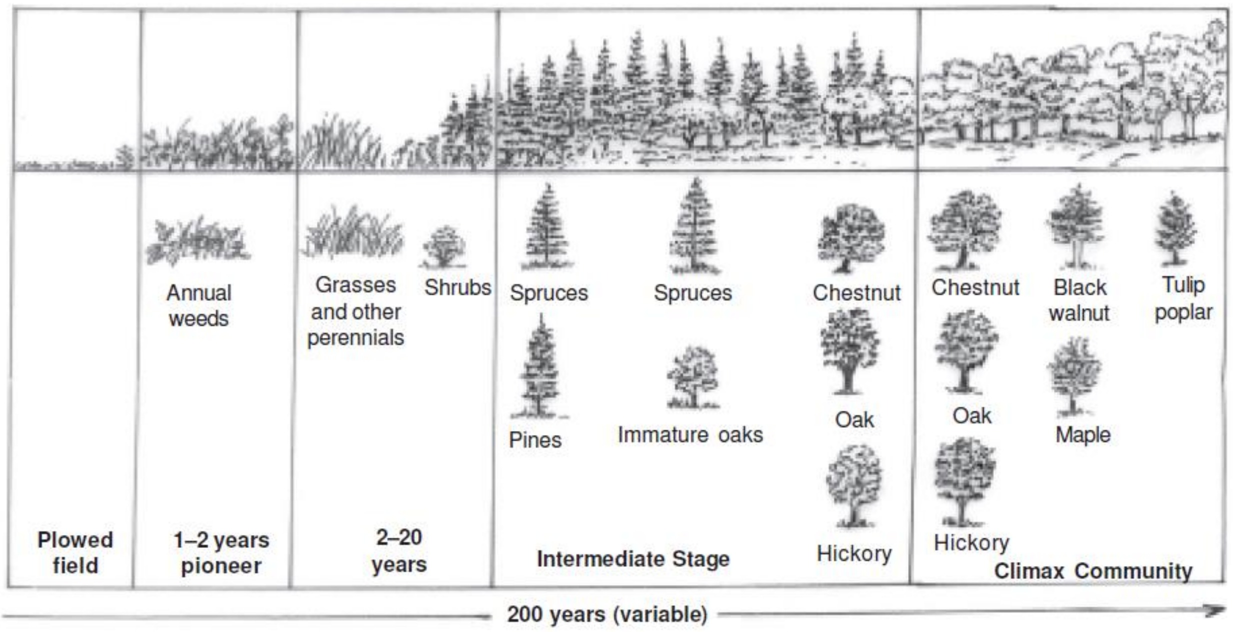
The animals of such a community also exhibit succession which to a great extent is determined by plant succession. However animals of such successional stages are also influenced by the types of animals that are able to migrate from neighbouring communities. A climax community as long as it is undisturbed, remains relatively stable in dynamic equilibrium with the prevailing climate and habitat factors. Succession that occurs on land where moisture content is low for e.g. on bare rock is

known as **xerarch**. Succession that takes place in a water body, like ponds or lake is called **hydrarch**.

Secondary Succession

Secondary succession is the development of a community which forms after the existing natural vegetation that constitutes a community is removed, disturbed or destroyed by a natural event like hurricane or forest fire or by human related events like tilling or harvesting land.

A secondary succession is relatively fast as, the soil has the necessary nutrients as well as a large pool of seeds and other dormant stages of organisms.



Secondary succession on land

The study of these changes is important to understand the past and predict the future of ecosystem. As succession proceeds, changes occur not only in the biotic community but also in physical environment and overall structural and functional characteristics of ecosystems in a holistic manner. Thus, succession has been considered as ecosystem development that culminates in a stabilized ecosystem in which biomass and symbiotic function between organisms are maintained per unit of available energy flow.

3.3.7 Ecosystem Regulation and Stability

All ecosystems regulate and maintain themselves under a set of environmental conditions. While evaluating ecosystem functioning, it is important to know whether an ecosystem is in a state of change or stable. In any ecosystem, any environmental stress tries to disturb the normal ecosystem functions. However, there is always a natural tendency of ecosystem to resist the change and maintain itself in equilibrium with the environment. This self-regulatory mechanism is known as **homeostasis**. `

An ecosystem is an **open system** that receives input from the environment and produces an output. The output from one sub - system may become the input for another sub - system in an ecosystem. For instance, food produced by plants becomes input for an autotrophic subsystem, which further provides an input to heterotrophic subsystem. Input from each subsystem controls the output of another subsystem. In open systems, when some portion of the output may be fed back as input to control the functioning, the system is called a **cybernetic system**.

The system shows tolerance or resistance only within a maximum and minimum range, which is its range of tolerance known as **homeostatic plateau**. It responds to inputs and has outputs and set two types of system response – **negative feedback and positive feedback**.

Negative feedback mechanisms are deviation counteracting mechanisms which try to bring system back to its ideal conditions. They provide stability to ecosystem. All ecosystems have hundreds of negative feedback loops that keep every part of the system within the bounds necessary for proper functioning of system. Negative feedback keeps things the same. When part of a system changes too much from what it should be, other parts of the system change in a way that reverses the change in the first part. The function of negative feedback is to keep the parts of a system within limits that are necessary for survival.

Predator-prey interactions are examples of negative feedback. Predator (tiger) feeds on prey (deer) and reduces its population. This shows the interaction of predator with its prey through a negative feedback. If the predators are more, they will reduce the prey population to the extent that enough food is not available for the predators. So, some of them will die due to lack of food. Hence, the predator population is reduced and in turn, prey population will increase. The negative effect of predators on prey prevents an uncontrolled growth of a predator’s population, thereby stabilizing the population sizes of both predator and prey. If the negative feedbacks are weak or absent, population cycles can amplify and lead to extinction of one or both of the interacting species.

Homeostasis is an example of negative feedback in biological systems. Homeostasis is the control of an organism's internal physical and chemical conditions within limits required for the organism's
survival. For example, if body temperature increases above 37° C, negative feedback reduces the body temperature by reducing metabolic heat generation and increasing heat loss from the body (more blood supply to the skin and more sweating). If body temperature decreases below 37° C, negative feedback increases the body temperature by increasing heat generation (shivering) and decreasing heat loss (less blood supply to the skin and less sweating). Keeping the body temperature close to 37° C is essential for a person's survival.

The positive feedbacks are the deviation accelerating mechanisms. When part of a system increases, another part of the system changes in a way that makes the first part increases even more. There is positive feedback whenever A has a positive effect on B and B has a positive effect on A. Positive feedback is a source of instability; it is a force for change.

So the positive feedback mechanisms add to stress conditions and tend to take the system away from the optimal conditions. Exponential growth is an example of positive feedback. Exponential population growth occurs when there is surplus of food, space and other resources that allows a plant or animal population to grow without limit. More population leads to more growth and more births lead to an increasing population. In recent years, the human population exponential growth is reducing the ecosystem carrying capacity to provide the resources and absorb pollution. Human beings should try to keep the ecosystems within the homeostatic plateau. They should not contribute to positive feedbacks otherwise the ecosystem will collapse.

Ecosystem stability can be understood in context of resistance and resilience. The **resistance** is the ability of the system to resist the forces that tend to disrupt its state of equilibrium. On the other hand, resilience is the ease with which the system returns to its original equilibrium state following any perturbation. For example, a forest ecosystem with large biotic structure may better resist a fire outbreak than a grassland ecosystem with smaller biotic structure. Nevertheless, burnt grassland can quickly recover to its original state than a burnt forest that may take hundreds of years to recover.

3.4 Types of Ecosystem

The biosphere is an intricate net of carefully mixed life forms. Complex interactions of many macro and microscopic species of plants and animals, together with the rich arrays of symbiotic fungi and lichens, are the base of every ecosystem, from forests to coral reefs and freshwater to soils. All ecosystems are not only sources of rich biodiversity, but also extremely productive areas, offering a lot of benefits to mankind. Ecosystem structure includes the spatial distribution of species, their architecture (size, shape and pattern), organisation into communities or guilds, ecodiversity (multiple indices), seasonal and long term patterns, relationship to soil and climate characteristics and many other factors. Ecosystem function can be much harder to study and involves questions of nutrient cycling, productivity, decomposition, energy flow, water cycles, food webs, reproduction, predation, demographics (increasers and decreasers), resilience, stability and many other dynamic processes. All types of ecosystems fall into one of two categories: terrestrial or aquatic. Terrestrial ecosystems are land based, while aquatic are water based.

3.4.1 Terrestrial Ecosystems

The distribution of terrestrial ecosystems is primarily related to precipitation and temperature. Terrestrial ecosystems can be divided, mainly on the basis of the prevailing vegetation type, into three basic categories: forest, grassland and desert.

3.4.1.1 Forest Ecosystem

Forests worldwide are known to be critically important habitats in terms of the biological diversity they contain and in terms of the ecological functions they serve. Forests are multi-functional: they provide an often complex array of goods and services. Forest ecosystems cover large parts of the terrestrial land surface and are major components of the terrestrial carbon cycle. Trees, the main component of forest ecosystems, contain the largest stock or absolute quantity of the living forest biomass. The total forest biomass is about 677 petagram (Pg) and trees constitute 80% of the world's biomass. The forest is a complex and rich ecosystem as well as a valuable renewable natural resource. Its direct offerings include forest biomass, timber and a series of other forest products, storehouse of genetic material acting as genetic reservoir for future improvements of agricultural production and the most significant, along with the oceans, shelters of the planet's wildlife. The indirect offerings of forests are perhaps even more important for man and include protection of drainage basins against erosion and the creation and preservation of soil, regulation and stabilization of the water cycle, global climate stabilization through binding and storing of atmospheric CO_2, regulation of the local climate through the increase of evapotranspiration and, consequently, of humidity and reduction of the temperature variations amplitude, regulation of nutrients' circulation in the ecosystems, regulation of water and atmospheric air quality etc. Since the range of temperatures that allow forest development is exceptionally wide, a series of forest types succeed one another in different geographic latitudes. Forest ecosystems correspond also to a wide range of humidity values, from dry to very humid regions.

A. Tropical Rainforests

Tropical rainforests are restricted primarily to the equatorial zone between latitudes 10°N and 10°S in Central and South America, Africa, Southeast Asia and some islands in the Caribbean Sea and Pacific Ocean. Climates where tropical rain forests develop are always warm and receive at least 200 cm of precipitation throughout the year, with no less than 10 cm during any single month. Their soils are typically old and deeply weathered oxisols. Because they are relatively devoid of humus and clay, they take on the reddish colour of aluminium and iron oxides and retain nutrients poorly. In spite of the low nutrient status of the soils, rain forest vegetation is dominated by a continuous canopy of tall evergreen trees rising to 30–40 m. Tropical rain forests are teeming with life and have incredible biological diversity. Nearly 90 percent of all non-human primate species live in them. Tropical rainforests are under intense pressure from logging and agriculture.

B. Temperate Decidous Forest

Temperate decidous forest is typical of the eastern half of the United States, parts of south central and south eastern Canada, southern Africa and many areas of Europe and Asia. These areas generally receive 75 to 100 cm (30 to 60 inches) of relatively evenly distributed precipitation per year. The winters are relatively mild and plants are actively growing for about half the year. Temperate deciduous forests have fewer tree species than tropical rain forests. But the penetration of more sunlight supports a richer diversity of plant life at ground level. Most of the temperate deciduous forests have been heavily affected by human activity such as farming, periodic logging and furthermore they are the major population centres. Some of these diverse forests have been cleared and replaced with tree plantations consisting of only one tree species.

C. Temperate Evergreen Forest

Temperate rainforests exist in the coastal areas of northern California, Oregon, Washington, British Columbia, southern Alaska, New Zealand and the southwest coast of Chile. They typically receive at least 130 cm (50 inches) of rain each year. Furthermore, rain occurs throughout the year and the cool climate slows evaporation, so thing are generally damp. This abundance of water, along with fertile soil and mild temperatures, results in a lush growth of plants. In warm temperate climates near the Pacific coast in north western North America and in southern Chile, New Zealand and Tasmania, mild winters, heavy winter rains and summer fog create conditions that support extremely tall evergreen forests. In North America, these forests are dominated toward the south by coast redwood (Sequoia sempervirens) and toward the north by Douglas-fir (Pseudotsuga spp.). In contrast to rain forests in the tropics, temperate rain forests typically support few species. Because of the rich resource of trees, at least half of the original temperate rainforest has already been logged.

D. Tropical Dry Forests

Tropical dry forests are found in parts of Central and South America, Australia, Africa and Asia (particularly India and Myanmar). Many of the tropical dry forests have a monsoon climate in which several months of heavy rainfall are followed by extensive dry periods ranging from a few to as many as eight months. Since the rainfall is highly seasonal, many of the plants have special adaptations for enduring drought. Many of these forests occur in areas of very high human population. Therefore, the harvesting of wood for fuel and building materials has heavily affected these forests.

E. Taiga

Stretching in a broad belt centered at about 50°N in North America and about 60°N in Europe and Asia lies the evergreen coniferous forests or the boreal forest biome, often called taiga. In this subarctic climate, winters are long, dry and extremely cold, with sunlight available only 6–8 hours a day. Summers are short, with mild to warm temperatures and the sun typically shines 19 hours a day. Most boreal forests are dominated by a few species of coniferous (cone-bearing) evergreen trees such as spruce, fir, cedar, hemlock and pine that keep some of their narrow-pointed leaves (needles) all year long. Human impact is less severe than with many other biomes because population density is generally low in this region.

F. Tundra

The tundra is an extremely cold region that lacks trees and has a permanently frozen subsurface soil. This frozen soil layer is known as permafrost. The amount of precipitation is less than 25 cm (10 inches) per year and the short summer is generally wet because the winter snows melt in the spring and summer temperatures are usually less than 10°C (50°F). Soils tend to be acidic because of their high organic matter content. Arctic tundra is an expansive biome that has low productivity because it has a short growing season. Plants hold their foliage for years. Most plants are dwarf, prostrate woody shrubs, which grow low to the ground to gain protection under the winter blanket of snow and ice. Tundra is essential for global biodiversity, especially for migratory birds.

3.4.1.2 Grassland Ecosystem

Grassland ecosystems are ecologically and economically important and are of widespread occurrence. The potential distribution of grassland ecosystems to a large extent is determined by climatic variables, principally temperature and precipitation. Three factors including drought, fire and grazing by large ungulate herbivores, distinguish grasslands from other ecosystem types. They are located in areas in which water availability is below the requirement for the forest at some time during the year but is sufficient to support grasses as the dominant plant type. Grasslands in the wider sense are among the largest ecosystems in the world; their area is estimated to be 40.5 % of the terrestrial area excluding Greenland and Antarctica (White et al., 2000). Different types of grasslands include

A. Tropical Grasslands

Tropical grasslands also called **savannas** are found in tropical parts of Africa, South America and Australia and are characterized by extensive grasslands spotted with occasional trees or patches of trees. Although savannas receive 50 to 150 cm of rain per year, the rain is not distributed evenly throughout the year. Typically, a period of heavy rainfall is followed by a prolonged drought which results in a very seasonally structured ecosystem. Fire and grazing undoubtedly play important roles in maintaining the character of the savanna biome, particularly in wetter regions, as grasses can persist better than other forms of vegetation under both influences. Savannas are characterized by a codominance of grasses and woody plants. Such vegetation is characteristic of regions with alternating wet and dry seasons. Savannas range from grass with occasional trees to shrubs to communities where trees form an almost continuous canopy as a function of precipitation and soil texture. Productivity and decomposition in savanna ecosystems are closely tied to the seasonality of precipitation. Savannas support a large and varied assemblage of both invertebrate and vertebrate herbivores. The African savanna is dominated by a large, diverse population of ungulate fauna and associated carnivores. Savannas have been heavily impacted by agriculture.

B. Temperate Grasslands

Temperate grasslands, also known as prairies or steppes, are widely distributed over temperate parts of the world. Temperate grasslands cover vast expanses of plains and gently rolling hills in the interiors of North and South America, Europe and Asia. In these grasslands, winters are bitterly cold, summers are hot and dry and annual precipitation is fairly sparse and falls unevenly through the year. In North America, grasslands develop within continental climate zones where rainfall ranges between 30 and 85 cm per year and winters are cold. The growing season increases from north to south from about 120 to 300 days. These grasslands are often called **prairies**. Extensive grasslands are also found in central Asia, where they are called **steppes**. Precipitation is infrequent, so organic detritus does not decompose rapidly and the soils are rich in organic matter and nutrient content. The vegetation is dominated by grasses, which grow to heights over 2 m in the moister parts of these grasslands and to less than 0.2 m in more arid regions. Fires are infrequent in temperate deserts because the habitat produces little fuel.

C. Mediterranean Shrublands

The Mediterranean shrublands, also called chaparral, are located near oceans and are dominated by shrubby plants. Mediterranean shrublands have a climate with wet, cool winters and hot, dry summers. Rainfall is 40 to 100 cm (15 to 40 inches) per year. This biome is typical of the Mediterranean coast and is also found in coastal southern of Chile and southern Australia. The vegetation is dominated by woody shrubs that are adapted to withstand the hot, dry summer. Often the plants are dormant during the summer. Chaparral consists mostly of dense growths of low-growing evergreen shrubs and occasional small trees with leathery leaves that reduce evaporation. During the long, hot and dry summers, chaparral vegetation becomes very dry and highly flammable. Fire is a common feature of this biome and the shrubs are adapted to withstand occasional fires.

3.4.1.3 Deserts

Deserts cover 17% of the world's land mass and harbour almost one-third of terrestrial global carbon stock. A desert often is defined as an area that receives less than 10 inches (25.4 cm) of unevenly distributed precipitation over the year. Much of this land lies between 15° and 30° latitude, where the air that is carried aloft along the Intertropical Convergence Zone subsides to form the semi-permanent high-pressure cells that dominate the climate of tropical deserts. Climatic conditions of aridity lead to high radiation and high evaporation. Lack of water by climate can be the main reason under all temperature regimes. Arid regions are defined as areas where potential evapotranspiration is higher than precipitation. The most important factors that affect life in the desert biomes include radiation, heat and temperature, wind, water and nutrition. The radiant environment to which organisms in the desert environment are exposed is complex including, inter alia, direct solar radiation, diffuse radiation from clouds and the atmosphere and considerable short wave radiation reflected from the soil's surface and other objects. The heat to which a desert organism is exposed comes not only from solar radiation but includes metabolic heat production, radiant heat transfer, conduction, convection and evaporative heat exchange, all of which are exacerbated in the desert environment. Wind and the role of limited water in the water balance of the organisms are also important influencing factors, together with nutritional stress.

The deserts are complex ecosystems with diverse and fragile groupings of sometimes bizarre plants, animals and fungi and little studied members of the Protista and Monera. The biomes may be influenced by their positions in coastal, inland or rain shadow deserts. Key characteristics of the biota are their adaptations to aridity, climate variability, scant summer and winter rainfall patterns and, most importantly, unpredictable rainfall. The adaptations fostering tolerance may take the form of morphological, physiological or behavioural. Some desert plants use deep roots to tap into groundwater. Others such as prickly pear and saguaro cacti use widely spread shallow roots to collect water after brief showers and store it in their spongy tissue. Evergreen plants conserve water by having wax coated leaves that minimize evapotranspiration. Others, such as annual wildflowers and grasses, store much of their biomass in seeds that remain inactive, sometimes for years, until they receive enough water to germinate. The hot deserts range from those lacking vegetation to ones with some combination of chenopods, dwarf shrubs and succulents.

Despite their aridity, desert ecosystems support a surprising diversity of animal life, including a wide assortment of beetles, ants, locusts, lizards, snakes, birds and mammals. The mammals are mostly herbivorous species. Desert rodents, particularly the family Heteromyidae and ants feed largely on seeds and are important in the dynamics of desert ecosystems. Seed-eating herbivores can eat up to 90 percent of the available seeds. That consumption can distinctly affect plant composition and plant populations. Desert carnivores, such as foxes and coyotes, have mixed diets that include leaves and fruits; even insectivorous birds and rodents eat some plant material. Omnivory, rather than carnivory and complex food webs, seems to be the rule in desert ecosystems. The infrequent rainfall coupled with high rates of evaporation limit the availability of water to plants, so primary productivity is low. Ephemerality and micro-climate exploitation are found in many desert plants. Diapause, as exemplified by temporary pond inhabitants, is usually facultatively, not seasonally, controlled in desert ecosystems. Prolonged dormancy, or aestivation, is important for ectothermic vertebrates. Birds and large mammals may undergo seasonal migration to take advantage of temporary resource availability. Deserts tend to have relatively low biomass of plants and animals simply because of the arid environment. Nevertheless, most deserts have relatively high diversity with respect to reptiles and invertebrates and sometimes to succulent plants. Depending on the definition of the desert area, the degree of endemism of invertebrates, reptiles and some plants can be high.

TYPES OF DESERT IN WORLD			
HOT DESERTS		**COLD DESERTS**	
1 Arabian	Arabian Peninsula	1 Atacama	Coasts of Peru and Chile
2 Australian	(Great Sandy, Victoria, Simpson, Gibson, and Sturt) Australia	2 Gobi	Northern China and Southern Mongolia
3 Chihuahuan	North Central Mexico and South-western United States (Arizona, New Mexico, Texas)	3 Great Basin	Western United States (Idaho, Nevada, Oregon, and Utah)
4 Kalahari	South-western Africa	4 Iranian	Iran, Afghanistan, and Pakistan
5 Mojave	South-western United States (Arizona, California, Nevada)	5 Namib	Coasts of South-western Africa
6 Monte	Argentina	6 Takla Makan	Western China
7 Sahara	Northern Africa	7 Turkestan	Parts of the Middle East and South-western Russia
8 Sonoran	South-western United States (Arizona, California) and parts of Mexico (Baja Peninsula, Sonora)		
7 Thar	India and Pakistan		

Threats from water mismanagement, overgrazing and over browsing by livestock, agricultural expansion, a lack of law enforcement and introduced and exotic species are expected to result in loss of desert species and habitats. Human population growth and its distribution across the desert will be one of the most important issues that will be faced during the next century. Construction of large desert cities, soil destruction by off-road vehicles and urban development, soil salinization from irrigation, depletion of underground water supplies, land disturbance and pollution from mineral extraction and storage of toxic and radioactive wastes are some of such anthropogenic activities that are posing threat to desert ecology. Deserts take a long time to recover from disturbances because of their slow plant growth, low species diversity, slow nutrient cycling (because of little bacterial activity in their soils) and lack of water. Protection of seemingly barren desert areas for their undiscovered endemic plants and animals could be expected to yield valuable results.

3.4.2 Aquatic Ecosystems

An important determiner of the nature of aquatic ecosystems is the amount of salt dissolved in the water. Those that have little dissolved salt are called freshwater ecosystems and those that have a high salt content are called marine ecosystems. Several other important factors include the ability of the sun’s rays to penetrate the water, the depth of the water, the nature of the bottom substrate and the water temperature.

Aquatic organisms

Plankton: The main kinds of organisms in aquatic ecosystems are free-floating, very small organisms called plankton. Phytoplankton is the most important kind of plankton, because phytoplankton consists of producers. The other species of plankton are consumers (zooplankton). **Nekton:** is a group of larger, swimming consumers, which eat plankton or other consumers. Examples of nekton are fish and turtles.

Benthos: are the bottom-dwelling organisms.

Decomposers: These include bacteria, fungi and other microorganisms, are the other major group in the food web. These organisms decompose organic material into simple inorganic substances. Some of the decayed material is subsequently recycled as nutrients, such as phosphorus (in the form of phosphate, PO_4^{-3}) and nitrogen (in the form of ammonium, $NH4^{+}$) which are readily available for new plant growth. Carbon is released largely as carbon dioxide that acts to lower the pH of bottom waters.

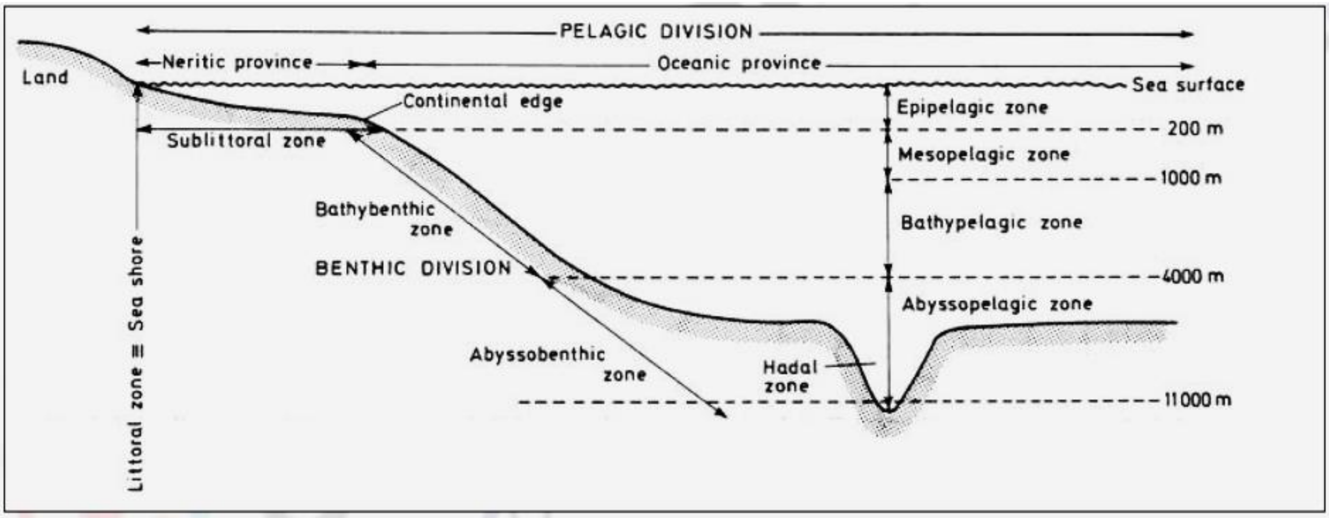
3.4.2.1 Marine Ecosystem

Seawater covers approximately 71 percent of the earth’s surface, an area of about 361 million square kilometres (139 million square miles) comprising the major ocean areas. In the deepest parts the bottom lies more than 10000 m from the surface and the average depth is about 3700 m. In oceans the surface area lighted by the sun is small compared to the total volume of water. This small volume of sunlit water and the dilute solution of nutrients limit primary production. All of the seas are interconnected by currents, influenced by wave actions and tides and characterized by salinity. Vertical stratification is a key feature of aquatic ecosystems. Light decreases rapidly with depth and communities below the photic zone (light zone, often reaching about 20 m deep) must rely on energy sources other than photosynthesis to persist. Temperature also decreases with depth. Warm, bright, near-surface communities, such as coral reefs and estuaries, are among the world's most biologically productive environments. Temperature also affects the amount of oxygen and other elements that can be absorbed in water. There are broadly two ways in which organisms live in the sea; they float or swim in the water, or they dwell on or within the sea bottom. Hence there are two major divisions of the environment, the **Pelagic** and the **Benthic**, the Pelagic Division comprising the whole body of water forming the seas and oceans and the Benthic Division the entire sea bottom.

A. Pelagic Marine Ecosystem

The pelagic is divided into two provinces: the neritic province, water that overlies the continental shelf and the oceanic province. Because conditions change with depth, the pelagic is divided into several distinct vertical layers or zones.

The pelagic zone can be further subdivided into ecological zones based on depth: in the **epipelagic or photic zone**(0-200m) , there are sharp gradients in illumination, temperature and salinity; the **mesopelagic** (200-1000m), has little light to penetrate and the temperature gradient is more even and gradual, without much seasonal variation and this zone contains an oxygen-minimum layer and often the maximum concentration of nutrients (nitrate and phosphate);in the **bathypelagic** (1000-4000m), darkness is virtually complete, except for bioluminescent organisms; temperature is low; and water pressure is great; and the **abyssopelagic region** (4000 to 6000m) Areas deeper than 6000m are called **hadalpelagic regions** – which includes areas found in deep-sea trenches and canyons, while they account for the deepest regions on the planet's oceans, they compose a very small fraction of the total oceanic environment (for example, the Mariana trench is a hadal environment). The pelagic environment is home to two basic groups of marine organisms. The first group consists of the **plankton** (Greek for "wandering") which is appropriate because they possess little power to "swim" any significant distance and are thus passively transported by ocean currents. Planktonic plants are known as **phytoplankton** and planktonic animals are known as **zooplankton** (e.g. jellyfish, small crustaceans, pelagic snails, etc.). The second group of pelagic marine organisms are the free swimming nekton, including marine mammals, fish, squid and some larger crustaceans.



Ecological Divisions of the Marine Ecosystem

Coral reef ecosystems

Coral reefs are among the best-known marine systems, because of their extraordinary biological productivity and their diverse and beautiful organisms. Reefs are colonies of minute, colonial animals (coral polyps) that live symbiotically with photosynthetic algae. Calcium-rich coral skeletons shelter the algae and algae nourish the coral animals. They are a unique accumulation of dead skeletal material built up by carbonate secreting organisms, mostly living coral (Cnidaria, Anthozoa) but also coralline red algae (Rhodophyta, Corallinaceae),green calcerous algae (Halimeda), foraminifera and mollusks. Although various types of corals can be found from the water's surface to depths of 6000 m, reef-building corals are generally found at depths of less than 45 m. Reefs are among the most endangered biological communities. Sediment from coastal development, farming, sewage, or other pollution can reduce water clarity and smother coral. Destructive fishing practices, including dynamite and cyanide poison, have destroyed many Asian reefs. Reefs can also be damaged or killed by changes in temperature, by invasive fish and by diseases often lead to coral bleaching.

Mangrove swamp ecosystems

Mangroves are the dominant ecosystems that line the coasts of subtropical and tropical coastlines around the world. Mangrove ecosystems demonstrate close links between vegetation assemblages and geo-morphologically defined habitats. Mangroves are a diverse group of salt-tolerant trees that grow along warm, calm marine coasts around the world. Growing in shallow, tidal mudflats, mangroves help stabilize shorelines, blunt the force of storms and build land by trapping sediment and organic material. Detritus, including fallen leaves, collects below mangroves and provides nutrients for a diverse community of animals and plants. Both marine species (such as crabs and fish) and terrestrial species (such as birds and bats) rely on mangroves for shelter and food. Mangroves are found in south Florida, the Caribbean, Southeast Asia, Africa and other parts of the world where tropical mudflats occur.

B. Benthic Marine Ecosystems

Benthic organisms (those living on the floor of the deep ocean) vary with depth and substrate. They are strictly heterotrophic and depend on organic matter that drifts to the bottom. They include filter feeders, collectors, deposit feeders and predators. The sea bottom and the seashore together make up the Benthic Division which comprises three major zones, the Littoral, the Sublittoral and the Deep Sea Zones. The **Littoral Zone** includes the greater part of the seashore together with the wave-splashed region above high tide level. The **Sublittoral Zone** is the shallow sea bottom extending from the lower part of the shore to the continental edge. The **Deep Sea Zone** lies below the continental shelf and can be subdivided into **Bathybenthic** and **Abyssobenthic** Zones. The Bathybenthic zone lies between the continental edge and a depth of about 4000 m, comprising mainly the continental slope. The Abyssobenthic Zone is the bottom below 4000 m, including the continental rise, abyssal plain and deeper parts of the sea floor.

Estuaries

Rivers eventually reach the sea. The place where the one-way flow of freshwater meets the incoming and outgoing tidal water is an estuary. Estuary is defined as a semi-enclosed coastal body of water that extends to the effective limit of tidal influence, within which seawater entering from one or more free connections with the open sea or any other saline coastal bodies of water is significantly diluted with freshwater derived from land drainage and can sustain euryhaline biological species, either a part or whole of their life cycle. The intermingling of freshwater and tides creates a nutrient trap exploited by estuarine life.

Estuaries are especially important as nursery sites for fish and crustaceans such as flounder and shrimp. The adults enter these productive, sheltered areas to reproduce and then return to the ocean.

3.4.2.2 Freshwater Ecosystems

Freshwater ecosystems, the study of which is known as **limnology**, are conveniently divided into two groups: lentic or standing water habitats and lotic or running water habitats.

a) Lentic

The term lentic refers to standing bodies of water such as lakes, reservoirs and ponds. Lakes and ponds are large, natural bodies of standing water. These are fed mainly by rainfall and melting snow. Communities occur in a wide range of water bodies and nutrient conditions under diverse climates. Most of them are young in geological sense. Ponds may be seasonal with life span of few weeks and months, or perennial with age of several hundred years. While lakes and ponds have much in common, lakes are larger and deeper. The greater size and depth of lakes makes for some differences in dissolved oxygen levels, plant growth and temperature. There is a very large variety of freshwater lakes, from fishing ponds to Lake Baikal in Siberia. Lakes date back as far as the ice ages. For example, Lake Baikal of Russia and some others are very ancient. Lake Baikal is the oldest, largest and deepest freshwater lake in the world. It contains 20% of the world's total unfrozen freshwater reserve. Lake Vostok, in Antarctica, is one of the largest sub-glacial lakes in the world. On top of the lake is an icecap four kilometers thick. The ice actually insulates the water, preventing it from freezing.

The warmer part of the lake with small temperature gradient is called **epilimnion** and the cooler part of the lake is called **hypolimnion**. These two layers are separated by **metalimnion**, characterized by a steep decline in temperature and include thermocline.

Lakes and ponds consist of different life zones. Typically, four zones are distinct in ponds and lakes:

(i) **Littoral Zone:** The littoral zone is found near the shore, light reaches up to the bottom and rooted plants grow. It is the most productive zone of a lake, because it gets abundant sunlight and it receives nutrients from land run-off. The littoral zone sustains floating plants, surfaced plants, submerged plants and phytoplankton. There are also large quantities of decomposers and some animal species, such as frogs, fish and insects.

(ii) **Limnetic zone:** The open water zone, where light intensity is adequate and plankton are the dominant biota. This is the zone on the surface of the lake, extending to the depth where sunlight penetrates. Depending on the available nutrients it contains phyto- and zooplankton and various fish species. Phytoplankton includes desmids, diatoms and filamentous algae, are the primary producers and form the base on which the rest of life depends. Also suspended in the water column are small grazing animals, called crustaceans that feed on the phytoplankton; these animals form an important link in energy flow in the limnetic zone.

(iii) **Profundal zone:** This constitutes the deep water with light very low or absent. Life in the profundal zone depends on the supply of energy and nutrients from the limnetic zone. Only heterotrophic organisms occur in this zone.

(iv) **Benthic Zone:** The bottom zone of a lake is a region of marked biological activity. Associated with the benthic community are organisms which are called periphyton or aufwuchs. Aufwuchs on stones and debris constitute a mixture of algae, fungi and bacteria. In the benthic region are found aquatic insects, molluscs (clams, snails) other invertebrates, worms and crayfish. Loktak Lake is the largest natural freshwater lake in the north-eastern region of India and plays an important role in the ecological and economic security of the region .

Classification of Lakes

One system for classifying lakes is based on their productivity on the basis of their relative nutrient richness. On the basis of nutrient enrichment, the lakes are of the following types:

Oligotrophic: An oligotrophic lake is one which has a relatively low productivity due to the low nutrient content in the lake. The waters of these lakes are usually quite clear due to the limited growth of algae in the lake. These lakes are usually found in the cold regions of the world where mixing of nutrients is rare.

Mesotrophic: Lakes with an intermediate level of productivity are called mesotrophic lakes. These lakes are usually clear water with submerged aquatic plants.

Eutrophic: Lakes have high levels of biological productivity due to high concentration of nutrients, especially nitrogen and phosphorus.

Eutrophication is the process of increased productivity of a lake as it ages. Eutrophication might occur naturally or due to human impact. Often this process is greatly accelerated by human influence and is termed cultural eutrophication.

Wetlands

Wetland ecosystems are estimated to cover more than 1,280 million hectares globally. Wetlands are area of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres. They are areas of land where water covers the soil – permanently or just at certain times and include: rivers, swamps, marshes, billabongs, lakes, lagoons, oases, salt marshes, mudflats, mangroves, coral reefs, bogs, fens and peatlands. There are even underground wetlands. There are a range of wetland classifications used for different purposes, based on hydrogeomorphology and/or vegetation characteristics, such as:

- Marine (coastal wetlands, including coastal lagoons, rocky shores and coral reefs)
- Estuarine (including deltas, tidal marshes and mangrove swamps)
- Lacustrine (wetlands associated with lakes)
- Riverine (rivers and wetlands along rivers and streams)
- Palustrine (marshes, swamps and bogs). Threats to wetland ecosystems comprise the increasing biotic and abiotic pressures and perils.

b) Lotic

The term ‘Lotic’ refers to the running water ecosystems such as streams and rivers. Apart from being a crucial ecosystem linking the land and ocean systems, rivers serve as a prominent geological agent in tropical and subtropical regions. River ecology deals mainly with the energy transformation, nutrient turnover and storage and processing of organic matter. Rivers are basically heterotrophic as a substantial proportion of the biotic energy that drives stream communities is organic matter derived from allochthonous sources. Many aquatic plants, invertebrates and fishes have adapted to fill a specific niche. Within most rivers, the pattern of flow variation and its ramifications in terms of substrate stability and water quality, is the dominant factor controlling species distributions. Lotic ecosystems are longitudinally interdependent and that energy processing depends on the retention and cycling of nutrients by biological communities in upstream areas. Biological community of a river ecosystem includes a variety of plants and animals. Producers in aquatic systems include diatoms, blue green algae and water moss. Nymphs of dragon flies, may flies and stone flies, beetles, snails, fishes, etc. are the common consumers in river ecosystems. Riparian and in stream vegetations are the integral components of the river ecosystems. The riparian vegetation plays an important role in sustaining the vitality of rivers. It is a source of organic matter, which forms an important source of energy in most of the river ecosystems.

3.5 Check Your Progress

A. Fill in the blanks:

1. Pyramid of ……….. is always upright.
2. The term ecosystem was coined by …………….. .
3. The organisms who feed directly on producers are called…………. .
4. The .... is defined as a collection of food chains which are interconnected at multiple tropic levels.
5. Guano deposits on the coasts of Peru are rich in…………… .
6. The ultimate stable and culminating community during succession is called a ………… .
7. The inherent property of all living organisms to resist change is called………… .
8. The concept of food web looks ecologically more .... than the concept of food chain.
9. Each food chain is a descriptive diagram including a series of arrows, each pointing from one species to another, representing the flow of .... from one feeding group of organisms to another.
10. Flow of energy in an ecosystem is unidirectional while movement of nutrients is ………… .

B. Choose the correct option:

1. The progressive accumulation of some non-biodegradable chemicals through the food chains is known as
   a) Ecological balance
   b) Biological magnification
   c) Trophic structure
   d) Bio-degradation
2. The type of succession occurring on a bare rock is called …………. .
   a) Halosere
   b) Lithosere
   c) Hydrosere
   d) None of these
3. The darker zone in the lakes where light penetration is negligible is called ……….. .
   a) Littoral zone
   b) Limnetic zone
   c) Profundal zone
   d) Euphotic zone
4. The organisms which feed on dead organisms, wastes of living organisms are called …… .
   a) Chemotrophs
   b) Carnivores
   c) Detritivores
   d) Decomposers
5. Gross primary productivity is highest in the …………. .
   a) Open oceans
   b) Grasslands
   c) Wet tropical forests
   d) Agroecosystem
6. Estuaries have the following characteristics:
   a) Fresh and salt water
   b) Rich biodiversity

c) High productivity

d) None of these

7. The topical grasslands in Africa with tall grasses scattered with shrubs or stunted trees are called

a) Savannas

b) Pampas

c) Steppes

d) Prairies

8. Which of the following requires maximum energy?

a) Secondary consumer

b) Decomposer

c) Primary consumer

d) Primary producer

9. The bottom area where production is less than respiration in a pond ecosystem is termed as

a) Profundal zone

b) Tidal zone

c) Benthic zone

d) Limnetic zone

10. What type of food chain is it?

dead animals → blow fly maggot → maggots → frog → snake

a) Detrital food chain

b) Decomposer food chain

c) Predator food chain

d) Grazing food chain

11. "The pyramid of energy is always upright" states that

a) The energy conversion efficiency of herbivores is better than carnivores

b) The energy conversion efficiency of carnivores is better than herbivores

c) Producers have the lowest energy conversion efficiency

d) Energy conversion efficiency is the same in all trophic levels.

12. Which of the following lake zones has phytoplanktons in abundance?

a) Profundal zone

b) Tidal zone

c) Benthic zone

d) Limnetic zone

3.6 Summary

- *The simple autotroph–heterotroph–decomposer classification represents the structure and functions of an ecosystem.*
- *All organisms, living or dead are potential food for some other organism and thus, there is essentially no waste in the functioning of a natural ecosystem.*
- *The energy flow in an ecosystem is unidirectional or one-way or non-cyclic flow. It flows from producer to herbivores to carnivores organisms; it is never reused back in the food chain unlike the nutrients which move in a cycle. As the flow of energy takes place, there is a gradual loss of energy at each level.*
- *The biogeochemical cycles are of two basic types - gaseous cycles (such as nitrogen and carbon, the reservoir is in the atmosphere or hydrosphere (ocean); sedimentary cycles – such as phosphorus cycle, the reservoir is in the lithosphere.*
- *Pyramids of numbers can be either upright, inverted or spindle shaped, depending on the ecosystem.*
- *Pyramids of biomass measure the amount of energy converted into living tissue at the different trophic levels.*
- *Pyramids of energy are always upright since energy decreases at each trophic level.*
- *The succession is a community controlled process even though physical environment determines the patterns, rates of change and development.*
- *All ecosystems regulate and maintain themselves under a set of environmental conditions.*
- *The ecosystems respond to inputs and have outputs and set two types of system response – negative feedback and positive feedback.*
- *Ecosystem stability can be understood in context of resistance and resilience. The resistance is the ability of the system to resist the forces that tend to disrupt its state of equilibrium. On the*

other hand, resilience is the ease with which the system returns to its original equilibrium state following any perturbation.

- *The ultimate source of energy for all ecological systems is Sun. The solar energy is captured by the green plants and transformed into chemical energy and bound in glucose as potential energy during the process of photosynthesis. In this stored form, other organisms take the energy and pass it on further to other organisms.*
- *The flow of energy in ecosystem follows first and second law of thermodynamics.*
- *The energy flow models link the trophic levels with each other showing the inputs and losses of energy at each trophic level.*
- *Single Channel Energy Flow Model depicts that the flow of energy is unidirectional and noncyclic and at each tropic level there is progressive decrease in energy as heat in the metabolic reactions and also some of the energy is utilized at each tropic level.*
- *The double channel or Y-Shaped energy flow model depicts the simultaneous working of grazing and detritus food chains in an ecosystem.*
- *Universal Energy Flow Model represents the basis for a general explanation of ecosystem trophic flows. The model can be applied to any living component, whether it is plant, animal, microorganism, individual, population or trophic group.*
- *All types of ecosystems fall into one of two categories: terrestrial or aquatic. Terrestrial ecosystems are land based, while aquatic are water based.*
- *Terrestrial ecosystems can be classified into three types i.e. forest ecosystem, grassland ecosystem and desert ecosystem.*
- *Global aquatic ecosystems fall into two broad categories defined by salinity – fresh water ecosystems and salt water ecosystems.*
- *The two major divisions of the Marine ecosystem are the Pelagic and the Benthic, the Pelagic Division comprising the whole body of water forming the seas and oceans and the Benthic Division the entire sea bottom.*
- *Fresh water ecosystems can be divided into two groups: lentic or standing water habitats and lotic or running water habitats.*

3.7 Keywords

- **Food chain:** The sequence of eating and being eaten in an ecosystem is known as food chain.
- **Food web:** A food web is defined as a network of interwoven food chains with numerous producers, consumers and decomposers operating simultaneously at each trophic level so that there are a number of options of eating and being eaten at each trophic level.
- **Decomposition:** It is a biological process of breakdown of complex organic materials (carbohydrates, proteins, amino acids, nucleic acids, etc.) into the simpler one (CO_2, H_2O and inorganic nutrients like N, P, S, etc.). It results from both biotic and abiotic processes.
- **Ecological Succession:** The ecological succession is defined as an orderly process of changes in the biotic community structure and function with time mediated through modifications in the physical environment ultimately culminating into a stable community known as climax.
- **Homeostasis:** There is always a natural tendency of ecosystem to resist the change and maintain itself in equilibrium with the environment. This self-regulatory mechanism is known as homeostasis.
- **Ecological efficiency:** It can be defined as the product of efficiencies in which organisms utilize their food resources and convert them into biomass for next higher trophic level.

3.8 Self-Assessment Test

1. What is an ecosystem? Explain its structural components.
2. Why are ecosystems dynamic in nature? Give the various functional components of an ecosystem.
3. "Energy transformation in ecosystems is explained in relation to the laws of thermodynamics." Elucidate.
4. Discuss the models of energy flow in an ecosystem.
5. Define Food chain and food web with the help of examples and discuss their significance.
6. What are phytoplanktons? How do nektons differ from zooplanktons?
7. What do you understand by Ecological Pyramid? Distinguish between pyramid of energy and pyramid of number.
8. List the various steps of carbon cycle in a sequence.
9. What role do decomposers play in an ecosystem?

10. **Define primary production and secondary production.** Why are tropical wet forests and estuaries most productive?
11. What is homeostasis? What are feedback mechanisms?
12. What are the different zones in a lake ecosystem?
13. Explain 'ecological succession'
14. What are (i) climax community and (ii) pioneer species?

