ENVIRONMENTAL STUDIES

[Foundation Course]

BA (Environmental Studies)
Third Semester

[ENGLISH EDITION]

Directorate of Distance Education
TRIPURA UNIVERSITY

Reviewer

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SYLLABI-BOOK MAPPING TABLE

Environmental Studies

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Unit 1: Nature of Environmental Studies and Natural Resources • Environmental Studies: Definition, Scope and Importance • Renewable and Non-renewable Resources • Natural Resources and Associated Problems (a) Forest Resources: Use and Over-exploitation, Deforestation, Case Studies, Timber Extraction, Mining, Dams and their Effects on Forests and Tribal People. (b) Water Resources: Use and Over-utilization of Surface and Ground Water, Floods, Drought, Conflicts Over water, Dams-benefits and Problems. (c) Mineral Resources: Use and Exploitation, Environmental Effects of Extracting and using Mineral Resources, Case studies. (d) Food Resources: World Food Problems, Changes caused by Agriculture and Over Grazing, Effects of Modern Agriculture, Fertilizer-problems, Water Logging, Salinity, Case studies. (e) Energy Resources: Growing Energy Needs, Renewable and Non-renewable Energy Sources, Use of Alternate Energy Sources, Case studies. (f) Land Resources: Land as a Resource, Land Degradation, Man Induced, Landslides, Soil Erosion and Desertification. Role of an Individual in Conservation of Natural Resources	**Unit 1:** Nature of Environmental Studies and Natural Resources **(Pages 3-37)**
Unit 2: Ecosystems and Biodiversity Conservation • Concept of an Ecosystem • Structure and Function of an Ecosystem • Producers, Consumers and Decomposers • Energy Flow in the Ecosystem • Ecological Succession • Food Chains, Food Webs and Ecological Pyramids (a) Forest Ecosystems: Structure and Functions (b) Biodiversity: Definition, Genetic, Species and Ecosystem Diversity	**Unit 2:** Ecosystems and Biodiversity Conservation **(Pages 39-87)**

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(f) Endangered, Endemic, Exotic Species in India
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The environment is very important to people because it directly influences their lives. People depend largely on the environment for survival. The environment comprises the relationship between people, animals, plants, and even non-living things. It is important to study the environment and learn how to conserve it especially now that technology is beginning to ruin the natural resources and the ecosystem.

Awareness about global issues is now being spread through international conferences so that immediate solutions can be applied. The issues may range from dynamite fishing to global warming, and forest denudation to mining. With rapid urbanization and technological advancement, there is a need to study each step that may alter the environment so that the natural ecosystem may still be protected or replaced by a better one.

This book, *Environmental Studies*, has been designed keeping in mind the self-instruction mode (SIM) format and follows a simple pattern, wherein each unit of the book begins with the Introduction followed by the Unit Objectives for the topic. The content is then presented in a simple and easy-to-understand manner, and is interspersed with Check Your Progress questions to reinforce the student's understanding of the topic. A list of Questions and Exercises is also provided at the end of each unit. The Summary and Key Terms further act as useful tools for students and are meant for effective recapitulation of the text.

UNIT 1 NATURE OF ENVIRONMENTAL STUDIES AND NATURAL RESOURCES

Structure

1.0 INTRODUCTION

Environment is the total of water, air and land, the interrelationships among them and also with human beings, other living organisms and property. In order to study environment, one needs knowledge inputs from various disciplines.

At present, we are confronted with two conflicting scenarios. On the one hand, there are possibilities of a bright future with press button living, space shuttles, information technology, genetic engineering and such other advances in science and technology. On the other hand, a grim scenario is looming large with burgeoning population, starved of resources and choked by pollution. Faced with such imminent threats, there is a growing realization that rational utilization of environmental endowments of life support systems like water, air and soil is a must for sustainable development.

Academic disciplines are created to help us understand the universe better. While nature can be understood using the disciplines, it is not 'divided' into disciplines. For instance, a certain phenomenon may be referred to as a chemical change while another as a physical one. But these categories are only perceptions.

'Environmental studies' is about the environment. Not the environment from the point of view of any one particular discipline, but a study and understanding of the interlinkages—the complex ways in which one phenomenon, one action, is

connected to another, how the same thing can be understood from different perspectives, perspectives that are often rooted in different disciplines.

The problems of pollution and wanton degradation of environmental resources cannot be solved without proper understanding of their causes and effects and this is why the environmental studies is so important.

1.1 UNIT OBJECTIVES

After going through this unit, you will be able to:

- Explain the nature of the subject environmental studies
- Ascertain the need and scope of environmental studies
- Analyse how environmental studies is an interdisciplinary subject
- Learn the need to create awareness for environmental issues
- Discuss the concept of natural resources
- Distinguish between renewable and non-renewable resources
- Describe the important natural resources such as forest, water, minerals, food, energy and land resources

1.2 ENVIRONMENTAL STUDIES: DEFINITION, SCOPE AND IMPORTANCE

Environmental science, in its broadest sense, is the science of complex interactions that occur among the terrestrial, atmospheric, living and anthropological environments. It includes all the disciplines such as chemistry, biology, sociology and government that affect or describe these interactions.