3.9 Answers to check your progress

A. Fill in the blanks

1. Energy 2. Tansley 3. Herbivores 4. Food web 5. Phosphorus 6. Climax

7. Homeostasis 8. Stable 9. Energy 10. Cyclic

B. Choose the correct answer

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

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BIODIVERSTY: INTRODUCTION, VALUE OF BIODIVERSITY, THREATS AND CONSERVATION OF BIODIVERSITY

Structure

4.0 Learning Objectives

After studying this unit you will be able to:

- *Define biodiversity and explain the need for its conservation.*
- *Identify and define genetic, species and ecosystem diversity.*
- *Explain the biogeographical classification of India.*
- *List the values of diversity.*
- *Describe consumptive use and productive use.*
- *Identify the social, ethical, aesthetic and optional values of biodiversity.*
- *Describe biodiversity at the global, national and local levels.*
- *Define hotspots in diversity and explain why India is a megadiversity nation.*
- *Identify and describe threats to biodiversity, such as habitat loss, poaching of wildlife, man–wildlife conflicts and list some endangered and endemic species of India.*
- *Explain conservation of biodiversity in terms of in-situ and ex-situ conservation of biodiversity.*

4.1 Meaning of Biodiversity

The enormous variability in life forms and their associations is generally referred as biodiversity. Biological diversity or "bio-diversity" was first conceptualised by Edward O Wilson in 1988. In the Convention on Biological Diversity (CBD) at earth summit, all participating Governments agreed on an official definition of biological diversity as: "*The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*." Therefore, biodiversity is the variety of the life forms including their genetic make up and all kinds of their assemblages.

The living beings range from very small size microbes to large size mammals. In the most widely used system of classification these have been divided into 5 main kingdoms: Monera, Protista, Fungi, Plantae and Animalia based on certain common features and are further subdivided into many categories. However, whether small or large organism, each plays a unique role and is important for ecological balance and environment. As per scientific estimates, a large number of organisms have extinct from the earth since its formation due to various natural processes but in last 100 years the rate of extinction increased due to anthropogenic activities. Keeping in view the extreme importance of biodiversity, it is important to save it.

4.1.1 Levels of Biodiversity

The complexity of the diversity in life is manifested in variety of forms and functions of organism and their communities. Basically, this diversity of life is divided into three fundamental hierarchical categories that describe different living systems that can be measured in different ways. These categories are species, genetic and ecosystem diversity.

4.1.1.1 Genetic Diversity

When the genes within the same species show different versions due to new combinations, it is called genetic variability or diversity.

It is the basic source of biodiversity. The genes found in organisms can form enormous number of combinations each of which gives rise to some variability. Genes are the basic units of hereditary information transmitted from one generation to other. For example, all rice varieties belong to the species *Oryza sativa*, but there are thousands of wild and cultivated varieties if rice which show variations at the genetic level and differ in their colour, size, shape, aroma and nutrient content of the grain. This is the genetic diversity of rice.

4.1.1.2 Species Diversity

This is the variability found within the population of a species or between different species of a community.

It represents broadly the species richness and their abundance in a community. There are two popular indices of measuring species diversity known as *Shannon-Wiener index and Simpson index.*

What is the number of species on this biosphere? The estimates of actual number vary widely due to incomplete and indirect data. The estimates given by Wilson in 1992 put the total number of living species in a range of 10 million to 50 million. Till now only about 1.5 million living and 300,000 fossil species have been actually described and given scientific names. It is quite likely that a large fraction of these species may become extinct even before they are discovered and enlisted.

4.1.1.3 Ecosystem Diversity

This is the diversity of ecological complexity showing variations in physical characters, ecological niches, trophic structure, food-webs, nutrient cycling etc.

The ecosystem variations with respect to physical parameters include moisture, temperature, altitude, precipitation etc. Thus, there occurs tremendous diversity within the ecosystems, along these gradients.

We may consider diversity in forest ecosystem, which is supposed to have mainly dominance of trees. But, while considering a tropical rainforest, a tropical deciduous forest, a temperate deciduous forest and a boreal forest, the variations observed are just too many and they are mainly due to variations in the above mentioned physical factors.

The ecosystem diversity is of great value that must be kept intact. This diversity has developed over millions of years of evolution. If we destroy this diversity, it would disrupt the ecological balance. We cannot even replace the diversity of one ecosystem by that of another. Coniferous trees of boreal forests cannot take up the function of the trees of tropical deciduous forest lands and vice versa, because ecosystem diversity has evolved with respect to the prevailing environmental conditions with well-regulated ecological balance.

4.1.2 Values of Biodiversity

Environmental services from species and ecosystems are essential at global, regional and local levels. Production of oxygen, reducing carbon dioxide, maintaining the water cycle, protecting soil are important services. The world now acknowledges that the loss of biodiversity contributes to global climatic changes. Forests are the main mechanism for the conversion of carbon dioxide into carbon and oxygen. The loss of forest cover, coupled with the increasing release of carbon dioxide and other gases through industrialization contributes to the **‘greenhouse effect’**. Global warming is melting ice caps, resulting in a rise in the sea level which will submerge the low lying areas in the world. It is causing major atmospheric changes, leading to increased temperatures, serious droughts in some areas and unexpected floods in other areas. Biological diversity is also essential for preserving ecological processes, such as fixing and recycling of nutrients, soil formation, circulation and cleansing of air and water, global life support (plants absorb CO_2, give out O_2), maintaining the water balance within ecosystems, watershed protection, maintaining stream and river flows throughout the year, erosion control and local flood reduction.

Food, clothing, housing, energy, medicines, are all resources that are directly or indirectly linked to the biological variety present in the biosphere. This is most obvious in the tribal communities who gather resources from the forest or fisherfolk who catch fish in marine or freshwater ecosystems. For others, such as agricultural communities, biodiversity is used to grow their crops to suit the environment. Urban communities generally use the greatest amount of goods and services, which are all indirectly drawn from natural ecosystems. It has become obvious that the preservation of biological resources is essential for the well-being and the long-term survival of mankind. This diversity of living organisms which is present in the wilderness, as well as in our crops and livestock, plays a major role in human ‘development’. The preservation of ‘biodiversity’ is therefore integral to any strategy that aims at improving the quality of human life.

4.1.2.1 Consumptive use value

The direct utilisation of timber, food, fuelwood, fodder by local communities. The biodiversity held in the ecosystem provides forest dwellers with all their daily needs, food, building material, fodder, medicines and a variety of other products. They know the qualities and different uses of wood from different species of trees and collect a large number of local fruits, roots and plant material that they use as food, construction material or medicines. Fisherfolk are highly dependent on fish and know where and how to catch fish and other edible aquatic animals and plants.

4.1.2.2 Productive use value

The biotechnologist uses biorich areas to ‘prospect’ and search for potential genetic properties in plants or animals that can be used to develop better varieties of crops that are used in farming and plantation programs or to develop better livestock. To the pharmacist, biological diversity is the raw material from which new drugs can be identified from plant or animal products. To industrialists, biodiversity is a rich store-house from which to develop new products. For the agricultural scientist the biodiversity in the wild relatives of crop plants is the basis for developing better crops. Genetic diversity enables scientists and farmers to develop better crops and domestic animals through careful breeding. Originally this was done by selecting or pollinating crops artificially to get a more productive or disease resistant strain. Today this is increasingly being done by genetic engineering, selecting genes from one plant and introducing them into another. New crop varieties (cultivars) are being developed using the genetic material found in wild relatives of crop plants through biotechnology. Even today, species of plants and animals are being constantly discovered in the wild. Thus these wild species are the building blocks for the betterment of human life and their loss is a great economic loss to mankind. Among the known species, only a tiny fraction have been investigated for their value in terms of food, or their medicinal or industrial potential. Preservation of biodiversity has now become essential for industrial growth and economic development. A variety of industries such as pharmaceuticals are highly dependent on identifying compounds of great economic value from the wide variety of wild species of plants located in undisturbed natural forests. This is called **biological prospecting**.

4.1.2.3 Social values

While traditional societies which had a small population and required less resources had preserved their biodiversity as a life supporting resource, modern man has rapidly depleted it even to the extent of leading to the irrecoverable loss due to extinction of several species. Thus apart from the local use or sale of products of biodiversity there is the social aspect in which more and more resources are used by affluent societies. The biodiversity has to a great extent been preserved by traditional societies that valued it as a resource and appreciated that its depletion would be a great loss to their society.

The consumptive and productive value of biodiversity is closely linked to social concerns in traditional communities. ‘Ecosystem people’ value biodiversity as a part of their livelihood as well as through cultural and religious sentiments. A great variety of crops have been cultivated in traditional agricultural systems and this permitted a wide range of produce to be grown and marketed throughout the year and acted as an insurance against the failure of one crop. In recent years farmers have begun to receive economic incentives to grow cash crops for national or international markets, rather than to supply local needs. This has resulted in local food shortages, unemployment (cash crops are usually mechanised), landlessness and increased vulnerability to drought and floods.

4.1.2.4 Ethical and moral values

Ethical values related to biodiversity conservation are based on the importance of protecting all forms of life. All forms of life have the right to exist on earth. Man is only a small part of the Earth’s great family of species. Don’t plants and animals have an equal right to live and exist on our planet which is like an inhabited spaceship? We do not know if life as we know it exists elsewhere in the universe. Do we have the right to destroy life forms or do we have a duty to protect them? Apart from the economic importance of conserving biodiversity, there are several cultural, moral and ethical values which are associated with the sanctity of all forms of life. Indian civilization has over several generations preserved nature through local traditions. This has been an important part of the ancient philosophy of many of our cultures. We have in our country a large number of sacred groves or ‘**deorais**’ preserved by tribal people in several States. These sacred groves around ancient sacred sites and temples act as gene banks of wild plants.

4.1.2.5 Aesthetic value

Knowledge and an appreciation of the presence of biodiversity for its own sake is another reason to preserve it. Quite apart from killing wildlife for food, it is important as a tourist attraction. Biodiversity is a beautiful and wonderful aspect of nature. Sit in a forest and listen to the birds. Watch a spider weave its complex web. Observe a fish feeding. It is magnificent and fascinating. Symbols from wild species such as the lion of Hinduism, the elephant of Buddhism and deities such as Lord Ganesh and the vehicles of several deities that are animals, have been venerated for thousands of years. Valmiki begins his epic story with a couplet on the unfortunate killing of a crane by a hunter. The 'Tulsi' has been placed at our doorsteps for centuries.

4.1.2.6 Option value

Keeping future possibilities open for their use is called option value. It is impossible to predict which of our species or traditional varieties of crops and domestic animals will be of great use in the future. To continue to improve cultivars and domestic livestock, we need to return to wild relatives of crop plants and animals. Thus the preservation of biodiversity must also include traditionally used strains already in existence in crops and domestic animals.

4.1.2.7 Ecosystem Service Value

It refers to the services provided by ecosystems. Recently, a non-consumptive use value related to self-maintenance of the ecosystem and various important ecosystem services has been recognized. The services include prevention of soil erosion, prevention of floods, maintenance of soil fertility, cycling of nutrients, fixation of nitrogen, cycling of water, role of ecosystem as carbon sinks, pollutant absorption and reduction of the threat of global warming etc.

Different categories of biodiversity value clearly indicate that ecosystem, species and genetic diversity all have enormous potential and a decline in biodiversity will lead to huge economic, ecological and socio-cultural losses.

4.3 Biodiversity at Global, National and Local Levels

There are at present 1.8 million species known and documented by scientists in the world. However, scientists have estimated that the number of species of plants and animals on earth could vary from 1.5 to 20 billion! Thus the majority of species are yet to be discovered.

Most of the world's bio-rich nations are in the South, which are the developing nations. In contrast, the majority of the countries capable of exploiting biodiversity are Northern nations, in the economically developed world. These nations however have low levels of biodiversity. Thus the developed world has come to support the concept that biodiversity must be considered to be a 'global resource'. However, if biodiversity should form a 'common property resource' to be shared by all nations, there is no reason to exclude oil, or uranium, or even intellectual and technological expertise as global assets.

India's sovereignty over its biological diversity cannot be compromised without a revolutionary change in world thinking about sharing of all types of natural resources.

Countries with diversities higher than India are located in South America such as Brazil and South East Asian countries such as Malaysia and Indonesia. The species found in these countries, however, are different from our own. This makes it imperative to preserve our own biodiversity as a major economic resource. While few of the other 'megadiversity nations' have developed the technology to exploit their species for biotechnology and genetic engineering, India is capable of doing so.

Throughout the world, the value of biologically rich natural areas is now being increasingly appreciated as being of unimaginable value. International agreements such as the **World Heritage Convention** attempt to protect and support such areas. India is a signatory to the convention and has included several protected Areas as World Heritage sites. These include Manas on the border between Bhutan and India, Kaziranga in Assam, Bharatpur in U.P., Nandadevi in the Himalayas and the Sunderbans in the Ganges delta in West Bengal. India has also signed the **Convention in the Trade of Endangered Species (CITES)** which is intended to reduce the utilization of endangered plants and animals by controlling trade in their products and in the pet trade.

4.3.1 India as a Megadiversity Nation

India is one of the 12 mega biodiversity countries in the world. India is divided into 10 biogeo-graphic regions. Diverse physical features and climatic situations have resulted in formation of forests, grasslands, deserts, wetlands, coastal and marine ecosystems.

It is estimated that India ranks 10th among the plant rich countries of the world, 11th in terms of number of endemic species of higher vertebrates and 6th among the centers of diversity and origin of agricultural crops.

Distribution of species in some major groups of flora and fauna in India

Group-wise species distribution			
Plants	Number	Animals	Number
Bacteria	850	Lower groups	9979
Fungi	23000	Mollusca	5042
Algae	2500	Arthropoda	57,525
Bryophytes	2564	Pisces (Fishes)	2546
Pteridophytes	1022	Amphibia	428
Gymnosperms	64	Reptiles	1228
Angiosperms	15000	Birds	204
		Mammals	372

Reasons for India as a mega-diversity nation:

1. Endemism

Species which are restricted only to a particular area are known as endemic. These species are not found anywhere else. Unique climate and geographic features of a certain region make many species endemic. India shows a good number of endemic species. About 4,900 species of flowering plants are endemic to the country. About 62% amphibians are endemic to India. Western Ghats are the site of maximum endemism.

2. Centre of origin

Many species are known to have originated in India. Nearly 500 species of flowering plants have their origin in India. Nearly 166 species of crop plants and 320 species of wild relatives of cultivated crops originated in India.

3. Marine diversity

7500 km long coastline of our country exhibits a rich biodiversity. Mangroves, coral reefs back waters etc. are found along the coastline. Different types of fishes, amphibians, mollusks, crustaceans are also found.

4. Hot spots of biodiversity

There are 35 such hot spots of biodiversity in the world out of which three are present in India, namely the **Eastern Himalayas, Western Ghats and Indo-Burma hotspot.**

4.3.2 Biogeographical Classification of India

India is seventh largest country in the world and Asia's second largest country. Though India accounts to only 2 % of the total landmass of the world, it accounts for about 7% of the total species in the world.

Biogeography refers to the study of distribution, evolution, dispersal and environmental relationship of plants and animals. **Biogeographic classification of India** is the division of India according to biogeographic characteristics. There are ten biogeographic zones in India. Each zone has its own characteristic climate, soil, topography and biodiversity.

The ten biogeographic zones of India are

1) **Trans–Himalayan region**: The Himalayan ranges immediately north of the Great Himalayan range are called the Trans- Himalayas. The Trans-Himalayan region has sparse vegetation. A variety of wild sheep and goat community is found here.

   Plants: Pine, Deodar

   Animals: Snow leopard, black-necked crane.

2) **The Himalayan region:** The Himalayas consist of the youngest and high altitude, steep mountain chains in the world. Rich temperate flora is present. The forests are very dense with tall trees.

   Plants: Oak, chestnut, pine, deodar.

   Animals: Wild sheep, mountain goats, panda and snow leopard.

3) **The Indian desert:** This region consists of parts of Rajasthan, Kutch and parts of Gujarat. The climate is very hot during summer and cold during winter. Annual rainfall is less than 70 cms. The plants are mostly xerophytes.

   Plants: Date palm, cactus, Babul, wild palm.

   Animals: Camels, wild asses, foxes, mice, desert cat and snakes. Indian Bustard, a highly endangered bird is also found here.

4) **The semi arid region:** Semi-arid regions are found near the desert. It is a transitional zone between the desert and the denser forests of the Western Ghats. The natural vegetation is thorn forest. Vegetation is generally discontinuous.

   Plants: Thorny scrubs, grasses, bamboos, xerophytic herbs etc.

   Animals: Birds, jackals, leopards, lion, eagles, snakes, fox, buffaloes etc.

5) **The Western Ghats:** Western Ghats is a 1600 km long mountain range running through the west coast of India. It covers the states of Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra and Gujarat. The mountains rise to average altitudes between 900 and 1500 m above sea level.

   Plants: Rubber, tea, coffee, pepper etc.

   Animals: Monkey, elephant, deer etc.

6) **The Deccan peninsula:** Beyond the Western Ghats is Deccan Plateau. It is a semi-arid region lying in the rain shadow of the Western Ghats. This is the largest unit of the Peninsular Plateau of India. Different types of forests are found here.

   Plants: Teak, Neem, Banyan etc.

   Animals: Monkey, tiger, elephant, deer etc.

7) **The Gangetic plain:** In the north is the Gangetic plain extending up to the Himalayan foothills. This is the largest unit of the Great Plain of India named after the main river Ganga.

   Plants: Teak, sal, Banyan etc.

   Animals: Rhinoceros, Deer, Rabbit, Alligator

8) **The coastal region:** India has a coastline extending over 5,500 km. Larger parts of the coastal plains are covered by fertile soils on which different crops are grown.

   Plants: Coconut trees, Banana, Bamboo etc.

   Animals: Turtle, Dolphin, crabs etc.

9) **The north-east region:** It comprises the contiguous Seven Sister States (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura), plus the Himalayan state of Sikkim. North-east India has one of the richest flora in the country.

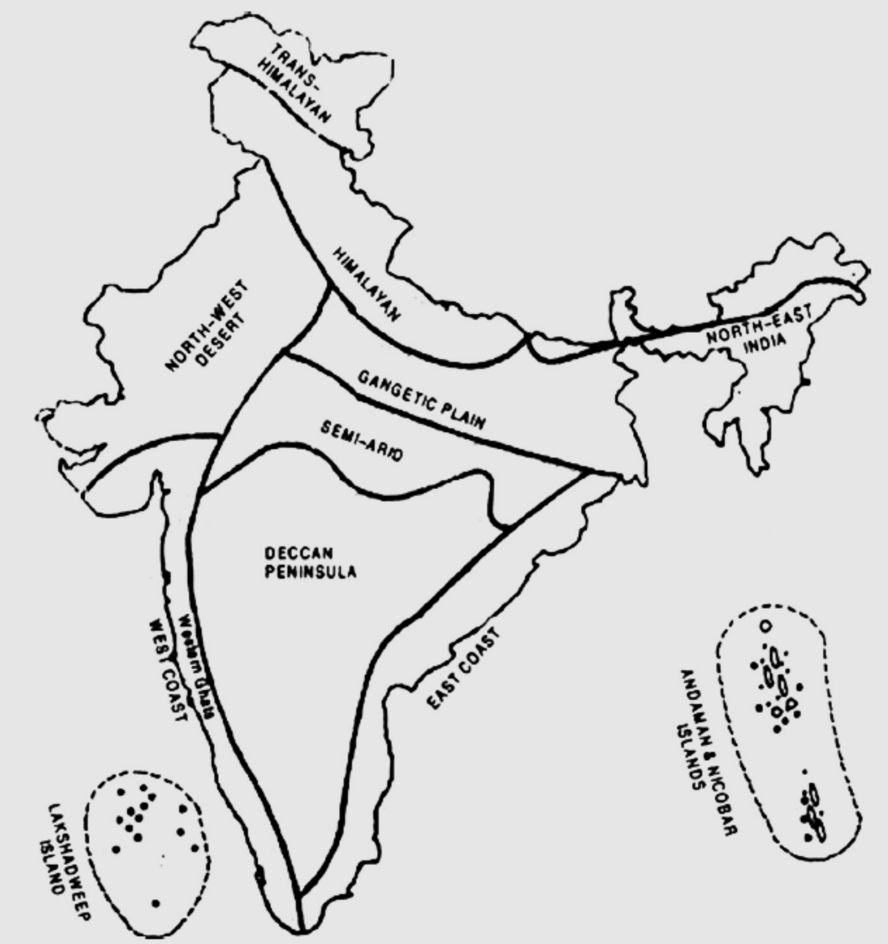
   Plants: Bamboo, several species of orchids etc.

   Animals: Elephant, Rhinoceros etc.

10) **The Indian islands:** The two groups of islands, i.e., Lakshadweep in the Arabian Sea and Andaman-Nicobar islands in Bay of Bengal differ significantly in origin and physical characteristics.

Plants: Coconut, Cashew nut

Animals: Dolphin, Alligator



Biogeographical classification of India

4.4 Conservation of Biodiversity

4.4.1 Hotspots of Biodiversity

Areas which exhibit high species richness as well as high species endemism are termed as **hot spots of biodiversity**. These are areas that support natural ecosystems that are largely intact and where native species and communities associated with these ecosystems are well represented. They are also areas with a high diversity of locally endemic species, which are species that are not found or are rarely found outside the hotspot. The concept of biodiversity hotspots was given by Norman Myers in 1988.

According to Conservation International (CI), to qualify as a hotspot a region must meet two strict criteria:

- It must contain at least 1,500 species of vascular plants (> 0.5% of the world's total) as endemics.
- It has to have lost at least 70% of its original habitat OR It must have 30% or less of its original natural vegetation.

In 1999, CI identified 25 biodiversity hotspots in the book "Hotspots: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions". Collectively, these areas held as endemics about 44% of the world's plants and 35% of terrestrial vertebrates in an area that formerly covered only 11.8% of the planet's land surface. The habitat extent of this land area had been reduced by 87.8% of its original extent, such that this wealth of biodiversity was restricted to only 1.4% of Earth's land surface. In 2005 CI published an updated titled "Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions". Currently, there are 35 Biodiversity Hotspots.

4.4.1.1 Biodiversity importance of hotspots

The biodiversity importance of hotspots is due to the high vulnerability of habitats and high irreplaceability of species found within large geographic regions. This means that these areas and the species present within them are both under high levels of threat and of significant global value based on their uniqueness. Therefore, operations that occur within global biodiversity hotspots should follow rigorous biodiversity assessments to prevent further biodiversity loss within these areas. This is a global scale approach based on coarse scale ecoregions that therefore, has limited use for site-scale assessment and decision making. Biodiversity hotspots will include areas of high biodiversity importance as well as degraded land and urban areas and therefore more detailed assessments are needed to locate the actual distribution of biodiversity within these areas.

4.4.1.2 Social-cultural values of hotspots

Given the richness of hotspot ecosystems, hotspots are often areas which offer essential ecosystem services. It is estimated that biodiversity hotspots, despite comprising 2.3% of the Earth’s surface, account for 35% of the global ecosystem services. Furthermore, hotspots are home to 2.08 billion people which add significance to the ecosystem services that they provide. Biodiversity hotspots can include a variety of human land-uses, rural and urban, as well as protected areas under a range of possible governance types therefore many social and/or cultural values are likely to be present in some parts. This however is irrespective of the identification of the area as a biodiversity hotspot.

4.4.1.3 Global Biodiversity Hotspots

Currently, there are 35 Biodiversity Hotspots. Overall, these hotspots once covered 15.7 percent of the Earth's land surface. In all, 86 percent of the hotspots' habitat has already been destroyed, such that the intact remnants of the hotspots now cover only 2.3 percent of the Earth's land surface. The biodiversity hotspots hold especially high numbers of endemic species. Each hotspot faces extreme threats and has already lost at least 70% of its original natural vegetation. Over 50% of the world’s plant species and 42% of all terrestrial vertebrate species are endemic to the 35 biodiversity hotspots.

Africa

A total of 08 Hotspots in African continent hold a diversity of plant and animal life, many of which are found nowhere else on Earth. 1. Cape Floristic Region 2. Coastal Forests of Eastern Africa 3. Eastern Afromontane Guinean Forests of West Africa 5. Horn of Africa 6. Madagascar and the Indian Ocean Islands 7. Maputaland-Pondoland-Albany 8. Succulent Karoo

Asia-Pacific

Composed of large land areas as well as islands dotting the Pacific seas, these 14 Hotspots represent important biodiversity. 1. East Melanesian Islands 2. Himalaya 3. Indo-Burma 4. Japan

5. Mountains of Southwest China 6. New Caledonia 7. New Zealand 8. Philippines 9. Polynesia-Micronesia 10. Southwest Australia 11. Forests of Eastern Australia (new) 12. Sundaland 13. Wallacea 14. Western Ghats and Sri Lanka

Europe and Central Asia

From the Mediterranean Basin to the Mountains of Central Asia, these four Hotspots are unique in their diversity. 1. Caucasus 2. Irano-Anatolian 3. Mediterranean Basin 4. Mountains of Central Asia

North and Central America

North and Central America play host to thousands of acres of important habitat. 1. California Floristic Province 2. Caribbean Islands 3. Madrean Pine-Oak Woodlands 4. Mesoamerica

South America

From Brazil's Cerrado to the Tropical Andes, South America has some of the richest and most diverse life on Earth. 1. Atlantic Forest 2. Cerrado 3. Chilean Winter Rainfall-Valdivian Forests 4. Tumbes-Chocó-Magdalena 5. Tropical Andes

4.4.1.4 Biodiversity Hotspots of India

There are 4 major biodiversity hot spots present in India. They are:

1) **Himalaya**:
   - This includes the entire Indian Himalayan region (and that falling in Pakistan, Tibet, Nepal, Bhutan, China and Myanmar) .
   - The Himalayan hotspot has nearly 163 globally threatened species (both flora and fauna) including the One-horned Rhinoceros [Vulnerable], the Wild Asian Water buffalo [Endangered].
   - There are an estimated 10,000 species of plants in the Himalayas, of which one-third are endemic and found nowhere else in the world.
   - The area has long been recognized as a rich centre of primitive flowering plants and is popularly known as the 'Çradle of Speciation'.

- Species of several families of monocotyledons, Orchidaceae, Zingiberaceae and Arecaceae are found in the area. Gymnorperms and Pteridophytes (ferns) are also well represented here.
- The area is also rich in wild relatives of plants of economic significance e.g. rice, banana, citrus, ginger, chilli, jute and sugarcane.
- It is also regarded as the centre of origin and diversification of five palms of commercial importance, namely coconut, arecanut, palmyra palm, sugar palm and wild date palm. Tea (Thea sinensis) has been cultivated in this region for the last 4,000 years. Many wild and allied species of tea, the leaves of which are used as a substitute for tea, are found in the North East, in their natural habitats.
- The Taxol plant (Taxus wallichiana) is sparsely distributed in the region and is listed under the red data category due to its overexploitation for extraction of a drug effectively used against cancer.
- A few threatened endemic bird species such as the Himalayan Quail, Cheer pheasant, Western tragopan are found here, along with some of Asia's largest and most endangered birds such as the Himalayan vulture and White-bellied heron.
- Mammals like the Golden langur, The Himalayan tahr, the pygmy hog, Lang-urs, Asiatic wild dogs, sloth bears, Gaurs, Muntjac, Sambar, Snow leopard, Black bear, Blue sheep, Takin, the Gangetic dolphin, wild water buffalo, swamp deer call the Himalayan ranged their home.

2) Indo-Burma:

- This includes entire North-eastern India, except Assam and Andaman group of Islands (and Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China) .
- Much of this region has been deteriorating rapidly in the past few decades.
- This region is home to several primate species such as monkeys, langurs and gibbons with populations numbering only in the hundreds.
- Many of the species, especially some freshwater turtle species, are endemic.
- Almost 1,300 bird species exist in this region including the threatened white-eared night-heron [Endangered], the grey-crowned crocias [Endangered] and the orangenecked partridge [Near Threatened].

- It is estimated that there are about 13,500 plant species in this hotspot, with over half of them endemic. A wide array of orchid and ginger species (there are more than 1,000 orchid species in Thailand alone) and many tropical hardwood trees, including commercially valuable dipterocarp species and teak (Tectona grandis).

3) Western Ghats and Sri Lanka:

- This includes entire Western Ghats (and Sri Lanka).
- The wide variation of rainfall patterns in the Western Ghats, coupled with the region's complex geography, produces a great variety of vegetation types.
- Some prominent genera and families are represented by large numbers of endemic species, such as Impatiens with 76 of 86 species endemic, Dipterocarpus with 12 of 13 species endemic and Calamus with 23 of 25 species endemic. Of the 490 tree species recorded from low- and midelevation forests, 308 species are endemic. The only gymnosperm tree, Podocarpus (= Nageia) wallichianus, is also endemic. Of the 267 species of orchids, 130 are endemic.
- There are over 6000 vascular plants belonging to over 2500 genera in this hotspot, of which over 3000 are endemic. Much of the world's spices such as black pepper and cardamom have their origins in the Western Ghats. Nearly 235 species of endemic flowering plants are considered endangered.
- Similarly, plant diversity and endemism in Sri Lanka are quite high, with 3,210 flowering plant species in 1,052 genera, of which 916 species and 18 genera are endemic. Amazingly, all but one of the island's more than 55 dipterocarp species is found nowhere else in the world. In addition, the island's ferns (although not recently assessed) are estimated to number about 350 species. Approximately 433 plant species and at least five genera, are confined to Sri Lanka and the Western Ghats combined.
- Rare fauna of the region include –Asian elephant, Niligiri tahr, Nilgiri langur, Flying squirrel, Indian tigers, lion tailed macaque [All Endangered], Indian Giant squirrel [Least Concern], etc.
- The highest concentration of species in the Western Ghats is believed to be the Agasthyamalai Hills in the extreme south. The region also harbors over 450 bird

species, about 140 mammalian species, 260 reptiles and 175 amphibians. Over 60% of the reptiles and amphibians are completely endemic to the hotspot.

- Remarkable as this diversity is, it is severely threatened today. The vegetation in this hotspot originally extended over 190,000 square km. Today, its been reduced to just 43,000 sq. km. In Sri Lanka, only 1.5% of the original forest cover still remains.

4.4.2 Threats to Biodiversity

Due to rapid increase in human population, the demand for food, shelter, energy, raw materials also increased. Deforestation resulted in the extinction of species. It is estimated that every year nearly 10000 species becomes extinct. Extinction of species results in the loss of biodiversity.

Factors leading to loss of biodiversity:

1. **Destruction of Habitats:** Destruction and loss of natural habitat is the major reason for biodiversity loss. Due to deforestation animals are deprived of shelter and food.
2. **Habitat Fragmentation:** Sometimes the loss of habitat occurs slowly in installments as it is is divided into small and scattered patches. This is known as habitat fragmentation. Some wild animals like bears and large cats need large territories to live and fluorish. Habitat fragmentation affects their population as they breed only in the interiors of the forests.
3. **Disturbance and pollution:** Ma- made activities such as air/water pollution, eutrophication etc affects biodiversity adversely. Increase in acidity of water bodies due to acid rain may result in the death of fishes and other aquatic organisms. Forest fire can result in habitat destruction and death of animals. Soil pollution due to the use of pesticides kills bacteria and insects.
4. **Introduction of exotic species:** Exotic species are new species entering a geographical region. They alter the habitat and natives cannot survive. Exotic species may kill or eat native species to the point of extinction. Disease causing microorganism if introduced may cause epidemic and eliminate the native species completely.

   Example: Water hyacinth is exotic species which was introduced from South America. Excessive growth of this resulted in clogging of rivers and lakes. It even threatens the survival of fishes and many aquatic species in India.

5. **Hunting and over exploitation:** Man hunts wild animals for food, safety and pleasure which can result in extinction of species. Example: Disappearance of dodo. Over fishing is depleting marine and fresh water living resources. Many species of fishes, sea turtles, sea cows and whales are facing extinction.
6. **Poaching:** Killing of wild animals for illegal trading of wildlife products is called poaching. Despite international ban, products from endangered species, smuggling of wildlife items like furs, horns, tusks and herbal products are still going on. Animal products of commercial value include ivory, horn, teeth and bone.
7. **Man wildlife Conflicts:** Sometimes wild animals like elephant, lion and tiger may come out from their natural habitat and cause damage to life and property of humans. Conflicts between man and wild animals are called man- wildlife conflict. It is estimated that every year in our country around 300 people die due to animal attack. These attacks are common in places where human settlement is closer to forest areas.

Reasons for man-wild life conflict

- **Habitat loss:** Loss of habitat forces the animal to move out of forests.
- **Human encroachment:** Humans occupy animal habitat, leaving animals want of space.
- **Disease:** Ill, weak and sick animals attack humans for self protection.
- **Shortage of food and water during summer:** Severe summer may result in shortage of water and food. So animals enter human settlements in search of food and water.
- **Man eating tendency:** Usually ill, weak and injured animals have a tendency to attack man. But the biggest problem is that if human-flesh is tested once then the tiger does not eat any other animal. At the same time, it is very difficult to trace and cull the man-eating tiger and in the process many innocent tigers are also killed.
- **Electric fencing:** Very often farmers put electric fencing around farm lands. Elephants and other animals may get injured, suffer in pain and turn violent.
- **Protection**: Females of many animals attack to secure their babies.

Remedial measures to curb man-animal conflict

- **Tiger Conservation Project (TCP)** has made provisions for making available vehicles, tranquillizer guns, binoculars and radio sets etc. to tactfully deal with any imminent danger.
- **Adequate crop compensation and cattle compensation** scheme must be started, along with substantial cash compensation for loss of human life.
- **Solar powered fencing** should be provided along with electric current proof trenches to prevent the animals from straying into fields.
- **Cropping pattern** should be changed near the forest borders and adequate fodder, fruit and water should be made available for the elephants within forest zones.
- **Wild life corridors** should be provided for mass migration of big animals during unfavourable periods. About 300 km2 area is required for elephant corridors for their seasonal migration.
- In Similipal Sanctuary, Orissa there is a ritual of wild animal hunting during the months of April-May for which forest is burnt to flush out the animals. Due to massive hunting by people, there is a decline in prey of tigers and they start coming out of the forest in search of prey. Now there is WWF-TCP initiative to curb this ritual of '**Akhand Shikar**' in Orissa.

4.4.3 Red List of Threatened Species (Red Data Book)

Red Data Book is a state document established for documenting rare and endangered and threatened species of animals and plants. International Union for Conservation of Nature and Natural Resources (IUCN) publishes list.

The main objectives are:

- Identification and documentation of endangered species
- Create awareness about the importance of threatened biodiversity
- Defining conservation priorities and guiding conservation action

Species are classified by the IUCN Red List into nine groups according to rate of decline, population size, area of geographic distribution etc.:

a) **Extinct (EX):** No known individuals remaining.

b) **Extinct in the wild (EW):** Known only to survive in captivity like zoo etc. No animals found free in wild.

c) **Critically endangered (CR):** Extremely high risk of extinction in the wild.

d) **Endangered (EN):** High risk of extinction in the wild.

e) **Vulnerable (VU):** High risk of endangerment in the wild.

f) **Near threatened (NT):** Likely to become endangered in the near future.

g) **Least concern (LC):** Lowest or no risk.

h) **Data deficient (DD):** Not enough data to make an assessment of its risk of extinction.

i) **Not evaluated (NE):** Has not yet been evaluated against the criteria.

Keystone Species

A keystone species is an organism that defines an entire ecosystem and its absence can cause an ecosystem to change or cease to exist. They have low functional redundancy, which means if a species disappear then no other species could replace them thus leaving a void in the ecological niche. Hence the ecosystem would exert a radical change and allow new invasive species to populate the habitat. Any living organism can be a keystone species and need neither enormous in size nor abundant. Nevertheless, practically most of the examples for this type have enormous influence on the food web and varies from habitat to habitat.

The expulsion of a keystone species from an ecosystem triggers a set of negative changes. One such example is the overpopulation of one species, which leads to disappearance of other species. A well-documented case of such a chain of events was the elimination of wolves from the Yellowstone National Park at the beginning of the last century. The negative effect on the national park’s biodiversity was so profound that authorities have taken steps to introduce this keystone predator back.

4.4.4 Biodiversity Conservation

Biodiversity has so many uses (genetic, commercial, cultural, medical and aesthetic) associated with it, hence it is worth protecting. Conservation of biodiversity refers to the protection, preservation, management, or restoration of plants and animals.

Conservation efforts can be grouped into the following two categories:

1. **In-situ** (on-site) conservation includes the protection of plants and animals within their natural habitats or in protected areas. Protected areas are land or sea dedicated to protect and maintain biodiversity.
2. **Ex-situ** (off-site) conservation of plants and animals outside their natural habitats. These include botanical gardens, zoo, gene banks, seek bank, tissue culture and cryopreservation.

4.4.4.1 In-situ methods

a) **Protection of habitat:** The main strategy for conservation of species is the protection of habitats in representative ecosystems. Currently, India has ninety six National Parks, five hundred Wildlife Sanctuaries, thirteen Biosphere Reserves, twenty seven Tiger Reserves and eleven Elephant Reserves covering an area of 15.67 million hectares or 4.7 % of the geographical area of the country. Twenty one wetlands, thirty mangrove areas and four coral reef areas have been identified for intensive conservation and management purposes by the Ministry of Environment and Forests, Govt. of India.

National parks and sanctuaries

India is unique in the richness and diversity of its vegetation and wildlife. India's national parks and wildlife sanctuaries (including bird sanctuaries) are situated Ladakh in Himalayas to Southern tip of Tamil Nadu with its rich bio-diversity and heritage.

Wildlife sanctuaries in India attract people from all over the world as the rarest of rare species are found here. With 96 national parks and over 500 wildlife sanctuaries, the range and diversity of India's wildlife heritage is unique. Some of the main sanctuaries in India are: The Jim Corbett Tiger Reserve- Uttaranchal, Kanha National Park, Madhya Pradesh, Bandhavgarh National Park- Madhya Pradesh, Ranthambhor National Park-Sawai Madhopur, Gir National Park-Sasangir (Gujarat) etc.

Wildlife lovers eager to see magnificent Bird Sancturaty at Bharatpur, Rajasthan as it is the second habitat in the world that is visited by the Siberian Cranes in winter and it provides a vast breeding area for the native water birds, Great Indian bustard is found in the Indian deserts. In wesern Himalayas, one can see birds like Himalayan monal pheasant, western tragopanm koklass, white crested khalij pheasant, griffon vultures, lammergiers, choughs, ravens. In the Andaman and Nicobar region, about 250 species and subspecies of birds are found, such as rare Narcondum horn bill, Nicobar pigeon and megapode. While the national parks and sanctuaries in South India, too. For e.g. Madumalai in Tamil Nadu and Bandipur Tiger Reserve and Nagahole National Park in Karnataka. Many National Parks and Sancturies have been established to preserve wildlife in their natural environment. Some of them are given below along with important species found there.

- Kaziranga sanctuary (Assam) – One-horned rhinoceros
- Manas sanctuary (Assam) – Wild buffaloes
- Gir forest (Gujarat) – Lions, chital, sambar, wild bears
- Kelameru bird sanctuary (Andhra Pradesh) – Pelicans and marine birds
- Dachigam sanctuary (Jammu and Kashmir) – Kashmir stags, Himalayan tahr, wild goats, sheep, antelopes.
- Bandipur sanctuary (Karnataka) – Indian bison, elephants, langurs
- Periyar sanctuary (Kerala) – Elephants, barking deer, sambhar
- Kanha National Park (Madhya Pradesh) – Tiger, leopards, wild dogs
- Simipal National Park (Orissa) – Mangroves, marine turtles lay eggs
- Bharatpur bird sanctuary (Rajasthan) – Ducks, herons
- Corbett National Park (Uttaranchal) –Tigers, barking deer, sambar, wild bear, rhesus monkey.
- Jaladpara sanctuary (West Bengal) – Rhinoceros

Wildlife Conservation Society (WCS) India in association with other NGO partners and tribal people, is making every possible effort to develop new models of wildlife conservation to preserve India’s most treasured fauna and to protect the environment.

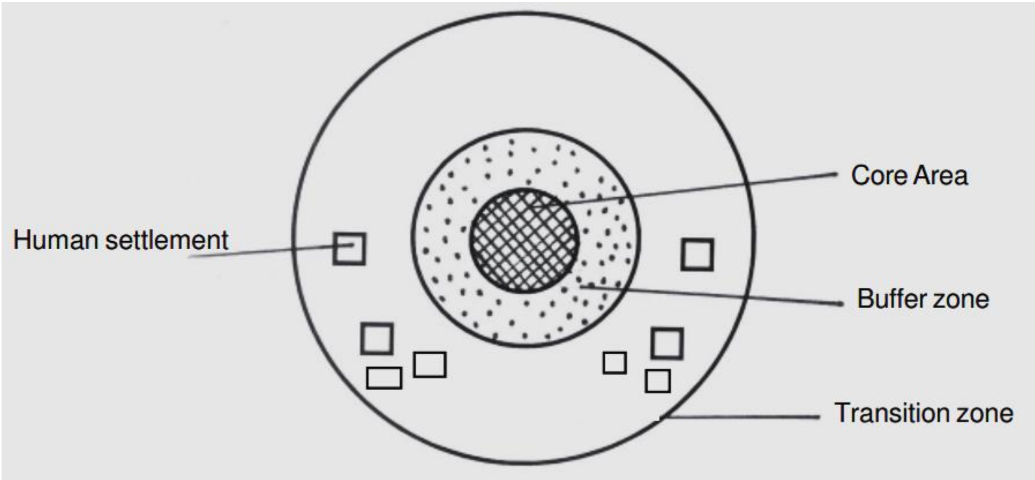
Biosphere Reserves

These are representative parts of natural and cultural landscapes extending over large areas of terrestrial or coastal/marine ecosystems which are internationally recognized within UNESCO's Man and the Biosphere Programme **Thirteen biodiversity**- rich representative ecosystems , largely within the forest land (total area – 53,000 sq. km.), have been designated as Biosphere Reserves in India.

List of Biosphere Reserves in India

	Name of the Biosphere Reserve	State	Area in km^2
1.	Great Rann of kutch	Gujarat	12,454
2.	Gulf of Mannar	Tamil Nadu	10,500
3.	Sunderbanas	West Bengal	9,630
4.	Cold Desert	Himachal Pradesh	7,770
5.	Nandadevi	Uttarakhand	5.860
6.	Nilgiri	T.N., Kerala, Karnatak	5,520
7.	Dehang-Dibang	Arunachal Pradesh	5.112
8.	Pachmarhi	Madhya Pradesh	4981.72
9.	Seshachalam Hills	Andhra Pradesh	4755
10.	Similipal	Odisha	4374
11.	Achanakamar-Amarkantak	Madhya Pradesh, Chattisgarh	3835
12.	Manas	Assam	2837
13.	Khangechendzonga	Sikkim	2620
14.	Agasthyamalai	Kerala, T.N.	1828
15.	Great Nicobar	Andaman & Nicobar Islands	885
16.	Nokrek	Meghalaya	820
17.	Dibru-Saikhowa	Assam	765
18.	Panna	Madhya Pradesh	

The concept of Biosphere Reserves (BR) was launched in 1975 as a part of UNESCO's Man and Biosphere Programme, dealing with the conservation of ecosystems and the genetic material they contain. A Biosphere Reserve consists of core, buffer and transition zones. (a) The core zone is fully protected and natural area of the Biosphere Reserve least disturbed by human activities. It is legally protected ecosystem in which entry is not allowed except with permission for some special purpose. Destructive sampling for scientific investigations is prohibited. (b) The buffer zone surrounds the core zone and is managed to accommodate a greater variety of resource use strategies and research and educational activities. (c) the transition zone, the outermost part of the Biosphere Reserve, is an area of active cooperation between the reserve management and the local people, wherein activities like settlements, cropping, forestry , recreation and other economic that are in harmony with the conservation goals. Till date there were 553 biosphere reserves located in 107 countries.



Human Settlement (A terrestrial BR – Biosphere reserve)

The main functions of the biosphere reserves are:

- Conservation: Long term conservation of representatives, landscapes and different types of ecosystems, along with all their species and genetic resources.
- Development: Encourages traditional resource use and promote economic development which is culturally, socially and ecologically sustainable.
- Scientific research, monitoring and education- Support conservation research, monitoring, education and information exchange related to local, national and global environmental and conservation issues.

b) Species-oriented projects: Certain species have been identified as needing a concerted and specifically directed protection effort. Project Tiger, Project Elephant and Project crocodile are examples of focusing on single species through conserving their habitats.

Project Tiger

A success in species conservation Tigers which were once abundant in Indian forests have been hunted. As a result tiger population within the country declined drastically from estimate of 40,000 at the turn of century to 1200 by the 1970. This led to initiate the Project Tiger in 1973 with the objective of conserving and rescuing this species from extinction. In

2007, there were more than 40 Project Tiger wildlife reserves covering an area of 37,761 km². Project Tiger helped to increase the population of these tigers from 1,200 in the 1970s to 3,500 in 1990s. However, a 2008 census held by Government of India revealed that the tiger population had dropped to 1,411. A total ban has been imposed on hunting of tigers and trading in tiger products at the national and international levels. Elaborate management plans are made for each of the tiger reserves for tiger habitat improvement and anti - poaching measures.

Project Elephant

Project Elephant was launched in February, 1992 to assist states having free ranging populations of wild elephants to ensure long-term survival of identified viable populations of elephants in their natural habitats. The project is being implemented in twelve states viz. Andhra Pradesh, Arunachal Pradesh, Assam, Jharkhand, Karnataka, Kerala, Meghalaya, Nagaland, Orissa, Tamil Nadu Uttaranchal and West Bengal.