In the broadest sense, environmental science may be defined as the study of earth, air, water and living environments and the effects of technology thereupon. To a significant degree, environmental science has evolved from investigations of the ways by which, and place in which living organisms carry out their life cycles. This is the discipline of natural history, which in recent times has evolved into ecology, the study of environmental factors that affect organisms and how organisms interact with these factors and with each other.

Environmental science is divided into the study of the atmosphere, the hydrosphere, the geosphere and the biosphere.

Environmental science is now a mature and viable discipline. The past three decades have witnessed a growing awareness of the affects of human activity upon earth's resources and during this period, environmental study has emerged as a multidisciplinary field of study to examine the interaction of people with the environment.

Environmental Science and Chemisty

This relation is known as environmental chemistry. It may be defined as the study of the sources, reactions, transport, effects and fates of chemical species in water, soil, and air environments and the effects of technology thereon.

One of environmental chemistry's major challenges is the determination of the nature and quantity of specific pollutants in the environment.

Environmental Science and Biology

The ultimate environmental concern is that of life itself. The discipline that deals specifically with the effects of environmental chemical species on life is environmental biochemistry.

Biological processes are not only profoundly influenced by chemical species in the environment, they largely determine the nature of these species, their degradation, and even their syntheses, particularly in the aquatic and soil environments. The study of such phenomena forms the basis of environmental biochemistry.

Environment and Economics

Economic environment refers to all those factors or forces which contribute to the economic impact on the man, his activities and his region. Resources, industrial production, population, agriculture, infrastructure and the various stages in the economic development like economic conditions, economic policies, economic planning, economic philosophy, economic system and trade cycle are major internal and external factors which make up the total economic environment.

Availability of resources and the technology to exploit them plays the most significant role in the economic development or economic environment of a region. As the distribution of natural resources due to geographical factor is uneven, the resources have become concentrated in some specific regions only. These gifted regions have exploited these resources for their economic development and have come to be known as developed countries. Examples of such countries are USA, France and UK. Whereas, the other regions which had poor resource concentration and which are still in the developing stage have come to be known as developing countries. Thus, it is the economic environment of a region or country that decides its status, i.e., developed or developing.

Population factor has its own say as regards to economic environment of a region, as more resources are needed to feed more mouths. This requires more exploitation of resources which not only hampers the resource reserves, but also affects the ecosystem of that region.

However, a stable economic environment does not always help the mankind. The main disadvantage of it is its impact on the physical environment. It could be said that both economic and political are interdependent on each other. Erstwhile East Germany and West Germany serve as a good example of interdependence of political and economic environment. East Germany with their poor economic environment was left with no other alternative other than merging with West Germany, which had strong and stable economic environment.

Every human activity necessary for economic development affects the local, regional or global environment. The effects may be short-term or long-term in nature. In the present situation, problems like deforestation, extinction of rare species of flora and fauna, global warming, epidemics such as Katrina, Rita cyclones in USA, earthquakes in Jammu and Kashmir, heavy rainfalls and floods are some of the major environmental problems the world is facing on various levels today. Rapid industrialization, agricultural development, extraction of various energy and other resources, which contribute to the economic environment of the region, are some of the main factors responsible for deteriorating the quality of the physical environment. Economic stability and awareness about environmental pollution play a very important role in sustainable development. Environmental taxes in the form of penalties have its role in safeguarding the environment from getting too polluted. Taxes are generally based on the concept that those who create the pollution must also pay for them. Vehicular pollution and industrial pollution in air and water can be controlled through environmental legislation and penalties.

Cultural Environment

It is the manmade environment or manmade landscape. It may also be called as humanized landscape. The cultural environment is the imprint of man's activities, his occupation and utilization of the physical resources for his own benefit. All manmade features such as buildings, settlements, roads and plantation are called cultural features. We may call this cultural environment as a social environment or socio-cultural environment or even social heritage. As per the passage of time, man has acquired technical and scientific knowledge. Through this powerful tool he is changing fast the physical environment into a cultural landscape. Cultural environment have their tools in the natural environment and in the cultural level of the different human groups. As the natural environment differs from place to place, cultural environment also should differ accordingly, hence, human activities and achievements depend not only upon natural environment, but also upon manmade environment. Culture develops on nature; it means it has its roots in nature. Cultural environment is only the human adaptation and adjustment to natural or physical environment. In other words, man as per his knowledge and capacity superimposes culture on nature. It goes on piling one after another, and grows in size and importance. Sometimes, it becomes difficult to trace back the link with the physical base. As an example, we have changes in many villages in India. Cultural environment is simple and more directly connected with physical base in the early stages, but becomes more complex and indirect as the human society grows in knowledge and size. At this stage, the natural environment quality starts degrading and the question of ecological disorders and natural imbalance crops up. Ecological disorder is the direct result of human action, partly through his numbers and partly through his skills. All actions of men are not wise or far-sighted, and hence, it leads to environmental crises. The various ecosystems show signs of progressive deterioration because of man's hasty, negligent, unplanned actions which ultimately leads to environmental degradation. Environmental degradation is greater in advanced rather than in primitive societies, more in the industrial and urban than rural, agricultural or pastoral interiors.