Crocodile breeding and management project

This project was started in 1976 with FAO - UNDP assistance to save three endangered crocodilian species, namely, the fresh water crocodile, salt water crocodile and the rare gharial. The project surveyed the crocodile habitats and facilitated their protection through declaration of sanctuaries and National Parks. Captive breeding and reintroduction or restocking programmes involved careful collection of eggs from the wild. Thousands of crocodiles of three species have been reared at sixteen centres and several of these have been released in the wild. Eleven sanctuaries have been declared specially for crocodile protection including the National Chambal Sanctuary in Madhya Pradesh.

c) Sacred forests and sacred lakes:

A traditional strategy for the protection of biodiversity has been in practice in India and some other Asian countries in the form of sacred forests. These are small forest patches protected by tribal communities due to religious sanctity. These have been free from all disturbances. Sacred forests are located in several parts of India i.e. Karnataka, Maharashtra, Kerala, Meghalaya , Similarly, several water bodies for example, Khecheopalri lake in Sikkim, have been declared sacred by the people, leading to protection of aquatic flora and fauna.

4.4.4.2 Ex-situ Conservation

a) **Botanical gardens, zoos, etc.**

To complement in-situ conservation efforts, ex-situ conservation is being undertaken through setting up botanic gardens, zoos, medicinal plant parks, etc by various agencies. The Indian Botanical Garden in Howrah (West Bengal) is over 200 years old. Other important botanical gardens are in Ooty, Bangalore and Lucknow. The most recent one is The Botanical Garden of Indian Republic established at NOIDA, near Delhi in April, 2002. The main objectives of this garden are –

- ex-situ conservation and propagation of important threatened plant species,
- serve as a Centre of Excellence for conservation., research and training,
- build public awareness through education on plant diversity and need for conservation.

A number of zoos have been developed in the country. These zoological parks have been looked upon essentially as centres of education about animal species and recreation. They have also played an important role in the conservation of endangered animal species such as the Manipur Thamin Deer (Cerus eldi eldi) and the White winged Wood Duck (Cairina scutulata). Notable successful examples of captive breeding are those of Gangetic gharial (Gavialis gangeticus), turtles and the white tiger.

b) **Gene Banks :** Ex-situ collection and preservation of genetic resources is done through gene banks and seed banks. The National Bureau of Plant Genetic Resources (NBPGR), New Delhi preserves seeds of wild relatives of crop plants as well as cultivated varieties; the National Bureau of Animal Genetic Resources at Karnal, Haryana maintains the genetic material for domesticated animals and the National Bureau of Fish Genetic Resources, Lucknow for fishes.

c) **Cryopreservation:** (“freeze preservation”) is particularly useful for conserving vegetative propagated crops. Cryopreservation is the storage of material at ultra low temperature of liquid nitrogen (-1960C) and essentially involves suspension of all metabolic processes and activities. Cryopreservation has been successfully applied to meristems, zygotic and somatic embryos, pollen, protoplasts cells and suspension cultures of a number of plant species.

d) **Conservation at molecular level (DNA level):** In addition to above, germplasm conservation at molecular level is now feasible and attracting attention. Cloned DNA and material having DNA in its native state can all be used for genetic conservation. Furthermore, non-viable material representing valuable genotypes stored in gene banks can all be used as sources of DNA libraries from where a relevant gene or a combination of genes can be recovered.

e) **Legal measures** : Market demand for some body parts like bones of tiger, rhino horns, furs, ivory, skins, musk, peacock feathers , etc. results in killing the wild animals. **The Wildlife Protection Act** (1972) contain provisions for penalties or punishment to prevent poaching and illegal trade. India is also a signatory to the **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)**. The Convention entered into force on 1st July, 1975. In addition to this, India is also a signatory to **Convention on Biological Diversity (CBD)**, which it signed on 29th December, 1993 at Rio de Janeiro during the Earth Summit. The Convention has three key objectives: 1. Conservation of biological diversity, 2 Sustainable use of biodiversity and 3. Fair and equitable sharing of benefits arising out of the utilization of genetic resources.

The CITES and the CBD are international initiatives. Government of India have also passed the Biological Diversity Act, 2002.

Biological Diversity Act, 2002

- This Act provides for setting up of a National Biodiversity Authority (NBA), State Biodiversity Boards (SBB) and Biodiversity Management Committees (BMC) in local bodies.
- All foreign nationals organizations require prior approval of NBA for obtaining biological resources and/or associated knowledge for any use.
- Similarly, Indian nationals or organizations will require to give prior intimation to the concerned SBB about any biological resources being imported for commercial use. The SBB may prohibit the import if found to violate the objectives of conservation, sustainable use and benefit sharing.

- However, local people and communities of the area, including Vaids and Hakims will have free access to use biological resources within the country for their own use, medicinal purposes and research.
- While granting approvals, NBA will impose terms and conditions to secure equitable sharing of benefits.
- There is a enabling provision for setting up a framework for protecting traditional knowledge.
- The monetary benefits, fees and royalties, as a result of approvals by NBA are to be deposited in National Biodiversity Fund which will be used for conservation and development of areas from where the resource has been accessed, in consultation with local self-government.
- World Wide Fund for Nature (WWF) and World Conservation Union supports projects to promote conservation and appropriate development of Biosphere Reserves.

4.5 Check Your Progress

A. Fill in the blanks

1. Quinine is obtained from the bark of …………… tree.
2. Illegal killing of prohibited endangered animals is called……………. .
3. Shannon –Wiener index gives measure of ……………….
4. Loss of habitat in instalments leading to small scattered patches is known as………………….. .
5. Nanda Devi, Manas and Sunder bans are examples of………………… .
6. There are 34 biodiversity hot spots in the world, of which ……. exist in India.
7. Drugs, fuelwood and food derived from biodiversity represent …………… value of biodiversity.
8. Bandipur national park is located in ………..
9. A ……………. is an area dedicated for the conservation of wildlife along with its environment.
10. ……….......... refers to the variety and variability among all groups of living organisms.

B. Choose the correct option

1) The scientific study of the geographic distribution of plants and animals is called

   a) biodiversity.
   b) biogeography.
   c) ecology.
   d) biology.
2) Kaziranga National Park is famous for:
   a) One-horned rhino
   b) hangul
   c) tiger
   d) Elephant
3) The total area of India is classified into following number of biogeographical zones:
   a) Six.
   b) Eight.
   c) Nine.
   d) Ten.
4) Biodiversity hotspots can be defined as
   a) evergreen forests of tropic region.
   b) biologically rich areas with large percentage in endemic species.
   c) desert areas.
   d) All of the above.
5) Species with very restricted distribution over relatively small ranges is called
   a) endangered species.
   b) extinct species.
   c) endemic species.

d) None of the above.

6) The major threats to biodiversity is due to

a) habitat loss/degradation.

b) pollution and global climatic changes.

c) extinction of species by aggressive non-native species.

d) All of the above.

7) Protection and preservation of endangered species away from their natural habitat under human care in zoos, nurseries and laboratories is known as

a) in-situ conservation.

b) ex-situ conservation.

c) biodiversity conservation.

d) None of the above.

8) Protection of endangered species by preserving the entire ecosystem is known as

a) in-situ conservation.

b) ex-situ conservation.

c) biodiversity conservation.

d) None of the above.

9) The concept of biodiversity hotspots is given by

a) E.P. Odum.

b) Norman Myers.

c) James Lovelock.

d) Rachel Carson.

10) Which of the following is an endemic species found in Western Ghats, India?

a) Marsh Mongoose.

b) Indian Rhinoceros.

c) Brown Palmcivet.

d) Flying Squirrel.

11) Which of the following is not a world heritage site of India?

a) Sundarbans National Park.

b) Manas Wildlife Sanctuary.

c) Simlipal.

d) Kaziranga National Park.

12) Those species whose population may extinct any time is called

a) Endangered species

b) Endemic species

c) All of the above

d) None

13) Which of the following is an in-situ tiger reserves in India?

a) Dudhwa.

b) Gulf of Myanmar.

c) Western Ghats.

d) Agasthyamalai.

14) Which of the following is not a biosphere reserve of India?

a) Sundarbans.

b) Great Nicobar.

c) Periyar National Park.

d) Khangchenzonga.

15) Which of the following is a biodiversity hotspot in India?

a) Succulent Karoo.

b) Mediterranean Basin.

c) Sundland.

d) Eastern Himalayas.

16) Which of the following animals is endemic to India?

a) Snow Leopard.

b) Blue Whale.

c) Asian Elephant.

d) Red Colobus Monkey.

17) The variety and the numbers of living organisms present in an ecosystem is called

a) biodiversity.

b) biopiracy.

c) biogeography.

d) bioprospecting.

18) Variation of genes within the same species is

a) genetic diversity.

b) species diversity.

c) biodiversity.

d) ecosystem.

19) Extinction of a weaker species by an aggressive alien species is the result of

a) endemism of weaker species.

b) habitat loss.

c) the Domino Effect.

d) All of the above.

20) Which of the following is an example of ex-situ conservation?

a) Biosphere reserve

b) Gene bank

c) Sanctuary

d) National park

4.6 Summary

- *Biodiversity refers to the totality of genes, species and ecosystems of plant, animals or micro-organisms in a region. Study of biodiversity has become very important recently after realising the value of biodiversity for our survival. It has many medicinal, commercial, economic and scientific uses.*
- *Wild relatives of cultivated crop plants are the source of genes for disease resistance and several other attributes required for crop improvement.*
- *Biodiversity also provides valuable services like water conservation, clean air, soil conservation and improvement of soil fertility, pollution break-down, aesthetic needs and so on.*
- *The total number of species on earth is estimated to range from 5-100 million, but only about 1.8 million species have so far been described.*
- *India is very rich in biodiversity and is one of 12 megadiversity countries globally recognized. In India, 70 % of the country's area has been surveyed and around 45,000 species of microorganisms and plants; and 81,000 species of animals have been described till date.*
- *Biodiversity has 3 levels - i) genetic, ii) species and iii) community or ecosystem. Species are distinct units of diversity and each species plays a specific role in a ecosystem.*
- *The diversity within a species often increases with environmental variability. Species diversity refers to the variety of species within a region. In ecosystem biodiversity, the biodiversity increases from polar regions towards the equator and from high elevations to low elevations.*

- *Habitat loss and fragmentation, over-exploitation, environmental pollution, climate change and introduction of exotic species pose major threat to biodiversity. It is estimated that 14,000-40,000species are being lost every year from the tropical forests alone.*
- *The IUCN Red list is the world's most comprehensive inventory of the global conservation status of threatened plant and animal species.*
- *It is important to ensure the conservation of landscapes, ecosystems, species and genetic resources failing which it will create survival crisis for mankind.*
- *Conservation strategies include in-situ (on-site)and ex-situ (off-site) approaches.*
- *Habitat protection is the main in-situ approach. The Protected Area Network for habitat protection includes national parks, wildlife sanctuaries, biosphere reserves, sacred groves or sacred forests.*
- *Ex-situ conservation is done by setting up botanical gardens, zoos, gene banks and seed banks, cryopreservation and preservation of germplasm.*
- *Areas that need immediate protection for conservation of biodiversity are called Biodiversity Hot Spots.*
- *Convention on Biodiversity is an important international instrument promoting biodiversity conservation globally.*
- *IUCN and WWF are among the leading international organizations concerned with biodiversity conservation. The Wildlife Protection Act (1972) and Biodiversity Act (2002) at the national level and The CITES and The Convention on Biodiversity at the international level regulate the trade in biodiversity and promote its conservation and sustainable use.*

4.7 Keywords

- **Biological diversity** can be defined as the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.
- Areas that need immediate protection for conservation of biodiversity are called **Biodiversity Hot Spots.**

- When the genes within the same species show different versions due to new combinations, it is called **genetic variability or diversity**.
- **Species Diversity** is the variability found within the population of a species or between different species of a community.
- **Ecosystem Diversity** is the diversity of ecological complexity showing variations in physical characters, ecological niches, trophic structure, food-webs, nutrient cycling etc.
- A variety of industries such as pharmaceuticals are highly dependent on identifying compounds of great economic value from the wide variety of wild species of plants located in undisturbed natural forests. This is called **biological prospecting**.
- Species which are restricted only to a particular area are known as **endemic species**.
- **Biogeography** refers to the study of distribution, evolution, dispersal and environmental relationship of plants and animals.
- Sometimes the loss of habitat occurs slowly in instalments as it is is divided into small and scattered patches. This is known as **habitat fragmentation**.

4.8 Self Assesment Questions

1) What is biodiversity? Discuss the values and significance of biodiversity.
2) What do you mean by conservation of biodiversity? State and explain basic approaches to wildlife conservation.
3) What are the threats to biodiversity?
4) India is a mega biodiversity nation. Justify the statement.
5) Biodiversity can be grouped into three levels based on their nature and taxonomical status. Briefly explain the levels of biodiversity.
6) Discuss the causes of and remedial steps that can curb the man-wildlife conflicts.
7) Distinguish between endangered and endemic species with examples?
8) What are various in-situ and ex-situ methods of conservation?

9) What are hotspots of biodiversity? Which are the hotspots found in India? Discuss their salient features.

10) What is Red Data Book? What do you mean by extinct, endangered, vulnerable and rare species?

4.9 Answers to check your progress

A. Fill in the blanks

1. cinchona 2. Poaching 3. species diversity 4. habitat fragmentation 5. biospheres reserves 6. 3 7. Consumptive 8. Karnataka 9. National Park 10. Biodiversity

B. Choose the correct option

1 (b) 2 (b) 3 (d) 4 (b) 5 (c) 6 (d) 7 (b) 8 (a) 9 (b) 10 (c) 11 (c) 12 (a) 13 (a) 14 (c) 15 (d) 16 (b) 17 (a) 18 (a) 19 (c) 20 (d)

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ENVIRONMENTAL POLLUTION: TYPES, CAUSES, EFFECT AND CONTROL MEASURES

Structure

5.0 Learning Objectives

5.1 Atmosphere

5.2 Environmental Pollutions

5.2.1 Air pollution

5.2.2 Water Pollution

5.2.3 Soil Pollution

5.2.4 Marine pollution

5.2.5 Noise pollution

5.2.6 Thermal pollution

5.2.7 Nuclear Hazards

5.3 Role of an Individual in Prevention of Pollution

5.4 Check Your Progress

5.5 Summary

5.6 Keywords

5.7 Self-Assessment Test

5.8 Answers to check your progress

5.9 References/ Suggested Readings

5.0 Learning Objectives

After studying this unit you should be able to:

- *define the terms pollution and pollutants*
- *list various kinds of pollution*
- *describe types of pollution, sources, harmful effects on human health and control of air pollution, indoor air pollution, noise pollution*
- *describe water pollution, its causes and control*
- *describe thermal pollution*
- *describe soil pollution, its causes and control*
- *describe radiation pollution, sources and hazards*
- *explain the role of individuals in the prevention of pollution*

5.1 Atmosphere

Atmosphere is a gaseous envelope surrounding the planet which is held together by Earth's gravity. Earth's atmosphere is over 100 km thick, but major part of it is within 16 km from the surface. Pressure exerted by atmosphere is known as atmospheric pressure. At sea level, atmospheric pressure is about 1 kg per cm^2.

Functions of atmosphere

a) **Blocking harmful rays:** Harmful ultra violet radiation from the sun is blocked by ozone layer, which is a part of our atmosphere.

b) **Source of Oxygen and Carbondioxide:** Atmosphere acts a source for both oxygen and carbondioxide which is essential for respiration and photosynthesis.

c) **Maintenance of earth's temperature:** Atmosphere cause heat retention and keep earth surface warm. In the absence of atmosphere the temperature of earth would be sub zero in the night.

d) **Saving earth from meteors:** Most meteoroids that enter the Earth's atmosphere vaporize completely due to high temperature and friction and never reach the planet's surface.

e) Climate and weather: Earth gets heated non-uniformly by the sun resulting in different weather patterns. Air sets in motion resulting in winds causing cyclones, monsoon, rainfall etc.

Gas Name	Chemical Formula	Percent Volume
Nitrogen	N_2	78.08%
Oxygen	O_2	20.95%
Argon	Ar	0.93%
Carbon Dioxide	CO_2	0.0360% (can vary)
Neon	Ne	0.0018%
Helium	He	0.0005%

Average composition of the atmosphere up to an altitude of 25 km

Atmosphere layers

Atmosphere becomes thinner and thinner as we go higher. There is no distinct boundary between the atmosphere and space. An imaginary line called **Karman line**, represents the boundary between the Earth's atmosphere and outer space. It lies approximately 100 km from earth's surface.

Earth's atmosphere is divided into five main layers according to their temperature characteristics: i) Troposphere ii) Stratosphere iii) Mesosphere iv) Thermosphere v) Exosphere

a) Troposphere

Troposphere is the bottom layer of the atmosphere which is closest to Earth's surface. It extends to an average height of 12 km (over the poles, 8 km; above the equator, 16 km). Temperature decreases with height in this layer. The rate of decrease of temperature with height is called, **lapse rate**. Average lapse rate in troposphere is –6.5 °C / km. Troposphere ends at **tropopause**. On reaching tropopause, temperature stops decreasing with height.

b) Stratosphere

Stratosphere is the second layer. It starts above the troposphere and extends to about 50 km above ground. Ozone layer is found in stratosphere and it absorbs harmful radiation from the sun. In this layer, temperature increases with height; just opposite to that in troposphere. The air is about a thousand times thinner here than it is at sea level. Thin air, absence of vertical winds and clouds helps smooth travel of jet planes. Stratospehere end at **stratopause**, where temperature neither decreases nor increases with height up to some level.

Mesosphere

Mesosphere starts at 50 km and extends to 85 km. In this layer, temperature decreases with height as in troposphere. This layer plays crucial role in radio communication. Sunlight passing through this layer causes molecules to ionize. These ionized particles reflects radio waves sent from earth. The top of the mesosphere, called the **mesopause**. At mesopause, the average temperature is about minus 90 °C.

c) Thermosphere

Thermosphere extends from about 90 km to 1,000 km. Temperatures can get up to 1,500 °C at this altitude. The density of air is very low.

d) Exosphere

Exosphere is the outermost layer of the atmosphere. It is extremely thin and merges into outer space. It is composed of very widely dispersed particles of hydrogen and helium. Satellites orbits the earth in exosphere.

Chemical and photochemical reactions in the atmosphere

Atmosphere is a dynamic system with wide fluctuations of the parameters (composition, temperature, humidity and intensity of sunlight). So, different processes will be observed under different atmospheric conditions. Many chemical and physical processes take place in the atmosphere. Some of them occur naturally while others occur due to human interventions.

The study of chemical reactions in the atmosphere is difficult due to a) very low concentrations involved b) low pressure c) high temperature d) high altitude. These reactions cannot be easily simulated in the laboratory and the detection and analysis of the reaction products extremely difficult.

Chemical reactions in the atmosphere can occur as: a) collisions between molecules in gas phase b) on the surfaces of solid particles (particulate matter) or in aqueous solution (in water droplets).

In gas phase reactions, the molecules are far apart. Therefore, some reactive species can exist for significantly longer time before reacting. The reactions that take place in water droplets are mostly acid-base reactions. Reactions on particle surfaces are of less importance because of the short residence time particles spend in the atmosphere.

Oxygen and Ozone Chemistry

Ozone layer is a layer in earth's atmosphere containing relatively high concentration of ozone (O_3). Ozone layer is found in the lower part of the stratosphere from approximately 20 to 30 km above earth. The ozone layer is often referred to as the **"umbrella of life"** because it protects life on Earth from harmful UV rays.

The **Dobson Unit** is the most common unit for measuring ozone concentration. One Dobson Unit is the number of molecules of ozone that would be required to create a layer of pure ozone 0.01 mm thick at a temperature of 0 °C and a pressure of 1 atmosphere. Over the Earth's surface, the ozone layer's average thickness is about 300 Dobson Units or a layer that is 3 mm thick.

Ozone formation

Ozone in the stratosphere is produced by photochemical reactions involving O_2. When molecular oxygen in the stratosphere absorbs ultraviolet radiation with wavelengths less than 240 nm, it breaks apart into two oxygen atoms.

$$O_2 + h\nu \rightarrow 2\,O \text{ (light of } \lambda < 240 \text{ nm)}$$

These oxygen atoms formed combine with O2 molecules to form ozone in the presence of a third body M.

$$O + O_2 + M\ (N_2 \text{ or } O_2) \rightarrow O_3 + M$$

The third body M absorbs the excess energy liberated by the above reaction and there by stabilizes the O_3 molecule.

Decomposition of ozone

Ozone absorbs ultraviolet radiation with longer wavelengths (~290 nm and above). It causes the ozone to decompose into O_2 molecules and oxygen atoms.

$$O_3 + h\nu \rightarrow O_2 + O \text{ (light of } \lambda > 290 \text{ nm)}$$

There is a dynamic equilibrium between ozone formation and destruction. Ozone strongly absorbs uv light in the region of 220-290 nm and protects the life on earth from severe radiation damage. Only a strong fraction of uv light reaches the lower atmosphere and earth.

Process of ozone production and destruction, initiated by ultraviolet radiation, are often referred to as **Chapman Reactions**. There is equilibrium between the formation and destruction of ozone. This equilibrium is disturbed by reactive atoms of chlorine, bromine etc. which destroy ozone molecules and result is thinning of ozone layer generally called **ozone hole**.

Causes for ozone hole formation

Chlorofluorocarbons (CFCs): Major reason for the depletion of ozone layer is halogen atoms (F, Cl, Br) which are formed by the photochemical decomposition of CFC's. **CFC** is an organic compound that contains only carbon, chlorine, hydrogen and fluorine. CFC's are widely used as coolants in refrigeration systems and air conditioners, propellants for aerosols due to low boiling point. These slowly rise up and reach stratosphere and cause depletion of ozone. The chemical reaction can be represented as

$CF_2Cl_2 + h\nu \rightarrow CF_2Cl + Cl$

$Cl + O_3 \rightarrow ClO + O_2$

$ClO + O \rightarrow Cl + O_2$

In the third step, Cl is generated again which can cause the reaction to continue like a chain reaction. One chlorine atom can thereby destroy thousands of ozone molecules. Similarly other atoms present in CFC like Fluorine and Bromine can also cause similar effect.

Effects of Ozone Depletion

Ozone depletion in the stratosphere will result in more UV radiation reaching the earth especially UV-B (290-320 nm).

In humans:

- The UV-B radiations affect DNA. Any change in DNA can result in mutation.
- Can cause skin cancer.

- Absorption of UV rays by the lens and cornea of may result in cataract.
- Melanin producing cells of the epidermis will be destroyed by UV-rays resulting in immune suppression.

In plants and animals:

- Phytoplanktons are sensitive to UV radiation. Decrease in phytoplankton population inturn affects the population of zooplankton, fish, marine animals, infact the whole aquatic food chain.
- Yield of certain crops like rice, wheat, soybean, cotton, bean, pea etc will decrease.
- UV radiation result in increasing the rate of evaporation through leaf stomata and decreases the moisture content of the soil. This can result in decreased crop production.

Other implications:

- UV radiation can cause degradation of paints, plastics and other polymer materials.
- It contributes to the Global Warming. If ozone depletion continues, the temperature around the world may rise even up to 5 degrees.

Control of ozone layer depletion

- **Reduce/replace the usage of CFC's:** One molecule of CFC destroys more than few thousands of ozone molecules via chain reaction. So usage of CFC's has to be discouraged and kept minimum. Use of other alternative coolants which are less damaging has to be promoted.
- **Reduce the use of methyl bromide:** Methyl bromide is an insecticide used for fumigation. It is a source for bromine atoms which can destroy ozone. Its use has to be controlled.
- **Control of deforestation:** Check in deforestation will ensure slightly higher percentage of oxygen in the atmosphere.
- **Proper maintenance:** Air conditioning and refrigerating units should regularly be checked for leaks and corrected if any.

5.2 Environmental Pollution

Environmental pollution can be defined as any undesirable change in the physical, chemical or biological characteristics of any component of the environment (air, water, soil), which can cause harmful effects on various forms of life or property. The material that causes pollution is called **pollutant**.

From an ecological perspective pollutants can be classified as follows:

- **Biodegradable or non-persistent pollutants:** These pollutants are biodegradable and can be easily broken down by natural biological processes. **Example:** domestic sewage, discarded vegetables, etc.
- **Non-degradable pollutants:** These are the pollutants, which decompose very slowly by the natural processes. **Example:** inorganic salts, metallic oxides, aluminium cans, DDT.

On the basis of the form in which they persist in the environment, pollutants can be categorized under two types:

- **Primary pollutants:** These are substances which are emitted directly from some identifiable sources and remain in that form. Examples are:

  Sulphur compounds: SO_2 produced by the oxidation of fuel.

  Carbon compounds: Oxides of carbon ($CO+CO_2$) and hydrocarbons.

  Nitrogen compounds: NO_2 and NH_3

  Halogen compounds: Hydrogen fluoride (HF) and hydrochloric acid (HCl).

  Particulate matter: Soot

- **Secondary pollutants:** The secondary pollutants are produced from primary pollutants. Primary pollutants undergo chemical reaction in the environment to become secondary pollutant. **Example:** Smoke, a primary pollutant combines with fog to form hazardous smog. SO_3 is formed by the oxidation of SO_2.

5.2.1 Air pollution

Air pollution is the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or cause damage to the environment. These substances include gases, particulate matter, radioactive substances etc.

5.2.1.1 Sources of air pollution

a) **Natural sources:** Forest fire and volcanic eruption can lead to air pollution. Hydrocarbons emitted by decomposition of organic matter can lead to air pollution. Pollen grains are also a pollutant.

b) **Anthropogenic or Man-made Sources:**

Man-made sources include population explosion, burning of fossil fuels, vehicular discharges, rapid industrialization, agricultural activities and modern warfare. All these lead to global warming.

1. **Population explosion**: The fast growth rate of population will create several serious problems in a chain reaction. Increase in population will create global warming and the emission of Greenhouse gases. These in turn will result in a rise in sea levels. Population explosion will also cause an increase in demand for food followed by the need for more land for cultivation thus causing destruction and loss of forest cover and wildlife.
2. **Burning of fossil fuels and fires**: Burning of conventional fossil fuels such as coal, lignite, petroleum and natural gas produces gaseous by-products which are poisonous, these include CO2, CO, CH4, SO2 and oxides of nitrogen. These gases pollute the air and make it unfit for breathing. However the quality and concentration of these pollutants depends on the type of fuel used. The smoke from the chimneys of a factory and the dust from anthropogenic activities contain a large amount of sulphur and nitrogen, respectively. Sulphur and nitrogen burn in the atmosphere to produce their oxides. Both are highly soluble in water and form sulphuric, sulphurous and nitric acid, respectively. These acids come down to the earth along with rain in the form of acid

rain or acid precipitation. They are responsible for the destruction of the ecosystem and corrosion in factories.

3. **Vehicular discharges**: In urban areas, about 75 percent of the air pollution is caused by automobile emissions. Automobiles run mainly on petrol or diesel. They pollute the air not only with exhaust gases but also with tiny bits of lead from tetraethyl lead that is contained in gasoline so as to prevent engine knock. A mixture of carbon monoxide (about 77 percent), oxides of nitrogen (about 8.4 percent), hydrocarbons (about 14 percent) and leaded gas along with some particulate of lead is emitted due to incomplete combustion of hydrocarbons (petrol and diesel) in internal combustion engines. These discharged gases react with oxides of nitrogen in the presence of sunlight to produce highly toxic photochemical smog.
4. **Rapid industrialization:** The advancement in science has led to the establishment of several industries such as the chemical industry, paper and pulp mills, cotton mills, metallurgical plants smelters, petroleum refineries, mining, synthetic rubber industries and tanneries. These industries are responsible for 20 percent of the air pollution as they discharge pollutants of the gaseous, liquid and particulate type. The most common pollutants are CO, CO_2, NO, NO_2, SO_2 and H_2S.
5. **Agricultural activities:** Different types of insecticides, pesticides and herbicides used in agriculture pollute the air through air currents thereby end up making the air hazardous for both human and animal health.
6. **Modern warfare:** To a large extent, radioactive rays from nuclear reactors, nuclear explosions and modern war explosives cause extensive air pollution and suffering to mankind.
7. **Smoking:** Smoking of cigarettes, bidis and other tobacco products causes many diseases due to the presence of carcinogenic tar in tobacco smoke. Other substances in this category are opium, dhatura and some other herbs.

   Non-smokers, living or working around smokers are also vulnerable to health problems such as irritation, bronchitis and even cancer of the lung and larynx as well as coronary diseases. In spite of common knowledge and the statutory warning that states, 'Smoking is injurious to health', smoking is very common and continues to be a major social problem.

Common Air Pollutants, their Sources and Effects on Human Beings

Pollutant	Source	Pathological effect on human beings
Sulphur dioxide	Combustion of coal and oil	Causes chest constriction, headache, vomiting and, ultimately, death due to respiratory ailments.
Nitrogen oxide	Soft coal, automobile exhaust	Inhibits cilia action so that soot and dust penetrates far into the lungs.
Hydrogen sulphide	Refineries, chemical industries and bituminous fuels	Causes nausea, irritation of eyes and throat.
Carbon monoxide	Burning of coal, gasoline motor exhaust	Reduces oxygen carrying capacity of blood.
Hydrogen cyanides	Blast furnace, fumigation, chemical plants	Interferes with nerve cells, produces dry throat, indistinct vision, headache.
Ammonia	Explosives, dye-making, fertilizer plants and lacquers	Inflames upper respiratory passage.
Phosgene	Chemical and dye-making industry	Induces coughing, irritation and fatal pulmonary oedema.
Aldehydes	Thermal decompositions of oils, fats and glycerols	Irritates nasal and respiratory tracts.
Arsenic	Process involving metal or acid containing arsenic soldering	Damages red blood cells, kidneys and causes jaundice.
Suspended particles (ash, soot, smoke, etc.)	Incinerator and almost every manufacturing process	Causes emphysema, irritation in the eyes and possibly, cancer.

5.2.1.2 Common Air Pollutants

a) Carbon dioxide: Low concentrations of CO_2 are not harmful. A high concentration of CO_2 can displace oxygen in the lungs. Less oxygen availability can result in rapid breathing, rapid heart rate, emotional upsets and fatigue. Lack of oxygen can result in permanent damage to organs including the brain and heart. CO_2 is the major gas that cause green-house effect.

b) Carbon monoxide: CO is a very poisonous gas and is produced by incomplete combustion of fuel. CO, being a very strong ligand, binds strongly with Fe present in the haemoglobin. CO has affinity for haemoglobin 210 times more than oxygen. Thus it interferes with the oxygen carrying capacity of blood.

$$\underset{\text{Oxyhaemoglobin}}{HbO_2} + CO \rightarrow \underset{\text{carboxyhaemoglobin}}{HbCO} + O_2$$

In presence of CO, haemoglobin is unable to transport oxygen to various parts of the body. This causes the reduction in oxygen levels in the tissues. Prolonged exposure leads to dizziness, reduced vision and even death. People who survive severe CO poisoning may suffer long-term health problems.

c) Oxides of Nitrogen: These include NO and NO_2 (usually denoted by NO_x), which are released by automobiles and chemical industries as waste gases and also by burning of materials. These are harmful and lower the oxygen carrying capacity of blood. Oxides of nitrogen especially NO_2 can irritate the lungs and cause conditions like chronic bronchitis and emphysema. Oxides of nitrogen dissolve in water forming nitric acid resulting in acid rain.

d) Oxides of Sulphur: High concentration of SO_2 causes chlorosis (yellowing of leaves), damage to mucous membrane etc. SO_2 and SO_3 react with water to form Sulphuric and sulphurous acids resulting in acid rain.

e) Hydrocarbons: These are unburnt discharges from incomplete combustion of fuel in automobiles.

f) Particulate Matter: Industries and automobiles release fine solid and liquid particles into the air. These are injurious to respiratory tract.

5.2.1.3 Effects of Air Pollution

Effect on Plants:

- SO_2 causes chlorosis and also results in the death of cells and tissues.
- Fluorides and PAN damage leafy vegetables such as lettuce and spinach.
- Oxides of nitrogen and fluorides result in decrease in crop productivity.
- Smog bleaches and blaze foliage of important leafy plants.
- Hydrocarbons cause premature yellowing, fall of leave and flower buds, discoloration and curling of sepals and petals.
- Smoke and dust cover the leaf surface and reduce photosynthetic capacity of plants.
- Ozone damages cereals, fruits and cotton crop.

Effect on Man:

Effect of pollutants on animals and man are as follows

- **Ozone:** Breathing ozone can result in a variety of health problems including chest pain, coughing, throat irritation etc. It can worsen bronchitis and asthma. Ground level ozone also can reduce lung function and can cause inflammation of the linings of the lungs.
- **SO_2:** SO_2 causes drying of mouth, scratchy throat, irritates the nose and eyes and disorders of respiratory tract. It also cause coughing, wheezing, shortness of breath, or a tight feeling around the chest.
- **NO_x:** Short or long term exposure to oxides of nitrogen can cause severe respiratory illness, aggravate asthma and cause lung malfunction.
- **CO:** CO diffuses into blood stream and reduces oxygen transport. CO damages cardiovascular system. Prolonged exposure leads to dizziness, reduced vision and even death.
- **Hydrocarbons:** Hydrocarbons can act as carcinogens and lead to different cancers.
- **Suspended particles (Particulate matter):** These can aggravate bronchitis and asthma. Prolonged exposure can lead to reduced lung function.

Effects on aquatic life:

Air pollutants like oxides of nitrogen and sulphur, dissolve in rain water resulting in acid rain. High acidity (lower pH) in fresh water lakes affects aquatic organisms. Some of the freshwater lakes have experienced total fish death.

Effects on materials:

Air pollutants can cause damage to exposed surfaces. Presence of SO_2 and moisture can accelerate corrosion of metallic surfaces. SO_2 can affect fabric, leather, paint, paper, marble and limestone. Ozone in the atmosphere can cause cracking of rubber tyres. Oxides of nitrogen can also cause fading of cotton and rayon fibres.

5.2.1.4 Control of Air Pollution

Air pollution can be minimized by the following methods:

- **Afforestation and controlling deforestation:** Trees should be planted on the roadside, riverbanks, parks and' open places as they can act as "pollution moderators".
- **Law enforcement:** Pollution control laws should be enforced strictly. Constant monitoring of industrial/automobile exhaust must be carried out.
- **Use of low sulphur coal:** Using low sulphur coal in industries or removing sulphur from coal can considerably reduce air pollution.
- **Using non-conventional sources of energy:** Use of eco-friendly energy sources like solar energy, wind energy can reduce air pollution.
- **Increasing the height of chimneys:** The height of chimneys can be increased to the highest possible level so that pollutants are emitted to higher levels.
- **Removal of particulate matter:** Particles larger than 50 mm are separated in gravity settling tanks. Using cyclone collectors or electrostatic precipitators separates fine particles.
- **Checking vehicular pollution:** Pollution by vehicles can be minimized by regular tune-up of engines; replacement of more polluting old vehicles; installing catalytic converters.

5.2.1.5 Smog

Smog is a kind of air pollution. The word '*Smog*' is derived from smoke and fog. When smoke is combined with the fog present in the atmosphere the *smog* is formed.

Smoke = Smog +Fog

Types of Smog :

a) **London smog:** London smog usually occurs during early morning hours. Coal containing large amounts of sulphur, produce SO_2 on burning which can result in smog. The main constituent of London-type smog is soot, fly ash, sulphur dioxide, sodium chloride and calcium sulfate particles. If concentrations are high enough, sulphur dioxide produces sulphuric acid. Due to the presence of reducing impurities it is known as **reducing smog**.

   Health problems: SO_2 can severely affect respiratory system. Higher amounts of SO_2 can even lead to death. Great smog of London in 1952 caused death of more than 4000 people. Smog -related deaths were primarily attributed to pneumonia, bronchitis, tuberculosis and heart failure.

b) **Los Angeles smog (Photochemical smog):** Los Angeles smog usually happens in noon, as the reactions forming smog are triggered by sunlight. It was first reported in the city of Los Angeles and hence the name. It is mainly composed of ozone, volatile hydrocarbons (VOC), Peroxy acetyl nitrate (PAN), nitrogen dioxide etc. Since it contains oxidizing impurities it is also known as **oxidizing fog**.

   NO_2 + Sunlight $\rightarrow$ NO +$O^{\bullet}$

   $O_2 + O^{\bullet} \rightarrow O_3$

   $O_3 + NO \rightarrow O_2 + NO_2$

   Nitrogen dioxide (NO_2) can also react with oxygen, hydrocarbons (unburnt petrol) or radicals produced from volatile organic compounds in the presence of sunlight to form toxic products such as **peroxyacetyl nitrates** (PAN) ($CH_3CO\text{-}OO\text{-}NO_2$):

   It is also formed by the reaction of aldehydes and hydroxyl radicals.

$$CH_3CHO + {}^{\bullet}OH \rightarrow CH_3\dot{C}O + H_2O$$

$$CH_3\dot{C}O + O_2 \rightarrow CH_3COOO^{\bullet}$$

$$CH_3COOO^{\bullet} + {}^{\bullet}NO2 \longleftrightarrow \underset{\text{PAN}}{CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-O-O-NO_2}$$

PAN is relatively stable molecule and have long lifetimes in cooler air. Because of this, it may travel long distances. In warmer climates, it may break down and release toxic NO_2, which produces additional ozone and hydroxyl radicals. In this way, PAN can be considered as a reservoir of NO_x species.

Problems associated with PAN:

- PAN is a highly potent oxidant that is both toxic and irritating. It causes eye irritations at very low concentrations (even in ppb levels). It also irritates the respiratory system.
- PAN can cause impaired breathing or lung lesions following inhalation exposure in animals.
- PAN inhibits efficiency of photosynthesis in plants. PAN is more toxic to plants than ozone. It causes discoloration of leaves.
- PAN also reduces the plant's ability to store food, grow and reproduce. These plants are more vulnerable to attacks by pests and diseases.

Health problems caused by photochemical smog: Ozone has the ability to oxidize and destroy lung tissue. Short term exposures to elevated levels of ozone (above 75 ppm) can lead to coughing, wheezing, difficulty in breathing etc. Prolonged exposure to smog can cause a permanent reduction in lung function, elevate the risk of developing asthma.

A comparison of London smog and photochemical smog

Name	London smog (New York smog, grey smog)	Photochemical smog (L.A. smog, Denver smog, brown smog)
Weather	It occurs early mornings.	It occurs during mid day (noon)
Content	Particulates, Sulfur oxides	NO_x, ozone, PAN, hydrocarbons.
Sources	Burning coal.	Gasoline, combustion. (primarily from automobile exhaust)
Nature	Reducing in nature	Oxidizing in nature

5.2.1.6 Acid Rain

Acid rain is rain or any other form of precipitation that is unusually acidic (pH below 5.6). Acid rain literally means 'the presence of excessive acids in rain waters'. Acid rain can be wet or dry. Natural rain water has a pH of 5.6 at 20 °C due to dissolution of CO_2 in water (carbonic acid). Any precipitation less than pH 5.6 can be considered acidic. Typical acid rain has a pH value of 4 or lower. Acid precipitation is a mixture of strong mineral acids sulphuric acid (H_2SO_4), nitric acid (HNO_3) and in some locations, hydrochloric acid (HCl).

Causes:

a) **Oxides of Nitrogen:** Oxides of nitrogen, represented by NO_x is mainly responsible for acid rain. Automobile exhaust, factory emission contains large amounts of NO_2. It is also emitted by natural processes like lightning, volcanic eruptions, forest fires and action of bacteria in the soil.

   Nitrogen dioxide (NO_2) reacts with water to form nitrous acid (HNO_2) and nitric acid (HNO_3)

   $2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$

b) **Oxides of sulphur:** Oxides of Sulphur (SO_2 and SO_3 represented as SO_x) are produced when fossil fuels containing sulphur are burnt. Small amounts are found in automobile exhaust. Large amounts of these gases are produced while processing of crude oil, in utility factories and iron and steel factories. SO_2 is also produced naturally by volcanic activity.

   Sulphur dioxide reacts with water to form sulphurous acid (H_2SO_3)

   $SO_2 + H_2O \rightarrow H_2SO_3$

   Sulphur dioxide (SO_2) can be oxidised gradually to sulphur trioxide (SO_3)

   $2\,SO_2 + O_2 \rightarrow 2SO_3$

   Sulphur trioxide (SO_3) reacts with water to form sulphuric acid (H_2SO_4)

   $SO_3 + H_2O \rightarrow H_2SO_4$

Effects of acid rain

On plant life

- **Loss of waxy coating on leaves:** Frequent acid rain dissolves the waxy protective coating of the leaves and plants become more susceptible to disease. When leaves are damaged, the efficiency of photosynthesis is reduced drastically.
- **Root damage:** Roots of plants are damaged by acid rain, causing the growth of the plant to be stunted, or even in its death.
- **Death of micro organisms:** Useful microorganisms which release nutrients from decaying organic matter, into the soil are destroyed. This can result in the availability of less nutrients for the plants.
- **Loss of beneficial nutrients from the soil:** Acid rain washes away the beneficial minerals and nutrients in soil before the plants have a chance of using them for their growth.

On animal life

- **Heavy metal leaching:** Acid rain can cause leaching of harmful mercury and aluminium salts from the soil and rocks. It is then carried into the lakes causing damage to aquatic ecosystem.
- **Death of aquatic organisms:** When the pH reaches 5.5, plankton, certain insects and crustaceans begin to die. At a pH of around 5.0, the fish population begins to die. Below pH 5.0, entire fish population may die.
- **Loss of fertility:** It results in the fish's ability to maintain their calcium levels. This impairs reproduction the ability of the fish, because the eggs become too weak or brittle. This can result in killing of fish.

In humans

- **Respiratory problems:** Acid rain can cause nose and eye irritation, headache, asthma and dry coughs. Acid rain can aggravate asthma.
- **Buildings and monuments**
- **Deterioration of buildings:** It causes deterioration of buildings especially made of marble Acid rain caused tarnishing of Taj Mahal. Dry acid deposition containing SO_2 is primarily

from the exhaust of Mathura refineries. Oil refineries in Mathura emit nearly 25 tonnes of SO_2 per day despite using low sulphur content coal.

- **Deterioration of objects:** Acid rain corrodes ceramic, textiles, paints and metals. Rubber and leather deteriorate if exposed to acid rain. It damages metals and car finishes.

Control of acid rain

- **Use of low sulphur content coal:** Coal with lower sulphur content is desirable to use in thermal plants.
- **Replacement of coal by natural gas:** Replacement of coal by natural gas would also reduce the problem substantially.
- **Reduction of NO_x and SO_x emission:** Emission of SO_2 and NO_2 from industries and power plants should be reduced by using pollution control equipments.
- **Strict law enforcement:** Strict laws must be brought for air pollution reduction (especially emission of CO_2, NO_2 and SO_2). Heavy fine must be imposed if accepted emission levels are crossed.
- **Use of renewable sources of energy:** Use of alternate eco friendly sources of energy can minimize pollutants and hence acid rain.
- **Use of eco-friendly vehicles:** Pollutants can be minimized by using pollution control devices like catalytic converters in vehicles. Another method is the usage of natural gas as fuel in automobiles.

5.2.1.7 Particulate Pollution

Particulate refers to small, light weight solid particles which are suspended in air. They differ widely in terms of particle density and particle size. Its size varies from 0.1mm to 100 mm. Small particles have large total surface area and so it carries high pollutant load. Examples of particulate pollutants include aerosols, dust, smoke, fumes, mist, fly ash, soot etc.

Causes:

Main cause for particulate pollution are forest fires, volcanic eruptions, debris and fly ash formed by burning fuels, automobile exhaust etc.

Consequences:

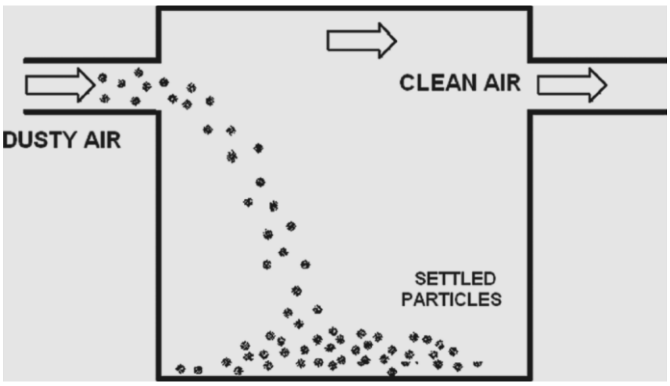
- Particulate matter may lead to severe health problems which include.
- Premature death in people with heart or lung disease.
- Nonfatal heart attacks.
- Irregular heartbeat.
- Aggravated asthma
- Decreased lung function and
- Increased respiratory symptoms such as irritation of the airways, coughing or difficulty breathing.

5.2.1.8 Air Pollution Control Devices

There are five main categories of **particulate control devices** which are widely used.

a) **Gravity settling chamber**

As the name implies, gravity settling chambers are employed for the removal of dparticles from the gas stream by simply settling under the influence of gravity. This method is used only for very large particles (approximately 75 micrometers and larger). Particles having heavier density obeys Stokes law and settle at the bottom of the chamber from where it is removed.

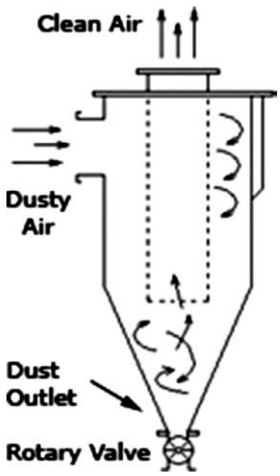


Gravity Settling Chamber

b) Cyclone collector

Cyclone collector is a mechanical separator where centrifugal force (instead of gravitational force) is used to remove the particulate matter. Centrifugal force which is several times greater than gravitational force can be generated by a spinning gas stream. This causes particulate containing gas to change direction often and particulate matter is thrown along the tangent and finally settles.

It is used after the settling chamber to collect the smaller particulate matter that could not be collected in the settling chamber. Major disadvantage is that it is very expensive.



Cyclone Collector

c) Particulate wet scrubbers

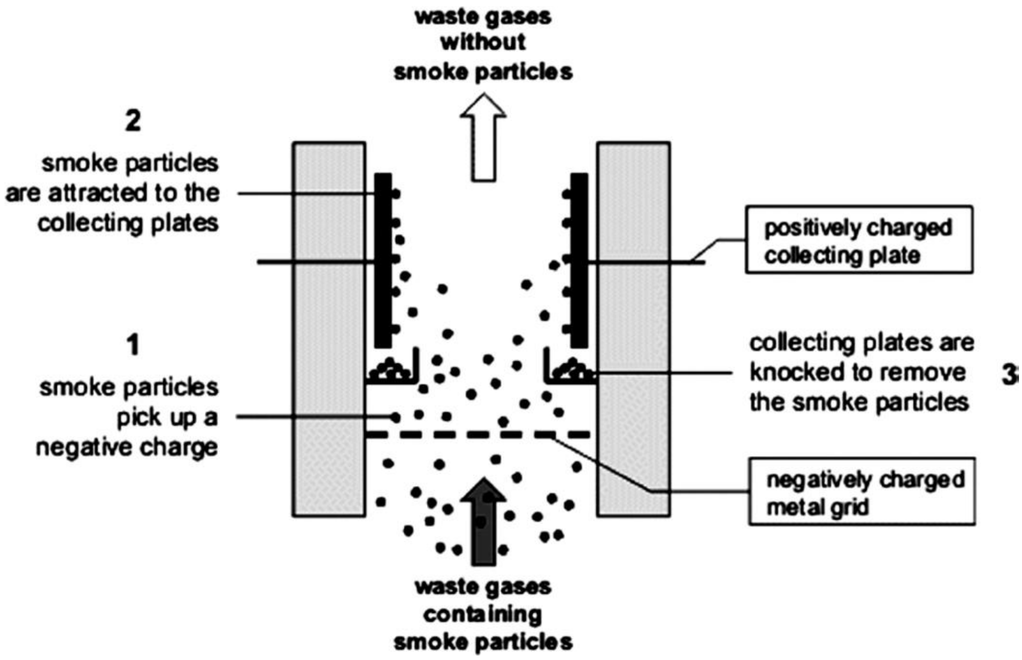
In a wet scrubber, the polluted gas stream is brought into contact with the scrubbing liquid. The scrubbing liquid is usually sprayed so as to remove the pollutants. It is very useful in removing SO2 and other small particulate matter.

Advantages of wet scrubbers

- Wet scrubbers have the ability to handle high temperatures and moisture.
- Wet scrubbers can remove both gases and particulate matter.
- Wet scrubbers can neutralize corrosive gases.

d) Electrostatic precipitators

An electrostatic precipitator (ESP) uses non-uniform, high-voltage fields to apply large electrical charges to polluted gas particles moving through the field. The charged particles move toward an oppositely charged collection surface, where they get collected.

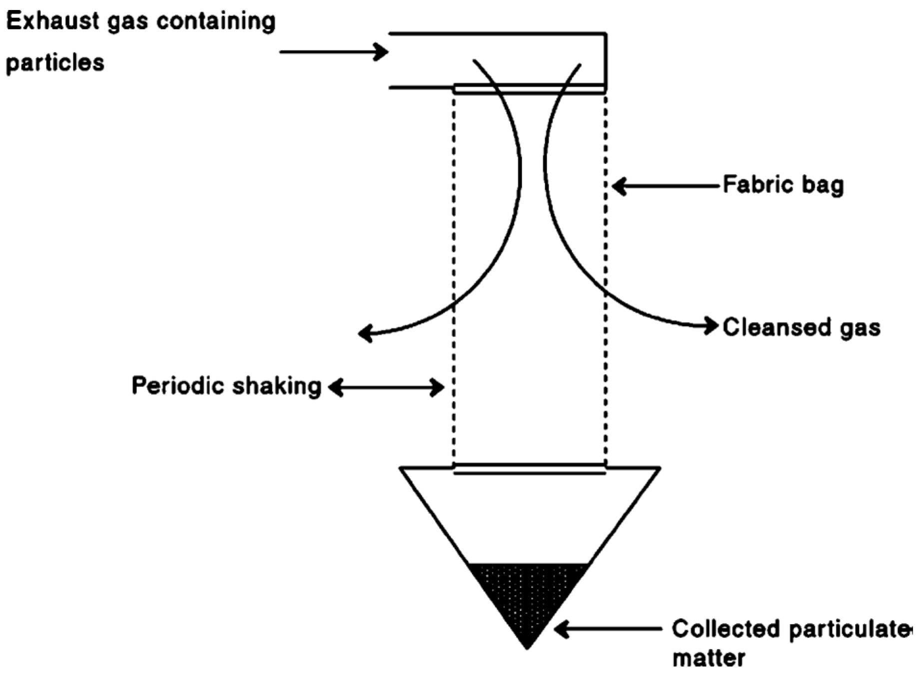


Electrostatic Precipitator

e) Fabric filters

Fabric filters consists of fabrics that allow the passage of gas but retain and collect particulate matter on the surfaces of filter bags. The bags can be made of cotton, synthetic, or glass-fiber material in either a tube or envelope shape. Gas containing dust enter the bag house and pass through fabric bags that act as filters.

Periodically, the fabric composing the filter is shaken to remove the particulate matter. They are most efficient and cost effective types of dust collectors available. More than 99% for very fine particulates can be collected and removed from the gas stream.



Fabric Filter

Emission Control of NO_x , CO , HC

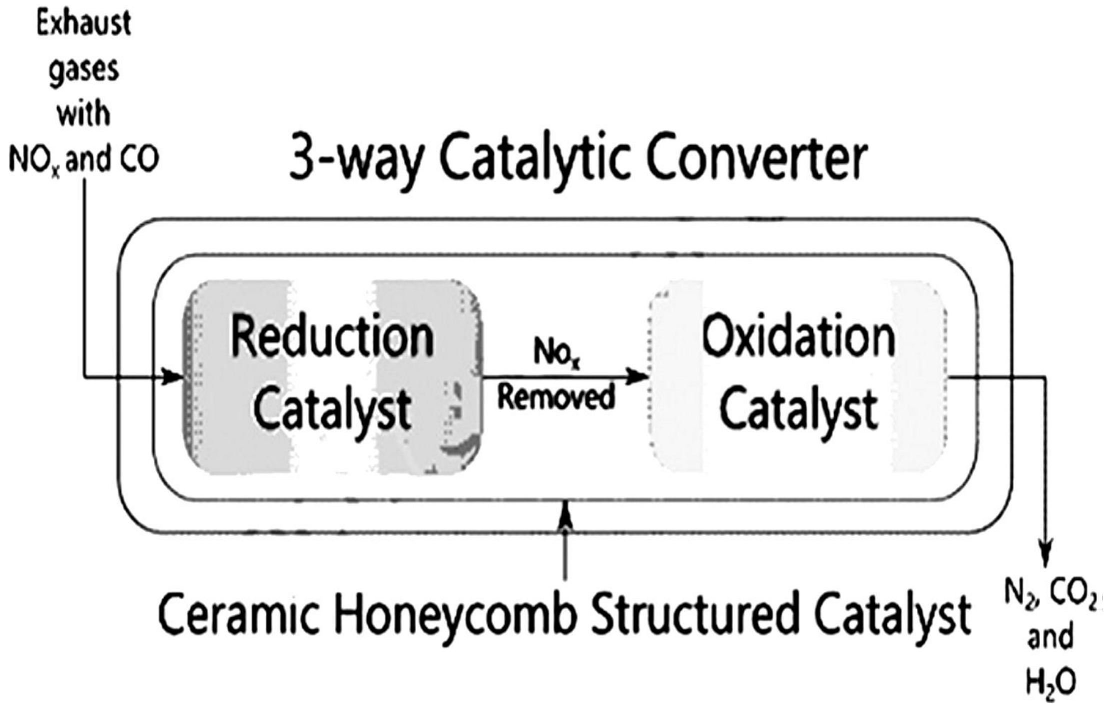
Use of catalytic convertors:

Catalytic convertors are used in automobiles to reduce emissions of certain harmful compounds like NO_x, CO and hydrocarbons. Catalyst used in a catalytic converter is a combination of platinum (Pt), palladium (Pd) and rhodium (Rh). These metals coat a ceramic honeycomb (or ceramic beads) contained within a metal casing that is attached to the exhaust pipe. Honeycomb structure of the catalytic converter's provides maximum surface area. Due to greater surface area only less amount of catalyst has to be used.

Three-Way Catalytic Converter

A three-way catalytic converter has three simultaneous tasks:

- Reduction of nitrogen oxides to nitrogen and oxygen
- Oxidation of carbon monoxide to carbon dioxide
- Oxidation of unburnt hydrocarbons (HC) to carbon dioxide and water.



In the first step, the catalytic converter uses a **reduction catalyst** composed of Rh to reduce the NO_x. As the nitrogen oxides (NO and NO_2) pass through the device, the catalyst converts these to form oxygen gas (O_2) and nitrogen gas (N_2).

$2\ NO \rightarrow N_2 + O_2$

$2\ NO_2 \rightarrow N_2 + 2\ O_2$

In the second step, an **oxidative catalyst** of Pt and Pd decreases emissions of carbon monoxide (CO) and unburned hydrocarbons (HC) by converting into CO_2 and water.

$2\ CO + O_2 \rightarrow 2\ CO_2$

$C_2H_4 + 3\ O_2 \rightarrow 2\ CO_2 + 2\ H_2O$

Reducing Pollution

Catalytic convertors are widely used in modern gasoline engines. They are reliable and efficient in reducing pollution. Nearly 90% of the hydrocarbons, carbon monoxide and nitrogen oxides produced are converted into less harmful compounds. Catalytic converters are not so efficient in diesel engines which runs at lower temperature than gasoline engines. Catalytic converters work best at higher temperatures.

5.2.1.9 Indoor Air Pollution

The most important indoor air pollutant is **radon gas**. Radon gas can cause lung cancer. Radon is emitted from building materials like bricks, concrete, tiles etc. Radon is also present in groundwater and natural gas and is emitted indoors while using them.

Many houses in the developing countries use fuels like coal, dung-cakes, wood and kerosene as domestic fuel. Incomplete combustion produces the toxic gas carbon monoxide. Coal contains varying amounts of sulphur which on burning produces sulphur dioxide.

5.2.1.10 Air Pollution – Case Study

Air pollution is a serious problem addressed by modern society. There have been many instances where pollution affected thousands of people.

Bhopal gas tragedy

Bhopal gas tragedy is considered to be the world's worst industrial disaster.

Place: Bhopal, Madhya Pradesh.

Date: Night of 2^{nd} and morning of 3^{rd} December, 1984

Company: Union Carbide India Limited (UCIL)

Gas responsible: Methyl isocyanate (MIC). MIC was an intermediate used for the production of pesticide, Sevin.

Toxic effects of MIC: MIC is a volatile fluid with a boiling point of about 40˚C. MIC cause irritation of mucous membrane. At higher concentrations, it cause difficulties in breathing, with pressure over the chest and pain when inhaling. MIC also has an irritating effect on moist skin and may cause injury to the cornea of the eye.

Reason for the tragedy: It is widely believed that water entered the tank where about 40 ton MIC was stored. A combination of the human error and an improper plant safety system resulted in disaster.

Tragedy: During the night of 2–3 December 1984, water entered tank containing 40 tons of MIC. This started the chemical reaction which was accelerated by contaminants, high temperatures and was catalyzed by iron (stainless steel pipelines). The resulting exothermic reaction increased the temperature inside the tank to over 200°C and raised the pressure forcing about 30 tons of MIC to escape. The gases were blown in southeastern direction over Bhopal. The huge cloud of deadly gas quickly spread out from the factory and enveloped an area of over 20 km^2.

Early morning, people living around the Union Carbide chemical factory in Bhopal woke up coughing, their eyes burning. Thousands died immediately. People were in Panic and the police instructed people to run away from the gas. This only resulted in inhaling even more gas. By morning streets of Bhopal was covered by corpses of humans and animals.

Death: Four months after the tragedy, the Indian government reported to its parliament that 1,430 people had died. However, it is estimated that the death toll could be much higher. Many lost vision permanently.

After effects: Union Carbide Chairman, CEO Warren Anderson was arrested and released on bail by the Madhya Pradesh Police in Bhopal on 7 December 1984. Legal battle is still going on between Union Carbide (now Dow Chemicals) and Indian authorities. Most of the victims and their families are yet to receive the compensation.

5.2.2 Water Pollution

Earth is the only planet containing water. Hence it is known as “blue planet”. About 71% of the earth’s surface is covered by water, out of which only 0.014% can be used for domestic, agriculture and industrial purposes and rest is locked in oceans, polar ice caps, giant glaciers and rock crevices. Water is so essential part of plant and animal life that without which life cannot survive. So it is important to save, preserve and reuse water.

5.2.2.1 Physical and Chemical Characteristics of Water

1. **Colour:** Pure water is colourless. Sometimes underground water is coloured due to humus, iron, manganese salts.
2. **Taste:** The taste of water is due to the presence of dissolved minerals and salts. The brackish taste of water is due to the presence of excess amounts of salts like NaCl and KCl.
3. **Odor:** Pure water is odorless. Unpleasant odor may be due to the presence of organic matter, decaying vegetation, bacteria, gases like H_2S and NH_3.
4. **Turbidity:** It is due to the presence of finely divided colloidal, insoluble impurities like inorganic matter, clay, silica, silt etc.
5. **Specific heat:** Water has a high specific heat. So, it can absorb large amounts of heat energy before it begins to get hot.
6. **Environmental significance:** High specific heat means that water releases heat energy slowly when it cools. Water's high specific heat allows for the stabilization of the Earth's climate and helps organisms regulate their body temperature more effectively.
7. **pH:** Water in pure state has a neutral pH. As a result, pure water is neither acidic nor basic. pH of water changes when salts or gases are dissolved in it. Rain has a naturally acidic pH of about 5.6 because it contains dissolved CO_2 and SO_2.
8. **Surface tension:** Water has a high surface tension. This makes water drops spherical. It also causes water to stick to the sides of vessels.
9. **Environmental significance:** Water's high surface tension allows for the formation of water droplets and waves, allows plants to move water (and dissolved nutrients) from their roots to their leaves. Small insects walk on the surface of water due to this high surface tension.
10. **Thermal properties:** Water has interesting thermal properties. Water contracts when heated from 0°C, its melting point, to 4°C. Water has maximum density at 4°C. It expands greatly as it freezes; as a result, ice is less dense than water and floats on it.

11. **Environmental significance:** In cold countries, only the top layer of the lake or river freezes. Underneath the frozen upper layer, the water remains in its liquid form and does not freeze. This thick layer of ice acts as an insulator and prevents freezing of the water below. Due to the presence of water beneath, fish and other aquatic animals are able to survive in the frozen lakes and ponds.

5.2.2.2 Water quality parameters

- **Water quality** refers to the chemical, physical, biological and radiological characteristics of water.
- **Physical tests:** Colour, temperature, turbidity, suspended solids, odour and taste.
- **Chemical tests:** pH, BOD, COD
- **Biological tests:** Coliform count

5.2.2.3 Water pollution

Water pollution is the any alteration in physical, chemical or biological characteristics of water making it unsuitable for domestic and industrial purposes often causing health hazard.

Sources of water pollution

a) **Point source:** When a source of pollution can be readily identified, it is said to be a **point source. Example:** Factory outlet, Power plant outlet.

b) **Non point source:** It is difficult to trace the origin of these water pollutants. **Example:** acid rain, percolation of fertilizer or pesticides into ground water.

Parameters	Reason for analysis
Temperature	Many aquatic organisms are cold-blooded. Each species has its own optimum (best) water temperature. If the water temperature shifts too far from the optimum, the organism suffers. Temperature of water is influenced by: a) Color of the water. b) Depth of water c) Time of the year d) Volume of water e) Temperature of effluents dumped into water.
pH	pH is an indicator for healthy aquatic life. Any drastic change in pH can result in the death of the species. Most fish can tolerate pH values of about 5.0 to 9.0. Certain organisms like mussels, clams, oysters are sensitive to acidic pH as it may cause the destruction of the $CaCO_3$ shell.
Turbidity	Turbidity refers to "how cloudy is water?". Turbidity results in scattering of light. Turbidity may be due to organic and/or inorganic constituents. Water could be turbid due to the presence of algae. Turbidity may cause the growth of microorganisms and hence may increase the possibility for waterborne disease.
Dissolved Oxygen (DO)	Dissolved oxygen (DO) is oxygen that is dissolved in water. DO level in good fishing waters is about 8 ppm. When DO levels drop below about 3.0 parts per million, most of the fishes die. A high DO level in drinking is good because it gives water a better taste. However, high DO levels speed up corrosion in water pipes.
Conductivity	The ability of water to conduct electricity is termed conductivity. Presence of dissolved salts increases the conductivity of water. Rain water has very low conductivity (~50 µS/cm) while sea water has very high conductivity (~50,000 µS/cm). As conductivity measures the dissolved ions in water it is also commonly used as a measure of total dissolved solids.
Biochemical Oxygen Demand, BOD	BOD denotes the amount of oxygen needed by micro-organisms for oxidation of decomposable organic matter under aerobic conditions. High B.O.D. means that there is less of oxygen to support life and indicates organic pollution. High BOD is an indication of poor water quality.
Chemical Oxygen Demand, COD	COD is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as ammonia and nitrite.
Microbiological Total Coliform Count Faecal Coliform Count	Microbiological test is conducted to detect the Level of pollutions caused by living things especially humans. These tests are based on coliform bacteria as the indicator organism. The presence of these bacteria confirms that the water has been polluted with faeces of humans or other warm-blooded animals.

5.2.2.4 Causes of water pollution

a) **Domestic sewage:** This includes household's wastes like food wastes, synthetic detergents used for washing clothes and cleaning bathrooms and latrines.

b) **Industrial effluents:** Industrial wastes (often untreated) are discharged into the nearby rivers and other water sources. Textiles, sugar and fertilizers factories, oil refineries, drugs manufacture, rubber and rayon fibres, the paper industries etc. cause significant water pollution.

c) **Agricultural sources:** Extensive use of fertilizers, pesticides, herbicides result in severe water pollution. From soil these reach water causing eutrophication, biomagnification etc.

d) **Thermal pollution:** In power plants and nuclear power stations, water is used as coolant. Hot water produced when enters lakes or rivers raises temperature of water body, which kills fishes and other aquatic life.

e) **Pathogenic organisms:** Sewage and domestic waste from houses contains pathogenic organisms viz., protozoa, worms-eggs and bacteria etc. This water if consumed causes jaundice, typhoid, dysentery, cholera, etc.

f) **Waste heat:** Discharge of waste heat from industries increases the temperature of water bodies and affects aquatic organisms.

5.2.2.5 Consequences of water pollution

Effects on ecosystem

- **Ecosystem destruction:** Water pollution can kill many species, disrupting the entire ecosystem.
- **Eutrophication:** Excess of phosphates and nitrate may result in algal bloom called **eutrophication**. This may eventually lead to the death of the water body.
- **Loss of species:** Many organisms find hard to survive in polluted environment which may lead to migration or extinction of species. **Example:** Acid rain severely affects mussels, oysters etc. (shell made of $CaCO_3$)

- **Biomagnification:** Pesticide residues, heavy metals etc. concentrate when passed through food chain or food web. While passing through the organisms, the concentration of pollutants gets increased, called **biomagnification**.

Effects on Human Health

- **Heavy metals:** Compounds of mercury damages brain. Cadmium salts damages kidneys and liver. Lead compounds are known to affect the proper functioning of brain.
- **Water born diseases:** Water pollution makes water unfit for drinking purposes. Polluted water can cause certain waterborne diseases like diarrhoea, typhoid, cholera and jaundice.
- **Other complications/diseases:** Presence of excess nitrates and fluorides can cause **blue baby syndrome and** defects in teeth and bones called **fluorosis** respectively. Nitrates get reduced to nitrites in stomach which can result in stomach cancer.

Effects on animal health

- **Shortage of drinking water:** Water pollution may lead to severe scarcity in drinking water for animals. This may lead to large scale death of aquatic and terrestrial animals
- **Imbalance in the ecosystem:** Water pollution can lead to reduced reproduction rate, diseases, imbalances secondary food chains etc.

5.2.2.6 Control of water pollution

- **Water treatment:** Domestic sewage and industrial wastes should be treated before discharging them into water bodies.
- **Minimal use of pesticides and fertilizers:** Use of pesticides, insecticides and fertilizers should be done judiciously. Rapid biodegradable substitutes for pesticides should be employed.
- **Afforestation and control of deforestation:** Planting trees would reduce pollution by sediments, silt and mud in the river banks.
- **Cooling towers/ponds:** These can be used to cool the hot water from industries before discharging into the rivers. This can control thermal pollution.

- **Domestic methods:** Separate ponds and tanks to be used for bathing cattle and animals. In villages, septic tanks should be made in every house. Rivers and lakes should not be used for bathing or washing as it contaminates water.

5.2.2.7 Some terminologies related with water pollution

Biochemical oxygen demand (BOD)

BOD is the measure of the quantity of oxygen used by microorganisms (e.g., aerobic bacteria) in the oxidation of organic matter. The result is that the oxygen content of the water will be decreased.

Generally, it takes 5 days to perform the BOD test. The BOD5 of natural water is calculated from the dissolved oxygen concentration, which is measured at zero time and after 5 days of incubation at 20 °C. The BOD5 can be calculated as BOD5 = D0 - D1, in which the BOD5 is in mg/L and D0 and D1 are the dissolved oxygen concentration in mg/L at time 0 and 5 days, respectively. The difference is the dissolved oxygen used by the microorganisms in the biochemical oxidation of organic matter.

Typical concentration of BOD5 for streams and rivers throughout the world are 2 to 15 mg/ L and the observed range is 2 to 65 mg/L.

Chemical oxygen demand (COD)

Chemical oxygen demand (COD) is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as Ammonia and nitrite. COD is typically determined by digesting the sample in a strong oxidizing agent under acidic conditions. This is a chemical method usually completed within few hours.

$KMnO_4$ is the oxidizing chemical and used as the oxygen source with concentrated sulphuric acid added to yield a strong acid medium. Silver sulfate is added as a catalyst and to minimize the interference of chloride. Mercuric sulfate is also added to inhibit interferences of metals on the oxidation of organic compounds. The COD observed in natural streams and rivers is 2 mg/L to 100 mg/L.

The advantages of the COD test as compared to the BOD test are:

- COD results are available much faster.

- The COD test oxidizes a wider range of chemical compounds.
- It can be standardized more easily.

COD and BOD do not necessarily measure the same types of oxygen consumption. BOD is only a measure of oxygen consumed by aquatic microorganisms to decompose or oxidize organic matter. COD refers the requirement of dissolved oxygen for the oxidation of both organic and inorganic constituents. Hence COD must be greater than BOD.

5.2.2.8 Waste Water Treatment

Sewage is the liquid wastes from toilets, kitchens, baths etc. that are disposed off through sewer. Sewage contains aerobic and anaerobic bacteria, pathogen, microorganism, chemicals etc. Domestic sewage and industrial wastes should be properly treated before these are drained in the mainstream water.

The main functions of sewage treatment are the following:

- Kill the pathogens
- Eliminate the harmful chemicals
- Remove the colour and bad odour.

Three steps are involved in sewage treatment.

- Primary treatment
- Secondary treatment
- Tertiary treatment

Primary treatment:

It is used to remove suspended and floating wastes from waste water by physical and chemical methods. It involves the following steps.

a) **Screening:** Using bar screens and mesh screens floating, suspended and coarse particles are removed by passing sewage water through it.
b) **Silt and grit removal:** Sand, powdered glass etc. called grit are removed by slowly passing sewage water through grit chambers. Heavier sand and broken glass settles down by gravity.
c) **Removal of oil and grease:** Sewage water is kept in a skimming tank and compressed air is blown. Oil and grease form froath and float on the surface. It is skimmed off.

d) Sedimentation process: In this process, the fine suspended particles which do not settle down by gravity are coagulated by the addition of coagulating agents like alum, $FeSO_4$ etc. Sedimented particles are filtered off.

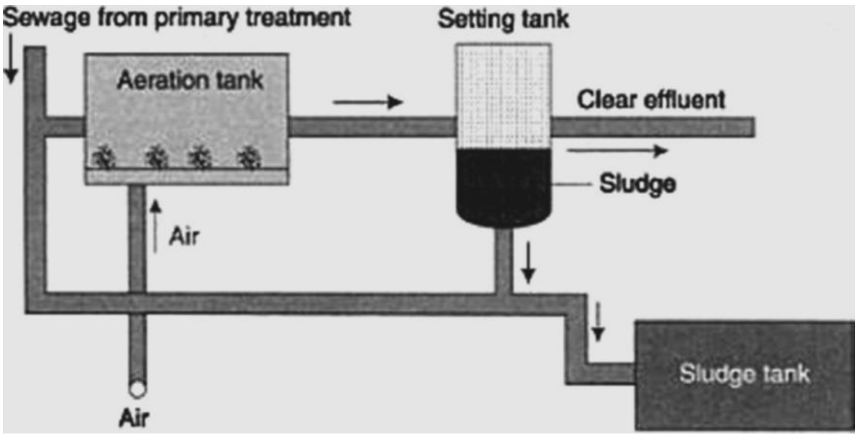
Primary treatment can reduce the BOD of the incoming wastewater by 20–30% and the total suspended solids by some 50–60%.

Secondary treatment (Biological treatment):

Secondary (biological) treatment removes the dissolved organic matter that escapes primary treatment. This is achieved by microbes consuming the organic matter as food and converting it to carbon dioxide, water and energy for their own growth and reproduction. Most commonly employed secondary treatment methods are **activated sludge method** and **tricking filter method**.

a) Activated sludge method:

Activated sludge is biologically active and has a large population of aerobic bacteria which rapidly oxidize the organic matter. Activated sludge is obtained by the aeration of the sewage in the earlier step of the treatment process. Wastewater after sedimentation is mixed with required quantity of activated sludge (containing micro-organisms like algae and aerobic bacteria) in an aeration tank as shown in the figure.

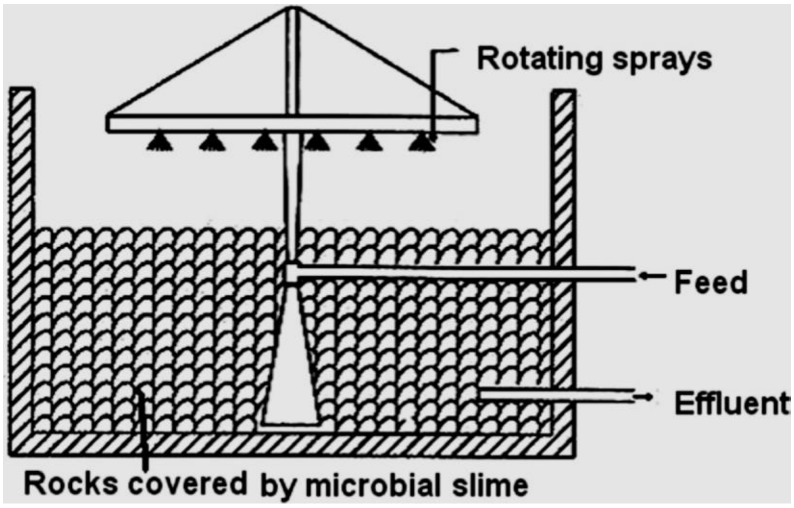


The mixture is aerated by passing air through it for hours. Because of the aerobic conditions the organic matter in the sewage gets fully oxidized.

After aeration, the sewage is finally passed through settling tanks to remove suspended impurities. Purified water plus sludge is sent to the tank where sludge settles down. A part of this sludge is used for the purification of fresh batch of sewage while the rest is pumped into sludge disposal tank. Purified water is pumped out and collected separately.

b) Tricking filter method :

Trickling filter normally consists of a rock bed 1 to 3 meters in depth. The surfaces of these rocks are covered with microbial slime consisting of bacteria, protozoa, molds, algae, insect larvae etc. Sewage is sprinkled on it by means of slow rotating arms. As sewage trickles over, microorganisms present in the sewage grow on the surface of filtering media using the organic material of the sewage as food. On the completion of aerobic oxidation, the treated sewage is taken to the settling tank and sludge is removed. The advantages of this method is the ease of operation and low cost.



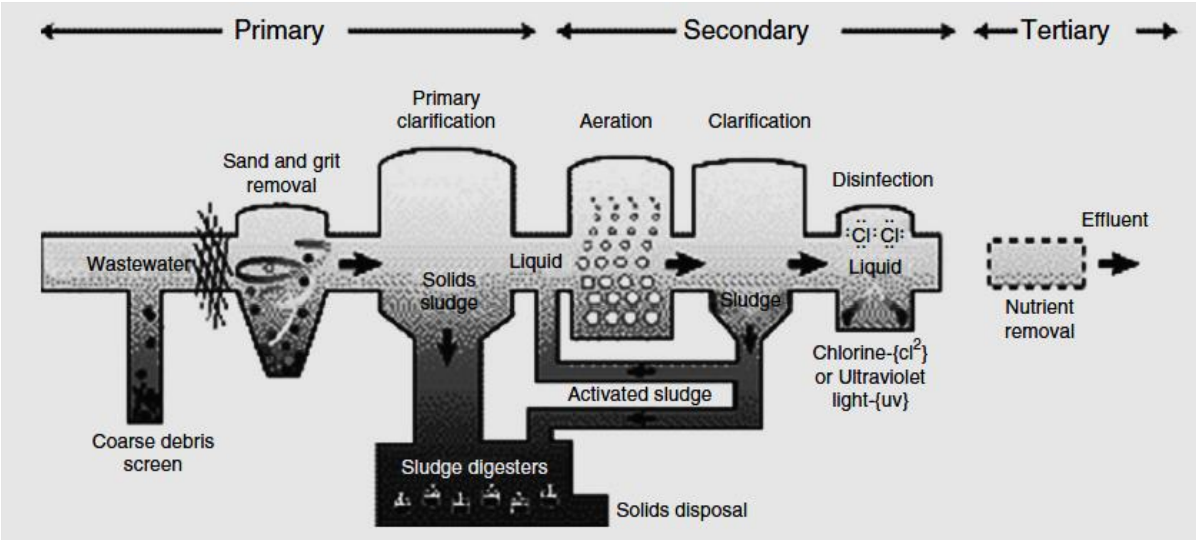
Tertiary treatment:

Both primary and secondary treatments remove most of the organic matter present in the sewage and it lowers the BOD. But this waste water still contain oxygen demanding wastes, nitrates, phosphates and toxic metal salts. These are removed by tertiary treatment.

- **Removal of phosphate:** It is done by adding lime. Phosphates are precipitated as calcium phosphate.

$3Ca(OH)_2 + 2PO_4^{-3} \rightarrow Ca_3(PO_4)_2 + 6OH^-$

- **Coagulation and sedimentation:** Addition of alum or $FeSO_4$ neutralizes the charge on colloidal particles and precipitates them.
- **Filtration:** Water is then passed through bed filled with gravel, coarse sand and fine sand to remove suspended matter.
- **Disinfection:** Harmful bacteria are killed by passing Cl_2 gas, UV or ozone.



5.2.2.9 Water Pollution – Case Studies

Minamata disease

Minamata disease was discovered for the first time at Minamata City, Japan, in 1956.

- **Place:** Minamatha Bay, Japan
- **Date:** In 1950's
- **Company:** Chisso Corporation's chemical factory
- **Chemical responsible: Mercury compounds**. Inorganic mercury salts are used as catalyst for the preparation of acetaldehyde. These compounds were drained into the bay without any treatment for many years. Gradually inorganic mercury were converted into highly toxic organic mercury species- methyl mercury, dimethyl mercury by microorganisms. This was consumed by weeds, small fishes and finally reached man. This was a classic example of biomagnification.

- **Health issues:** Symptoms of Minamata disease include numbness in the limbs, difficulty in moving the hands and legs, a narrow vision, difficulty in hearing, hand and leg tremors and movement disorders of the eyeballs, etc. In severe cases, people could become mad or unconscious, leading to death. Animals were also severely affected. Cats became “mad” and “committed suicide”. Birds fell down from sky dead.

Itai-itai disease

Itai-itai disease (ouch-ouch sickness), was a case of mass cadmium poisoning in Toyama Prefecture, Japan, starting around 1912. Cadmium poisoning caused softening of the bones and kidney failure. This disease made bone fragile and weak, when touched caused severe pain causing the victim to say “Ouch-Ouch” and hence the name. The disease is named for the severe pains caused in the joints and spine. The mining companies were sued for the damage.

5.2.3 Soil Pollution

Soil is a thin covering over the land formed by weathering of rocks. It consists of a mixture of minerals, organic material, living organisms, air and water that together support the growth of plant life. **Soil pollution** is the presence of toxic chemicals (pollutants or contaminants) in soil which can cause health problems to living organisms or ecosystem.

5.2.3.1 Sources of Soil Pollution

The major sources of soil pollution are:

a) **Industrial Wastes:** Many factories like sugar, cement, fertilizer, leather etc. produces large amount of toxic solid wastes which causes severe soil pollution. Thermal power plants generate a large quantity of “Fly ash”. Industrial sludge may contain various salts, toxic metals like mercury, lead, etc.

b) **Urban Wastes:** Wastes likes plastics, glasses, garbage and rubbish materials, rubber etc. from houses can pollute soil. Many of these are non-biodegradable and quite toxic.

c) **Agricultural practices:** Fertilizers, Insecticides, fungicides, pesticides etc. can accumulate in the soil. This can kill the useful microorganisms in the soil and finally enter the near by water bodies.

d) **Radioactive pollutants:** Radioactive fallout from nuclear dust, laboratories may contain highly radioactive materials. Isotopes of radium, uranium, thorium, strontium, iodine, caesium etc. reach the soil and persist there for a long time and keep on emitting radiations.

e) **Biological wastes:** Human and animal wastes (excreta) can contaminate soil. The sewage sludge contains many pathogenic organisms, bacteria, viruses and intestinal worms which cause soil pollution.

5.2.3.2 Effects of soil pollution

a) **Decrease in agricultural productivity:** Many waste materials like plastics, glass etc. are non-biodegradable. Dumping them on land can change the pH of the soil, severely affect the fertility and hence productivity. Many of these substances are toxic for the useful micro organisms present in soil.

b) **Ground water pollution:** Percolation of toxic wastes causes ground water pollution. Chemicals, pesticides, fertilizers from soil may percolate and contaminate ground-water resources.

c) **Spread of diseases:** Pathogens present in the wastes and excreta contaminate the soil. Housefly, mosquito etc. can act as a carrier for these diseases.

d) **Radiation sickness:** Radioactive fallout on vegetation can cause radioisotopes to enter the food chain in the grazing animals. Some of these radioisotopes replace essential elements in the body and cause abnormalities. **Example:** Strontium-90 (instead of calcium) gets deposited in the bones and tissues. The bones become brittle and are prone to fracture.

e) **Salination of soil:** Increase in the concentration of soluble salts in soil is called salination. This adversely affects the quality and productivity of soil. Excessive irrigation cause soil salinity and vegetation loss.

5.2.3.3 Control of soil pollution

a) **Recycling of soild wastes:** Materials like paper, glass and plastics can be recycled and reused. Metals should be recovered from scrap and disposed materials.

b) **Use of eco-friendly agricultural methods:** Use of chemical fertilizers should be reduced. Biofertilizers and manures should be used. Use of pesticides can be reduced by adopting biological control of pests.

c) **Proper disposal of solid wastes:** Solid wastes should be properly collected and disposed off by appropriate method.

d) **Production of bio-manure/bio-gas from soild wastes:** Biodegradable organic waste should be used for generation of biogas. Cattle dung can be used for methane generation. Waste can be used for making compost manure.

5.2.4 Marine pollution

Marine pollution is defined as the discharge of hazardous waste substances (solid or liquid) into sea water causing harm to marine organisms.

5.2.4.1 Causes of marine pollution

a) **Oil spillage:** Most important marine pollutant is oil. Tankers transporting oil cause oil pollution. On the successful delivery of oil through sea-route, empty tankers are filled with water called ballast-water to maintain balance. The ballast-water containing residual oil is released into the sea on completion of return journey. Leakage in oil tankers, oil pipe lines also causes oil spillage. Oil spillage is also caused by refinery operations.

b) **Heavy metals:** Heavy metals like lead, cadmium, mercury etc can reach sea through various rivers, sediments etc.

c) **Pesticides and Insecticides:** Indiscriminate use of fertilizers and pesticides can lead to marine pollution. Finally these chemicals make their way into the ocean.

d) **Other man made pollutants:** Plastics and other synthetic materials are light weight and non biodegradable. Hence cause a serious threat to marine life.

5.2.4.2 Effects of marine pollution

a) **Oil:** Oil, being lighter than water, forms a layer and floats on the surface of water. This affects the exchange of O_2 and CO_2 between atmosphere and sea water. The equilibrium is affected. This in turn affects phytoplankton, zooplankton, algal species, various species of invertebrates, coral reefs, fish, birds, mammals etc. Fishes die because the fish gills get laden with oil. Oil also affects water birds. Oil disrupts the insulating capacity of feathers. Death occurs due to loss of buoyancy and birds drown.

b) **Heavy metals:** Heavy metals like mercury, cadmium, lead etc. cause severe health hazards for aquatic flora and fauna. These metals can magnify over food chain (biomagnification)

c) **Pesticides and other chemicals:** Many of the chemicals are non-bio degradable and stay in water for long time. Many pesticides like DDT can cause biomagnifications.

d) **Plastics:** Many animals like fishes, turtles consume plastic causing gastro-intestinal health problems.

5.2.4.3 Control measures of marine pollution

1) Industrial wastes should not be discharged in coastal waters.
2) Dumping of toxic, hazardous wastes and sewage sludge should be banned.
3) Developmental activities on coastal areas should be minimized.
4) Oil and grease from service stations should be processed for reuse.
5) Oil ballast should not be dumped into sea.
6) Ecologically sensitive coastal areas should be protected by not allowing drilling.

5.2.5 Noise pollution

Noise pollution is excessive, displeasing, unwanted and undesirable sound that disrupts the activity or balance of human or animal life.

Noise is undesirable and unwanted sound. Not all sound is noise. What may be considered as music to one person may be noise to another. Unlike other pollutants noise does not accumulate in the environment.

Sound is measured in a unit called the **'Decibel'**. Ordinary conversation has a noise value of 60 decibels. If loudness exceeds 80 decibels, it can cause noise pollution. Noise becomes troublesome above 140 decibels.

5.2.5.1 Sources of Noise Pollution

a) **Transport/Traffic:** One of the main sources of noise is various modes of transportation (like air, road, rail-transportation). For example, noise caused by taking off and landing of airplanes exceed 110 db.

b) **Industrial activity:** Use of sirens, heavy machines, engines, turbines, cutting, grinding etc. causes significant noise pollution.

c) **Domestic activity:** Use of grinders, food blenders, television, music system can produce unpleasant loud sound disturbing the neighbourhood.

d) **Celebrations:** People celebrate festivals by exploding crackers. Diwali, New year, marriages etc. involve extensive use of firecrackers.

5.2.5.2 Effects of Noise pollution

Noise pollution can cause the following effects.

a) **Hearing damage:** Noise can cause temporary or permanent hearing loss. It depends on intensity and duration of sound level.

b) **Physical and mental balance:** Constant noise affects a man physically and mentally. Physical effects include blood vessels to contract, skin to become pale, muscles to constrict and rise in blood pressure leading to tension, insomnia (sleeplessness) and nervousness. Lack of concentration anxiety, stress and mental fatigue are significant health effects of noise.

c) **Interferes with man's communication:** In a noisy area communication is severely affected. This may increase the rate of accidents especially in industries.

d) **Affects efficiency and productivity:** Noise pollution result in decreased work efficiency and productivity. Sometimes, accidents can also happen.

e) **Health effects:** Loud and sudden noise affects the brain. Loud noise can affect health of pregnant mothers and small infants.

5.2.5.3 Control of Noise Pollution

Following methods can be used to control noise pollution:

1) **Reduce noise at the source:** Sources of noise pollution like heavy vehicles and old vehicles may not be allowed to ply in the populated areas.

2) **Proper maintenance:** Proper oiling will reduce the noise from the machinery and other moving parts.

3) **Use of sound absorbing substances/silencers:** Use of substances that absorb sound or silencer in motor vehicles can reduce the intensity of noise pollution. Proper acoustics of buildings will reduce noise pollution.
4) **Planting trees:** Trees should be planted all around the hospitals, libraries and schools and colleges. These trees can absorb noise.
5) **Personal precaution:** Industrial workers should be provided with ear plugs or cotton plugs. Rooms in hospitals can be made sound proof. People should not cause nuisance to public by playing music, television very loud
6) **Law enforcement:** Strict legislation can minimize noise pollution during various festivals and social functions. Use of loud horns should banned.

5.2.6 Thermal pollution

Thermal pollution is a form of water pollution that refers to degradation of water quality by any process that changes ambient water temperature. It can be defined as presence of waste heat in the water which can cause undesirable changes in the natural environment.

Industries take water from rivers and lakes, use it for cooling purposes and then returns the heated water back to its source. Thermal power plants, nuclear power plants uses water as a coolant. Here, water is heated to produce steam, which is used to drive the turbines that generate electricity. Steam is condensed into water after it leaves the turbines. For this condensation, water is taken from a water body. This heated water, which is at least 15°C higher than the normal is discharged back into the water body.

5.2.6.1 Causes of Thermal Pollution:

a. **Industries:** Heat producing industries like thermal power plants, nuclear power plants, oil refineries, steel mills etc. uses water for various purposes. Waste water, often above ambient temperature is discharged to nearby water body causing thermal pollution.
b. **Nuclear power plants:** Nuclear power plants use water as coolant. After heat exchange water having higher temperature is discharged to water body.
c. **Domestic homes:** Hot water discharged from homes (geyser) and kitchen can also cause thermal pollution.

5.2.6.2 Effects of Thermal pollution

1) **Reduction in amount of dissolved oxygen:** Thermal pollution can lead to decrease in dissolved oxygen content of water. Solubility of oxygen in water is decreased at high temperature. This can severely affect aquatic plants and animals as they depend on dissolved oxygen for photosynthesis.
2) **Death of aquatic organism:** Most of the marine animals are unable to withstand a temperature increase of 4 to 5°C. Sponges, mollusks and crustaceans are killed when temperature reaches above 37°C. This can result in significant changes in the aquatic ecosystem.
3) **Increased toxicity of chemicals at higher temperature:** Toxicity of pesticides, detergents and chemicals in the effluents increases with increase in temperature.
4) **Migration of fishes:** Some of the less tolerant fishes migrate to cooler areas due to thermal pollution.
5) **Change in the ecosystem:** The composition of flora and fauna of the ecosystem will change. The species sensitive to increased temperature are destroyed and are replaced by temperature tolerant species.
6) **Reduced fertility rate in fishes:** The eggs of fish may hatch early or fail to hatch at all causing decrease in population.
7) **Change in metabolic activities:** At higher temperatures, aquatic organisms require more oxygen for metabolic activities.

5.2.6.3 Control of Thermal pollution

The following methods can be employed for control of thermal pollution:

(i) Cooling ponds, (ii) Spray Ponds and (iii) Cooling towers

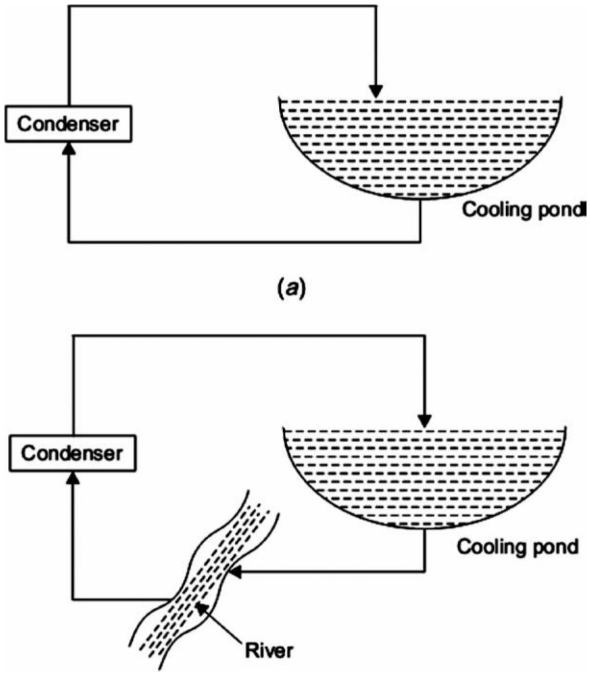
a) **Cooling Ponds:**

Cooling ponds constitute simplest method of controlling thermal pollution. The cooling pond receives hot water from the thermal plant’s condensers and it is stored in ponds. Energy is dissipated mainly through evaporation (natural evaporation cools the water). Once the water has cooled in the pond, it is reused by the plant or discharged in nearby water body. New water is added to the system to replace the water lost through evaporation.