Population and Environment

Population plays a major role in the socio-economic environment of a country, especially the size or density of the population. It has its impact on the natural environment also. Majority of the population being poor causes more environmental damage due to mutually reinforcing effect between poverty and environmental damage. The poor being both the victim and the agent of environmental damage.

The world population, which is growing at the rate of 1.7 per cent per year, is highly alarming. If this trend continues, there will be addition of another 3.7 billion (1 billion = 1000 million) or more to the present population level in another three to four decades. This rapid growth will affect both economic and physical environments at regional as well as global level. Traditional land and resources will be subjected to more and more overuse. Even the government will not be in a position to keep up with the infrastructural and human needs of the growing population.

Environment and Political set-up

Political environment refers to the influence exerted by the three main political institutions, viz. legislature, executive and judiciary. It helps to shape, direct, develop and control many of the human activities including the business antipollution laws. The executives, also called government, implements whatever is decided by legislature and the executive, function in public interest and within the boundaries of the constitution. A stable and dynamic political environment is a must for the development of mankind.

The type of government plays a significant role in the political environment of a country as it is guided by certain firm policies of its own. The form of government may be democratic, communist, dictatorial and monarchy. Any change in the form may be counterproductive and may affect the nation from several angles, i.e., economic, business, socio-cultural and physical as all these segments are interdependent.

1.2.1 Scope of Environmental Studies

A study of environmental science is getting a lot of attention not only in the field of pollution control, but also to sustain the life and nature.

It helps us to understand the nature of environment and its components, the nature of disturbing factors and the various methods to overcome these disturbing factors which affect sustainability and natural living.

The scope of environmental science and its management has increased from manufacturing pollution control equipment, sewage and effluent treatment plants, biomedical waste treatment and fly ash management.

The subject is multidisciplinary in nature. It unfolds environmental issues for those who are directly or indirectly concerned with this discipline. Corporate leaders, students of universities and colleges and student-managers realize that environmental protection and resource conservation have to be considered as a normal part of conducting business and understanding nature. Similarly, environmental concern has

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to be a part of the policies of the various governmental organizations. The same is true for public leaders whose sensitization is vital in this regard. Issues of environmental protection and 'Right to Clean Environment' have already trickled down from educated and affluent people to the general public. Those who are not economically well off are equally affected, if not more, due to environmental problems. Thus, environmental concerns have to be on the agenda of all organizations.

In India, we have been witnessing significant environmental degradation during the last few decades. Increasing industrialization, high-intensity agriculture, (use of fertilizers and pesticides) deforestation, soil erosion, urbanization, transportation and population growth are the major environmental problems and these are likely to increase. If the desire to attain higher living standards also increases, then the problem would be too acute to be manageable.

Industry has a significant role in environmental protection. More and more business executives have now identified environment as an issue that affect their companies.

It is believed by scientists and leaders in the industry that if we do not come to terms with environmental issues, irreversible processes would set in, which would ultimately lead to human suffering not only of in the countries of the South, but also the North. Most environmental problems are well known though we may not have found solutions for all. The problems are both global and national and all these pose serious challenges not only to our planet, but also to our way of life. Human beings are not a separate entity, they are a part of the surrounding, our ecosystem—air, water, land—not only that, but one cannot think of human survival if the services provided by the environment do not become available. Without a suitable habitat, neither animals nor plants nor humans can survive. If the habitat is degraded/damaged, life will be adversely affected. Since the environment provides all the resources that are used in the process of production of goods or services, the responsibility of the industry is of paramount consideration. Industry not only has to consider issues like profit, quality standards, legislation and regulatory controls, but has to go a step beyond.

Our natural resources are either renewable or non-renewable, the latter have to be conserved and the use of the former judicious. Besides the issue of resources, our living style, rate of consumption and disposal of waste have created problems for the management of landfills for wastes, air quality, water table and many other environmental problems.

In short, the scope of environmental studies is broad-based and it encompasses a large number of areas and aspects, listed as follows:

- Natural resources—their conservation and management
- Ecology and biodiversity
- Environmental pollution and control
- Social issues in relation to development and environment
- Human population and environment

1.2.2 Importance of Environmental Studies

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

The study of environmental science makes us understand the scientific basis for establishing a standard which can be considered acceptably safe, clean and healthy for man and ecosystem.

Most environmental scientists agree that if pollution and other environmental deterrents continue at their present rates, the result will be irreversible damage to the ecological cycles and balances in nature upon which all life depends. Environmental scientists warn that fundamental, and perhaps drastic changes in human behaviour will be required to avert an ecological crisis.

To safeguard a healthy environment that is essential to life, humans must learn that Earth does not have infinite resources. Earth's limited resources must be conserved and, where possible, reused. Furthermore, humans must devise new strategies that combine environmental progress with economic growth. The future growth of developing nations depends upon the development of sustainable conservation methods that protect the environment, while also meeting the basic needs of citizens.

Environmental study is the subject in which we examine important issues related to the environment. It is an exploratory description of issues. Each issue can be probed more deeply.

Environmental studies is an important but neglected body of knowledge. It concerns itself with life support system and is closely related with development and economic growth. Many a time, both development and economic growth are not easily reconciled. We have to choose between environment and development.

It is a reality that industrialized countries have a high level of development and decent standard of living at the expense of the environment and depletion of natural resources. The real question is how long is Mother Earth likely to suffer and how long will this be sustainable? Developing countries, on the other hand, are still struggling to achieve a minimum standard of living though they are also equally contributing to the environmental damage.

Both, industrialized and underdeveloped or developing countries damage, deplete and pollute the environment. Developing countries want accelerated growth to fulfil their basic needs and the real question is should they follow in the footsteps of their big brothers, i.e., the developed countries? It is a fact that both the consumption and the lifestyle of people have a direct relation to environmental problems. Therefore, living habits and attitudinal and ethical questions have now cropped up which are the main concerns for environmental studies, and deep study is required to understand the environmental problems.

The most important questions that bother every developing country is what should be the ideal combination of pattern of growth and development, which model

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of development as well as of business should be followed so that we do not ignore the principle that underlie sustainability. For this, we need changes at the local, national, regional and global levels, together with an economic and social transformation at the level of individuals and communities.

This forms a part of the business environment. Business environment is divided into two categories, viz., external and internal environment. External environment includes political, economic, social, legal, technological, international and natural environment. On the other hand, internal environment includes people, culture, work ethics and attitudes.

The government and their agencies, the non-governmental organizations, the judiciary and now the corporate sector also expresses a great concern on matters relating to natural environment and ecosystem.

There are several environmental problems which have been solved by using environmental studies. Some of these are: (a) global warming (b) population problems (c) depletion of ozone layer d) habitat destruction and species extinction (e) energy production (f) groundwater depletion and contamination.

The importance of environmental studies and proper awareness about safeguarding the environment from pollution is so much that it can be made a mandatory requirement in industrial project clearance, environmental impact assessment and green funding.

1.2.3 Need for Awareness

Everybody should be aware of what is happening around them. Awareness regarding the state of affected environment is a must for every human being living on this planet. Already, the world is affected by several environmental problems, the effect of which is directly felt by its inhabitants. Nobody can escape the wrath if fallen, may it be the people of developing countries or the developed ones.

Looking at the present pathetic state of the environment and the knowledge people have about it, it has become evident for every country to educate their masses, so that they can start understanding the problems that they are facing at present and would face in the future.

In fact, almost all nations of the world have geared up in creating awareness among their people. Media is playing a leading role in this process. Several means are being employed to educate the masses. Various advertisements, documentaries, feature films, etc., are being made. Newspapers and other magazines are publishing a lot of articles on this subject as well.

Government with its separate ministry—Ministry of Environment and Forest—has also launched many campaigns like displaying several hoardings and posters throughout the country. The state ministries are also playing important roles in generating awareness among the masses. Plantation of trees on various occasions, especially on World Environment Day which falls on 5 June every year, is undertaken on a large scale.

The issue of Enron Power Project (Dabhol Power Project), now called Ratnagiri Power Project, in Konkan area of Maharashtra was much politicized and the environmental issues were put forth as political propaganda. There is always a need to have awareness of the issues and knowledge as to how environmental ailments are to be avoided and a balance is struck between growth and environment.

CHECK YOUR PROGRESS

1. What comprises 'environment'?
2. Define environmental science.
3. What does a natural ecosystem include?
4. What are the problems that are being solved by using environmental studies?
5. How is media playing a major role in creating awareness among people?

1.3 NATURAL RESOURCE

According to Ramade (1984), a natural resource is defined as a form of energy and/or matter which is essential for the functioning of organisms, populations and ecosystems. In the case of humans, natural resource, refers to any form of energy or matter essential for the fulfilment of physiological, socio-economic and cultural needs, both at the individual level and that of the community.

Examples of natural resources are water, air, soil, minerals, coal, forests, crops and wild life.

The basic ecological variables—energy, space, time and diversity are sometimes together called natural resources. These natural resources maintain the ecological balance among themselves. Man is the only organism who has disrupted this delicate balance.

1.3.1 Renewable and Non-renewable Resources

There are many different classifications of natural resources.

Odum's Classification

According to Odum (1971), natural resources can be divided into two categories, 1. renewable and 2. non-renewable resources.

1. **Renewable resources:** Resources that can be replenished through rapid natural cycles are known as renewable resources. These resources are able to increase their abundance through reproduction and utilization of simple substances. Examples of renewable resources are plants (crops and forests), and animals who are able to reproduce and maintain life cycles. Some examples of renewable resources which do not have a life cycle, but can be recycled are wood and wood-products, pulp products, natural rubber, fibres (e.g., cotton,

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jute, animal wool, silk and synthetic fibres) and leather. In addition to these resources, water and soil are also classified as renewable resources. Water is no longer referred to as a renewable resource. However, water is sometimes no longer referred to as such. This is because of its loss in natural replenishment due to global warming, increased deforestation and resulting disturbances in the hydrological cycle. Water's status of infinity is severely under threat.