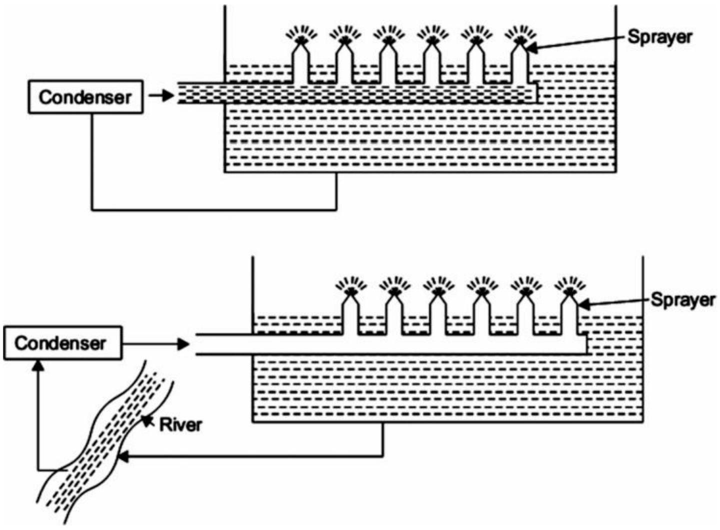
b) **Spray Ponds:** Hot water from condensers is received in spray ponds. Received water is sprayed through nozzles where fine droplets are formed. Excess heat from these fine droplets is dissipated to the atmosphere. Water gets cooled as it comes down. Cooled water is collected and returned to the water body.

c) **Cooling Towers:**

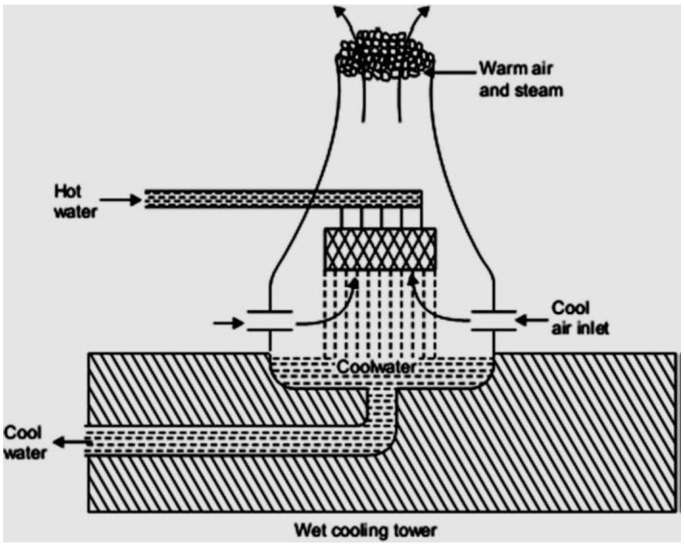
- **Wet cooling tower:** Hot water is sprayed over baffles. Cool air is made to enter from the sides. This takes away the heat and cools the water. Cooled water can be discharged to the water body. One major disadvantage of this method is that large amount of water is lost through evaporation.



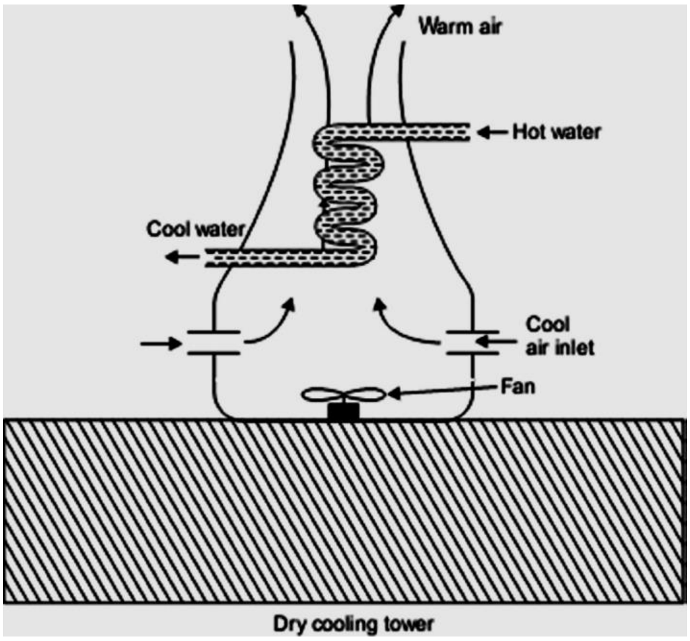
Cooling Pond



Spray Pond



- **Dry cooling tower:** In dry cooling tower, hot water is made to flow through a series of coiled pipes. Cool air is passed over these hot pipes mechanically with the help of fans. Unlike the previous method, there is no significant water loss. However, installation and operation cost makes dry cooling tower much expensive than wet cooling tower.



5.2.7 Nuclear Hazards

Nuclear energy can be both beneficial and harmful depending on the way in which it is used. For example, X-rays are used to examine bones for fractures, cancer is treated with the help of radioactive isotopes. Nuclear power plants are used for production of electricity. However, nuclear energy can be used for the manufacture of nuclear weapons. The radioactive wastes generated from nuclear power plants can cause serious environmental damage.

Nuclear hazards is defined as the physical pollution of air, water or land by radioactive sub-stances emitting harmful radiations which can cause health hazards to living beings.

5.2.7.1 Causes of Nuclear Hazards

a) **Natural causes:** Natural sources of radiation include cosmic rays coming from space, Radioactive Radon-222 present in rocks, Uranium, Thorium and other species present in rocks and minerals.

b) **Anthropogenic causes:** These are some man made radiation sources.

- **Nuclear power plants:** Every nuclear power plant produces few kilogram of highly radioactive wastes. Many of these wastes have long half life period and will continue to emit radiations for many years if not disposed properly.

- **Nuclear accidents:** Accidents happening in a nuclear reactor may lead to the leakage of radioactive materials which can cause serious health concerns. **Example:** Chernobyl reactor meltdown in 1986, Fukushima Daiichi leakage in 2011.
- **Weapons of mass destruction:** Many developed countries have the technology to prepare nuclear weapons. Use of these weapons can pollute environment and can have devastating effects. Eg: Atomic Bomb dropped on Hiroshima and Nagasaki.
- **Laboratories:** X-rays are widely used in hospitals. Radioactive materials are used in cancer therapy and treatment. Leakage of these can cause various problems.

5.2.7.2 Biological Effects of Radiations

1. **Death:** Very high radiation doses are found to be harmful and may kill the organisms which are exposed within minutes.
2. **Mutation:** Radiations can result in genetic damage, which induce mutations in the DNA. Mutations alter the genetic makeup of the organism and may be transmitted to several generations.
3. **Cancer:** Radioactive iodine (I 131) accumulates in thyroid gland and causes thyroid cancer. Radioactive Strontium-90 can replace calcium in the bones and causes leukemia or cancer of bone marrow. Ionizing radiations can also induce various types of cancer.
4. **Somatic damages:** Somatic damage includes burns, miscarriages, eye cataract etc can happen if a person is exposed to radiation beyond permissible limit. Low level exposure can result in temporary decrease in Red blood cell count, Mild radiation sickness etc.

5.2.7.3 Control of Radiation pollution

Nuclear power plants:

Nuclear power plants should be located in a place where density of population is very less.

Proper disposal of wastes, from both laboratories and nuclear power plants, should be done.

Better operator training and better instrumentation is required to avoid nuclear accidents.

Leakage of radioactive elements or radiations from nuclear reactors, laboratories should be checked regularly.

Regular inspection of areas of nuclear activities for radiation level must be done.

Workers in nuclear plants should be given training about nuclear safety. They should be provided with safety measures to safe guard them against accidents.

General awareness:

Public should be made aware about various hazards of nuclear radiation and should be educated about the precautionary measures to be taken, in case of a radioactive fall out.

5.2.7.4 Methods used for disposal of nuclear wastes

- **Deep ocean disposal:** In this method, nuclear wastes are filled in containers made of borosilicate glass. Borosilicate glass prevents leakage of any nuclear radiation. This container is enclosed in another water-tight metal container and dumped into the ocean. These containers will rest in the ocean floor.
- **Deep geological burial:** In this method, radioactive wastes are buried in containers deep underground. These materials will decay naturally over thousands of years.
- **Nuclear waste recycling:** In this method, radioactive wastes are recycled or reused. Wastes containing uranium, plutonium and other fission products are separated using various chemical processes. However, this method is very expensive and can be used only for some nuclear wastes.

5.2.7.5 Nuclear Hazards- Case Studies

As of January 2015, thirty countries worldwide are operating 437 nuclear reactors for electricity generation and 71 new nuclear plants are under construction in 15 countries. Nuclear power plants provided 12.3 percent of the world’s electricity production in 2012. Most of the nuclear hazards known are related to nuclear reactors. Due to human or machine error, nuclear chain reaction goes uncontrolled resulting in core melt down. Radioactive debris is spread all over resulting in massive destruction to life and property.

Hiroshima and Nagasaki incident

Place: Hiroshima and Nagasaki

Date: August 6, 1945 at 8:15 A.M. and August 9, 1945 at 11:02 A.M.

Name of the bomb: Little boy and Fat man. Little Boy was simple uranium 235-based bomb and was untested till Hiroshima. Fat Man, the Nagasaki bomb, was a more complex plutonium bomb.

Reason: Attack of Japan on Pearl harbour.

Hiroshima Bombing: Atomic bomb was dropped on Hiroshima on August 6, 1945 at 8:15 A.M. The energy released was equivalent of 20,000 tons of TNT. Within few seconds half of the city vaporized. According to estimates, 80,000 people were instantly vaporized. Over 1.5 lakhs were injured by radiation. Most of buildings collapsed making people homeless. The city was unbelievably devastated. After the explosion, it rained heavily in northwest of the city. This "black rain" contained dirt, dust, soot and highly radioactive particles. It caused more contamination even in areas that were remote from the explosion.

Nagasaki Bombing: At 11:02 A.M., the atomic bomb, "Fat Man," was dropped over Nagasaki. It was a plutonium based atomic bomb. Half of the population were killed and many sustained severe injuries. City was completely devastated by the bombing. People were clueless about the situation, they ran for help.

The tragedy was not limited to present population. Future generations also suffered from various diseases. Even the babies in the mother's womb were affected. Blindness, deafness, skin diseases and cancers, distortion of bones and other parts became common for many years. For many years high amounts of cancer, birth defects and tumours made life of the victims miserable.

Chernobyl disaster

Place: Chernobyl nuclear power plant, Ukraine

Date: 26 April, 1986

Reason: Faulty operations of shutting down the plant

Incident: On 26 April, 1986 the accident occurred at the reactor of the Chernobyl power plant which was designed to produce 1000 MW electrical energy. The reactor working continuously for 2 years was to be shut down for intermediate repairs. Top executives were busy in the preparations for national holiday, The May Day. Due to improper shutting down operations, an explosion occurred in the reactor at 01:23 hrs on April 26, 1986. It was soon followed by another explosion three seconds later. Graphite rods caught fire. The reactor temperature rose to more than 2000 °C. Fuel and radioactive debris shot as a cloud. The debris and gases drifted over most of the Europe. Belarus, Poland, Denmark, Sweden and Norway were affected.

Hundreds of people died and many were hospitalized. Radioactive cloud was rich in Iodine-131, Cesium-134 and Cesium-137. It was estimated that nearly 6 lakh were exposed to the radiations. People were warned not to consume milk, water and other products. There was huge increase in cancer cases especially, thyroid cancer and leukaemia. Number of cases reported for thyroid cancer in children shot up as they consumed contaminated milk and milk products. Fields could not be cultivated for many years. Trees were destroyed. Now, Chernobyl is free from radiation and is a popular tourist destination.

Fukushima – Daiichi nuclear disaster

Place: Fukushima, Japan

Date: Started on 11 March, 2011

Reason: Tsunami on 11 March, 2011

Incident: Fukushima Daiichi nuclear disaster was a result of series of equipment failures and nuclear meltdowns. Large amount of radioactive materials were released from the Fukushima Nuclear Power Plant, following an earthquake and tsunami on 11 March, 2011. It is the largest nuclear disaster since the Chernobyl disaster of 1986.

The plant had six separate boiling water reactors. Tsunami caused flooding of the rooms containing the emergency generators. These generators stopped working. This resulted in stoppage of water (coolant) circulation in the reactor. Reactors were overheated and reactors 1, 2 and 3 experienced full meltdown in few days. Several chemical explosions occurred. People were evacuated within few mile radii. Large amounts of radioactive materials might have been released into ocean waters. People were advised not to use tap water and certain food materials. On 16 December, 2011, Japanese authorities declared the plant to be stable.

5.3 Role of an Individual in Prevention of Pollution

The role of an individual in maintaining a pollution free, pure and congenial environment and in preserving its resources is actually the need of the hour. Every human being has the responsibility to protect the mother earth. A small effort made by each individual at his own place can have pronounced effect at the global level. It is aptly said, **"Think globally act locally"**.

Individuals can play an important role in abatement of air, water, soil or noise pollution. Some roles are given below.

5.3.1 Air pollution reduction

- Maintenance of vehicles should be proper as to avoid introduction of harmful gases and other pollutants in to the atmosphere.
- Cut down the use of chlorofluorocarbons (CFCs) as they destroy the ozone layer.
- Use CFC free refrigerators.
- Use of less polluting fuels like hydrogen, natural gas instead of coal, petrol etc.
- Use mass transport system. For short-visits use bicycle or go on foot. Decrease the use of automobiles.
- Plant more trees. Trees can act as scavengers for many toxic gases.
- Concentrate more in pollution prevention than pollution control.

5.3.2 Water pollution reduction

- Use pesticides only when absolutely necessary. Overdose of pesticides should be avoided. Use alternate pest control methods (biological control).
- Use phosphate-free detergents. This can minimize eutrophication of water bodies.

- Commercial inorganic fertilizers can be replaced by organic manure.
- Hazardous wastes from industries must be treated before dumping to water bodies.
- Don't wash laundry, vehicles or clean vessels in open water bodies.

5.3.3 Soil pollution reduction

- Biodegradable materials can be converted into compost or manure or for the production of bio-gas.
- Plastics bags, glass bottles etc. can be reused.
- Use of rechargeable batteries will reduce soil metal pollution.
- Promote reuse and recycling wherever possible and reduce the production of solid wastes.

5.3.4 Noise pollution reduction

- Music lovers can use head phones to listen to music systems.
- Minimize the use of loud speakers and other devices which produce noise.
- Proper maintenance of vehicles to prevent making loud noise.
- Planting trees can help in reduction of noise pollution.
- Limit the use of crackers during festival season. See to it that crackers don't produce unbearable noise.
- The use of horn while driving should be minimized.

5.4 Check Your Progress

A. Fill in the blanks

1. CO has affinity for haemoglobin ………. times more than oxygen.
2. Air pollutants affect plants by entering through …………….. .
3. Sound frequency is expressed in …………. .
4. Noise levels considered as threshold of pain are ………….. dB.

5. Blue baby syndrome is caused by the presence of ………. in drinking water.
6. Nutrients nitrate and phosphates cause ……………. in water bodies.
7. ………. disease occurred due to consumption of fish contaminated with methyl mercury.
8. Radioactive strontium affects the bones by depositing in the bones instead of …………
9. The main pollutants emitted by thermal power plants are ………….. and …………. .
10. Excess of fluoride in drinking water causes defects in teeth and bones, a disease called ……….. .

B. Choose the correct option

1. Electrostatic precipitator is used for
   a) Control of water pollution
   c) Control of air pollution
   d) Removal of macro particles.
   e) Removal of precipitate
2. Oil in water affects fish by affecting
   a) Gills
   b) Scales
   c) Eyes
   d) none of these
3. The pollutants released by jet planes are
   a) Aerosols
   b) Colloids
   c) Smog
   d) Dust
4. A disease caused by eating fish contaminated by industrial waste containing mercury compounds

   is known as
   a) Minamata disease
   b) Osteosclerosis
   c) Bright's disease
   d) Hashimoto's disease

5. Green house effect refers to
   a) Ability of atmosphere to retain water vapour
   b) Ability of certain atmospheric gases to trap heat and keep the planet relatively warm
   c) Ability of cloud to scatter electromagnetic radiation
   d) Highly varying temperature fluctuations felt during the winter months
6. Air pollution from automobiles can be controlled by fitting
   a) Wet scrubber
   b) Fabric filter
   c) Catalytic converter
   d) Cyclone separator
7. Itai-Itai disease in Japan was caused by consumption of rice contaminated with
   a) Mercury
   b) Iron
   c) Cadmium
   d) Zinc
8. Thermal pollution can be controlled by
   a) Cooling ponds
   b) Spray ponds
   c) Cooling towers
   d) All of these
9. Which among the following is a greenhouse gas
   a) Nitrous oxide
   b) Oxygen
   c) Sulphur dioxide
   d) Hydrogen
10. Bhopal gas tragedy occurred due to leakage of :
   a) MIC
   b) DDT
   c) SO_2
   d) Dioxins

5.5 Summary

- *Pollutants are the agents that cause undesirable changes in the quality of air, water and soil. Anthropogenic activities are primarily responsible for pollution and environmental degradation. The natures of pollutants largely depend on factors like our life style, occupation, habits, traditions and*
- *awareness etc.*
- *Unmindful use of resources, by-products of industrial processes, waste generation, lack of will on the part of people to treat and manage the effluents and wastes are the contributory factors in polluting the environments. Biodegradable pollutants breakdown easily but nondegradable pollutants when introduced in any component of the ecosystem can cycle through all the environmental components i.e. air, water and soil.*
- *In the ecosystem pollutants affect the humans and other life forms directly or indirectly by causing damage to materials and crops. Persistent pollutants such as heavy metals and persistent organic compound enter the food chain, get biomagnified at the higher levels of food chain and eventually reach the human beings, causing a variety of health problems.*
- *Public awareness of the causes and problems caused by pollution and active involvement of individuals and communities, apart from strict environment law and their strict implementations are essential to control environmental pollution. Use of ecofriendly technologies are highly effective in combating the problem of pollution caused by industry.*

5.6 Keywords

- **Air Pollution:** Air pollution is the introduction into the atmosphere of chemicals, particulates, or biological materials that cause discomfort, disease, or death to humans, damage other living organisms such as food crops, or damage the natural environment or built environment.
- **Biodegradable Pollutants:** Biodegradable pollutants are broken down by the activity of microorganisms and enter into the biogeochemical cycles.
- **Non-Biodegradable pollutants:** Non-biodegradable pollutants are those having stronger chemical bondage, so do not break down into simpler and harmless products.

- **Marine Pollution:** It refers to ocean contamination, especially with man-made waste or byproducts.
- **Noise:** Noise is unwanted sound or sounds of duration, intensity, or other quality that cause some kind of physiological or psychological harm to humans or other living things.
- **Oil Spills:** An oil spill is a release of a liquid petroleum hydrocarbon into the environment due to human activity and is a form of pollution.
- **Ozone:** Ozone is created everywhere in the atmosphere through chemical reactions under the influence of UV-light.
- **Pollution:** The presence in or introduction into the environment of a substance or thing that has harmful or poisonous effects.
- **Smog:** It is a combination of the words smoke and fog.
- **Soil Pollution:** It is defined as the build-up in soils of persistent toxic compounds, chemicals, salts, radioactive materials, or disease causing agents, which have adverse effects on plant growth and animal health.
- **Thermal Pollution:** Thermal pollution can occur when water is used as a coolant near a power or industrial plant and then is returned to the aquatic environment at a higher temperature than it was originally.
- **Water Pollution:** It can be defined as the contamination of the water bodies when pollutants are released into the water without thorough treatment and removal of harmful components. Water pollution is any chemical, physical or biological change in the quality of water that has a harmful effect on any living thing that drinks or uses or lives in it

5.7 Self-Assessment Questions

1. What is meant by environmental pollution and pollutants? Describe the various kinds of pollutions.
2. What is air pollution? List out the main causes and effects of air pollution.
3. What is meant by water pollution? Give some causes and effects of water pollution.
4. Discuss the measure to control water pollution.

5. What is soil pollution? What are its causes and effects? Give your suggestions to control soil pollution.
6. Describe the causes, effects and control measures of marine pollution.
7. Write down the causes, effects and measures to control noise pollution.
8. Describe the causes, effects and control measures of thermal pollution.
9. Describe the causes, effects and control measures of nuclear hazards.
10. Highlight the role of an individual in prevention of pollution.

5.8 Answers to Check Your Progress

A. Fill in the blanks

1. 210 2. Stomata 3. Hertz 4. 140 5. Nitrate 6. Eutrophication 7. Minamata 8. Calcium 9. Fly ash and SO_2 10. Fluorosis

B. Choose the correct option

1. b) 2. a) 3. a) 4. a) 5. b) 6. c) 7. c) 8. d) 9. a) 10. a)

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SOLID WASTE MANAGEMENT AND DISASTER MANAGEMENT

Structure

6.0 Learning Objectives

6.1 Types of Solid Wastes

6.2 Solid Waste Management

6.3 Minimising the Waste Production

6.4 Disaster Management: Floods, Earthquakes, Cyclones, Landslides

6.5 Check Your Progress

6.6 Summary

6.7 Keywords

6.8 Self-Assessment Test

6.9 Answers to check your progress

6.10 References/ Suggested Readings

6.0 Learning Objectives

After studying this unit, you should be able to :

- *explain solid waste types and their management*
- *describe the causes, effects and control measures of urban and industrial wastes*
- *explain the causes, effects and management of flood, cyclone, drought*
- *explain the causes, effects and management of earthquake and landslides*

6.1 Types of Solid Wastes

The combined effects of population explosion and changing modern living standards have had a cumulative effect in the generation of a large amount of various types of wastes. Solid waste can be classified into different types depending on their source.

- Municipal solid waste (MSW)
- Industrial waste
- Hazardous waste
- Biomedical or hospital waste: as infectious waste.
- Agricultural waste

6.1.1 Municipal Solid Waste (MSW)

The term municipal solid waste (MSW) is generally used to describe most of the non-hazardous solid waste from a city, town or village that requires routine collection and transport to a processing or disposal site. Sources of MSW include private homes, commercial establishments and institutions, as well as industrial facilities. However, MSW does not include wastes from industrial processes, construction and demolition debris, sewage sludge, mining waste or agricultural wastes. MSW is also called as trash or garbage. In general, domestic waste and MSW are used as synonyms.

Municipal solid waste contains a wide variety of materials. It can contain food waste (like vegetable and meat material, leftover food, eggshells etc.), which is classified as wet garbage as well as paper, plastic, tetrapak, plastic cans, newspaper, glass bottles, cardboard boxes, aluminium foil, metal items, wood pieces, etc., which is classified as dry garbage. The different types of domestic wastes generated and the time taken for them to degenerate is illustrated in the table given below.

Common domestic wastes	Approximate time taken for degeneration
Organic kitchen waste vegetables, fruits	1—2 weeks
Paper, cardboard paper	15 days—1 month
Cotton clothes	2—5 months
Woolen clothes	about a year
Metal cans, tin, aluminum	100—500 years
Plastics	1 million years

Domestic wastes and their degeneration time

India's urban population slated to increase from the current 330 million to about 600 million by 2030, the challenge of managing municipal solid waste (MSW) in an environmentally and economically sustainable manner is bound to assume gigantic proportions. The country has over 5,000 cities and towns, which generate about 40 million tonnes of MSW per year today. Going by estimates of The Energy Research Institute (TERI), this could well touch 260 million tonnes per year by 2047.

The functional elements of MSW management

The municipal solid waste industry has four components: recycling, composting, landfilling and waste-to-energy via incineration. The primary steps are generation, collection, sorting and separation, transfer and disposal/utilisation.

Waste generation encompasses activities in which materials are identified as no longer being of value and are either thrown out or gathered together for disposal.

The functional element of **Collection** includes not only the gathering of solid waste and recyclable materials, but also the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be a materials processing facility, a transfer station or a landfill disposal site.

Waste handling and separation involves activities associated with waste management until the waste is placed in storage containers for collection. Handling also encompasses the movement of loaded containers to the point of collection. Separating different types of waste components is an important step in the handling and storage of solid waste at the source. The types of means and facilities that are now used for the recovery of waste materials that have been separated at the source include curbside collection, drop off and buy back centres.

Transfer and transport involves two main steps. First, the waste is transferred from a smaller collection vehicle to larger transport equipment. The waste is then transported, usually over long distances, to a processing or disposal site. Today the disposal of wastes by land filling or land spreading is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from materials recovery facilities (MRFs), residue from the combustion of solid waste, compost or other substances from various solid waste processing facilities. A modern sanitary landfill is not a dump; it is an engineered facility used for disposing of solid wastes on land without creating nuisances or hazards to public health or safety, such as the breeding of insects and the contamination of ground water.

Municipal solid waste can be used to **generate energy**. Several technologies have been developed that make the processing of MSW for energy generation cleaner and more economical than ever before, including landfill gas capture, combustion, pyrolysis, gasification and plasma arc gasification. While older waste incineration plants emitted high levels of pollutants, recent regulatory changes and new technologies have significantly reduced this concern. In USA, Environmental Protection Agency (EPA) regulations in 1995 and 2000 under the Clean Air Act have succeeded in reducing emissions of dioxins from waste-to-energy facilities by more than 99 percent below 1990 levels, while mercury emissions have been by over 90 percent The EPA noted these improvements in 2003, citing waste-to-energy as a power source “with less environmental impact than almost any other source of electricity”.

Municipal solid waste management is more of an administrative and institutional mechanism failure problem rather than a technological one. Until now, MSW management has been considered to be almost the sole responsibility of urban governments, without the participation of citizens and other stakeholders. The Centre and the Supreme Court, however, have urged that this issue be addressed with multiple stakeholder participation. Cities in India spend approximately 20% of the city budget on solid waste services.

6.1.2 Hazardous Wastes

Hazardous wastes are those that can cause harm to human and the environment. Wastes are classified as hazardous if they exhibit any of four primary characteristics based on physical or chemical properties of toxicity, reactivity, ignitability and corrosivity.

Types of Hazardous wastes:

- **Toxic wastes**

  Toxic wastes are those that are poisonous in small or trace amounts. Some may have acute or immediate effect on human or animals. They me be carcinogenic or mutagenic, so causing biological changes in the children of exposed people and animals. Example: pesticides and heavy metals.

- **Reactive wastes**

  Reactive wastes are those that have a tendency to react vigorously with air or water and therefore they are unstable to shock or heat, generate toxic gases or explode during routine management. Example: Gun powder and nitro-glycerine.

- **Ignitable waste**

  These are the wastes that burn at relatively low temperatures (<6 ^{o}C) and are capable of spontaneous combustion during storage, transport or disposal. Example: Gasoline, paint thinners and alcohol.

- **Corrosive wastes**

  These are those that destroy materials and living tissues by chemical reactions. Example: acids and bases.

- **Infectious wastes**

  These includes human tissue from surgery, used bandages and hypoderm needles from hospital wastes.

Sources of Hazardous Wastes

Chemical manufacturing companies, petroleum refineries, paper mills, smelters and other industries. plastic industries. Thousands of chemicals are used in industries, when used incorrectly or inappropriately they can cause health hazards. PCBs (Polychlorinated biphenyls) are resistant to fire and do not conduct electricity very well, which makes them excellent materials for several industrial purposes. Rainwater can wash PCBs out of disposal areas in dumps and landfills thus contaminating the water. PCBs do not break open very rapidly in the environment and thus retain their toxic characteristics. They cause long-term exposure problems to both human and wildlife.

Many household chemicals like solvents and products used in automotive care can be quite toxic to humans as well as wildlife. When these products are used incorrectly they have the potential to be harmful.

Effects of Hazardous Wastes

As most of the hazardous wastes are disposed on or in land, the most serious environmental effect is contaminated ground water. Once ground water is polluted with hazardous wastes, it is very often not possible to reverse the damage. Pesticides form residues in the soil that are washed into streams which then carry them forward. The residues may persist in PCBs (poly chlorinated biphenyls) and when they are concentrated in the kidneys and liver, they cause damage, they also cause reproductive failure in birds and mammals. Exposure can occur through ingestion, inhalation and skin contact, resulting in acute or chronic poisoning. Lead, mercury and arsenic are hazardous substances which are often referred as heavy metals. Most of the lead absorbed by people is stored in the bones. Lead can affect red blood cells by reducing their ability to carry oxygen and shortening their life span. Lead may also damage nervous tissue, resulting in brain disease. Mercury is used in production of chlorine and as a catalyst in the production of some plastics. Mercury build up in body over long period of time is known to cause brain damage. Minamata disease occur due to mercury poisoning. Vinyl chloride is a chemical that is widely used in plastic manufacture. A continuous exposure of it in humans can cause deafness, vision problem, circulation disorders and bone deformities.

Control of Hazardous Wastes

Common methods for disposing of hazardous wastes are land disposal and incineration Industries need to be encouraged to generate less hazardous waste in the manufacturing process. Although toxic wastes cannot be entirely eliminated, technologies are available for minimizing recycling and treating the wastes. Integrated pest management practices (IPM) reduce the usage of pesticides. Substitute the use of PCBs and vinyl chloride with chemicals that are less toxic. Polyvinyl chloride use can be lowered by reducing the use of plastics.

6.1.3 Industrial Wastes

These contain more of toxic substances and require special treatment. Food processing industries, metallurgical, chemical and pharmaceutical units, breweries, sugar mills, paper and pulp industries, fertilizer and pesticide industries are major ones which discharges toxic wastes.

Effects of Industrial Wastes

Most common observation is that the health of the people living in the neighbourhood of dumping sites is severely affected. The exposure may cause disorders of nervous system, genetic defects, skin diseases and even caner. The liquid effluents discharged by the industries contain inorganic and organic pollutants and they enter into water bodies causing destruction of fish, formation of sediments, and pollution of ground water and release of foul odours.

Control of Industrial Wastes

Waste minimization technologies have to be developed. Source reduction, recycling and reuse of materials need to be practiced on a large scale. Hazardous waste should not mix up with general waste. Source reduction involves altering the design, manufacture or use of products & materials to reduce the amount and toxicity of materials that get thrown away. Local communities and voluntary organizations should educate the industrialists as well as the public about dangers of pollution and the need to keep the environment clean. Land filling, incineration and composting technologies need to be followed.

6.2 Solid Waste Management

Steps involved in solid waste management are: a) Collection b) Transportation c) Storage d) Segregation e) Processing f) Disposal

a) **Collection:** Waste from our homes is generally collected by our local authorities through regular waste collection for recycling.

b) Transportation: Wastes are carried from homes to storage centre. Vehicles used for transportation of wastes shall be covered. Waste should not be left open and scattering should be prevented.

c) Storage: Collected waste materials are stored properly. It should not create unhygienic and insanitary conditions around it. Wastes stored are not exposed to open atmosphere. Bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be printed white and those for storage of other wastes shall be printed black.

d) Segregation: Collected solid wastes are separated. Some wastes are recycled. Recycling is the reprocessing of discarded materials into new useful products. Recycling occurs in three phases: a) sorting of wastes and collecting recyclables, b) creation of raw materials from recyclables, c) production of new products from raw materials. The process recycling saves money, energy and also reduces pollution. Recycling of paper will reduce cutting of trees for making fresh paper.

e) Processing: Treatment methods are selected based on the composition, quantity and form of the waste material. Treatment and disposal options are chosen according to the nature of waste.

Following are methods of solid waste management:

Incineration: Incineration is the most common thermal treatment process. This method is often used when waste contain hazardous material and organic content. It is the combustion of waste in the presence of oxygen. After incineration, the wastes are converted to carbon dioxide, water vapour and ash. Incineration significantly reduces the volume of the waste, rendering it harmless and reducing transportation costs. During incineration high levels of toxic dioxins, furans, lead and cadmium may be emitted.

- **Advantages:**
  - It requires minimum land
  - It can be operated in any weather
  - The volume of wastes are reduced to about 25%
- **Disadvantages:**
  - It is expensive to build and operate
  - High energy requirement.

- Cause significant air pollution due to burning of wastes. Foul smell is also produced.

Pyrolysis and Gasification: Pyrolysis and gasification are similar processes which decompose organic waste by heating it to high temperatures. Gasification uses a low oxygen environment while pyrolysis allows no oxygen.

Composting: Composting is the controlled aerobic decomposition of organic matter by the action of micro organisms and small invertebrates. Separated compostable wastes are dumped into earthen trenches and then covered with earth. Organic matter such as dead and dry leaves and twigs are decomposed by worms and insects and is finally broken down by bacteria and fungi, to form a dark rich soil-like material called **compost**. This soil can be used as a manure for farms and gardens. Most widely used composting is vermicomposting-using earthworms.

Sanitary landfill: Sanitary Landfills are designed to greatly reduce or eliminate the risks that waste disposal may pose to the public health and environmental quality. In a sanitary landfill, garbage is spread out in thin layers. It is then covered with mud or clayor plastic and then compacted. Next layer of wastes is spread on top of this, followed by another layer of soil. Suitable precautions are taken so that underground water is not contaminated. When landfill is full it is covered with clay, sand, gravel and top soil to prevent seepage of water.

- **Landfill Advantages**
  - Segregation not required.
  - Simple and economical.
  - When a landfill is complete, it can be reclaimed, built on or used as parks or farming land.
- **Landfill Disadvantages**
  - Landfill can pollute the water, the air and also the soil.
  - Landfill can result in decrease in soil fertility.
  - Improperly constructed landfill can pollute underground water.
  - Landfill can attract animals and insects like rats, mosquitoes, cockroaches etc.
  - Landfill can also cause sicknesses in communities.
  - Anaerobic decomposition produces methane, a dangerous greenhouse gas.

6.3 Minimising the Waste Production

Waste production can be minimized by adopting the 3 R's principle: **Reduce, Reuse, Recycle.** Reduce the amount and toxicity of garbage and trash that you discard. Reuse containers and try to repair things that are broken. Recycle products wherever possible, which includes buying recycled products i.e. recycled paper books, paper bags etc. These are processes that involve integrated waste management practices (IWM). They can reduce the wastes generated by approximately 50 %.

Reduce (Waste prevention)

Waste prevention, or source reduction, means consuming and discarding less, is a successful method of reducing waste generation. Backyard composting, double sided copying of papers, purchasing durable, long- lasting environmentally friendly goods (products and packaging that are free of toxics), redesigning products to use less raw material for production and transport packaging reduction by industries are the normal practices used and have yielded substantial environmental benefits. Source reduction prevents emissions of many greenhouse gases, reduces pollutants, saves energy, conserve resources and reduces wastes for new landfills and combustors. It reduces the generation of waste and is generally preferred method of waste management that goes a long way toward saving the environment.

Reuse

Re-use is the process, which involves reusing items by repairing them, donating them to charity and community groups, or selling them. Reusing products is an alternative to recycling because the item does not need to be reprocessed for its use again. Using durable glassware, steel, using cloth napkins or towels, reusing bottles, reusing boxes, purchasing refillable pens and pencils are suggested.

Recycling

The process of recycling, including composting, has diverted several million tons of material away from disposal. Recycled materials include batteries-recycled at a rate of 93%, paper and paperboard at 48% and yard trimmings at 56%. These materials and others may be recycled through drop off centres, buy-back programs and deposit systems. Recycling prevents the emission of many greenhouse gases that affect global climate, water pollutants, saves energy, supplies valuable raw materials to industry, creates jobs, stimulates the development of greener technologies, conserves resources for our children's future and reduces the need for new landfills and combustors. For example, by recycling of solid waste in 1996, the United States prevented the release of 33 million tons of carbon into the air roughly the amount emitted annually by 25 million cars. Recycling can create valuable resources and it generates a host of environmental, financial and social benefits. Materials like glass, metal, plastics and paper are collected, separated and sent to processing centres where they are processed into new products. The advantages of recycling are it conserves resources for future generation, prevents emissions of greenhouse gases and pollutants, saves energy, supplies valuable raw materials to industries, stimulates the development of greener technologies, reduces the need for new landfills and incinerators.

6.4 Disaster Management: Floods, Earthquakes, Cyclones, Landslides

The Indian sub-continent is highly prone to natural disasters. Floods, droughts, cyclones and earthquakes are recurrent phenomena in India. Susceptibility to disasters is compounded by frequent occurrences of man-made disasters such as fire. The changing topography (topo = land) due to environmental degradation also increasing vulnerability to natural disasters. In 1988, 11.2%of total land area was flood prone, but in 1998 floods inundated 37% geographical area. Four major disasters that India has experienced in the recent past are the earthquake in Latur (Maharashtra in 1993), super cyclone in Orissa (1999), the earthquake in Gujarat (2001) and Tsunami in Tamilnadu and Andhra Pradesh in December 2004. Frequent disasters lead to enormous loss of life and property. Physical safety-especially that of the vulnerable groups is routinely threatened by hazards. Natural disasters cannot be prevented but their damaging impact can be reduced through better forecast and preparedness to take up effective rescue measures. The four major disasters mentioned above have very clearly illustrated that we need multi-hazard prevention, response and recovery plans for natural hazards so that threat to human life and property is minimized. Disaster risk management is essentially a development problem. Preparedness and planning for disaster management have to be taken up along with environmental concerns that the country is facing today.

6.4.1 Floods

Floods are sudden and temporary inundation of a large area as an overflowing of rivers or reservoirs.

Causes

Floods are caused by rains, high winds, cyclones, tsunami, melting snow or dam burst. Flood can happen gradually or can happen suddenly due to heavy rains, breach of the water storage and control structures, spillover. Siltation of the rivers and reservoirs and this can enhance the incidence and magnitude of floods.

Effects

- **Casualties**: Human and livestock death due to drowning, serious injuries and outbreak of epidemics like diarrhea, cholera, jaundice or viral infections are common problems faced in flood affected areas. Even wells, other source of drinking water get submerged resulting in acute shortage of safe drinking water during floods. Consequently often people are forced to drink the contaminated floodwater, which may cause serious diseases.
- **Structural damage:** During floods mud huts and buildings built on weak foundations collapse endangering human lives and property. Damage may also be cause to roads, rail, dams, monuments, crops and cattle. Floods may uproot trees and may cause landslides and soil erosion.
- **Material loss:** Household articles including eatables, electronic goods, beds, clothes, furniture get submerged in water and get spoilt all materials mounted on ground e.g. food stock, equipment, vehicles, livestock, machinery, salt pan and fishing boats can be submerged and spoilt.
- **Utilities damage:** Utilities such as water supply, sewerage, communication lines, power-lines, transportation network and railways are put at risk.
- **Crop loss**: Apart from the loss of human and cattle life, floods cause severe devastation of standing agricultural **crops**. Floods water spoils the stored food-grains or harvested crop. Floods may affect soil characteristics and may turn them infertile due to the erosion of the top soil or in coastal areas agricultural lands may turn saline due to flooding by sea water.

Flood control

Flood control can be achieved through various means. The floodwater can be reduced by reducing the run-off water through afforestation. Forests promote rainwater percolation in the ground, thus recharging the groundwater and reducing the run-off water. Construction of dams also reduces flood water through storage. Dams can store water, which cannot be accommodated in the river downstream may cause floods. Water can be released in a controlled manner from the dam. Desilting, deepening and increasing embankment increase the capacity of a river/channel/drain.

Management

The flood damage can be considerable reduced and loss of human lives can prevented through proper planning of flood control and management measures.

- **Identification of flood prone areas:** A rational planning for flood management involves identification the flood prone areas and frequency and magnitude of flooding in these areas.
- **Flood forecasting:** Normally there is a reasonable timely warning by alerting people and moving them to safer area well in time. Measurement of intensity of rainfall in the catchment area provide sufficient clue to hydrology engineers to calculate the possible submergence area along a river well before the flooding occurs. Accordingly expected run-off volume people can be warned to evacuate the likely areas to be flooded and advise to go to safer places along with their belongings including livestock. In India has a large network of rain measuring stations, flood warnings are issued by the Central Water Commission (CWC), Irrigation and Flood Control Department and Water Resources Department.
- **Land use planning:** Land use planning is very important for all the developmental activities. No major development should be permitted in flood prone areas. If construction is unavoidable it should be able to withstand the flood forces. Buildings should be constructed on elevated areas. Afforestation should be encouraged. Deforestation in the catchments areas should be discouraged because deforestation results in excessive run off water and causes soil erosion, which is the main cause of river siltation resulting in floods. Any construction, which causes obstruction in drainage flow, should not be permitted.

Encroachment of the storm water drains should not be allowed. This reduces the risk of floods.

- **Some precautionary measures are as follows** –
  - Build houses away from flood prone area.
  - Keep yourself alert and updated to weather and flood forecasting information. • In case evacuation warnings are issued, immediately go to the shelters provided.
  - When you are moving to a shelter, move your valuable articles to safer elevated places so that they are not destroyed by flood water.
  - Store extra food, such as rice, pulses etc. for emergency.
  - Do not touch any loose electric wire to avoid electrocution.
  - Do not spread rumours or listen to them.
  - Make provision for adults and children who need special diet.
  - After the flood is over, get yourself and your family members inoculated against diseases and seek medical care for injured and sick.
  - Clear the house and dwellings of debris.
  - Report any loss to the revenue authorities.

6.4.2 Drought

Drought is an event that results from lower than normal expected rainfall over a season or period. The low rainfall is insufficient to meet the needs of human beings, plants, animals and agriculture. Short fall in rain results in drying of rivers, lakes, reservoirs and drying of wells due to excessive withdrawal and poor recharge of ground water and loss of crop yield due to shortage of water are some of the main indicators of drought.

Causes

Drought occurs due to shortage of rainfall. As per Meteorological Department if rainfall is deficient by more than 10% of the annual average rainfall, the condition is said to be that of drought. The severity of drought is determined by the extent of deviation of rainfall from the average. In the recent past frequency of periods of drought have increasing due to deforestation and environmental degradation.

Effects

- Drought has severe effects on agriculture. To start with drought affects mostly rainfed crops and subsequently the irrigated crops. The herdsman, landless labours, subsistence farmers, women, children and farm animals are most affected.
- Crop failure or food shortage leading to large scale starvation and death.
- Affects dairy activities, timber and fisheries.
- Increases unemployment.
- Depletion of ground water.
- Increases energy consumption for pumping water from deep aquifers.
- Reduces energy production in hydro-electric power plants.
- Loss of biodiversity; and reduced landscape quality.
- Causes health problems, increased poverty, reduced quality of life and social unrest leading to migration.

Management

The adverse effects of drought can be minimised if some measures are taken. A regular monitoring of rainfall, water availability in reservoirs, lakes and rivers as well as it's comparison with the demand. When water availability decreases than demand, water consumption need to be reduced by adopting various water conservation measures. These include economizing water consumption, by increasing water use efficiency, reducing wastage, reusing the wastewater for inferior uses. Use of efficient methods of irrigation and sowing low water-consuming crops are some important measures to overcome drought. Rain water harvesting increases water availability. Water harvesting is done by either allowing the run-off water from all the catchment areas to a common point and storing it in a reservoir or allowing it to percolate into the ground so far recharging groundwater.

6.4.3 Earthquake

Earthquake is a sudden release of energy accumulated in deformed rocks of earth crust causing the ground to tremble or shake. Earthquake can occur suddenly any time of the year without any warning causing severe loss of life and property. We are aware of the severe damage caused by earthquakes of Latur (1993) and Bhuj (2002).

The intensity of an earthquake is related to the amount of energy released when rocks give way to the forces within the earth. It is measured with the help of an instrument known as seismograph. The intensity is measured on Richter scale (after inventor C.F. Richter). Following values indicate degree of damage.

Intensity on Richter Scale	Extent of damage
upto 3	No damage
3-5	Cracks in old building
5-7	Cracks in roads
Above 8	Collapsing of Buildings

Causes

Earthquakes are natural ways of releasing energy by earth. An earthquake occurs in certain pockets of the earth which has geological faults. Such areas have already been identified.

Effects

Structural damage: Earthquakes may cause physical damage to the buildings, roads, dams and monuments. High rise buildings or building built on weak foundations are especially susceptible to earthquake damage. Household articles including electronic goods and furniture get damaged. Human and livestock deaths or serious injuries from collapsing of building are common followed by outbreak of epidemics like cholera, diarrhoea and infectious diseases. Utilities such as water supply, sewerage, communication lines, power-lines, transportation network and railways get damaged.

Management

The effects can be minimized if some of the following measures are taken:-

- Design of buildings: The buildings should be designed, especially in earthquake prone areas, in such a manner that they can withstand the stress of earthquake. Physical characteristics of soil should be analysed in order to ensure the strength to withstand the earthquake. Bureau of Indian Standards has formulated building designs and guidelines for constructions that withstand against earthquakes. Generally building design is approved by the concerned municipal authorities according to build by laws and safety requirements.

Training of the builders, architects, contractors, designers, house owners and government officials is important.

- Move out in the open;
- Keep calm, do not rush and panic, never use lift, keep away from windows, mirrors and furniture;
- Stand under strong beams that may not fall or creep under the dining table or a strong bed;
- If you are under a building and unable to move, cover your head and body with your arms, pillows, blankets to protect yourself from falling objects;
- If in a multistorey building, stay on the same floor. Do not use elevators or run towards the staircase;
- If travelling stop the vehicle away from building, walls, bridge, trees, electricity poles and wires;
- Check for structural damage and clear the blockage;
- Check for injuries. Apply first aid. Help others;
- If your home is badly damaged by earthquake, come out immediately. Collect all emergency supplies like food, water, first aid kit, medicines, flash light or torch, candles, matchbox, clothes etc. if possible;
- Keep away from buildings especially old and tall ones, electricity poles, wires and walls.

6.4.4 Cyclone

Cyclones are violent storms, often of vast extent, characterised by strong and high winds rotating about a calm center of low atmospheric pressure. This center moves onwards, often with velocity of around 50 km/h. Cyclones strike suddenly though it takes time for them to build up. Cyclone is generally followed by heavy rains causing floods. Satellite tracking can predict on possible affected areas and inhabitants fore-warned can be made for warning. Warning and evacuation is done along the projected path.