As a special case, solar energy although having a finite life, is considered as a renewable resource in as much as solar energy stocks are inexhaustible on the human scale.

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 and coal), metals (iron, copper, gold, silver, lead and zinc), minerals and salts (carbonates, phosphates and nitrates). Once a non-renewable resource is consumed, it is gone forever. Then we have to find a substitute for it or do without it.

   Non-renewable resources can further be divided into two categories, viz. (a) recyclable and (b) non-recyclable.

   (a) **Recyclable:** These are non-renewable resources which can be collected after they are used and can be recycled. These are mainly the non-energy mineral resources which occur in the earth's crust (e.g., ores of aluminium, copper and mercury) and deposits of fertilizer nutrients (e.g., phosphate stock and potassium and minerals used in their natural state (asbestos, clay and mica)

   (b) **Non-recyclable:** These are non-renewable resources which cannot be recycled in any way. Examples of these are fossil fuels and uranium, which provide 90 per cent of our energy requirements.

Biotic and Abiotic Resources

Some authors prefer to classify resources into biotic and abiotic resources.

(a) **Biotic resources**: These are living resources (e.g., forest, agriculture, fish and wild life) that are able to reproduce or replace them.

(b) **Abiotic resources**: These are non-living resources (e.g. petrol, land and minerals) that are not able to replace themselves or do so at such a slow rate that it is not useful to consider them in terms of the human life times.

Inexhaustible and Exhaustible Resources

Natural resources can also be classified as 1. inexhaustible and 2. exhaustible resources.

1. **Inexhaustible resources**: Resources which are not changed or exhausted by man's activities and are abundantly available are said to be inexhaustible. Examples are solar energy, atomic energy, wind power, power from tides, etc. Most of the renewable resources are classified as inexhaustible. But if not maintained properly, they become extinct. For example, ground water is

renewable only if water continues to percolate in the soil at a rate at which it is removed.

2. **Exhaustible resources**: These resources are limited in nature and they are non-maintainable, e.g., coal, petrol and some minerals. Hence, they come under the non-renewable category.

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.

The following are some of the major natural resources:

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

1.3.2 Problems Associated with the Conservation of Natural Resources

In this section, we will discuss the various problems associated with the conservation as natural resources.

1. Forest Resources

Forest resource is the dense growth of trees, together with other plants, covering a large area of land. Forests are one of the most natural resources found on earth. Covering earth like a green blanket, these forests not only produce innumerable material goods, but also provide several environmental services which are essential for life.

About one-third of the world's land area is forested, which includes closed as well as open forests. Former USSR accounts for about one-fifth of the world's forests, Brazil for about one-seventh and Canada and USA each has 6–7 per cent. However, it is a matter of concern that almost everywhere the cover of the natural forests has declined over the years. The greatest loss occurred in tropical Asia, where one-third of the forest resources have been destroyed.

Uses of Forests

Commercial uses: Forests provide us a large number of commercial goods which include timber, firewood, pulpwood, food items, gum, resins, non-edible oils, rubber,

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fibres, lac, bamboo canes, fodder, medicine, drugs and many more items, the total of which is estimated to cost more than $300 billion per year.

Half of the timber that is cut each year is used as fuel for heating and cooking. One-third of the wood harvest is used for building materials as lumber, plywood and hardwood, particle board and chipboard. One sixth of the wood harvest is converted into pulp and used for paper industry. Many forest lands are used for mining, agriculture, grazing, and recreation and for development of dams.

Ecological uses: While a typical tree produces commercial goods worth about $590, it provides environmental services worth nearly $196 to $250.

The ecological services provided by forests may be summed up as follows:

1. *Production of oxygen*: Trees produce oxygen by photosynthesis which is so vital for life on this earth. They are rightly called earth's lungs.
2. *Reducing global warming*: The main greenhouse gas, carbon dioxide (CO_2), is absorbed by the forests as a raw material for photosynthesis. Thus, forest canopy acts as a sink for CO_2, thereby reducing the problem of global warming caused by greenhouse gases such as CO_2.
3. *Wild life habitat*: Forests are the homes of millions of wild animals and plants. About 7 million species are found in the tropical forests alone.
4. *Regulation of hydrological cycle*: Forested watersheds act like giant sponges, absorbing the rainfall, slowing down the run-off and slowly releasing the water for recharging of the springs. About 50-80 per cent of the moisture in the air above tropical forests comes from their transpiration, which helps in bringing rains.
5. *Soil conservation*: Forests bind the soil particles tightly in their roots and prevent soil erosion. They also act as windbreaks.
6. *Pollution moderators*: Forests can absorb many toxic gases and can help in keeping the air pure and clean. They have also been reported to absorb noise and thus, help in preventing air and noise pollution.

Case Example: Forest Management

The management of forest resources in India has been one of the most challenging environmental issues in South Asia. Since 1951, degraded lands in India have doubled in size, reaching 174 million hectares by 1990. According to recent estimates, demand for fuel wood and fodder will triple within the next ten years.[1] Large-scale reforestation and watershed management programmes conducted by the Indian government have largely failed.[2] Community-based forest management has proved to be a feasible alternative and as of 1994, fifteen of India's twenty-eight states have formally initiated joint forest management (JFM) programmes.

Local communities in Orissa now manage 1,200 patches of forest, covering a total area of 186,900 hectares, through the efforts of 1,180 User Group Organizations (UGO). In the 360-hectare Binjgiri Protected Forest, for instance, environmental protection has been the driving force for improved forest management practices. Surrounded by rural villages, the forest was almost completely denuded by the late 1960s. Streams dried up, pond sedimentation

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increased, and fuelwood grew acutely scarce. Following the initiative of a former resident of Kesharpur, a movement to protect the Binjgiri Hill was initiated. The villagers of Kesharpur soon realized that the regenerating forest would be endangered if the other villages surrounding Binjgiri were not involved in its protection. This led to the creation of the 'Brikshya O'Jeevar Bandhu Parishad' (BOJBP; Friends of Trees and Living Beings), a grass-roots organization that provided essential leadership for community involvement in forest conservation.

Thanks to BOJBP's strong cultural links with the villagers of the region and to environmental awareness activities,[3] traditional village councils established rules for using the Binjgiri forest. Forest cutting and animal rearing were restricted. Families were assigned responsibility for taking turns patrolling the forest. The payoff was encouraging; water filled up in the streams that had dried out and water flowed for months after the rainy season ended. In addition, fish population grew more abundant as the pond water quality improved.

The community-based forest management systems in Orissa and elsewhere in India vary, depending on the condition and diversity of the local resources. In Puri district, where the Binjgiri forest is located, the great scarcity of natural resources led to the creation of BOJBP. The rules for forest use were well defined and moral sanctions such as requesting the violators to apologize in public were the rule. In other communities where resources were moderately scarce, as in Dhenkanal district, the villagers' lack of emotional attachment to the forest made fines and other more formal sanctions necessary. When resources were less scarce, user-group organizations were often organized more loosely, as happened in the Phulbani district.[4]

Community-based forest management systems succeed because they rely on the autonomy of villagers: regulatory measures for forest use are based on traditional community directives and norms. Government agencies should act as agile facilitators and legitimators, providing a supportive framework for community organization and supplying technical assistance. The state government in Orissa has realized that decentralization, or sharing of power with the communities, is fundamental to assuring long-term sustainability in the use of forest resources. This realization not only benefits local communities, but also the state and the nation.

Source: World Resources Institute; prepared with the assistance of Owen Lynch.

Notes:

1. Agarwal, Anil and Sunita Narain, *Towards Green Villages*. New Delhi: Centre for Science and Environment, 1989.
2. Poffenberger, Mark, *Joint Management for Forest Lands: Experiences from South Asia*. Ford Foundation, January 1990.
3. An example of this effective strategy is illustrated by this episode: after Mr Jognath Sahu, BOJBP's secretary, failed to persuade villagers to plant seedlings in a denuded piece of hill land, he stood with his family and few volunteers at a roadside and, as villagers passed, they touched their feet, asking them to plant a few seedlings. Thanks to this emotional appeal, BOJBP successfully attained its objective.
4. Kant, Sashi, Neera M. Singh and Kundan K. Singh, *Community Based Forest Management Systems: Case Studies from Orissa*. New Delhi: Indian Institute of Forest Management, April 1991, pp.42–43.

Overexploitation of Forests

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

Deforestation

According to the World Bank, The total forest area of the world in 2000 was estimated to be 40737562 Sq km, which was reduced to 40204180 in 2010. Deforestation rate is relatively less in temperate countries, but it is very alarming in tropical countries, where it is as high as 40-50 per cent; at the present rate, it is estimated that in the next sixty years we would lose more than 90 per cent of our tropical forests.

According to the India State of Forest Report (ISFR), 2015, the total forest and tree cover is 79.42 million hectare, which is 24.16 per cent of the total geographical area. India's forest and tree cover has increased by 5, 081 sq km. While the total forest cover of the country has increased by 3, 775 sq km, the tree cover has gone up by 1, 306 sq km. The report states that the majority of the increase in forest cover has been observed in open forest category mainly outside forest areas, followed by Very Dense Forest. While Open Forest area has increased by 4, 744 sq km, which is 9.14 per cent of the geographical area, the area under Very Dense Forest has increased by 2, 404 sq kms, which is 2.61 per cent of the geographical area. About 40 per cent forest cover is in 9 big patches of 10, 000 sq km and more. The increase in total forest cover also includes an increase in the mangrove cover.

However, we are still far behind the target of achieving 33 per cent forest area.

Major causes of deforestation

1. *Shifting cultivation:* There are an estimated 300 million people living as shifting cultivators who practice slash and burn agriculture. In India, we have this practice in the north-east and to some extent in Andhra Pradesh, Bihar and MP, which contribute to nearly half of the forest clearing annually.
2. *Fuel requirements:* Increasing demands for fuel wood by the growing population in India alone has shooted up to 300-500 million tonnes in 2001 as compared to just 65 million tonnes during independence, thereby increasing the pressure on forests.
3. *Raw materials 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, while fir tree wood is exploited greatly for packing apples.
4. *Development projects:* Massive destruction of forests occur for various development projects like hydroelectric projects, big dams, road construction and mining.