Causes

Cyclones are born in the hot, humid late-summer environment of the tropics as the sun warms the oceans, evaporation and conduction transfer heat to the atmosphere so rapidly that air and water temperatures seldom differ by more than 1 °F. The water vapour generated by such evaporation is the fuel that drives a tropical storm, because as the vapour condenses into clouds and precipitation it pumps enormous amounts of heat into the cyclone. The fuel supply is controlled by the evaporation rate—which explains why cyclones cannot develop when the ocean temperature is below about 24 °C. To develop and mature into a tropical storm, storm seedlings must overcome many obstacles. In fact only about nine of the more than 1000 seedlings tracked each year in the Atlantic will evolve into gale-force tropical storms or full-fledged cyclones the sole difference between harmless thunderstorms and a dangerous cyclone is the rotation that organizes weather systems. This spin, which meteorologists call vorticity, is ever-present in temperate latitudes, where the Coriolis Effect of the earth’s rotation is pronounced. But in the tropics the weak Coriolis Effect must be augmented by the wind itself. (The Coriolis Effect is the force caused by the earth’s rotation that deflects a moving body to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.)

When two wind currents move side by side, the faster current tends to curl around the slower one. If the faster current is on the right (viewed from upwind), the curl is to the left, yielding positive vorticity in the Northern Hemisphere because it adds to the counter clockwise Coriolis Effect; a right-hand curl creates negative vorticity. A curving wind also possesses vorticity—positive for a left-hand turn, negative for a right turn. When positive vorticity becomes strong enough to spin a storm seedling, it starts a chain reaction. The thunderstorms, not revitalized by a steady influx of warm, moist air, organize around a deepening low-pressure centre, called a tropical depression. This dramatically increases the likelihood of cyclone formation; fully 70 percent of these depressions develop into cyclones.

Tropical cyclones are known around the world by various names: hurricanes in the Atlantic and Caribbean, typhoons in the West Pacific, baguios in the Philippines, cordonazos in Mexico, Taino in Haiti. A tropical cyclone is essentially a rotating storm in the tropical oceans. It is conventionally defined as a circular storm with rotating wind speeds in excess of 64 knots (32 meters per second). The life span of a tropical cyclone is, on average, about six to nine days until it enters land or recurves into temperate latitudes, but this may vary from a few hours to as much as three to four weeks. Tropical cyclones form in the oceans between 5 to 30 degrees north and south of the equator. They are found in all oceans of the world, with the probable exception of the South Atlantic and the South Pacific east of 140^{o} W longitudes. No two tropical cyclones follow the same track; some recurve, some do not; some loop; some slow to a standstill and some will accelerate. The movement of a tropical cyclone is generally 12 knots or less. It is important to be aware of the regional names so that, for example, what is described as a severe cyclone in the Bay of Bengal will be understood as essentially the same phenomenon as that which is called a hurricane when it occurs in the north Atlantic.

Effects

Light weight structures built of mud, wood, old buildings with weak walls and structure without proper anchorage to the foundation are at risk. The settlements located in low lying areas of coastal regions are directly vulnerable. Settlements in adjacent areas are vulnerable to floods, mudslide or landslide due to heavy rain. Telephone and electricity poles and wires, fences, light building structures such as thatched, tin sheds roofs, signboards, hoardings, fishing boats and trees are most vulnerable to cyclone damages. Due to heavy rains people and their property might be washed away in floods or blown away by cyclone itself. The cyclone along in the coastal areas may cause sea waves to enter on land and flood it. This may cause saline water contamination of soil and water in the affected area, affecting water supply and severely affecting agricultural crops.

Management

It is important to identify the cyclone prone areas. No development should be permitted in cyclone prone areas. The building should be designed to withstand forces of wind and floods. All the elements holding the structures need to be properly anchored to resist the uplift. Coastal green belt has been found very effective in minimizing the effects of cyclones. Such green belts (trees growing along the coast) need to be developed along the coasts.

6.4.5 Landslides

Landslides are recurring phenomena in Himalayan region. It is a geological process which includes a wide range of mass movements, such as rock falls, deep failure of slopes and shallow debris flows. Although gravity acting on an over steepened slope is the primary reason for a landslide, there are other contributing factors affecting the original slope stability erosion by rivers, glaciers, or ocean waves create over steepened slopes. In recent years, however, intensive construction activity and the destabilizing forces of nature have aggravated the problem.

Landslides occur as a result of changes on the slope, sudden or gradual either in its composition, structure, hydrology or vegetation. The changes can be due to geology, climate, weathering, changing land use and earthquakes.

- Rock and soil slopes are weakened through saturation by snowmelt or heavy rains, earthquakes create stresses that make weak slopes fall.
- Volcanic eruptions produce loose ash deposits, heavy rain and debris flows.
- Vibrations from traffic, machinery, thunder and blasting can trigger weak slopes.
- Groundwater pressure acting to destabilize the slope.
- Excess weight from accumulation of rain or snow, stockpiling of rock or ore, from waste piles, or from man- made structures may stress weak slopes to fall.

A significant reduction in the hazards caused by landslides can be achieved by preventing the exposure of population and facilities to landslides and by physically controlling the landslides. Developmental programs that involve modification of the topography, exploitation of natural resources and change in the balance load on the ground should not be permitted. Some critical measures that could be undertaken to prevent further landslides are drainage measures, erosion control measures such a bamboo check dams, terracing, jute and coir netting and rockfall control measures such as grass plantation, vegetated dry masonry wall, retaining wall and most importantly preventing deforestation and improving afforestation.

Disasters cannot be totally prevented. However early warning systems, careful planning and preparedness on part of the vulnerable community would help in minimizing the loss of life and property due to these disasters.

6.5 Check Your Progress

A. Fill in the blanks

1) A compound which induces genetic changes on consumption is said to be ....if it causes formation of galls or morphological abnormalities it is known as .... and if it causes cancer, it is said to be ....
2) Transfer of waste “as is” without reprocessing, to another facility is known as waste .... When a transfer “as is” is not possible and it needs reprocessing for material recovery before it can be used in factory, then it is known as waste ....

3) Selection of a waste treatment process depends on many factors such as nature of the wastes, desired characteristics of the .... and economic and .... considerations.
4) Incineration, which is .... of wastes, is another method of detoxification of inflammable wastes. This method minimises the ..…….…..... of waste to be handled as well.
5) The principal hazard of improper waste disposal is the contamination of …............ and ……….…..... .
6) The point where first movement occurs during earthquake is called ……….
7) A cyclone is generally followed by ……….. .
8) Tropical cyclones are known as …………….. in Atlantic and Caribbean.
9) The 'Super cyclone' hit …………. in 1999.
10) ………… are huge revolving storms caused by winds blowing around a central area of low atmospheric pressure.

B. Choose the correct option:

1. Disaster Management includes:
   a) Mitigation
   b) Reconstruction
   c) Rehabilitation
   d) All of the above
2. The Richter scale expresses an earthquake's:
   a) Magnitude
   b) Location
   c) Duration
   d) Depth
3. Latur earthquake occurred in:
   a) 1991
   b) 1992
   c) 1993
   d) 1994
4. The term Municipal Solid Waste (MSW) is generally used to describe:

(a) Wastes from industrial processes, construction and demolition debris.

(b) Wastes from Private homes, commercial establishments and institutions.

(c) Mining wastes

(d) Agricultural wastes

5. The most serious environmental effect posed by hazardous wastes is ……….

(a) Air pollution

(b) Contamination of groundwater

(c) Increased use of land for landfills.

(d) None of these

6.6 <u>Summary</u>

- *The Indian sub-continent is highly prone to natural disasters. Floods, droughts, cyclones and earthquakes are a recurrent phenomenon in India. Floods are temporary inundation of large region as a result of increase in level of river or reservoir due to heavy rains, high winds, cyclones, tsunami, melting snow or dam burst. Floods cause heavy toll on life of people, livestock and materials. Deforestation resulting in soil erosion causing siltation of the rivers and reservoirs can enhance the incidence of floods.*
- *Earthquake is a sudden release of energy accumulated in deformed rocks of earth crust causing the ground to tremble or shake. The most important effect of earthquake is collapse of buildings especially high rise buildings or building built on weak foundations endangering human lives and properties.*
- *Disasters cannot be totally prevented. However early warning systems, careful planning and preparedness on part of the vulnerable community would help in minimizing the loss of life and property due to these disasters.*
- *Major disasters that India has experienced in the recent past are the Earthquake in Latur (Maharashtra in 1993), Super cyclone in Orissa (1999), the Earthquake in Gujarat (2001).*

- *Floods are temporary inundation of large region as a result of increase in level of river or reservoir due to heavy rains, high winds, cyclones, tsunami, melting snow or dam burst. Floods cause heavy toll on life of people, livestock and materials.*
- *Any disaster can interrupt essential services, such as the provision of health care, electricity, water, sewage/garbage removal, transportation and communications.*

6.7 Keywords

- **Natural disasters:** These disasters include floods, hurricanes, earthquakes and volcano eruptions that can have immediate impacts on human health, as well as secondary impacts causing further death and suffering from floods causing landslides, earthquakes resulting in fires, tsunamis causing widespread flooding and typhoons sinking ferries.
- **Cyclone:** Cyclones are huge revolving storms caused by winds blowing around a central area of low atmospheric pressure.
- **Disaster Management:** It is a process or strategy that is implemented before, during or after any type of catastrophic event takes place.
- **Earthquake:** An Earthquake is a sudden, rapid shaking of the earth caused by the breaking and shifting of rocks beneath the earth surface.
- **Floods:** Floods are caused by overflowing rivers result from heavy rains or from the melting of winter snow, or from both.
- **Landslides:** Landslides are simply defined as the mass movement of rock, debris or earth down a slope and have come to include a broad range of motions whereby falling, sliding and flowing under the influence of gravity dislodges earth material.

6.8 Self-Assessment Test

1. Discuss the causes, effects and control measures of urban and industrial wastes.
2. Discuss the causes, effects and management of Floods.
3. Discuss the causes, effects and management of Earthquake.
4. Discuss the causes, effects and management of Cyclones.
5. What do you understand by solid waste management.

6.9 Answers to check your progress

A. Fill in the blanks

1) mutagenic, teratogenic, carcinogenic 2) reuse, recycling 3) output stream, energy 4) oxidation, volume 5) soil, groundwater 6) epicentre 7) floods 8) hurricanes 9) Orissa 10) Cyclones

B. Choose the correct option:

1. d) 2. a) 3. c) 4. b) 5. b)

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SOCIAL ISSUES AND THE ENVIRONMENT: SUSTAINABLE DEVELOPMENT, URBAN PROBLEM RELATED WITH ENERGY, WATER CONSERVATION, RAIN WATER HARVESTING AND WATERSHED MANAGEMENT

Structure

7.0 Learning Objectives

After studying this unit, you should be able to:

- *Discuss the concept of Sustainable Development*

- *Explain the Energy related Problems of Urban People*
- *Describe methods of water conservation*
- *Describe Rain Water Harvesting*
- *Describe Watershed management.*

7.1 Sustainable Development

Human beings live in both natural and social world. Our technological development has strong impacts on the natural as well as the social components. When we talk of development, it cannot be perceived as development only for a privileged few who would have a high standard of living and would derive all the benefits. Development also does not mean an increase in the GNP (Gross National Product) of a few affluent nations. Development has to be visualized in a holistic manner,

where it brings benefits to all, not only for the present generation, but also for the future generations. There is an urgent need to inter-link the social aspects with development and environment. In this unit we shall discuss various social issues in relation to environment.

Sustainable development is defined as “meeting the needs of the present without compromising the ability of future generations to meet their own needs”.

This definition was given by the Norwegian Prime Minister, G.H. Brundtland, who was also the Director of World Health Organisation (WHO).

Today sustainable development has become a buzz word and hundreds of programmes have been initiated in the name of sustainable development. If you want to test whether or not a proposal will achieve the goals of sustainability just try to find out the following:

Does it protect our biodiversity?

Does it prevent soil erosion?

Does it slow down population growth?

Does it increase forest cover?

Does it cut off the emissions of CFC, SO_x, NO_x and CO_2?

Does it reduce waste generation and does it bring benefits to all?

These are only a few parameters for achieving sustainable growth. Until now development has been human-oriented, that too mainly, for a few rich nations. They have touched the greatest heights of scientific and technological development, but at what cost? The air we breathe, the water we drink and the food we eat have all been badly polluted. Our natural resources are just dwindling due to over exploitation. If growth continues in the same way, very soon we will be facing a "doom's day" - as suggested by Meadows et al (1972) in their world famous academic report "*The Limits to Growth".* This is unsustainable development which will lead to a collapse of the interrelated systems of this earth.

Although the fears about such unsustainable growth and development started in 1970's, yet a clear discussion on sustainable development emerged on an international level in 1992, in the UN Conference on Environment and Development (UNCED), popularly known as The Earth Summit, held at Rio de Janeiro, Brazil. The Rio Declaration aims at "a new and equitable global partnership through the creation of new levels of cooperation among states …". Out of its five significant agreements **Agenda-21** proposes a global programme of action on sustainable development in social, economic and political context for the 21st Century.

These are the key aspects for sustainable development:

a) **Inter-generational equity:** This emphasizes that we should minimize any adverse impacts on resources and environment for future generations i.e. we should hand over a safe, healthy and resourceful environment to our future generations. This can be possible only if we stop over-exploitation of resources, reduce waste discharge and emissions and maintain ecological balance.

b) **Intra-generational equity:** This emphasizes that the development processes should seek to minimize the wealth gaps within and between nations. The Human Development Report of United Nations (2001) emphasizes that the benefits of technology should seek to achieve the goals of intra-generational equity. The technology should address to the problems of the developing countries, producing drought tolerant varieties for uncertain climates, vaccines for infectious diseases, clean fuels for domestic and industrial use. This type of technological development will support the economic growth of the poor countries and help in narrowing the wealth gap and lead to sustainability.

7.1.1 Measures for Sustainable Development

Some of the important measures for sustainable development are as follows:

- **Using appropriate technology** is one which is locally adaptable, eco-friendly, resource-efficient and culturally suitable. It mostly involves local resources and local labour. Indigenous technologies are more useful, cost-effective and sustainable. Nature is often taken as a model, using the natural conditions of that region as its components. This concept is known as "*design with nature*".

  The Technology should use less of resources and should produce minimum waste.

- **Reduce, Reuse, Recycle approach:** The 3-R approach advocating minimization of resource use, using them again and again instead of passing it on to the waste stream and recycling the materials goes a long way in achieving the goals of sustainability. It reduces pressure on our resources as well as reduces waste generation and pollution.
- **Prompting environmental education and awareness:** Making environmental education the centre of all learning process will greatly help in changing the thinking and attitude of people towards our earth and the environment. Introducing the subject right from the school stage will inculcate a feeling of belongingness to earth in the small children. 'Earth thinking' will gradually get incorporated in our thinking and action which will greatly help in transforming our life styles to sustainable ones.
- **Resource utilization as per carrying capacity:** Any system can sustain a limited number of organisms on a long-term basis which is known as its **carrying capacity**. In case of human beings, the carrying capacity concept becomes all the more complex. It is because unlike other animals, human beings, not only need food to live, but need so many other things to maintain the quality of life.

  Sustainability of a system depends largely upon the carrying capacity of the system. If the carrying capacity of a system is crossed (say, by over exploitation of a resource), environmental degradation starts and continues till it reaches a point of no return.

Carrying capacity has two basic components:

- **Supporting capacity** i.e. the capacity to regenerate.
- **Assimilative capacity** i.e. the capacity to tolerate different stresses.

In order to attain sustainability it is very important to utilize the resources based upon the above two properties of the system. Consumption should not exceed regeneration and changes should not be allowed to occur beyond the tolerance capacity of the system.

- **India** has still to go a long way in implementing the concept of sustainable development. We have to lay emphasis on framing a well-planned strategy for our developmental activity while increasing our economic growth. We have tremendous natural diversity as well as a huge population which makes planning for sustainable growth all the more important and complex. The National Council of Environmental Planning and Coordination (NCPC) set up in 1972 was the focal agency in this regard. The Ministry of Environment & Forests, set up in 1985 has formulated guidelines for various developmental activities keeping in view the sustainability principles.

7.1.2 Urban Problems Related To Energy

Cities are the main centers of economic growth, trade, education, innovations and employment. Until recently, a big majority of human population lived in rural areas and their economic activities centered around agriculture, cattle rearing, fishing, hunting or some cottage industry. It was some 200 years ago, with the dawn of Industrial era, the cities showed a rapid development. Now about 50 percent of the world population lives in urban areas and there is increasing movement of rural folk to cities in search of employment. The urban growth is so fast that it is becoming difficult to accommodate all the industrial, commercial and residential facilities within a limited municipal boundary. As a result, there is spreading of the cities into the sub-urban or rural areas too, a phenomenon known as urban sprawl.

In developing countries too urban growth is very fast and in most of the cases it is uncontrollable and unplanned growth. In contrast to the rural set-up the urban set-up is densely populated, consumes a lot of energy and materials and generates a lot of waste.

The energy requirements of urban population are much higher than that of rural ones. This is because urban people have a higher standard of life and their life style demands more energy inputs in every sphere of life. The energy demanding activities include:

(i) Residential and commercial lighting.

(ii) Transportation means including automobiles and public transport for moving from residence to workplace.

(iii) Modern life-style using a large number of electrical gadgets in everyday life.

(iv) Industrial plants using a big proportion of energy.

(v) A large amount of waste generation which has to be disposed off properly using energy based techniques.

(vi) Control and prevention of air and water pollution which need energy dependent technologies.

Due to high population density and high energy demanding activities, the urban problems related to energy are much more magnified as compared to the rural population.

7.2 Water Conservation

Water being one of the most precious and indispensable resources needs to be conserved. The following strategies can be adopted for conservation of water:

1) **Decreasing run-off losses:** Huge water-loss occurs due to runoff on most of the soils, which 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 improved water-storage system.
   - **Contour cultivation** on small furrows and ridges across the slopes trap rainwater and allow more time for infiltration. Terracing constructed on deep soils have large water-storage capacity. On gentle slopes trapped run off is spread over a large area for better infiltration.

- **Conservation-bench terracing** involves construction of a series of benches for catching the run off water.
- **Water spreading** is done by channeling or lagoon-levelling. In channeling, the water-flow is controlled by a series of diversions with vertical intervals. In lagoon leveling, small depressions are dug in the area so that there is temporary storage of water.
- **Chemical wetting agents (Surfactants)** increase the water intake rates when added to normal irrigated soils.
- **Surface crop residues**, Tillage, mulch, animal residues etc. help in reducing run-off by allowing more time for water to penetrate into the land.
- **Chemical conditioners** like gypsum ($CaSO_4.2H_2O$) when applied to sodic soils improve soil permeability and reduce run off. Another useful conditioner is HPAN (hydrolysed polyacrylonitrile).
- **Water-storage structures** like farm ponds, dug-outs etc. built by individual farmers can be useful measures for conserving water through reduction of runoff.

2) **Reducing evaporation losses:** This is more relevant in humid regions. Horizontal barriers of asphalt placed below the soil surface increase water availability and increase crop yield by 35-40%. This is more effective on sandy soil but less effective on loamy sand soils.

   A co-polymer of starch and acrylonitrile called 'super slurper' has been reported to absorb water upto 1400 times its weight. The chemical has been found to be useful for sandy soils.

3) **Storing water in soil:** Storage of water takes place in the soil root zone in humid regions when the soil is wetted to field capacity. By leaving the soil fallow for one season water can be made available for the crop grown in next season.

4) **Reducing irrigation losses**
   - Use of lined or covered canals to reduce seepage.
   - Irrigation in early morning or late evening to reduce evaporation losses.
   - Sprinkling irrigation and drip irrigation to conserve water by 30-50%.
   - Growing hybrid crop varieties with less water requirements and tolerance to saline water help conserve water.

5) **Re-use of water**

- Treated wastewater can be used for ferti-irrigation.
- Using grey water from washings, bath-tubs etc. for watering gardens, washing cars or paths help in saving fresh water.

6) **Preventing wastage of water:** This can be done in households, commercial buildings and public places.
   - Closing taps when not in use
   - Repairing any leakage from pipes
   - Using small capacity flush in toilets.
7) **Increasing block pricing:** The consumer has to pay a proportionately higher bill with higher use of water. This helps in economic use of water by the consumers.

7.3 Rainwater Harvesting

Rainwater harvesting is a technique of increasing the recharge of groundwater by capturing and storing rainwater.

This is done by constructing special water-harvesting structures like dug wells, percolation pits, lagoons, check dams etc. Rainwater, wherever it falls, is captured and pollution of this water is prevented. Rainwater harvesting is not only proving useful for poor and scanty rainfall regions but also for the rich ones.

The annual average rainfall in India is 1200 mm, However, in most places it is concentrated over the rainy season, from June to September. It is an astonishing fact that Cherapunji, the place receiving the second highest annual rainfall as 11000 mm still suffers from water scarcity. The water flows with run off and there is little vegetation to check the run off and allow infiltration. Till now there is hardly any rain-water harvesting being done in this region, thereby losing all the water that comes through rainfall.

Rainwater harvesting has the following objectives:

1. to reduce run off loss
2. to avoid flooding of roads
3. to meet the increasing demands of water

4. to raise the water table by recharging ground water
5. to reduce groundwater contamination
6. to supplement groundwater supplies during lean season.

Rainwater can be mainly harvested by any one of the following methods:

a) by storing in tanks or reservoirs above or below ground.
b) by constructing pits, dug-wells, lagoons, trench or check-dams on small rivulets
c) by recharging the groundwater.

Before adopting a rain-water harvesting system, the soil characteristics, topography, rainfall pattern and climatic conditions should be understood.

7.3.1 Traditional Rain Water Harvesting

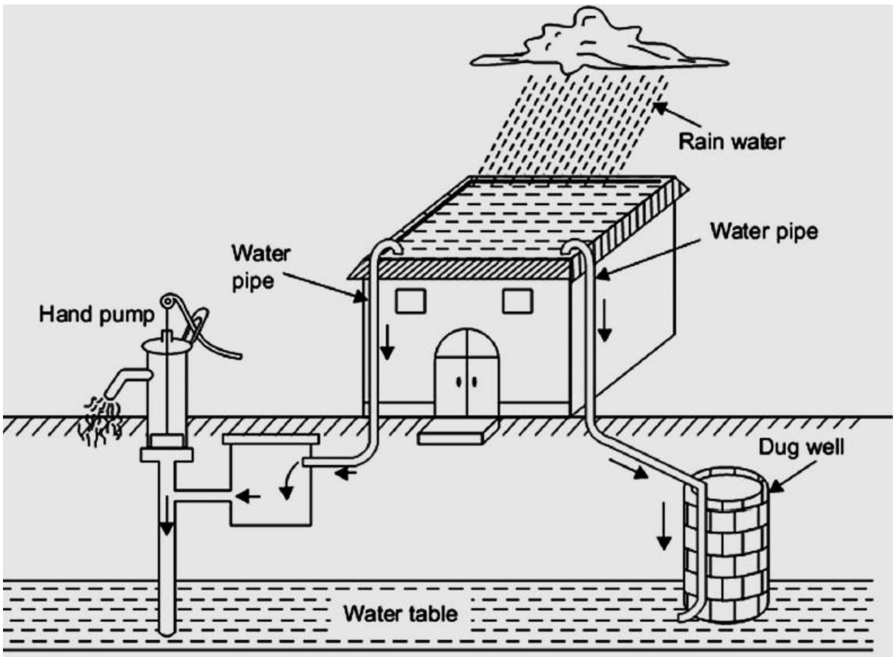
In India, it is an old practice in high rainfall areas to collect rainwater from roof-tops into storage tanks. In foot hills, water flowing from springs are collected by embankment type water storage. In Himalayan foot-hills people use the hollow bamboos as pipelines to transport the water of natural springs. Rajasthan is known for its 'tankas' (underground tanks) and 'khadins' (embankments) for harvesting rainwater. In our ancient times we had adequate *Talaabs, Baawaris, Johars, Hauz* etc. in every city, village and capital cities of our kings and lords, which were used to collect rain-water and ensured adequate water supply in dry periods.

7.3.2 Modern Techniques of Rain Water Harvesting

In arid and semi-arid regions artificial ground water recharging is done by constructing shallow percolation tanks. **Check-dams** made of any suitable native material (brush, poles, rocks, plants, loose rocks, wirenets, stones, slabs, sacks etc.) are constructed for harvesting runoff from large catchment areas. Rajendra Singh of Rajasthan popularly known as water man has been doing a commendable job for harvesting rainwater by building checkdams in Rajasthan and he was honoured with the prestigious Magsaysay Award for his work.

Groundwater flow can be intercepted by building **groundwater dams** for storing water underground. As compared to surface dams, groundwater dams have several advantages like minimum evaporation loss, reduced chances of contamination etc.

In **roof top rainwater harvesting**, which is a low cost and effective technique for urban houses and buildings, the rain-water from the top of the roofs is diverted to some surface tank or pit through a delivery system which can be later used for several purposes. Also, it can be used to recharge underground aquifers by diverting the stored water to some abandoned dug-well or by using a hand pump.



<u>Roof-top rainwater harvesting by recharging (i) through hand pump or (ii) through abondoned dugwell.</u>

All the above techniques of rainwater harvesting are low-cost methods with little maintenance expenses. Rainwater harvesting helps in recharging the aquifers, improves groundwater quality by dilution, improves soil moisture and reduces soil erosion by minimizing run-off water.

7.4 <u>Watershed Management</u>

The land area drained by a river is known as the river basin. The **watershed** is defined as the land area from which water drains under gravity to a common drainage channel. Thus, watershed is a delineated area with a well-defined topographic boundary and one water outlet.

The watershed can range from a few square kilometres to few thousand square kilometers in size. In the watershed the hydrological conditions are such that water becomes concentrated within a particular location like a river or a reservoir, by which the watershed is drained. The watershed comprises complex interactions of soil, landform, vegetation, land use activities and water. People and animals are an integral part of a watershed having mutual impacts on each other. We may live anywhere, we would be living in some watershed.

A watershed affects us as it is directly involved in sustained food production, water supply for irrigation, power generation, transportation as well as for influencing sedimentation and erosion, vegetation growth, floods and droughts. Thus, management of watersheds, treating them as a basic functional unit, is extremely important and the first such Integrated Watershed Management was adopted in 1949 by the Damodar Valley Corporation.

7.4.1 Watershed degradation

The watersheds are very often found to be degraded due to uncontrolled, unplanned and unscientific land use activities. Overgrazing, deforestation, mining, construction activities, industrialization, shifting cultivation, natural and artificial fires, soil erosion and ignorance of local people have been responsible for degradation of various watersheds.

7.4.2 Objectives of Watershed Management

Rational utilization of land and water resources for optimum production causing minimum damage to the natural resources is known as watershed management.

The objectives of watershed management are as follows:

1. To rehabilitate the watershed through proper land use adopting conservation strategies for minimizing soil erosion and moisture retention so as to ensure good productivity of the land for the farmers.
2. To manage the watershed for beneficial developmental activities like domestic water supply, irrigation, hydropower generation etc.
3. To minimize the risks of floods, droughts and landslides.

4. To develop rural areas in the region with clear plans for improving the economy of the region.

7.4.3 Watershed Management Practices

In the Fifth Five Year Plan, watershed management approach was included with a number of programmes for it and a national policy was developed. In watershed management, the aspects of development are considered with regard to the availability of resources.

The practices of conservation and development of land and water are taken up with respect to their suitability for peoples. benefit as well as sustainability. Various measures taken up for management include the following:

1. **Water harvesting:** Proper storage of water is done with provision for use in dry seasons in low rainfall areas. It also helps in moderation of floods.
2) **Afforestation and Agroforestry:** In watershed development, afforestation and crop plantation play a very important role. They help to prevent soil erosion and retention of moisture. In high rainfall areas woody trees are grown in between crops to substantially reduce the runoff and loss of fertile soil. In Dehradun, trees like *Eucalyptus* and *Leucaena* and grasses like *Chrysopogon* are grown along with maize or wheat to achieve the above objectives. Woody trees grown successfully in such agroforestry programmes include *Dalbergia sissoo* (Sheesham), *Tectona grandis* (Teak) and *Acacia nilotica* (Keekar) which have been used in watershed areas of river Yamuna.
3) **Mechanical measures for reducing soil erosion and runoff losses:** Several mechanical measures like terracing, bunding, bench terracing, no-till farming, contour cropping, strip cropping etc. are used to minimize runoff and soil erosion particularly on the slopes of watersheds. Bunding has proved to be a very useful method in reducing runoff, peak discharge and soil loss in Dehradun and Siwaliks.
4) **Scientific mining and quarrying:** Due to improper mining, the hills lose stability and get disturbed resulting in landslides, rapid erosion etc. Contour trenching at an interval of 1 meter on overburden dump, planting some soil binding plants like *Ipomoea* and *Vitex* and

draining of water courses in the mined area are recommended for minimizing the destructive effects of mining in watershed areas.

5) **Public participation:** People's involvement including the farmers and tribals is the key to the success of any watershed management programme, particularly the soil and water conservation. People's cooperation as well as participation has to be ensured for the same. The communities are to be motivated for protecting a freshly planted area and maintaining a water harvesting structure implemented by the government or some external agency (NGO) independently or by involving the local people. Properly educating the people about the campaign and its benefits or sometimes paying certain incentives to them can help in effective people's participation.

Successful watershed management has been done at Sukhomajri Panchkula, Haryana through active participation of the local people. Watershed management in Himalayan region is of vital importance

since most of the watersheds of our country lie here. Several anthropogenic activities accelerate its slope instability which need to be prevented and efforts should be made to protect the watershed by

preventing overgrazing, terracing and contour farming to check runoff and erosion etc. On steeper slopes with sliding faces, straw mulching tied with thin wires and ropes helps in establishing the vegetation and stabilizing the slopes.

7.5 Check Your Progress

A. Fill in the blanks

1. Sustainable development means meeting the need of present without ……… the ability of future generation.
2. The rainwater and water from other sources such as rivers and ponds seep through the ……. and fills the empty spaces and cracks deep below the ground. The process of seeping of water into the ground is called ……….. .
3. ………….. constructed in villages of Rajasthan have raised the water levels in the region.

4. In Himalayan foot-hills people use the …………… as pipelines to transport the water of natural springs.
5. Rajasthan is known for its …………. (underground tanks) and ……….. (embankments) for harvesting rainwater.

B. Choose the correct option

1. The world famous report on "The Limits to Growth" predicting that the world will meet the doom's day, if growth continues limitlessly, was written by
   a) Myers *et al*
   b) Meadows *et al*
   c) Brundtland
   d) Wilson et *al*
2. Which of the following statements about sustainable development is true?
   a) Sustainable development can support a high quality of life with continued population growth
   b) Sustainable development is only possible for people living in wealthy countries
   c) Sustainable development can only support limited levels of consumption.
   d) Sustainable development will be able to support everyone in the world at the United States level of consumption.
3. Sustainable development is NOT needed
   a) to Control Climate Change
   b) to maintain biodiversity
   c) to promote city development
   d) to promote well being
4. ……………. is a traditional method of rainwater harvesting.
   a) Check-dams
   b) groundwater dams
   c) roof top rainwater harvesting
   d) joharh
5. Which one of the following is not associated with reducing the run-off loss of water:
   a) Contour cultivation
   b) Chemical wetting

c) Surface crop residues

d) Fallow soil

7.6 Summary

- *Sustainable development is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs".*
- *Any system can sustain a limited number of organisms on a long-term basis which is known as its carrying capacity.*
- *The watershed is defined as the land area from which water drains under gravity to a common drainage channel. Thus, watershed is a delineated area with a well-defined topographic boundary and one water outlet.*
- *Rational utilization of land and water resources for optimum production causing minimum damage to the natural resources is known as watershed management.*
- *The watersheds are very often found to be degraded due to uncontrolled, unplanned and unscientific land use activities.*
- *Successful watershed management has been done at Sukhomajri Panchkula, Haryana through active participation of the local people.*
- *Before adopting a rain-water harvesting system, the soil characteristics, topography, rainfall pattern and climatic conditions should be understood.*

7.7 Keywords

- **Rain Water Harvesting (RWH):** Rainwater harvesting is the accumulation and deposition of rainwater for reuse before it reaches the aquifer.
- **Sustainable development:** It is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
- **The watershed** is defined as the land area from which water drains under gravity to a common drainage channel. Thus, watershed is a delineated area with a well-defined topographic boundary and one water outlet.

7.8 Self-Assessment Test

1. What do you mean by sustainable development? What are the major measures to attain sustainability?

2. Why is urban requirement of energy more than rural requirement?
3. Discuss the measures to conserve water.
4. What is rainwater harvesting? What are the purposes served by it?
5. What is a watershed? Critically discuss the objectives and practices of watershed management.

7.9 Answers to check your progress

A. Fill in the blanks

1. Compromising 2. Soil, infiltration 3. Check dams 4. Hollow bamboos 5. Tankas, khadins

B. Choose the correct option

1. c) 2. c) 3. c) 4. d) 5. d)

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SOCIAL ISSUES AND THE ENVIRONMENT II: ENVIRONMENTAL ETHICS, ISSUES, SOLUTIONS; CLIMATE CHANGES, CONSUMERISM, AIR (PREVENTION AND CONTROL OF POLLUTION) ACT, WATER (PREVENTION AND CONTROL OF POLLUTION) ACT, WILDLIFE PROTECTION ACT, FOREST CONSERVATION ACT AND PUBLIC AWARENESS

Structure

8.0 Learning Objectives

After studying this unit, you should be able to:

- *Define environmental ethics and explain the issues and possible solutions.*
- *Define climatic changes, global warming, acid rain, ozone layer depletion.*
- *Describe the issues involved in the enforcement of environmental legislation.*
- *Outline and explain the provisions of the Environment (Protection) Act, (Prevention and Control of Pollution) Act, Water (Prevention and Control of Pollution) Act, Wildlife Protection Act and Forest Conservation Act.*
- *Explain the need and importance of public awareness.*

8.1 Environmental Ethics: Issues and Solutions

Environmental ethics refers to the issues, principles and guidelines relating to human interactions with their environment.

It is rightly said, "*The environmental crisis is an outward manifestation of the crisis of mind and spirit*". It all depends on how do we think and act. If we think "*Man is all powerful and the supreme creature on this earth and man is the master of nature and can harness it at his will*", it reflects our **human-centric thinking**. On the other hand, if we think "*Nature has provided us with all the resources for leading a beautiful life and she nourishes us like a mother, we should respect her and nurture her*", this is an **earth-centric thinking**.

The first view urges us to march ahead gloriously to conquer the nature and establish our supremacy over nature through technological innovations, economic growth and development without much botheration to care for the damage done to the planet earth. The second view urges us to live on this earth as a part of it, like any other creation of Nature and live sustainably. So, we can see that our acts will follow what we think. If we want to check the environmental crisis, we will have to transform our thinking and attitude. That in turn, would transform our deeds, leading to a better environment and better future.

These two world-views are discussed here in relation to environmental protection:

(a) Anthropocentric Worldview: This view is guiding most industrial societies. It puts human beings in the center giving them the highest status. Man is considered to be most capable for managing the planet earth. The guiding principles of this view are:

- Man is the planet's most important species and is the in-charge of the rest of nature.
- Earth has an unlimited supply of resources and it all belongs to us.
- Economic growth is very good and more the growth, the better it is, because it raises our quality of life and the potential for economic growth is unlimited.
- A healthy environment depends upon a healthy economy.
- The success of mankind depends upon how good managers we are for deriving benefits for us from nature.

(b) Eco-centric Worldview: This is based on earth-wisdom. The basic beliefs are as follows:

- Nature exists not for human beings alone, but for all the species.
- The earth resources are limited and they do not belong only to human beings.
- Economic growth is good till it encourages earth-sustaining development and discourages earth-degrading development.
- A healthy economy depends upon a healthy environment.
- The success of mankind depends upon how best we can cooperate with the rest of the nature while trying to use the resources of nature for our benefit.

Environmental ethics can provide us the guidelines for putting our beliefs into action and help us decide what to do when faced with crucial situations. Some important ethical guidelines known as **Earth ethics or Environmental Ethics** are as follows:

- You should love and honour the earth since it has blessed you with life and governs your survival.
- You should keep each day sacred to earth and celebrate the turning of its seasons.
- You should not hold yourself above other living things and have no right to drive them to extinction.
- You should be grateful to the plants and animals which nourish you by giving you food.
- You should limit your offsprings because too many people will overburden the earth.

- You should not waste your resources on destructive weapons.
- You should not run after gains at the cost of nature, rather should strive to restore its damaged majesty.
- You should not conceal from others, the effects you have caused by your actions on earth.
- You should not steal from future generations their right to live in a clean and safe planet by impoverishing or polluting it.
- You should consume the material goods in moderate amounts so that all may share the earth.s precious treasure of resources.

If we critically go through the above ten commandments for earth ethics and reflect upon the same, we will find that various religions teach us the same things in one form or the other. Our Vedas have glorified each and every component of nature as gods or goddesses so that people have a feeling of reverence for them. Our religious and cultural rituals make us perform such actions that would help in the conservation of nature and natural resources. The concept of 'ahinsa' (non-violence) in Buddhism and Jainism ensure the protection and conservation of all forms of life, thereby keeping the ecological balance of the earth intact. Our teachings on '*having fewer wants*' ensures to put "*limits to growth*" and thus, guide us to have an eco-centric life style.

8.1.1 Global Climate Change

Climate is the average weather of an area. It is the general weather conditions, seasonal variations and extremes of weather in a region. Such conditions which average over a long period- at least 30 years is called climate.

The **Intergovernmental Panel on Climate Change (IPCC)** in 1990 and 1992 published best available evidence about past climate change, the greenhouse effect and recent changes in global temperature. It is observed that earth's temperature has changed considerably during the geological times. It has experienced several glacial and interglacial periods. However, during the past 10,000 years of the current interglacial period the mean average temperature has fluctuated by 0.5- 1°C over 100 to 200 year period. We have relatively stable climate for thousands of years due to which we have practised agriculture and increased in population. Even small changes in climatic conditions may disturb agriculture that would lead to migration of animals including humans.

Anthropogenic (man-made) activities are upsetting the delicate balance that has established between various components of the environment. Greenhouse gases are increasing in the atmosphere resulting in increase in the average global temperature.

This may upset the hydrological cycle, result in floods and droughts in different regions of the world, cause sea level rise, changes in agriculture productivity, famines and death of humans as well as livestock.

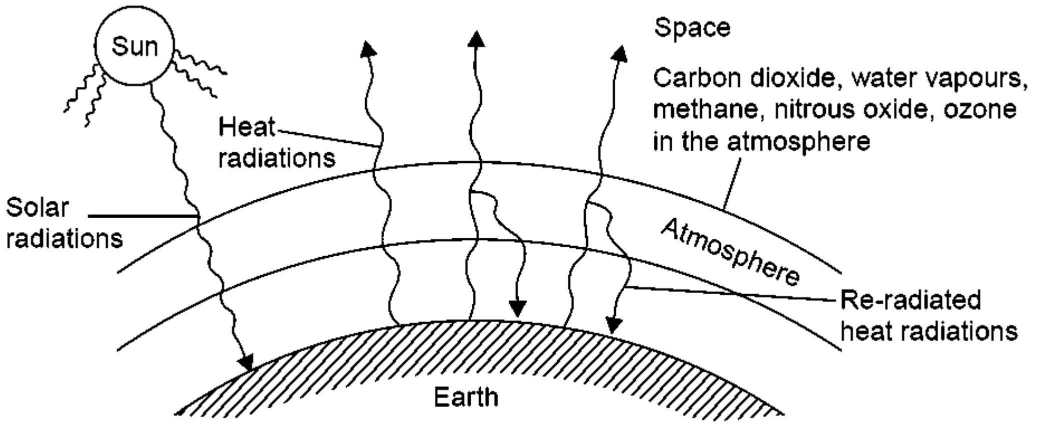
The global change in temperature will not be uniform everywhere and will fluctuate in different regions. The places at higher latitudes will be warmed up more during late autumn and winter than the places in tropics. Poles may experience 2 to 3 times more warming than the global average, while warming in the tropics may be only 50 to 100% on an average. The increased warming at poles will reduce the thermal gradient between the equator and high latitude regions decreasing the energy available to the heat engine that drives the global weather machine. This will disturb the global pattern of winds and ocean currents as well as the timing and distribution of rainfall. Shifting of ocean currents may change the climate of Iceland and Britain and may result in cooling at a time when rest of the world warms. By a temperature increase of 1.5 to 4.5°C the global hydrological cycle is expected to intensify by 5 to 10%. Disturbed rainfall will result in some areas becoming wetter and the others drier. Although rainfall may increase, higher temperatures will result in more evapo-transpiration leading to annual water deficit in crop fields.

8.1.2 Global Warming

Troposphere, the lowermost layer of the atmosphere, traps heat by a natural process due to the presence of certain gases. This effect is called **Green House Effect** as it is similar to the warming effect observed in the horticultural greenhouse made of glass. The amount of heat trapped in the atmosphere depends mostly on the concentrations of 'heat trapping' or 'green house' gases and the length of time they stay in the atmosphere. The major greenhouse gases are carbon dioxide, ozone, methane, nitrous oxide, chlorofluorocarbons (CFCs) and water vapours.

The average global temperature is 15°C. In the absence of greenhouse gases this temperature would have been -18°C. Therefore, Green House Effect contributes a temperature rise to the tune of 33°C. Heat trapped by greenhouse gases in the atmosphere keeps the planet warm enough to allow us and other species to exist. The two predominant greenhouse gases are water vapours, which are controlled by hydrological cycle and carbon dioxide, which is controlled mostly by the global carbon cycle. While the levels of water vapour in the troposphere have relatively remained constant, the levels of carbon dioxide have increased. Other gases whose levels have increased due to human activities are methane, nitrous oxide and chlorofluorocarbons. Deforestation has further resulted in elevated levels of carbon dioxide due to non-removal of carbon dioxide by plants through photosynthesis.

Warming or cooling by more than 2°C over the past few decades may prove to be disastrous for various ecosystems on the earth including humans, as it would alter the conditions faster than some species could adapt or migrate. Some areas will become inhabitable because of drought or floods following a rise in average sea level.



<u>The greenhouse effect</u>

8.1.2.1 Greenhouse Gases

The phenomenon that worries the environmental scientists is that due to anthropogenic activities there is an increase in the concentration of the greenhouse gases in the air that absorb infra-red light containing heat and results in the re-radiation of even more of the outgoing thermal infrared energy, thereby increasing the average surface temperature beyond 15°C. The phenomenon is referred to as the enhanced greenhouse effect to distinguish its effect from the one that has been operating naturally for millennia. The greenhouse gases present in the troposphere and resulting in an increase in the temperature of air and the earth are discussed here:

- **Carbon dioxide**

  It contributes about 55% to global warming from greenhouse gases produced by human activity. Industrial countries account for about 76% of annual emissions. The main sources are fossil fuel burning (67%) and deforestation, other forms of land clearing and burning (33%). CO_2 stays in the atmosphere for about 500 years. CO_2 concentration in the atmosphere was 355 ppm in 1990 that is increasing at a rate of 1.5 ppm every year.

- **Chlorofluorocarbons (CFCs)**

  These are believed to be responsible for 24% of the human contribution to greenhouse gases. They also deplete ozone in the stratosphere. The main sources of CFCs include leaking air conditioners and refrigerators, evaporation of industrial solvents, production of plastic foams, aerosols, propellants etc. CFCs take 10-15 years to reach the stratosphere and generally trap 1500 to 7000 times more heat per molecule than CO_2 while they are in the troposphere. This heating effect in the troposphere may be partially offset by the cooling caused when CFCs deplete ozone during their 65 to 110 years stay in the stratosphere. Atmospheric concentration of CFC is 0.00225 ppm that is increasing at a rate of 0.5% annually.

- **Methane (CH_4)**

  It accounts for 18% of the increased greenhouse gases. Methane is produced when bacteria break down dead organic matter in moist places that lack oxygen such as swamps, natural wetlands, paddy fields, landfills and digestive tracts of cattle, sheep and termites. Production and use of oil and natural gas and incomplete burning of organic material are also significant sources of methane. Methane stays in the atmosphere for 7-10 years. Each methane molecule traps about 25 times as much heat as a CO_2 molecule. Atmospheric concentration of methane is 1.675 ppm and it is increasing at a rate of 1% annually.

- **Nitrous Oxide (N_2O)**

  It is responsible for 6% of the human input of greenhouse gases. Besides trapping heat in the troposphere it also depletes ozone in the stratosphere. It is released from nylon products, from burning of biomass and nitrogen rich fuels (especially coal) and from the breakdown of nitrogen fertilizers in soil, livestock wastes and nitrate contaminated ground water. Its life span in the troposphere is 140-190 years and it traps about 230 times as much heat per molecule as CO_2. The atmospheric concentration of N_2O is 0.3 ppm and is increasing at a rate of 0.2% annually.

8.1.2.2 Impacts of Enhanced Greenhouse Effect

The enhanced greenhouse effect will not only cause global warming but will also affect various other climatic and natural processes.

1) **Global temperature increase:** It is estimated that the earth's mean temperature will rise between 1.5 to 5.5 °C by 2050 if input of greenhouse gases continues to rise at the present rate. Even at the lower value, earth would be warmer than it has been for 10,000 years.
2) **Rise in Sea Level:** With the increase in global temperature sea water will expand. Heating will melt the polar ice sheets and glaciers resulting in further rise in sea level. Current models indicate that an increase in the average atmospheric temperature of 3 °C would raise the average global sea level by 0.2.1.5 meters over the next 50.100 years. One meter rise in sea level will inundate low lying areas of cities like Shanghai, Cairo, Bangkok, Sydney, Hamburg and Venice as well as agricultural lowlands and deltas in Egypt, Bangladesh, India, China and will affect rice productivity. This will also disturb many commercially important spawning grounds and would probably increase the frequency of storm damage to lagoons, estuaries and coral reefs.