5. *Growing food needs:* In developing countries, this is the main reason for deforestation. To meet the demands of a rapidly growing population, agricultural lands and settlements are created permanently by clearing forests.
6. *Overgrazing:* The poor in the tropics mainly rely on wood as a source of fuel leading to loss of tree cover and the cleared lands are turned into grazing lands. Overgrazing by cattle leads to further degradation of these lands.

Major consequences of deforestation

Deforestation has far reaching consequences, which may be detailed as follows:

1. It threatens the existence of many wild life species due to destruction of their natural habitat.
2. Biodiversity is lost and along with that genetic diversity is eroded.
3. Hydrological cycle gets affected, thereby influencing rainfall.
4. Problems of soil erosion and loss of soil fertility increase.
5. In hilly areas, it often leads to landslides.
6. The effects of global warming may aggravate due to loss of oxygen generation and increase in the level of carbon dioxide in the air.

Case Example: Chipko Indian Movement

Deforestation is a severe problem in northern India and local people have banded together to prevent commercial timber harvesting. These people have adopted a unique strategy in recognizing trees as valuable, living beings. The Chipko Movement adherents are known literally as 'tree huggers'.

Historically, the Indian Himalayan region has been under the control of expatriates (particularly Germans) since 1855 in order to produce lumber for the railroads. The government nationalized one-fifth of the forest area and enacted the Indian Forest Act of 1878, which gave peasants access to those areas of the forests which were not commercially profitable.

Although there is no one particular person who can take credit for starting the movement, one name that seems to emerge as leader is that of Sunderlal Bahuguna. The protestors, consisting of mostly women and children, were called on by their leader to stop the usurpations of trees from Uttarakhand. The enduring nature of Chipko has raised several questions.

Environmental awareness increased dramatically in the 1990s in India and so did the number of organized lobbies to champion the cause of a cleaner environment. As a result, New Delhi introduced legislation aimed at curbing pollution, but the enforcement mechanism has been [lacking]. As early as August 1994, Chipko huggers wanted to stop the construction of the dam at Tehri because the protestors claimed it would uproot trees and cause floods. Today, most of the state legislators respect the peasants and their habitats. Nonetheless, to prevent future clearings, the Chipko 'tree huggers' are still very active.

Agriculture to feed the indigenous families of the hills is dependent on dense forest coverage. The peasants of India's hills depend on the forests for fuel, fodder, agricultural implements, building material, medicines and in times of dearth, food. Subsistence agriculture provide women the necessary nutrients needed to feed their families. In most cases, the surplus is sold.

India is caught in the vortex of a market economy and faced with multiple environmental hazards. The economy of hill societies is continuously deteriorating. Those most affected by the deforestation are the women of the villages as they must travel long distances to get firewood and fodder.

The debate is two-fold. The state and the means of survival are dependant on the Himalayas for this commercially profitable resource as well as its scientific richness. Most environmentalists associated with the Chipko Movement claim that this is a scheme or euphemism for economic exploitation. Recent research by Indian ecologists, ironically enough, commissioned by the Forest Department, clearly demonstrates that a huge gap exists between the theory of sustained yield and actual timber harvesting. It has been observed that output of logged material often exceeds the increase of forest stock.

Commercial Viability

Commercial timber operations received a boost when laboratory trials at the Forest Research Institute showed that the utilization of chir waste (the material after the conversion of logs to railway sleepers) for making paper was a viable proposition, and when further research at the FRI established that ash and hornbeam could be used for the manufacture of sports goods. As a result, thousands of tonnes of timber were sold annually to a paper mill in Saharanpur and a sport goods manufacturer in Allahabad. During World Wars I and II, huge quantities of sleepers, mostly of chir pine, were exported from Kumaun and supplied to the railways.

When the government needed to tighten controls, it gave the Forest Department control over the panchayats. Under the new mandate, the panchayats could only fell trees marked by the Department. Local sale of slate and resin were allowed only by permission. According to *Yugvani*, in a Hindi weekly published from Dehradun, the villagers could only retain a fixed share (40 per cent) of any royalty on the sale of produce from their forests.

In 1958, a committee was formed to investigate the grievances of the people of Uttarakhand concerning forest management. The Dasholi Gram Swarajya Sangh (DGSS), an organization based in Chamoli district and organized in the mid 1960s, combated obstacles to maintain their small resin and turpentine units. The Chipko Movement began in 1973 in Mandal village in the upper Alakananda valley. DGSS was refused permission to fell ash trees to be converted into agricultural implements. After DGSS did all they could to protest, a leading activist, Chandi Prasad Bhatt, suddenly thought of embracing the trees. Women took their children to the forests and formed a circle around the trees to prevent the felling of trees.

The success of Chipko has saved some 100,000 trees from being cut down, and there is an active fight for the survival of 70–80 per cent of saplings. This survival is credited mostly to the women of the peasant economy.