   In India, the Lakshadweep Islands with a maximum height of 4 meters above the level may be vulnerable. Some of the most beautiful cities like Mumbai may be saved by heavy investment on embankment to prevent inundation. Life of millions of people will be affected, by the sea level rise who have built homes in the deltas of the Ganges, the Nile, the Mekong, the Yangtze and the Mississippi rivers.

3) **Effects on Human Health:** The global warming will lead to changes in the rainfall pattern in many areas, thereby affecting the distribution of vector-borne diseases like malaria, filariasis, elephantiasis etc. Areas which are presently free from diseases like malaria, schistosomiasis etc. may become the breeding grounds for the vectors of such diseases. The areas likely to be affected in this manner are Ethiopia, Kenya and Indonesia. Warmer temperature and more water stagnation would favour the breeding of mosquitoes, snails and some insects, which are the vectors of such diseases. Higher temperature and humidity will increase/aggravate respiratory and skin diseases.
4) **Effects on Agriculture:** There are different views regarding the effect of global warming on agriculture. It may show positive or negative effects on various types of crops in different regions of the world. Tropical and subtropical regions will be more affected since the average temperature in these regions is already on the higher side. Even a rise of 2 °C may be quite harmful to crops. Soil moisture will decrease and evapo-transpiration will increase, which may drastically affect wheat and maize production.

   Increase in temperature and humidity will increase pest growth like the growth of vectors for various diseases. Pests will adapt to such changes better than the crops. To cope up with the changing situation drought resistant, heat resistant and pest resistant varieties of crops have to be developed.

8.1.2.3 Measures to Check Global Warming

To slow down enhanced global warming the following steps will be important:

- Cut down the current rate of use of CFCs and fossil fuel.
- Use energy more efficiently.
- Shift to renewable energy resources.
- Increase Nuclear Power Plants for electricity production.
- Shift from coal to natural gas.
- Trap and use methane as a fuel.
- Reduce beef production.
- Adopt sustainable agriculture.

- Stabilize population growth.
- Efficiently remove CO_2 from smoke stacks.
- Plant more trees.
- Remove atmospheric CO_2 by utilizing photosynthetic algae.

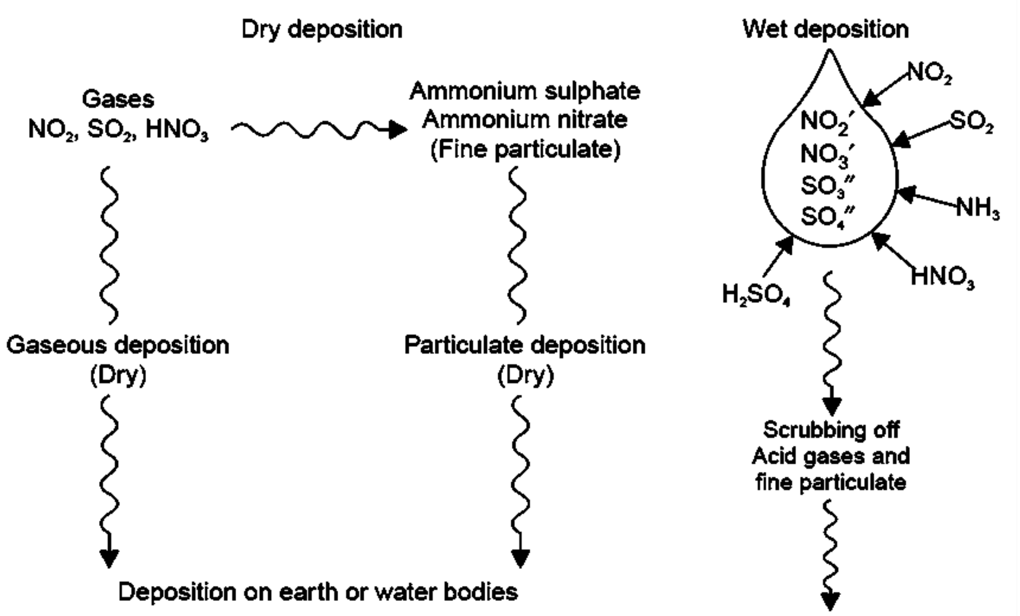
8.1.3 Acid Rain

Oxides of sulphur and nitrogen originating from industrial operations and fossil fuel combustion are the major sources of acid forming gases. Acid forming gases are oxidised over several days by which time they travel several thousand kilometres. In the atmosphere these gases are ultimately converted into sulphuric and nitric acids. Hydrogen chloride emission forms hydrochloric acid. These acids cause acidic rain. Acid rain is only one component of acidic deposition. Acidic deposition is the total of wet acidic deposition (acid rain) and dry deposition.

Rain water is turned acidic when its pH falls below. In fact clean or natural rain water has a pH of 5.6 at 20°C because of formation of carbonic acid due to dissolution of CO_2 in water.

The Adirondack Lakes located in the state of New York are known to receive acid rains. The strong acids like sulphuric acid (H_2SO_4) and nitric acid (HNO_3) dissolved or formed in rainwater dissociate or release hydrogen ions thereby increasing the acidity in rain drops.

Generally sulphuric acid forms a major fraction of acid rain, followed by nitric acid and a very small fraction of other acids. However, in urban areas calcium (Ca^{+2}), Magnesium (Mg^{+2}) and ammonium (NH^{+4}) ions help to neutralize the rain drops shifting the overall H^+ towards basic scale. The overall pH of any raindrop is due to the net effect of carbonic acid, sulphuric acid, nitric acid and other acidic constituents or any neutralizers such as ammonia.



Acid deposition (dry deposition and wet deposition)

In the absence of rain, dry deposition of acid may occur. Acid forming gases like oxides of sulphur and nitrogen and acid aerosols get deposited on the surface of water bodies, vegetation, soil and other materials. On moist surfaces or in liquids these acid forming gases can dissolve and form acids similar to that formed in acid rain. If the oxidizers are present on the liquid surfaces then these gases undergo oxidation to form acids. Fine particles or acid droplets can act as nuclei for water to condense to form rain droplets. By such process sulphuric acid is incorporated into the droplets. In the clouds additional SO_2 and NO_2 contact the droplets and get absorbed which can be oxidized by

the dissolved hydrogen peroxide (H_2O_2) or other oxidizers. In the droplets falling from the clouds additional acidic gases and aerosol particles get incorporated, further decreasing their pH. A unit decrease in pH value causes 10 times increase in acidity. Average pH in rainfall over eastern United States from April 1979 to March 1980 was less than 5.0. In India acid rain is recorded from certain places:

Name of place	pH of rainwater
Kodaikanal	5.18

Minicoy	5.52
Mohanbari	5.50

8.1.3.1 Effects of acid rain

Acid rain causes a number of harmful effects below pH 5.1. The effects are visible in the aquatic system even at pH less than 5.5.

- It causes deterioration of buildings especially made of marble e.g. monuments like Taj Mahal. Crystals of calcium and magnesium sulphate are formed as a result of corrosion caused by acid rain.
- It damages stone statues. Priceless stone statues in Greece and Italy have been partially dissolved by acid rain.
- It damages metals and car finishes.
- Aquatic life especially fish are badly affected by lake acidification.
- Aquatic animals suffer from toxicity of metals such as aluminium, mercury, manganese, zinc and lead which leak from the surrounding rocks due to acid rain.
- It results in reproductive failure and killing of fish.
- Many lakes of Sweden, Norway, Canada have become fishless due to acid rain.
- It damages foliage and weakens trees.
- It makes trees more susceptible to stresses like cold temperature, drought, etc. Many insects and fungi are more tolerant to acidic conditions and hence they can attack the susceptible trees and cause diseases.

8.1.3.2 Control of Acid Rain

- Emission of SO_2 and NO_2 from industries and power plants should be reduced by using pollution control equipments.
- Liming of lakes and soils should be done to correct the adverse effects of acid rain.
- A coating of protective layer of inert polymer should be given in the interior of water pipes for drinking water.

8.1.4 Wasteland Reclamation

Economically unproductive lands suffering from environmental deterioration are known as wastelands. The wastelands include salt affected lands, sandy areas, gullied areas, undulating uplands, barren hill-ridge etc. Snow covered areas, glacial areas and areas rendered barren after Jhum cultivation are also included in wastelands. More than half of our country's geographical area (about 175 million ha) is estimated to be wasteland, thus indicating the seriousness of the problem

for a country like ours which has to support 1/6th of the world's population.

Maximum wasteland areas in our country lie in Rajasthan (36 million ha) followed by M.P. and Andhra Pradesh. In Haryana the wastelands cover about 8.4% of the total land area and most of it comprises saline, sodic or sandy land areas.

Wastelands are formed by natural processes, which include undulating uplands, snow-covered lands, coastal saline areas, sandy areas etc. or by anthropogenic (man-made) activities leading to eroded, saline or waterlogged lands.

The major anthropogenic activities leading to waste land formation are deforestation, overgrazing, mining and erroneous agricultural practices. Although deserts are wastelands formed by natural process, but there are many human activities which accelerate the spreading of desert as we have already discussed.

8.1.4.1 Wasteland Reclamation Practices

Wasteland reclamation and development in our country falls under the purview of **Wasteland Development Board**, which works to fulfil the following objectives:

- To improve the physical structure and quality of the marginal soils.
- To improve the availability of good quality water for irrigating these lands.
- To prevent soil erosion, flooding and landslides.
- To conserve the biological resources of the land for sustainable use.

Some important reclamation practices are discussed here.

1. **Land development and leaching:** For reclamation of the salt affected soil, it is necessary to remove the salts from the root-zone which is usually achieved by leaching i.e. by applying excess amount of water to push down the salts. After a survey of the extent of salinity problem, soil texture, depth of impermeable layer and water table, land levelling is done to facilitate efficient and uniform application of water. After leveling and ploughing, the field is bunded in small plots and leaching is done. In continuous leaching, 0.5 to 1.0 cm water is required to remove 90% of soluble salts from each cm of the soil depending upon texture. If we use intermittent sprinkling with 25 cm water, it reduces about 90% salinity in the upper 60 cm layer.
2. **Drainage:** This is required for water-logged soil reclamation where excess water is removed by artificial drainage.
   (a) Surface drainage: This is used in areas where water stands on the fields after heavy rains by providing ditches to runoff the excess water. Usually 30-45 cm deep ditches lying parallel to each other at 20-60 m distance are able to remove 5 cm of water within 24 hours.

   (b) Sub-surface drainage: Horizontal sub-surface drainage is provided in the form of perforated corrugated PVC pipes or open-jointed pipes with an envelope of gravel 2-3 m below the land surface. Chances of evaporation of water leading to accumulation of salts almost become nil in this method.

   The World Bank has funded sub-surface drainage system at Sampla, Rohtak (Haryana) for reducing soil salinity by this method.
3. **Irrigation Practices:** Surface irrigation with precise land leveling, smoothening and efficient hydraulic design help to reduce water logging and salinity. High frequency irrigation with controlled amount of water helps to maintain better water availability in the upper root zone. Thin and frequent irrigations have been found to be more useful for better crop yield when the irrigation water is saline as compared to few heavy irrigations.
4. **Selection of tolerant crops and crop rotations:** Tolerance of crops to salts is found to range from sensitive, semi-tolerant, tolerant to highly tolerant. Barley, sugar beet and date-palm are highly tolerant crops which do not suffer from any reduction in crop yield even at a

high salinity with electrical conductivity (EC) of 10 dS/m. Wheat, sorghum, pearl millet, soyabean, mustard and coconut are salt-tolerant crops. Rice, millets, maize, pulses, sunflower, sugarcane and many vegetables like bottle gourd, brinjal etc. are semi-tolerant. These different crop combinations can be grown on saline soils.

5. **Gypsum amendment:** Amendment of sodic soils with gypsum is recommended for reducing soil sodicity as calcium of gypsum replaces sodium from the exchangeable sites.
6. **Green-manures, fertilizers and biofertilizers:** Application of farm yard manure or nitrogen fertilizers have been found to improve saline soils. Green manuring with dhaincha (*Sesbania aculeata*) sunhemp or guar have also been reported to improve salt-affected soils. Blue green algae have been found to be quite promising as biofertilizers for improving salt-affected soils.
7. **Afforestation Programmes:** The **National Commission on Agriculture (NCA)** launched several afforestation schemes in the VIth plan to cope up with the problem of spreading wasteland. The National Wasteland Development Board, in the Ministry of Environment and Forests has set a target of bringing 5 million ha of wasteland annually under firewood and fodder plantation.
8. **Social Forestry Programmes:** These programmes mostly involve strip plantation on road, rail and canal-sides, rehabilitation of degraded forest lands, farm-forestry, waste-land forest development etc.

8.2 Consumerism and Waste Products

Consumerism refers to the consumption of resources by the people. While early human societies used to consume much less resources, with the dawn of industrial era, consumerism has shown an exponential rise. It has been related both to the increase in the population size as well as increase in our demands due to change in life-style. Earlier we used to live a much simpler life and used to have fewer wants. In the modern society our needs have multiplied and so consumerism of resources has also multiplied. Our population was less than 1 million for thousands of years ever since we evolved on this earth. Today we have crossed the six billion mark and are likely to reach 11 billion by 2045 as per World Bank estimates. Let us see how the changing population trends influence consumerism of natural resources and generation of wastes. Two types of conditions of population and consumerism exist.

A. **People over-population:** It occurs when there are more people than available supplies of food, water and other important resources in the area. Excessive population pressure causes degradation of the limited resources and there is absolute poverty, under-nourishment and premature deaths.

   This occurs in less developed countries (LDCs). Here due to large number of people, adequate resources are not available for all. So there is less per capita consumption although overall consumption is high.

B. **Consumption over-population:** This occurs in the more developed countries (MDCs). Here population size is smaller while resources are in abundance and due to luxurious life-style per capita consumption of resources is very high. More the consumption of resources more is the waste generation and greater is the degradation of the environment.

   This concept can be explained by using the model of Paul Ehrlich and John Hodlren (1972):

Number of People	×	Per Capita use of resources	×	Waste generated per unit of resource used	=	Over all Environmental Impact

   In LDC.s - No. of people is very high, but per capita use of resources and waste generated are less.

   In MDC.s - No. of people is low, but per capita use of resources and wastes generated are very high.

The overall environmental impact of these two types of consumerism may be same or even greater in case of MDC.s. Thus, consumerism varies with the country and USA is known for maximum consumerism. The throw-away attitude and luxurious life-style of the west results in very high resource use as compared to less developed countries. With every unit of energy, mineral or any resource used there is waste generation and pollution in the environment.

Parameter	Percent global values USA	India
Population	4.7%	16 %
Production of Goods	21%	1 %
Energy use	25%	3 %
Pollutants/wastes	25%	3 %
CFC's Production	22%	0.7 %

A comparison of USA and India can illustrate this point more clearly. The table shows that although the population of India is 3.4 times more than that of U.S.A. its overall energy use and waste generation are less than 1/8th that of USA. Thus more consumerism leads to more waste production.

8.3 Environmental Legislation

India is the first country in the world to have made provisions for the protection and conservation of environment in its constitution. On 5th June, 1972, environment was first discussed as an item of international agenda in the **U.N. Conference on Human Environment** in Stockholm and thereafter **5th June** is celebrated all over the world as **World Environment Day**. Soon after the Stockholm Conference our country took substantive legislative steps for environmental protection. The Wildlife (Protection) Act was passed in 1972, followed by the Water (Prevention and Control of Pollution) Act 1974, the Forest (Conservation) Act, 1980, Air (Prevention and Control of Pollution) Act, 1981 and subsequently the Environment (Protection) Act, 1986.

8.3.1 Constitutional Provisions

The provisions for environmental protection in the constitution were made within four years of Stockholm Conference, in 1976, through the 42nd amendment as follows :

- **Article 48-A of the constitution provides**: '*The state shall endeavour to protect and improve the environment and to safeguard forests and wildlife of the country'*.

- **Article 51A(g) provides:** '*It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures*'.

  Thus our constitution includes environmental protection and conservation as one of our fundamental duties. Some of the important Acts passed by the Government of India are discussed here.

8.3.2 Wildlife (Protection) Act, 1972

The act, a landmark in the history of wildlife legislation in our country, came into existence in 1972. Wildlife was transferred from State list to concurrent list in 1976, thus giving power to the Central Govt. to enact the legislation.

The Indian Board of Wildlife (IBWL) was created in 1952 in our country, which after the enactment of the Wildlife (Protection) Act actively took up the task of setting up wildlife National Parks and sanctuaries. The major activities and provisions in the act can be summed up as follows:

1) It defines the wild-life related terminology.
2) It provides for the appointment of wildlife advisory Board, Wildlife warden, their powers, duties etc.
3) Under the Act, comprehensive listing of endangered wild life species was done for the first time and prohibition of hunting of the endangered species was mentioned.
4) Protection to some endangered plants like Beddome cycad, Blue Vanda, Ladies Slipper Orchid, Pitcher plant etc. is also provided under the Act.
5) The Act provides for setting up of National Parks, Wildlife Sanctuaries etc.
6) The Act provides for the constitution of Central Zoo Authority.
7) There is provision for trade and commerce in some wildlife species with license for sale, possession, transfer etc.
8) The Act imposes a ban on the trade or commerce in scheduled animals.
9) It provides for legal powers to officers and punishment to offenders.
10) It provides for captive breeding programme for endangered species.

Several Conservation Projects for individual endangered species like lion (1972), Tiger (1973), Crocodile (1974) and Brown antlered Deer (1981) were started under this Act. The Act is adopted by all states in India except J & K, which has it own Act.

Some of the major drawbacks of the Act include mild penalty to offenders, illegal wild life trade in J & K, personal ownership certificate for animal articles like tiger and leopard skins, no coverage of foreign endangered wildlife, pitiable condition of wildlife in mobile zoos and little emphasis on protection of plant genetic resources.

8.3.3 Forest (Conservation) Act, 1980

This act deals with the conservation of forests and related aspects. Except J & K, the act is adopted all over India. The Act covers under it all types of forests including reserved forests, protected forests or any forested land irrespective of its ownership.

The salient features of the Act are as follows:

1) The State Govt. has been empowered under this Act to use the forests only for forestry purposes. If at all it wants to use it in any other way, it has to take prior approval of central Government, after which it can pass orders for declaring some part of reserve forest for non-forest purposes (e.g mining) or for clearing some naturally growing trees and replacing them by economically important trees (reforestation).

2) It makes provision for conservation of all types of forests and for this purpose there is an Advisory committee which recommends funding for it to the Central Government.

3) Any illegal non-forest activity within a forest area can be immediately stopped under this Act.

Non-forest activities include clearing of forest land for cultivation of any type of plants/crops or any other purpose (except re-afforestation). However, some construction work in the forest for wildlife or forest management is exempted from non-forest activity (e.g. fencing, making water-holes, trench, pipelines, check posts, wireless communication etc.)

1992 Amendment in the Forest Act

1) In 1992, some amendment was made in the Act which made provisions for allowing some non-forest activities in forests, without cutting trees or limited cutting with prior approval of Central Govt. These activities are setting of transmission lines, seismic surveys, exploration, drilling and hydroelectric projects. The last activity involves large scale destruction of forest, for which prior approval of the Centre is necessary.

2) Wildlife sanctuaries, National Parks etc. are totally prohibited for any exploration or survey under this Act without prior approval of Central Govt. even if no tree-felling is involved.

3) Cultivation of tea, coffee, spices, rubber and plants which are cash-crops, are included under non-forestry activity and not allowed in reserve forests.

4) Even cultivation of fruit-bearing trees, oil-yielding plants or plants of medicinal value in forest area need to be first approved by the Central Govt. This is because newly introduced species in the forest area may cause an imbalance in the ecology of the forest. If the species to be planted is a native species, then no prior clearance is required.

5) Tusser cultivation (a type of silk-yielding insect) in forest areas by tribals as a means of their livelihood is treated as a forestry activity as long as it does not involve some specific host tree like Asan or Arjun. This is done in order to discourage monoculture practices in the forests which are otherwise rich in biodiversity.

6) Plantation of mulberry for rearing silkworm is considered a non-forest activity. The reason is same as described above.

7) Mining is a non-forestry activity and prior approval of Central Govt. is mandatory. The Supreme Court in a case T.N. Godavarman Thirumulkpad Vs. Union of India (1997) directed all on-going mining activity to be ceased immediately in any forest area of India if it had not got prior approval of Central government.

8) Removal of stones, bajri, boulder etc. from river-beds located within the forest area fall under non-forest activity.

9) Any proposal sent to central govt. for non-forest activity must have a cost-benefit analysis and Environmental Impact statement (EIS) of the proposed activity with reference to its ecological and socio-economic impacts.

Thus, the Forests (Conservation) Act has made ample provisions for conservation and protection of forests and prevent deforestation.

8.3.4 Water (Prevention and Control Of Pollution) Act, 1974

It provides for maintaining and restoring the wholesomeness of water by preventing and controlling its pollution. Pollution is defined as *such contamination of water, or such alteration of the physical, chemical or biological properties of water, or such discharge as is likely to cause a nuisance or render the water harmful or injurious to public health and safety or harmful for any other use or to aquatic plants and other organisms or animal life*.

The definition of water pollution has thus encompassed the entire probable agents in water that may cause any harm or have a potential to harm any kind of life in any way.

The salient features and provisions of the Act are summed up as follows:

1) It provides for maintenance and restoration of quality of all types of surface and ground water.
2) It provides for the establishment of Central and State Boards for pollution control.
3) It confers them with powers and functions to control pollution. The Central and State Pollution Control Boards are widely represented and are given comprehensive powers to advise, coordinate and provide technical assistance for prevention and control of pollution of water.
4) The Act has provisions for funds, budgets, accounts and audit of the Central and State Pollution Control Boards.
5) The Act makes provisions for various penalties for the defaulters and procedure for the same.

The main regulatory bodies are the Pollution Control Boards, which have been, conferred the following duties and powers:

Central Pollution Control Board (CPCB):

- It advises the central govt. in matters related to prevention and control of water pollution.

- Coordinates the activities of State Pollution Control Boards and provides them technical assistance and guidance.
- Organizes training programs for prevention and control of pollution.
- Organizes comprehensive programs on pollution related issues through mass media.
- Collects, compiles and publishes technical and statistical data related to pollution.
- Prepares manuals for treatment and disposal of sewage and trade effluents.
- Lays down standards for water quality parameters.
- Plans nation-wide programs for prevention, control or abatement of pollution.
- Establishes and recognizes laboratories for analysis of water, sewage or trade effluent sample.

The **State Pollution Control Boards** also have similar functions to be executed at state level and are governed by the directions of CPCB.

- The Board advises the state govt. with respect to the location of any industry that might pollute a stream or a well.
- It lays down standards for effluents and is empowered to take samples from any stream, well or trade effluent or sewage passing through an industry.
- The State Board is empowered to take legal samples of trade effluent in accordance with the procedure laid down in the Act. The sample taken in the presence of the occupier or his agent is divided into two parts, sealed, signed by both parties and sent for analysis to some recognized lab. If the samples do not conform to the prescribed water quality standards (crossing maximum permissible limits), then .consent. is refused to the unit.
- Every industry has to obtain consent from the Board (granted for a fixed duration) by applying on a prescribed performa providing all technical details, along with a prescribed fee following which analysis of the effluent is carried out.
- The Board suggests efficient methods for utilization, treatment and disposal of trade effluents.

The Act has made detailed provisions regarding the power of the Boards to obtain information, take trade samples, restrict new outlets, restrict expansion, enter and inspect the units and sanction or refuse consent to the industry after effluent analysis.

While development is necessary, it is all the more important to prevent pollution, which can jeopardize the lives of the people. Installation and proper functioning of effluent treatment plants (ETP) in all polluting industries is a must for checking pollution of water and land. Despite certain weaknesses in the Act, the Water Act has ample provisions for preventing and controlling water pollution through legal measures.

8.3.5 The Air (Prevention And Control Of Pollution) Act, 1981

Salient features of the act are as follows:

1) The Act provides for prevention, control and abatement of air pollution.
2) In the Act, *air pollution has been defined as the presence of any solid, liquid or gaseous substance (including noise) in the atmosphere in such concentration as may be or tend to be harmful to human beings or any other living creatures or plants or property or environment*.
3) Noise pollution has been inserted as pollution in the Act in 1987.
4) Pollution control boards at the central or state level have the regulatory authority to implement the Air Act. Just parallel to the functions related to Water (Prevention and Control of Pollution) Act, the boards performs similar functions related to improvement of air quality. The boards have to check whether or not the industry strictly follows the norms or standards laid down by the Board under section 17, regarding the discharge of emission of any air pollutant. Based upon analysis report consent is granted or refused to the industry.
5) Just like the Water Act, the Air Act has provisions for defining the constitution, powers and function of Pollution Control Boards, funds, accounts, audit, penalties and procedures.
6) Section 20 of the Act has provision for ensuring emission standards from automobiles. Based upon it, the state govt. is empowered to issue instructions to the authority incharge of registration of motor vehicles (under Motor Vehicles Act, 1939) that is bound to comply with such instructions.
7) As per Section 19, in consultation with the State Pollution Control Board, the state government may declare an area within the state as "**air pollution control area**" and can prohibit the use of any fuel other than approved fuel in the area causing air pollution. No person shall, without prior consent of State Board operate or establish any industrial unit in the "air pollution control area".

The Water and Air Acts have also made special provisions for appeals. Under Section 28 of Water Act and Section 31 of Air Act, a provision for appeals has been made. **An Appellate Authority** consisting of a single person or three persons appointed by the Head of the State, Governor is constituted to hear such appeals as filed by some aggrieved party (industry) due to some order made by the State Board within 30 days of passing the orders.

The Appellate Authority after giving the appellant and the State Board an opportunity of being heard, disposes off the appeal as expeditiously as possible.

8.3.6 The Environment (Protection) Act, 1986

The Act came into force on Nov. 19, 1986, the birth anniversary of our Late Prime Minister Indira Gandhi, who was a pioneer of environmental protection issues in our country. The Act extends to whole of India. Some terms related to environment have been described as follows in the Act:

1) **Environment** includes water, air and land and the inter-relationships that exists among and between them and human beings, all other living organisms and property.
2) **Environmental pollution** means the presence of any solid, liquid or gaseous substance present in such concentration, as may be, or tend to be, injurious to environment.
3) **Hazardous Substance** means any substance or preparation which by its physico-chemical properties or handling is liable to cause harm to human beings, other living organisms, property or environment.

The Act has given powers to the Central Government to take measures to protect and improve environment while the state governments coordinate the actions. The most important functions of Central Govt. under this Act include setting up of:

a) The standards of quality of air, water or soil for various areas and purposes.
b) The maximum permissible limits of concentration of various environmental pollutants (including noise) for different areas.
c) The procedures and safeguards for the handling of hazardous substances.
d) The prohibition and restrictions on the handling of hazardous substances in different areas.

e) The prohibition and restriction on the location of industries and to carry on process and operations in different areas.
f) The procedures and safeguards for the prevention of accidents which may cause environmental pollution and providing for remedial measures for such accidents.

The power of entry and inspection, power to take sample etc. under this Act lies with the Central Government or any officer empowered by it.

For the purpose of protecting and improving the quality of the environment and preventing and abating pollution, standards have been specified under Schedule I- IV of Environment (Protection) Rules, 1986 for emission of gaseous pollutants and discharge of effluents/waste water from industries. These standards vary from industry to industry and also vary with the medium into which the effluent in discharged or the area of emission. For instance, the maximum permissible limits of B.O.D. (Biochemical Oxygen Demand) of the waste water is 30 ppm if it is discharged into inland waters, 350 ppm if discharged into a public sewer and 100 ppm, if discharged onto land or coastal region. Likewise, emission standards vary in residential, sensitive and industrial area. Naturally the standards for sensitive areas like hospitals are more stringent. It is the duty of the Pollution Control Board to check whether the industries are following the prescribed norms or not.

Under the **Environmental (Protection) Rules, 1986** the State Pollution Control Boards have to follow the guidelines provided under Schedule VI, some of which are as follows:

1) They have to advise the Industries for treating the waste water and gases with the best available technology to achieve the prescribed standards.
2) The industries have to be encouraged for recycling and reusing the wastes.
3) They have to encourage the industries for recovery of biogas, energy and reusable materials.
4) While permitting the discharge of effluents and emissions into the environment, the State Boards have to take into account the assimilative capacity of the receiving water body.
5) The Central and State Boards have to emphasize on the implementation of clean technologies by the industries in order to increase fuel efficiency and reduce the generation of environmental pollutants.

Under the Environment (Protection) Rules, 1986 an amendment was made in 1994 for **Environmental Impact Assessment (EIA)** of Various Development Projects. There are 29 types of projects listed under Schedule I of the rule which require clearance from the Central Government before establishing.

Others require clearance from the State Pollution Control Board, when the proposed project or expansion activity is going to cause pollution load exceeding the existing levels. The project proponent has to provide EIA report, risk analysis report, NOC from State Pollution Control Board, Commitment regarding availability of water and electricity, Summary of project report/feasibility report, filled in a questionnaire for environmental appraisal of the project and comprehensive rehabilitation plan, if more than 1000 people are likely to be displaced due to the project.

Under the Environment (Protection) Act, 1986 the Central Government also made the Hazardous Wastes (Management and Handling) Rules, 1989. Under these rules, it is the responsibility of the occupier to take all practical steps to ensure that such wastes are properly handled and disposed off without any adverse effects. There are 18 Hazardous Waste categories recognized under this rule and there are guidelines for their proper handling, storage, treatment, transport and disposal which should be strictly followed by the owner.

The Environment (Protection) Act, 1986 has also made provision for environmental Audit as a means of checking whether or not a company is complying with the environmental laws and regulations. Thus, ample provisions have been made in our country through law for improving the quality of our environment.

8.3.7 Enforcement of Environmental Legislation: Major Issues

We have seen that there are a number of important environmental laws in the form of Acts for safeguarding our environmental quality. But inspite of these acts, we find that we are not able to achieve the target of bringing 33% of our land cover under forests. Still we are losing our wild life. The rivers have been turned into open sewers in many places and the air in our big cities is badly polluted. The status of environment shows that there are drawbacks in environmental legislations and problems in their effective implementation.

Let us examine some important issues related to our acts:

a) Drawbacks of the Wildlife (Protection) Act, (1972)

- It seems as if the Act has been enacted just as a fallout of Stockholm Conference held in 1972 and it has not included any locally evolved conservation measures.
- The ownership certificates for animal articles (tiger, leopard skins etc.) are permissible which very often serve as a tool for illegal trading.
- The wildlife traders in Jammu and Kashmir easily get illegal furs and skins from other states which after making caps, belts etc. are sold or smuggled to other countries. This is so happening because J & K has its own Wildlife Act and it does not follow the Central Wild Life Act. Moreover, hunting and trading of several endangered species prohibited in other states are allowed in J & K, thereby opening avenues for illegal trading in such animals and articles.
- The offender of the Act is not subject to very harsh penalties. It is just upto 3 years imprisonment or a fine of Rs. 25,000 or both.

b) Drawbacks of the Forest (Conservation) Act, 1980: This Act has inherited the exploitative and consumerist elements from the Forest laws of British period. It has just transferred the powers from state to centre, to decide the conversion of reserve forest lands to non-forest areas. Thus power has been centralized at the top. At the same time, the local communities have been completely kept out from the decision-making process regarding the nature of use of forest area. Very often, the tribals who lived in the forest and were totally dependent on forests retaliate when stopped from taking any resources from there and start criminal activities including smuggling, killing etc. The Act has failed to attract public support because it has infringed upon the human rights of the poor native people. They argue that the law is concerned about protecting the trees, birds and animals, but is treating the poor people as marginal. *Very poor community participation in the Act remains one of the major drawbacks which affects proper execution of the Act.* The forest-dwelling tribal communities have a rich knowledge about the forest resources, their importance and conservation. But, their role and contribution is neither acknowledged nor honoured.

Efforts are now being made to make up for the gaps in laws by introducing the principles of Public trust or Human rights Protection.

8.3.7.1 Drawbacks of Pollution Related Acts

- The power and authority has been given to central government with little delegation of power to state government. Excessive centralization very often hinders efficient execution of the provisions of the Acts in the states. Illegal mining is taking place in many forest areas. In Rajasthan alone, about 14000 cases of illegal mining have been reported. It becomes more difficult to check such activities at the central level.
- The provision of penalties in the Act is very insignificant as compared to the damage caused by the big industries due to pollution. The penalty is much less than the cost of the treatment/pollution control equipments. This always gives a loose rope to the industries.
- The Act has not included the 'right to information' for the citizens. This greatly restricts the involvement or participation of the general public.
- The Environment (Protection) Act, 1986 regarded as an umbrella Act, encompassing the earlier two Acts often seems superfluous due to overlapping areas of jurisdiction. For instance Section 24 (2) of the new Act has made a provision that if the offender is punishable under the other Acts like Water Act or Air Act also, then he may be considered under their provisions. Interestingly, the penalty under the older two Acts is much lighter than the new Act. So the offender easily gets away with a lighter punishment.
- Under Section 19, a person cannot directly file a petition in the court on a question of environment and has to give a notice of minimum 60 days to the central government. In case no action is taken by the latter, then alone the person can file a petition which certainly delays the remedial action.
- Litigation, particularly related to environment is very expensive, tedious and difficult since it involves expert testimony, technical knowledge of the issues and terminologies, technical understanding of the unit process, lengthy prosecutions etc.
- The State Boards very often lack adequate funds and expertise to pursue their objectives.
- A tendency to seek to exercise gentle pressure on the polluter and out of the court settlements usually hinder the implementation of legal measures.

- For small units it is very expensive to install Effluent Treatment Plant (ETP) or Air pollution control devices and sometimes they have no other option but to close the unit. The Act should make some provision for providing subsidies for installing treatment plants or common effluent treatment plants for several small units.
- The pollution control laws are not backed by sound policy pronouncements or guiding principles.
- The position of chairman of the boards is usually occupied by political appointee. Hence it is difficult to keep political interference at bay.
- The policy statement of the Ministry of Environment and Forests (1992) of involving public in decision-making and facilitating public monitoring of environmental issues has mostly remained on paper.

Environmental policies and laws need to be aimed at democratic decentralization of power, community-state partnership, administrative transparency and accountability and more stringent penalties to the offender. There is also a need for environmental law education and capacity building in environmental issues for managers.

8.4 Public Environmental Awareness

Public awareness about environment is at a stage of infancy. Of late, some awareness has taken place related to environmental degradation, pollution etc. but incomplete knowledge and information and ignorance about many aspects has often led to misconceptions.

Development has paved the path for rise in the levels or standards of living but it has simultaneously led to serious environmental disasters. Issues related to environment have often been branded as antidevelopment. The wisdom lies in maintaining a balance between our needs and supplies so that the delicate ecological balance is not disrupted.

Some of the main reasons responsible for widespread environmental ignorance can be summed up as follows:

a) Our courses in Science, technology, economics etc. have so far failed to integrate the knowledge in environmental aspects as an essential component of the curriculum.

b) Our planners, decision-makers, politicians and administrators have not been trained so as to consider the environmental aspects associated with their plans.
c) In a zeal to go ahead with some ambitious development projects, quite often there is purposeful concealment of information about environmental aspects.
d) There is greater consideration of economic gains and issues related to eliminating poverty by providing employment that overshadows the basic environmental issues.

8.4.1 Methods to Propagate Environmental Awareness

Environmental awareness needs to be created through formal and informal education to all sections of the society. Everyone needs to understand it because ‘environment belongs to all’ and ‘every individual matters when it comes to conservation and protection of environment’.

Various stages and methods that can be useful for raising environmental awareness in different sections of the society are as follows:

(i) Among students through education: Environmental education must be imparted to the students right from the childhood stage. It is a welcome step that now all over the country we are introducing environmental studies as a subject at all stages including school and college level, following the directives of the Supreme Court.

(ii) Among the Masses through mass-media: Media can play an important role to educate the masses on environmental issues through articles, environmental rallies, plantation campaigns, street plays, real eco-disaster stories and success stories of conservation efforts. TV serials like *Virasat, Race to save the Planet, Heads and Tails, Terra-view, Captain planet* and the like have been effective in propagating the seeds of environmental awareness amongst the viewers of all age groups.

(iii)Among the planners, decision-makers and leaders: Since this elite section of the society plays the most important role in shaping the future of the society, it is very important to give them the necessary orientation and training through specially organized workshops and training programmes.

Publication of environment - related resource material in the form of pamphlets or booklets published by Ministry of Environment & Forests can also help in keeping this section abreast of the latest developments in the field.

8.4.2 Role of Non-Government Organisations (NGO's)

Voluntary organizations can help by advising the government about some local environmental issues and at the same time interacting at the grass-root levels. They can act as an effective and viable link between the two. They can act both as an '**action group**' or a '**pressure group**'. They can be very effective in organizing public movements for the protection of environment through creation of awareness.

The '**Chipko Movement**' for conservation of trees by **Dasholi Gram Swarajya Mandal** in Gopeshwar or the '**Narmada Bachao Andolan**' organized by **Kalpavriksh**, are some of the instances where NGO's have played a landmark role in the society for conservation of environment.

The **Bombay Natural History Society (BNHS), the World Wide Fund for Nature - India (WWF, India) Kerala Sastra Sahitya Parishad, Centre for Science and Environment (CSE)** and many others are playing a significant role in creating environmental awareness through research as well as extension work. The recent report by CSE on more than permissible limits of pesticides in the cola drinks sensitized the people all over the country.

Before we can all take up the task of environmental protection and conservation, we have to be environmentally educated and aware. It is aptly said "**If you want to act green, first think green**".

8.5 Check Your Progress

A. Fill in the blanks:

1. Environmental Protection Act came into force in the year 1986 on birth anniversary of ………… .
2. Average global temperature is 15°C. In the absence of greenhouse gases the temperature would have been ……. .

3. The atmospheric emissions of NO_2 and ……. cause acid rains.
4. ………….. Act provides for setting up of National Parks and wildlife sanctuaries.
5. Noise has been included as pollution in the Air (Prevention and Control of Pollution) Act, 1981 in the year ……… .

B. Choose the correct option:

1. First of the major environmental protection acts to be promulgated in India was
   a) The water act
   b) The air act
   c) The environment act
   d) Noise pollution rules
2. Environment Protection act came into force in the year
   a) 1982
   b) 1987
   c) 1986
   d) 1983
3. The most important Greenhouse gas that is being affected by human activities and results in global warming is
   a) carbon dioxide.
   b) water vapour.
   c) methane.
   d) nitrous oxide.
4. The two acidic oxides mainly responsible for acid rain are
   a) sulphur dioxide and nitrous oxide.
   b) sulphur dioxide and sulphur trioxide.
   c) sulphur trioxide and nitrogen dioxide.
   d) sulphur dioxide and nitrogen dioxide.
5. Acid rain is any rain with pH
   a) below 5.6.
   b) above 5.6.

   c) equal to 5.6.
   d) exactly equal to 7.
6. Chlorofluorocarbons and freons are
   a) used as coolants in refrigerators.
   b) air conditioners.
   c) responsible for ozone layer depletion.
   d) All of the above.
7. The NGOs
   a) play a significant role in environmental protection.
   b) mainly work at the grass root level.
   c) act as the eyes and ears of the government.
   d) All of the above.
8. The United Nations Conference on Human Environment was organized at
   a) Rio de Janiero.
   b) Paris.
   c) Stockholm.
   d) Delhi.
9. …………… is a widely recognized study of environmental impacts on developmental projects
   a) Environmental Impact Assessment (EIA)
   b) Environmental Risk Assessment (EIA)
   c) Environmental Impact Statement (EIS)
   d) Environmental Management System (EMS)
10. Which article in constitution recognizes environmental protection as one of the fundamental duties of every citizen of India?
   a) Article 42
   b) Article 48A
   c) Article 51A(g)
   d) Article 52

8.6 Summary

- *In India, climate change has caused tremendous changes in the weather patterns across different parts of the country.*
- *The enhanced greenhouse effect will not only cause global warming but will also affect various other climatic and natural processes.*
- *India is the first country in the world to have made provisions for the protection and conservation of environment in its constitution.*
- *Article 48-A of the constitution provides: 'The state shall endeavour to protect and improve the environment and to safeguard forests and wildlife of the country'.*
- *Article 51A(g) provides: 'It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures'.*
- *Consumerism refers to the consumption of resources by the people. While early human societies used to consume much less resources, with the dawn of industrial era, consumerism has shown an exponential rise.*
- *Under the Environment (Protection) Rules, 1986 an amendment was made in 1994 for Environmental Impact Assessment (EIA) of Various Development Projects.*
- *Environmental policies and laws need to be aimed at democratic decentralization of power, community-state partnership, administrative transparency and accountability and more stringent penalties to the offender. There is also a need for environmental law education and capacity building in environmental issues for managers.*
- *On 5th June, 1972, environment was first discussed as an item of international agenda in the U.N. Conference on Human Environment in Stockholm and thereafter 5th June is celebrated all over the world as World Environment Day.*
- *The Environment (Protection) Act, 1986 not only has important constitutional implications but also an international background.*

8.7 Keywords

- **Acid rain:** It is rain consisting of water droplets that are unusually acidic because of atmospheric pollution - most notably the excessive amounts of sulphur and nitrogen released by cars and industrial processes.
- **Climate Change:** Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years.
- **Global Warming:** It is an increase in the average temperature of the earth's atmosphere, especially a sustained increase sufficient to cause climatic change.
- **Environmental ethics** refers to the issues, principles and guidelines relating to human interactions with their environment.
- Troposphere, the lowermost layer of the atmosphere, traps heat by a natural process due to the presence of certain gases. This effect is called **Green House Effect.**
- Economically unproductive lands suffering from environmental deterioration are known as **wastelands**. The wastelands include salt affected lands, sandy areas, gullied areas, undulating uplands, barren hill-ridge etc.

8.8 Self-Assessment Test

1. Write notes on
   a) role of NGO's in environmental protection and management.
   b) environmental ethics
2. Briefly discuss the salient features of wildlife protection act.
3. Write short notes on the following acts
   a) Water (prevention and control of pollution) Act, 1974
   b) Forest (conservation) Act, 1980
4. Write an elaborate note on the salient features of Environmental protection act.
5. Briefly describe the role of central and state pollution control boards in controlling pollution.
6. What are the issues involved in enforcement of environment legislation?

7. What is acid rain? What are its causes and effects?
8. Discuss various measures for wasteland reclamation.
9. "Population, consumerism and waste production are interrelated" – Comment.
10. Write short notes on:
    a) The Air (Prevention and Control of Pollution) Act, 1981.
    b) The Environment (Protection Act), 1986.
11. Write short notes on:
    a) Greenhouse gases.
    b) Global warming and its control.
12. What are the different methods to propagate environmental awareness in the society?

8.9 Answers to check your progress

A. Fill in the blanks:

1. Smt.Indira Gandhi 2. -18°C 3. SO_2 4. Wildlife (Protection) 5. 1987

B. Choose the correct option:

1. a) 2. c) 3. a) 4. d) 5. a) 6. d) 7. d) 8. c) 9. a) 10. c)

8.10 References/ Suggested Readings

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Subject Code: EVS-201_L	Vetter: Prof. Parveen Sharma

HUMAN POPULATION AND THE ENVIRONMENT: POPULATION GROWTH, EXPLOSION, HUMAN RIGHTS, HIV/AIDS, WOMEN AND CHILD WELFARE AND ROLE OF IT IN ENVIRONMENT AND HUMAN HEALTH

Structure

9.0 Learning Objectives

After studying this unit, you should be able to:

- *Describe human population and the environment.*

- *Explain population growth variation among nations.*
- *Explain population explosion.*
- *Describe family welfare programmes.*
- *Define environmental and human health, human rights and value education.*
- *Define HIV/AIDS, women and child welfare.*
- *Describe the role of information technology in the environment and human health.*

9.1 Population

Population is defined as the number of individuals of same species in a given area at a given time. **Population dynamics** refers to change of population with time. **Demography** is the statistical study of human population. It deals with (i) Changes in population size (growth or decline) (ii) Composition of the population (age groups, sex ratio) (iii) Distribution of population.

Current World population is **7.8 billion** (May 2015). World population exceeded 7 billion in March 2012. World population was around 1 billion in 1810. It became 7 times in past 200 years.

Current Indian population:	**1.21 billion (2011 census)**
Indian population growth rate:	**1.41% (ranked 102nd in the world in 2010)**
Birth rate:	**22.22 births/1,000 population**
Death rate:	**6.4 deaths/1,000 population**
Life expectancy:	**69.89 years**
–male:	**67.46 years**
–female:	**72.61 years**
Fertility rate:	**2.5 children born/woman**
Infant mortality rate:	**30.15 deaths/1,000 live births**
Most populated city:	**Mumbai (12.5 million)**
Population of Chennai:	**4.6 million (2011 census)**

Demographics of India

One out of every seven person in the world is an Indian. 75% of the population of India lives in the villages.

9.1.1 Population Characteristics

1. **Nature of Population growth**

   Population growth refers to the variation in population (increase or decrease) with time. Negative growth leads to decrease in population. Three types of population growth has been observed.

   a) Exponential growth
   b) Logistic growth
   c) Zero growth

a) Exponential growth:

If a population has a constant birth rate and no other factors like food or disease influence the population, then exponential growth is observed. In this case, birth rate alone controls the population. Example: growth in bacteria, some insects etc. It can be represented mathematically as, $\mathbf{P = P_0e^{rt}}$, where **P** is future population after **t** years, $\mathbf{P_0}$ is the present population, **r** is the annual growth rate. The curved obtained is 'J' shaped curve.

b) Logistic Growth:

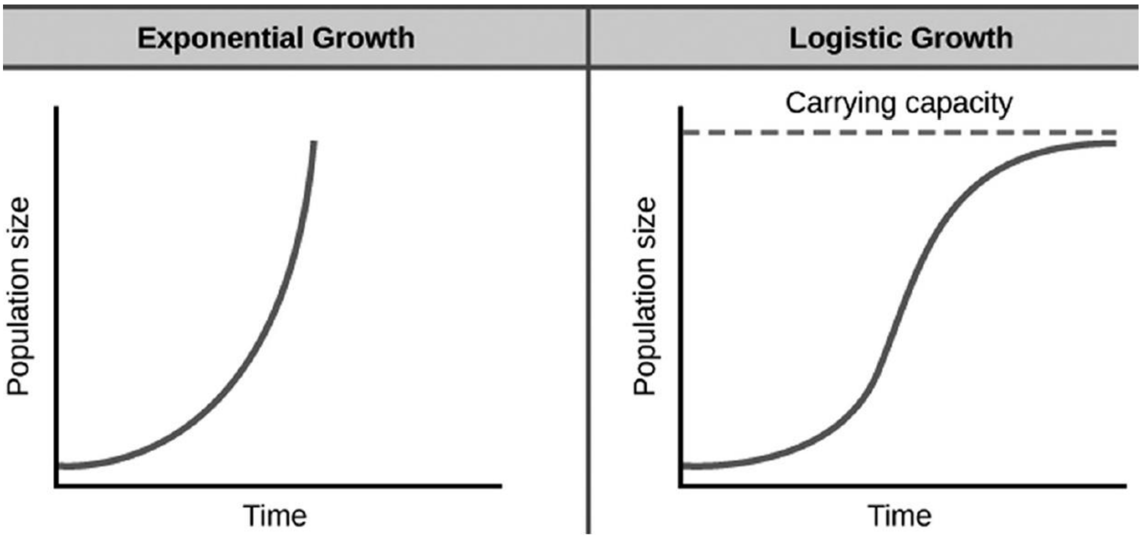
The logistic curve shows three phases

Lag phase: slow growth

Exponential phase: rapid growth

Stationary phase: stable growth

The curve is 'S' Shaped. In most real populations both food and disease become important factors to check population growth. Environment cannot support indefinite number of individuals. The maximum number it can support is determined by the "carrying capacity" of the environment. Carrying capacity of environment is defined as the number of species (humans, plants, animals) that it can support without environmental degradation.



c) **Zero (population) growth**

More developed countries (MDC) show zero population growth. This happens when birth rate becomes equal to death rate.

2. **Population Dispersion**

It describes how individuals are distributed themselves in their habitats. Three types of dispersion are seen:

a) **Uniform Dispersion:** Species are evenly distributed about their habitat.

- Species has the ability to survive anywhere in the habitat.
- This kind of distribution is more seen in plants so that there is less competition for water and nutrients as they are widely spaced.
- Animals like penguins show territorial behaviour.
- Example: Arrangement of shrubs in deserts.

b) **Random Distribution:** Population found randomly about their habitat.

- Individual have been distributed by chance
- Natural resources are distributed randomly, so animal populations which depend on them are also randomly distributed.
- Example: Dandelions grow randomly.

c) **Clumped Dispersion:** Population are clustered together (high density patches). This is the most common population distribution in nature.

- Caused by a number of factors: species are together for protection, species are grouped around natural resources necessary to their survival.
- Example: Herd of lions, flock of birds.

3. **Population Doubling Time**

Population doubling time is the time needed for a population to double its size at a constant annual growth rate. $\mathbf{T_d = 70/r}$, where T_d-doubling time in years (r- annual growth rate).
For example if a country has annual growth rate of 2%, its population doubling time will be 70/2 = 35 years.

4. **Total Fertility rate (TFR)**

Total fertility rate is the average number of children that would be born to a woman in her lifetime. TFR is almost 2 in most developed nations and around 5 in developing nations or less developed nation. In our country TFR was 6.1 in 1950 and currently it is 2.6 (2011 census).

5. **Crude birth rate**

Crude birth rate is the number of live births occurring during the year, per 1,000 people.

$$\text{Crude birth rate} = \frac{\text{Number of live births}}{\text{Estimated midyear population of that year}} \times 1000$$

6. **Mortality rate**

Mortality rate is the number of deaths per thousand of individuals in a year. Decrease in mortality rate will increase population. Due to technological advancements, better medical facilities and better literacy rate, the mortality rate has gone down in many countries.

7. **Infant mortality rate**

It is the number of infants dying before reaching one year of age, per 1,000 live births. The rate has declined in the last 50 years in our country.

8. **Crude death rate**

It is the number of deaths in a particular year per thousand people in a particular region.

$$\text{Crude death rate} = \frac{\text{Number of deaths}}{\text{Estimated midyear population of that year}} \times 1000$$

9. Replacement level

Replacement level is number of offsprings replacing two parents. For a developing nation this is always greater than 2, while for a developed country it is mostly under 2.

10. Migration

Migration is the movement of individuals into (immigration) or out of place (emigration) or country. People migrate from one place to another for better economic and social life.

11. Female –Male sex Ratio

Sex-ratio is the number of females per thousand males. Due to female infanticide and gender-based abortions, ratio has declined in many developing countries including India (933 : 1000).

12. Life expectancy

Life expectancy is the average age that a newborn infant is expected to attain in a given country.

13. Demographic transition

Demographic transition is the correlation between population growth and industrialization or economic development.

Demographic transition occurs in four phases:

(a) Pre industrial phase: This is characterized by high growth and death rates and overall increase in population is low.

(b) Transitional phase: Industrialization begins. Better hygiene, medical facility and food results in decreased death rate. Birth rate remains high. Most of the developing countries are currently in this phase.

(c) Industrial phase: Birth rate drops. Many developed countries are currently in this stage. A few developing countries have entered this phase.

(d) Post-industrial phase: Birth rate drops further and zero population growth is achieved. Many European countries are in this stage now. In some cases, population even declines.

14. Carrying capacity:

Carrying capacity is the number of individuals of a species that can be indefinitely sustained in a given area without harming the habitat. It depends and varies with the habitat. If growth exceeds carrying capacity, environmental resistance lower population size and population enter the death phase. Species will become threatened, endangered or extinct.

For example, in an aquarium if we introduce more fishes, the carrying capacity will be exceeded which result in the collapse of entire ecosystem.

15. Environmental Resistance:

Environmental resistance is any factor in the environment limiting carrying capacity.

9.1.2 Variation of Population Among Nations

World population has crossed 7 billion. The existing population is not uniformly distributed. Less developed countries have 75% of world's population while developed countries have only 25%.

9.1.2.1 Population Pyramid

Variation in population can be easily represented with the help of a population pyramid. A population pyramid represents the age and sex structure of a population. The shape of the pyramid reflects the characteristics of a population.

- Graphs are on their sides with the axis in the middle. Population plotted on the X-axis and age on the Y-axis. The number of males is shown on the left, females on the right in five-year age groups.
- Different age classes are pre-productive (0-14 yrs) reproductive (15–44 yrs) and post-productive (45yr and above)

Information derived from Population Pyramids

The following information can be obtained from population pyramids

- Birth and death Rate

- Life expectancy
- Sex ratio
- Fertility Rate
- Infant Mortality Rate
- Can relate to social and economic problems of the nation.

Based on the shape of the population pyramid there are three types of population pyramids

1. Pyramid Shaped
2. Bell shaped
3. Urn shaped

1. Pyramid Shaped: (Growing population)-Least Developing Countries

Characteristics:

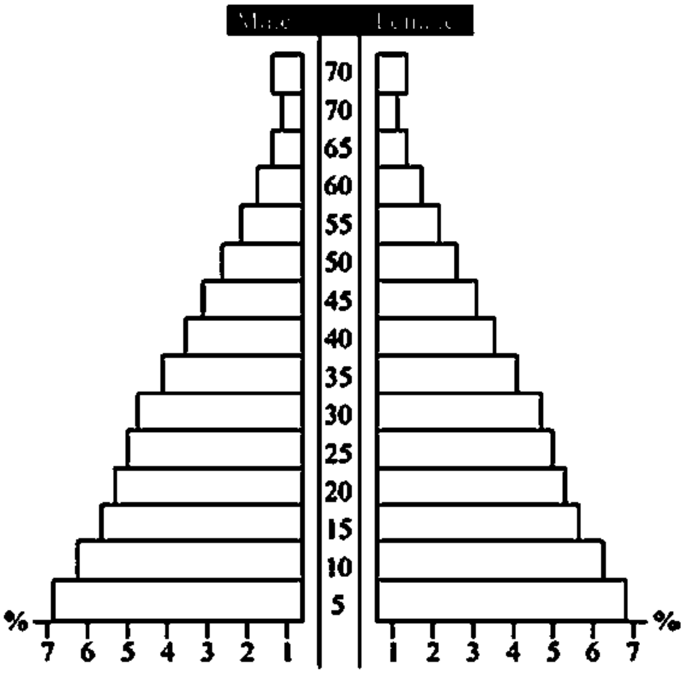
- Pyramid has a broad base and narrowing as it goes higher.
- Very young population is more and old people are less.
- Young individuals will soon enter into reproductive age resulting an increase in population.
- As the number of older people are less, death rate is less.
- This type of behaviour is characteristic of developing countries indicated by

  i. High Birth rate

  ii. Percentage of young population is higher.

  iii. Slow/moderate but steady growth rate.

- Developing countries like Congo, Philippines, Ethiopia, Nigeria etc.



2. Bell Shaped (Stable or zero population growth):

Characteristics

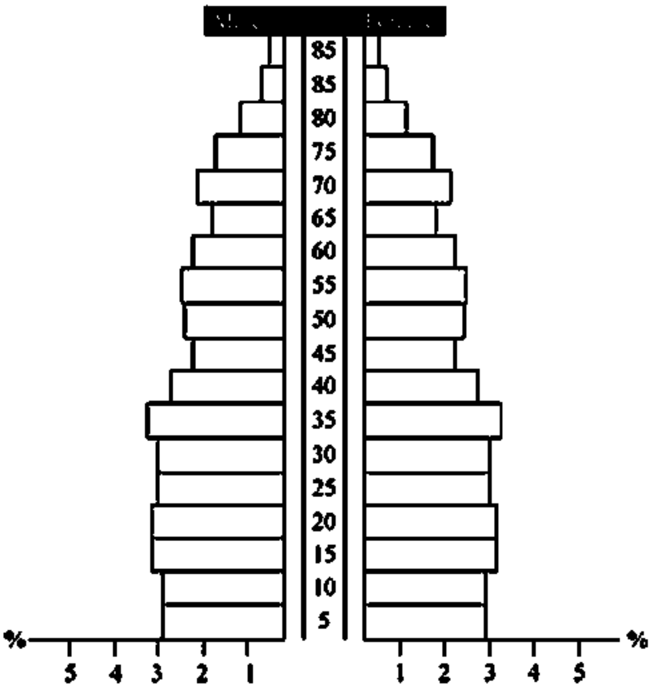
- It is bell shaped pyramid.
- It is characterized by almost equal birth and death rates.
- Birth rate is low, so the number of people in between 0-35 years remains almost the same. Number of individuals entering into reproductive age group remains almost the same. These pyramids indicate **stable** population results in zero population growth.
- Many developed countries follow this type of population behaviour. It is characterized by

  i. Declining Fertility

  ii. Declining Mortality

  iii. Moderate Growth Rate

- Countries like Finland, France have this kind of population growth.



3. Urn Shaped (Negative growth)

Characteristics

- This pyramid has a narrow base and narrow top.
- Declining birth and death rates.
- People in post-reproductive phase is higher hence there is a decline in the population.
- These are future developed countries characterised by

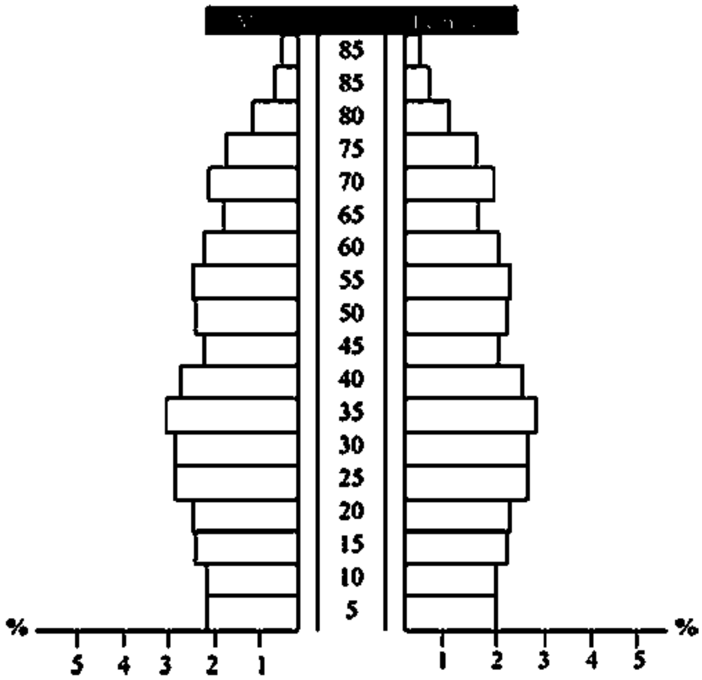
  i. Low fertility

  ii. Low Mortality

  iii. Ceasing Growth Rate

  iv. Very old Population

- Germany, Italy, Hungary, Sweden, Japan have this type of population pyramid.



9.1.3 Population Explosion

Population explosion is the rapid and significant increase in the size of a population caused by such factors as a sudden decline in infant mortality, death rate or an increase in life expectancy.

9.1.3.1 Causes of Population Explosion

ii) **Better health care facilities:** In the past few decades there has been a remarkable improvement in the health facilities which resulted in the decrease of mortality rates.

iii) **Increased food productivity and distribution:** Green revolution, use of scientific methods in agriculture resulted in increased food production which could feed millions. In other words, famine and drought incidents reduced considerably.

iv) **Illiteracy and lack of awareness about family planning concepts:** Due to illiteracy, many people in the under-developed countries still remain ignorant of family planning techniques.

v) **Believes and cultural reasons:** In many middle east countries, polygamy is common. Number of male children is of family prestige and pride. So parents prefer to have as many off springs (preferably male) as possible. Many parents believe that more children are needed to take care of them at their old age.

vi) **Eradication/control of diseases:** Many diseases like small pox have been eradicated completely. Other diseases like plague, polio, malaria is under check in many countries. Earlier, these diseases used to wipe out entire city.

vii) **Government and other agencies funding:** Many agencies like WHO, World bank, UNO and other agencies monitor the progress of many under developed countries by releasing funds for improved health facility, better living conditions. Many schools in India have adopted free mid day meal program which reduce poverty and starvation.

9.1.3.2 Consequences of population explosion

- **Inadequate fresh water:** Population explosion can lead to severe shortage of drinking water, especially in semi-dry or dry areas.
- **Depletion of natural resources:** It can lead to over exploitation of many natural resources (water, forest, mineral, food, energy, soil etc.).
- **Pollution:** More number of people will result in severe environmental pollution (air, water, soil, marine, noise etc.).
- **Deforestation:** Forests will be cleared for human settlement, agriculture etc. Deforestation causes extinction of rare and endangered species.
- **Poverty, malnutrition and starvation:** Shortage of food and drinking water among people can result in poverty and malnutrition.
- **Emergence of new epidemics and diseases:** Malnutrition along with unhygienic living conditions and lack of good healthcare facility can result in the emergence of epidemics
- **Unemployment issues, Lower wages:** Population explosion can result in serious unemployment issues as the number of people having minimum education will be more. Severe competition may result in the underpayment.
- **Climate change:** Growing population can result in the increase of greenhouse gases which can
  result in global warming.
- **Migration:** Population explosion may result in the migration of people from one place to another in search of food, water and facilities.

9.1.3.3 Control of Population Explosion

- Adoption of any family planning methods
- Late marriage reduce the fertility rate

- Health and sanitation
- Recreation facilities
- Emigration to other countries in search of better opportunities.
- Educating the youth about the problems associated with population explosion.
- High standard of living
- Creating awareness

9.2 Environment and Human Health

World health organisation (WHO) defines **health** as a state of complete physical, mental and social well-being and not merely the absence of diseases or infirmity. Environment and human health are very much related. Degradation of environment and poor living conditions may result in being sick. Some health issues related to environment are

a) Infectious Diseases
b) Disposal of Chemicals
c) Pesticide and heavy metal contamination
d) Occupational hazards
e) Noise
f) Radiation
g) Food
h) Settlement

a) **Infectious diseases**

Unhygienic conditions of environment forms the breeding grounds for various deadly diseases causing organism like virus, bacteria, vectors etc. This scenario is more common in the developing countries. Infectious organisms cause food poisoning, respiratory diseases and gastrointestinal diseases.

- **Water-borne(Polluted water):** Cholera, Dysentery, Amoebiosis, Hepatitis
- **Air-borne(Polluted air):** Asthma, Bronchitis, Pneumonia, Tuberculosis
- **Food-borne(Food-poisoning):** Cholera, Dysentery
- **Vector-borne:** Malaria, Typhoid, Filaria
- **Animal-borne:** Plague

b) **Disposed Chemicals**

A large number of chemicals are introduced in the environment by human activities. Chemicals can be hazardous (Example: explosives and inflammable chemicals), Carcinogenic (Example: aromatic hydrocarbons like benzene, various amines etc.), Mutagenic (Example: Polycyclic aromatic hydrocarbon, benzene) etc.

c) **Pesticide and heavy metal contamination**

Many pesticides can cause severe physiological problems. They can cause cancer, tumors, deformation of body parts, inhibit hormones in humans and other species and affect reproduction etc. Chemicals like DDT and other chlorinated pesticides accumulate in food chain and concentrate in body tissues as it goes to top of the food chain. Heavy metals, arsenic, chromium, lead, mercury can cause severe health issues.

d) **Occupational Hazards**

Workers in various factories, mines, construction of dams, buildings, commercial forms, forestry and agriculture are exposed to risks, especially health hazards Dust (lung diseases), dust contaminating free silica (silicosis), finest fibres of asbestos (asbestosis).

e) **Noise**

Sound levels beyond the permissible level of human ear may damage ears. Prolonged exposure to noise can cause hearing impairment, hypertension, heart diseases etc. It can affect pregnant mothers and their foetus.

f) **Radiation**

Cosmic and ultraviolet rays cause harmful effects on human health which may include cancer.

g) **Diet**

Contamination of food can cause indigestion, food poisoning and other various ill effects. Undernutrition or malnutrition makes humans prone to other diseases.

h) **Settlement**

Improper settlement and poor hygiene around settlement can cause various psychological problems.

9.2.1 Family Planning

Family planning is the planning of when to have children, how many children to have and the use of birth control and other techniques to implement such plans. Family planning allows couples to decide their family size and also the age interval between two offsprings. In short, family planning means a deliberate attempt to limit the size of family.

Following are some of the important family planning measures:

- **Use of contraceptives (Mechanical, Chemical methods):**
  Contraception means the prevention of pregnancy. There are many contraceptive techniques available for use.
- **Mechanical method**
  - **Condom (For male's use):** The condom is a thin sheath of rubber, which is put over the erect penis. Condom prevents sperms reaching the vagina during ejaculation. It is a cheap and effective method for family planning. It also protects from many sexually transmitted diseases by avoiding direct skin to skin contact.
  - **Diaphragm (For female's use):** The diaphragm is a rubber cup stretched over collapsible metal spring coil. It is designed to fit over the cervix (the mouth of uterus).
  - **Intrauterine Contraceptive Device (IUD):** It is a small metal or plastic device, which is designed to fit inside the uterus mouth. A doctor must fit and remove IUD. Example: Copper T
- **Chemical Method**
  - **Jellies, creams and foam:** Jellies, creams and foams are used as contraceptive agents. These jellies, creams or foams have germicidal power and kill sperms. They are applied on to vagina five to fifteen minutes before copulation to take place.
  - **Oral contraceptive:** These are popularly known as birth control pills or simply pills. It contains hormones (estrogens and progesterone) which suppress the production of ovum. Example: mala D.
  - **Sterilization:** It is surgical technique by which the passage of sperms or ovum is disconnected. Both men and women can be sterilized without loosing their ability to function sexually.
- **Vasectomy:** In man, the sterilization procedure is called a vasectomy. In this procedure the vasa deferentia, the tubes that lead from the testes to the ejaculatory ducts, are cut so that the sperm produced in the testis cannot reach the ejaculatory ducts to ejaculate.
- **Tubectomy:** In females, tubectomy is done. In this procedure, the fallopian tubes, which transport the egg from the ovaries to the uterus are cut and tied off.

9.2.2 Women and Child Welfare

Women and child development is of great importance in the socio-economic growth of any country because of following reasons.

i) They form high priority group as they form 70% of population in developing countries (65% in India)
ii) They constitute vulnerable or special risk as soft, weak, prone to diseases easily and most of them are economically depended on their spouse or parents.

In recent years, the **empowerment of women** has gained considerable interest. **National Commission for Women** was set up by an Act of Parliament in 1990 to protect the rights of women. Reservation of seats in the local bodies of Panchayats and Municipalities for women were made mandatory to involve women in decision making at the local levels.

Rights and Privileges of women

- Men and women have equal rights and opportunities in the political, economic and social spheres.
- Equal protection of law,
- Prohibit discrimination against any citizen on grounds of religion, race, caste, sex or place of birth,
- Securing all citizens, men and women, equally, the right to means of livelihood
- Equal pay for equal work
- Humane conditions of work and maternity relief.

Important Social Legislation relating to Women

- The Child Marriage Restraint (Amendment) Act, 1976
- The Equal Remuneration Act, 1976
- The Medical Termination of Pregnancy Act, 1971
- The Dowry Prohibition Act, 1961
- Family Courts

Policies Concerning Women's development

- The National Plan of Action for Women (NPA) was adopted in 1976.
- The National Perspective Plan for Women (NPP) aims at holistic approach for the development of women.
- National Policy for the Empowerment of Women (2001)

National Policy for the Empowerment of Women (2001)

The policy aims at:

- The advancement, development and empowerment of women in all spheres of life.

- Ensuring women's equality in power sharing and active participation in decision-making.
- Comprehensive economic and social empowerment of women.
- Partnership with community-based organizations.
- Implementation of international commitments and cooperation at the international, regional and sub-regional levels.

Various other schemes for women welfare

- **Balika samridhi yojana (1997)** – to encourage enrolment & retention of girl child in schools by providing free education for girl child along with a financial grant to the family below poverty line.

  Current Prime minister of India, Sri Narendra Modi has introduced and initiated many new schemes for women. Some are the following.
- **Beti Bachao Beti Padhao** (save girls, teach girls) in Haryana
- **Sukanya Samriddhi Accounts:** This account can be opened on a girl child's name by her natural (biological) parents or legal guardian.

Child welfare in India

The welfare of children is of utmost importance in the country's developmental agenda. Children are our supreme assets and also the future human resources of the country

Legislative measures and policies:

- Child Labour (Prohibition & Regulation Act) (1986): An Act to prohibit child labour in certain employments and to improve the conditions of work of children in certain other employments.
- The Child Marriage Restrain Act, 1929 -to abolish and eliminate child marriage.
- The Juvenile Justice (Care and Protection of Children) Act, 2000.
- The Commissions for Protection of Child Rights Act, 2005
- The National Policy for Children (1974): This Policy aims at providing adequate services towards children, both before and after birth and during the growing stages for their full physical, mental and social development.

Constitutional Provisions for children

- Free and compulsory education to all children of the age of six to fourteen years
- Prohibits trafficking of human beings and forced labour.

- Prohibits employment of children below the age of fourteen years in factories, mines or any other hazardous occupation

Other Schemes for Children welfare

Schemes/Projects Programmes being implemented by the **Ministry of Women and Child Development** are as under:

- Integrated Child Development Services (ICDS) Scheme
- Rajiv Gandhi National Creche Scheme for the children of working mothers
- Gramodya Yojana and Nutrition Programme for Adolescent Girls
- Integrated Programme for Juvenile Justice
- Balwadi Nutrition programmaes (1970-71) -to provide nutrition, informal schooling for providing early education to children of 3-5yrs
- Child labour eradication scheme (1984) -to shift child labour from hazardous jobs into schools
- Mid day Meal scheme for school children (1995) -To provide free mid day meal to primary school children in the country

Integrated Child Development Scheme (ICDS) -Launched in 1975

Objectives of ICDS:

- Proper psychological and overall development of the child
- Improve nutritional and health status of children 0-6 years
- Reduce incidence of mortality, morbidity, malnutrition and school drop-outs
- Enhance the capability of the mother and family to look after the health, nutritional and development needs of the child
- Achieve effective coordination of policy and implementation among various departments to promote child development

A few of the organisations who work with children’s rights in India are Plan India, CRY (Child Rights and You), Save the Children, Bal Vikas Dhara-New Delhi, Bachpan Bachao Andolan.

9.2.3 HIV / AIDS

HIV: HIV (Human Immunodeficiency Virus) is a virus that causes AIDS (Acquired Immuno-deficiency Syndrome). AIDS is a health condition in which a person is easily vulnerable and affected by a series of diseases due to poor immunity.

HIV by itself is not an illness and does not instantly lead to AIDS.

AIDS: Acquired Immunodeficiency Syndrome is a health condition that results from the deficiency in the body's immunity following HIV infection. It is a break down the body's immune system leaving the patient to a number of life threatening infections

Origin of HIV/AIDS

AIDS was discovered in 1983. Though definite source of this virus is not known, some theories have been suggested. It is generally believed that HIV has been transferred to humans from African monkeys.

Transmission of HIV

- Contaminated Fluids: Contamination of blood stream with HIV infected body fluids, particularly blood, semen, breast milk and vaginal fluid.
- Sharing of needles: Sharing of HIV contaminated needles in blood transfusion.
- Unprotected sex: By sexual contact with affected person
- Maternal-fetal transmission: Infected mother give birth to infected baby. Breast milk can also act as a transmission-medium.
- Improperly sterilized hospital tools: If surgical devices like syringes and scalpels, or even certain instruments, used on an infected person, are used on another person without proper sterilization. Contaminated needles or syringes used drugs. can cause infection.

HIV is not spread by

- Physical touch of infected persons
- Air borne- by means of sneezing or coughing
- Water borne -by means of saliva, tears etc.

Mechanism of HIV infection

- HIV is a retro virus which damages immune system by destroying lymphocytes (white blood cell), helper T cell.

Development of HIV:

- Incubation period is longer- an average of eight years
- During the incubation period, the virus will be multiplying, infecting and killing cells of the immune system

Four Stages of infection

- Initial Infection:destruction of helper T cells or lympocytes
- Asympotic or incubation period

- AIDS related complex (ARC)
- Final stage- Fully infected AIDS patients receiving different kinds of infection

What are the early and later symptoms of HIV/AIDS?

- Many people do not develop any symptoms when they first become infected with HIV.
- More persistent or severe symptoms may not surface for several years, even a decade or more.

Symptoms at later stage

- Lack of energy
- Rapid weight loss.
- Frequent fevers and sweats
- Fatigue combined with headaches and dizziness
- Long-lasting bouts of diarrhoea
- Swelling or hardening of glands located in the throat, armpit, or groin
- Increasing shortness of breath

How is HIV diagnosed?

Two types of tests are available to diagnose HIV infection :

1. Study the presence of antibodies produced by body in response to HIV

- ELISA (Enzyme Linked Immuno sorbent Assay),
- Western Blot (WB)
- Immunoflouroscent Assay (IFA).
- Saliva and Urine test

2. Study the presence of virus itself.

- **Polymerase Chain Reaction (PCR)** looks for HIV itself in the blood. This test can recognize the presence of the virus in the blood. It can detect the virus within a few days of infection.

Treatment against HIV and AIDS

- **HAART (Highly Active Antiretroviral Therapy)**

The commonly available treatment for AIDS is the treatment against opportunistic infections.

Prevention of AIDS

- Global education about disease
- Use of screened blood samples, disposable infections.

- Protected Sex (use of condoms)
- Monogamy or abstinence from sex
- The risk of HIV transmission from a pregnant woman to her baby is significantly reduced if she takes treatment during pregnancy
- It is necessary to treat STD as soon as you suspect infection
- The **National AIDS Research Institute (NARI)** was established in 1992 with the mission to promote biomedical research on HIV/AIDS in India with an aim to compliment and strengthen the National AIDS Control Programmes.

9.3 Human Rights

Human Rights and the salient features of the **Universal Declaration of Human Rights** was adopted by UN on December 10th 1948.

Human rights are the rights a person has, because he or she is a human being. Human rights are held by all persons equally, universally and forever. Human rights cannot be taken away from a person under any circumstances. These rights cannot be lost.

Human rights are considered as the basic standards without which people cannot live in dignity. To violate a person’s human rights is to treat that person as though he or she was not a human being. Human rights demands that the human dignity of all people be respected.

Some of the most important characteristics of human rights are the following:

- Human Rights are guaranteed by international standards and legally protected.
- Human Rights focus on the dignity of the human beings.
- Human Rights are indivisible and hence one cannot be denied, waived or taken away.
- Human rights are interrelated and universal.

Human Rights in India

Our Constitution guarantees every citizen of India seven fundamental rights.

1. **Right to equality:** This advocates equality before law. All are treated equal irrespective of religion, race, caste, gender or place of birth. All have equality of opportunity in matters of employment.
2. **Right to freedom:** This right includes freedom for speech and expression. It also includes right to practice any profession or occupation, right to life and liberty, right to education.
3. **Right against exploitation:** This prohibits all forms of forced labour, child labour and traffic of human beings.

4. **Right to freedom of religion:** This right ensure a person freedom to practice any religion and also freedom to manage religious affairs.
5. **Cultural and Educational rights:** It preserves the right of citizens to conserve their culture, language or script. The right of minorities to establish and administer educational institutions of their choice are also preserved.
6. **Right to constitutional remedies:** This right advocates for the enforcement of Fundamental Rights.
7. **Right to life:** This gives the right to live with human dignity. This includes rights such as right to education, health, shelter and basic amnesties that the state shall provide.

9.3.1 Value Education

Education assists in bringing about socio-economic and cultural progress of a country. It does not simply mean acquiring knowledge and information, it also mean the use of knowledge for the betterment of society.

'Values' – One's own principles and standards that enable one to judge between the right and wrong behaviour or actions or practices.

Need for value based Environmental education

Environment is a common property and our actions affect environment. Any degradation in environment affects our health and wellbeing. Value education in relation to environment provides an understanding and appreciation of nature and the importance of its conservation. It helps to promote the concept "citizen of the earth". It advocates duty of each individual to care for the earth and use its resources in a sustainable way.

Value-based Education

- Value based education teaches about
- Distinction between good and bad
- How to live life
- How to be happy and make others happy
- How to be compassionate, helpful, loving, generous and tolerant.
- How to move towards sustainable future
- Responsibility towards society and nation.

Following attitudes and behaviour to be incorporated through value based education

1. **Human values:** To develop positive attitudes towards environment and to recognize that ‘man in nature’ rather than ‘nature for man’.
2. **Social Values:** To develop values such love, compassion, tolerance and justice towards nature so that all forms of life (biodiversity) can be protected.
3. **Cultural and Religious Values:** To nurture, respect and protect every aspect of nature by considering them sacred (plants, rivers, mountains etc. are sacred)
4. **Ethical values:** To promote earth – citizenship thinking rather than human centric thoughts/ views
5. **Global Values:** To recognize that nature and all the natural phenomenon occurring in the earth are interconnected and exist in harmony. Disturbing the harmony will lead to ecological collapse.
6. **Spiritual values:** To develop principles of self control, contentment, reduction of desires and freedom from greed. These values will help to attain sustainable development and environmental conservation.

9.4 Environmental Impact Analysis/Assessment

Environmental Impact Assessment (EIA) is a process of evaluating the likely environmental impacts of a proposed project or development. It takes into account various inter-related socio-economic, cultural and human-health impacts of the proposed project, both beneficial and adverse.

EIA would necessarily involve the following stages:

1. **Screening:** This is the first step in EIA. Screening determines whether a proposed project falls within the remit of the Regulations, whether it is likely to have a significant effect on the environment and therefore requires an assessment.
2. **Scoping:** Scoping is done to identify which potential impacts that are relevant to assess. This is done based on legislative requirements, expert knowledge and public involvement. Alternative solutions are suggested so that adverse impacts on environment is minimized.
3. **Preparing the Environmental Impact Statement (EIS) or EIA report:** When it is decided that an assessment is required, the applicant must compile the information required to assess the likely significant environmental effects of the development. This can be done with the help of public authorities who provides him any relevant environmental

information in their possession. The information finally compiled by the applicant is known as an **Environmental Impact Statement (EIS)**.

4. **Review of the Environmental Impact Statement (EIS):** Review is based on the terms of reference and public participation.
5. **Decision-making:** A final decision is made on whether to approve the project or not and under what conditions.
6. **Monitoring, compliance, enforcement and environmental auditing:** Finally, after sanctioning the project, it is closely monitored to see whether the predicted impacts and proposed mitigation measures occur. It also ensures that unpredicted impacts or failed mitigation measures are identified and addressed in a timely fashion.

9.4.1 Role Of Information Technology In Environment And Human Health

Information Technology (IT) is defined as the collection, processing, storage and dissemination of information. IT is of immense help in the field of environmental education and health. It helps the development of internet facilities, Geographical information system, Remote sensing technologies etc. IT also assist to generate up-to-date information on various aspects of Environment and health. Obtained data is in computerized form and can be retrieved whenever required.

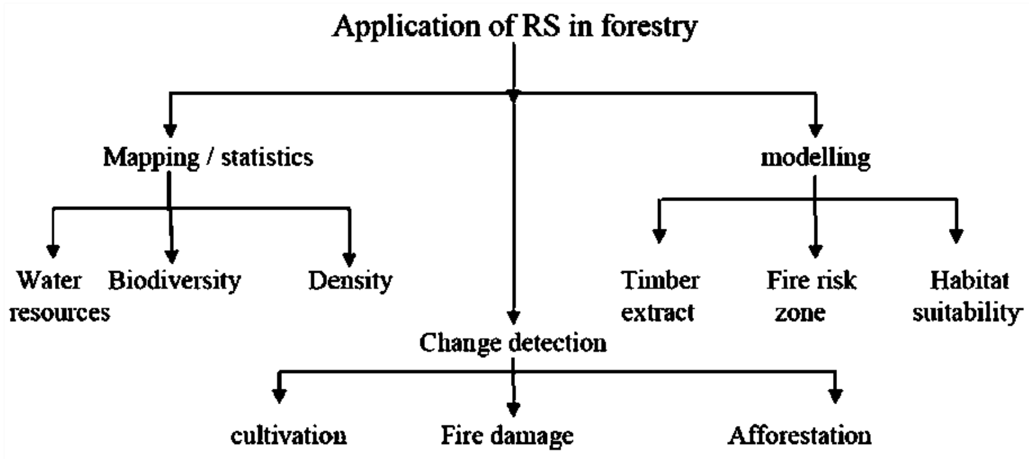
9.4.1.1 Role of IT in Environment

1. **ENVIS – Environmental Information System**
    - Government of India established Environmental Information System (ENVIS), in 1982. It was created to collect, handle and store Environmental Information.
    - Collects information from 25 centers all over the country.
    - Generates network of database on areas like pollution control, remote sensing, biodiversity, Environmental Management, renewable energy, Desertification, Mangroves, Wildlife, Mining etc.

Few objectives of ENVIS

- To build up a repository and dissemination centre in Environmental Science and Engineering
- To support and promote research and development in the area of environmental information technology.
- To promote exchange of information amongst developing countries.

2. **NIMS – National Information Management System**
   - The National Science and Technology Management Information System (NSTMIS), a division of Department of Science and Technology (DST) was created to build the information database on a continuous basis on natural resources in the country. It is devoted to scientific and technological activities.
3. **RIS – Remote Sensing Information System**
   - Remote Sensing is the collection of data by sensors not in direct contact with the phenomena of interest.
   - A typical RIS system has four elements: a source, the sensor, interactions with the atmosphere and interactions with the earth's surface.
   - Satellite imageries provide the actual information about various resources and their degradation in a digital form through remote sensing.
   - Satellite data provides correct, reliable and verifiable information about forest coverage, desertification, afforestation etc.
   - Provides information of ozone layer depletion, smog, approach of monsoon etc.
   - To discover many new reserves of oil, minerals etc.
   - To find out land cover, forest cover, bio diversity etc. by mapping
   - Plays a key role in Environmental Management, Environmental Impact Assessment etc.



4. **GIS – Geographical Information System**
   - GIS is a system designed to capture, store, manipulate, analyze, manage and present all types of geographical data.

- Different thematic maps containing digital information on a number of environmental aspects like water resources, soil type, forest land, grass land etc. are superimposed in a layered form in computer using software.
- For interpretation of polluted zones, degraded lands, emission sources etc.
- **Zoning Atlas** is prepared by GIS to locate suitable areas for industrial growth
- GIS plays a key role in resource mapping, environmental conservation, management, planning, Coral reef mapping etc.
- Helps in disaster Management and relief operations

5. **WWW – World Wide Web**
   - Internet and web resource materials, online learning centre, provides the most current and relevant information on environmental applications, problems & solutions etc.
   - Student and teacher friendly features: To get detailed information, case studies, current articles, career information, encyclopedia (Wikipedia), videos (youtube) etc.
6. **Computer based instruments for environment studies**
   - Environmental monitoring, data collection and analyses involve the extensive use of computers. Many techniques involve automated sampling and analysis. Almost all analytical techniques involved like Atomic absorption spectrometry, flame photometry etc are attached to computer where data can easily read, analysed, compared and stored.

9.4.1.2 Role of IT in Human Health

Information technology (IT) has the potential to improve the quality, safety and efficiency of health care. Combination of IT and health is **bioinformatics**. Some applications of computer based technology in the field of health are listed below.

1. **Electronic health records (EHR)**
   - EHR is a collection of electronic health information about individual patients.
   - It is a digital record which can be easily shared.
   - EHRs may include a range of data, including medical history, medication and allergies, immunization status, laboratory test results etc.
   - EHR saves considerable amount of time for doctors, as it contains entire medical history of the patient.
   - It also helps in easy access and sharing of information.
2. **Automated dispensing machines (ADMs)**

- This is an advanced automated technology which distributes required medication doses to the prescribed patients on time.

3. **Picture archiving and communications system (PACS)**
   - This captures and integrates diagnostic and radiological images from various devices (e.g., X-ray, MRI scan), stores them and disseminates them to a medical record, a clinical data repository etc.
4. **Medical Transcription**
   - Medical transcription is the transcribing (typing) of doctor's reports from dictated audio files. These files are used for diagnosis, information sharing and health care delivery.
5. **Teleconferencing**
   - Using latest computer aided technology, it is possible for a physician to have a teleconference with other medical experts in the middle of surgery.
6. **Endoscopy and Laproscopy**
   - E**ndoscopy** involves examining the inside of a person's body using an endoscope. An endoscope is a medical device consisting of a long tube with light or cameras attached that is used to look inside a body cavity or organ. The image of the organ can be seen on computer monitor and can be studied for the growth of tumor, cancer etc.
   - **Lapscropic** (key hole) surgery uses computer based applications.
7. **Instruments in health care**
   - Magnetic resonance imaging unit (MRI scan), Computed Axial Tomography (CT scan), Intensive Care units (ICU) etc widely use computers for functioning.
8. **Mobile blood banks**
   - Mobile blood banks have data of different blood groups and those who are in need of blood to meet critical medical situations can get it from these banks. Software application can help people to find a nearest donor from his/her own locality. List of blood donors with their blood group and phone numbers will be available through the application.

9.5 Check Your Progress

A. Fill in the blanks

1. When a population increases by a fixed percentage it is called ………… growth.

2. When birth plus immigration in a population are just equal to death plus emigration, it is known as ………….. .
3. The phenomenon of fall in death rates and birth rates due to improved living conditions leading to low population growth is called ………………. .
4. Universal Declaration of Human Rights was given by the UNO in the year ……….. .
5. ……………….. has been constituted by the Ministry of Environment and Forests for generating database on various environmental aspects.

B. <u>Choose the correct option</u>

1. Population growth in developing countries as compared to developed countries is
   a) negligible.
   b) slower.
   c) faster.
   d) at almost the same growth rate.
2. Family welfare programme
   a) covers family planning only.
   b) covers welfare measures of children, women, aged and the handicapped.
   c) Both a) and b)
   d) None of the above.
3. HIV destroys a kind defence cells in the body called
   a) CD4 helper lymphocyte cells.
   b) white blood cells.
   c) nerve cells.
   d) red blood cells.
4. HIV does not spread through
   a) contaminated blood.
   b) unprotected sex.
   c) from infected mother to her baby.
   d) sharing food vessels and eating food cooked by the infected person.
5. Which of the following is not a woman welfare programme?
   a) Establishment of a self-reliant women’s self-help group.
   b) Conducting workshop on mother and child care.
   c) Conducting medical awareness camps on health aspect of women.

d) None of the above.

6. The Department of Women and child development was set 1985 as a part of
   a) Ministry of Women and Child Welfare Department.
   b) Ministry of Human Resource Development.
   c) Both of the above.
   d) None of the above.
7. Which of the following is an autonomous organization of the Department of Women and child development?
   a) Rashtriya Mahila Kosh (RMK).
   b) Central Social Welfare Board (CSWB).
   c) Both of the above.
   d) None of the above.
8. Expanding population trend is predicted for the coming years when age- pyramid is
   a) Bell-shaped
   b) Pyramid shaped
   c) Urn-shaped
   d) None of these
9. UNEP stands for
   a) United Nations Environmental Policy.
   b) United Nations Environmental Programme.
   c) United Nations Environmental Protection.
   d) None of the above.
10. ENVIS generates database on :
    a) Coastal ecology
    b) Biodiversity
    c) Occupational health
    d) All of the above.
11. An environmental information system is an essential part of any government at
    a) only local level.
    b) local and international level.
    c) national, international and local levels.
    d) national and local levels.

12. The first cases of AIDS in the world was reported at
    a) Stockholm and Italy.
    b) Beijing and Taiwan.
    c) Italy, San Francisco and Beijing.
    d) New York and San Francisco.
13. One's own belief, principles, perceptions, feelings and behaviour to judge what is right and wrong is called
    a) morality.
    b) perception.
    c) life science.
    d) value education.
14. Equity and social justice are essential components of
    a) value education.
    b) conservation of biodiversity.
    c) human rights.
    d) environmental ethics.
15. CEDAW deals with
    a) Human rights for freedom of speech
    b) Discrimination against women
    c) Value education and awareness
    d) Environmental education

9.6 Summary

- *Growing population in developing countries means higher demand for energy, though it may not be of same magnitude as in developed ones.*
- *Expanding population of the world, especially of the developing countries means more pressure on natural resources.*
- *In developing countries, as contraceptive use has risen from 10% on average in the 1960s to over 50% today, the total fertility rate has fallen by half.*
- *The current rate of population growth in India is 1.58% and the total fertility rate is 3.*
- *In India, as in many developing countries, the family planning programme is the most direct public policy measure initiated to reduce the population growth rate.*

- *As per Constitution of India, Family Planning is in the Concurrent list. The approach under the programme during the First and Second Five Year Plans was mainly "Clinical" under which facilities for provision of services were created.*
- *Environmental health problems vary dramatically from region to region, reflecting geography, climate and perhaps most important, a country's level of economic development and policy choices.*
- *Human Rights are internationally agreed standards or rules regulating the conduct of states towards their own citizens and non-citizens. Human rights have been identified and operated through commissions or committees in many countries.*
- *About one-third of those currently living with HIV/AIDS are aged 15 to 24.*
- *Among various health problems, women of age group 15 to 20 and those who give birth to babies need special attention.*
- *Child development not only includes physical health of a child but also whole development that includes mental, emotional and educational aspects.*
- *Recent development in information and communication technology has opened up new ways of producing data, analysis of data and their dissemination.*

9.7 Keywords

- **Child Welfare:** "Child welfare" is a term used to describe a set of government and private services designed to protect children and encourage family stability.
- **Family Welfare Programmes:** The Family Welfare Program (FWP) seeks to introduce the concept of promoting the welfare of workers and their families as a key to workplace productivity and improved worker-management relations.
- **HIV - AIDS:** Human immunodeficiency virus infection / acquired immunodeficiency syndrome. (HIV/AIDS) is a disease of the human immune system caused by infection with human immunodeficiency virus (HIV).
- **Human Rights:** Human Rights are internationally agreed standards or rules regulating the conduct of states towards their own citizens and non-citizens.
- **Information Technology:** Information technology is the use of computers and networks to store, process and receive data.
- **Population:** A population is all the organisms of the same group or species who live in the same geographical area and are capable of interbreeding.

- **Population Explosion:** The term population explosion means rapid growth in population which affects the economic growth and progress of the per capita income of the people.
- **World Health Organization (WHO):** The World Health Organization (WHO) is a specialized agency of the United Nations (UN) that is concerned with international public health.

9.8 Self-Assessment Test

1. With a neat diagram explain the variation in population growth among various nations.
2. Write a brief note on family welfare programmes initiated by Government of India.
3. Discuss the role of Information Technology in environmental protection and human health.
4. Explain the causes, effects and control of AIDS.
5. Explain the environmental problems posed by population explosion.
6. Write the methods and strategies on imparting value education.
7. Briefly describe the various activities launched for women and child welfare in India.
8. Write a short note on human rights.

9.9 Answers to check your progress

A. Fill in the blanks

1. exponential 2. zero population growth 3. Demographic transition 4. 1948 5. ENVIS

B. Choose the correct option

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

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