The Chipko women's defense is that they are truly concerned about the preservation of forest area but at a higher level, it is the preservation of a little community and its values. On one hand, the Chipko women are seeking to escape from the commercial economy and the centralizing state; at yet another level they are assertive and aggressive, actively challenging the ruling-class vision of a homogenizing urban-industrial culture.

Discourse and Status

The Chipko people and the state regulating boards are somewhat in agreement, although no treaty exists to hold the two parties in any binding obligation. Even

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though the Chipko Movement has not officially had 'their day in court', they have presided over other litigations. The stage of the case towards conflict resolution seems to be moderate. In March 1987, the Himalayan battle forced the government to impose a fifteen-year ban on commercial felling of green trees in the hills of northern Uttar Pradesh.

By reversing the laws of the indigenous people, many loggers, landowners, corporations, plywood manufacturers, mining companies, consumers of cheap products, undiscerning tropical timbers buyers, developers of dams, political candidates, and scientific ecological seekers would be adversely affected.

Legal Standing

The local laws more times than not are incongruent with national laws. Because the peasants of the hills allot a certain amount of trees to be felled, their laws work for them; however, when the government tries to enforce their laws, more trees are excavated than the peasants desire. This makes it extremely difficult to keep an accurate count. No official treaties exist.

The Cultural Aspect

The Chipko people believe that the trees are living and breathing carbon dioxide, in essence, trees should be respected. The extensive forests were central to the successful practice of agriculture and animal husbandry. In addition, medicinal herbs were used for their healing powers. The hill people believed that the jungle of fruit, vegetables or roots were used as aids in the times of scarity. The dependence of the hill peasant on forest resources was institutionalized through a variety of social and cultural mechanisms. Through religion, folklore and oral tradition, the forests were protected by rings of love. Hilltops were dedicated to local deities and the trees around the spot regarded with great respect.

The Chipko Movement and Human Rights

Cultural relativism is defined as the position according to which local cultural traditions (including religious, political and legal practices) determine the scope of political and civil rights enjoyed by the people of a given community. Relativists claim that substantive human rights standards vary among different cultures and necessarily reflect national idiosyncrasies. What may be seen as a human rights violation in one country, may be seen as a natural course of action in another. The Chipko people fervently believe that the 'tree hugging', and tying rakhis around trees are based on cultural traditions. The cutting down of trees is a seen as violations of socioeconomic rights—second generation rights. This is seen as a direct violation of customary international law or the sovereign borders of the indigeous sector.

Source: Adapted from Charisse Espy, 'Chipko Indian Movement', *TED Case Studies*, Vol. 5, No. 1, January 1996, http://www.american.edu/TED/class/all.htm; accessed on 27 February 2008.

Major Activities in Forests

Timber extraction: Logging for valuable timber such as Teak and Mahogany not only involves a few large trees per hectare, but about a dozen more trees since they are strongly interlocked with each other by vines and construction of roads in forest causes further damage to the forests.

Mining: Mining operations for extracting minerals and fossil fuels like coal often involve vast forest areas. Mining from shallow deposits is done by surface mining,

while that from deep deposits is done by sub-surface mining. More than 80,000 ha of land in this country is presently under the stress of mining activities. Mining and its associated activities require removal of vegetation along with the underlying soil mantle and overlying rock masses. This results in defacing the topography and destruction of the landscape in the area.

Large-scale deforestation has been reported in Mussorie and Dehradun valley due to indiscriminate mining of various minerals over a length of about forty kilometres. The forested area has declined at an average rate of 33 per cent and the increase in non-forest area due to mining activities has resulted in relatively unstable zones, leading to landslides.

Indiscriminate mining in forests of Goa since 1961 has destroyed more than 50,000 ha of forest land. Coal mining in Jharia, Raniganj and Singrauli areas have caused extensive deforestation in Jharkhand. Mining of magnesite and soap-stones have destroyed 14 ha of forest in hill slopes of Khirakot, Kosi valley, Almora. Mining of radioactive minerals in Kerala, Tamilnadu and Karnataka are posing similar threats of deforestation. The rich forests of Western Ghats are also facing the same threat due to mining projects for excavation of copper, chromite, bauxite and magnetite.

Mining Engineerng: Mining engineering is a field that involves many of the other engineering disciplines as applied to extracting and processing minerals from a naturally occurring environment.

The need for mineral extraction and production is an essential activity of any technically proficient society. As minerals are produced from within a naturally occurring environment, disturbance of the environment as a result of mineral production is a given. Modern mining engineers must therefore be concerned not only with the production and processing of mineral commodities, but also with the mitigation of damage or changes to an environment as a result of that production and processing.

The two primary types of mine are underground mines and open-pit mines. Minerals that exist relatively deep underground (eg. some coal seams, gold and some metalliferous ores) are generally recovered using underground mining methods. Minerals like iron ore, shallow coal seams and bauxite are usually recovered from the surface by openpit mining.

Dams and their Effects on Forests and People

Big dams and rivers valley projects have multi-purpose uses and Pandit Jawaharlal Nehru used to refer to these dams and valley projects as 'Temples of modern India'. However, these dams are also responsible for the destruction of vast areas of forests. India has more than 1550 large dams, the maximum being in the state of Maharashtra (more than 600), followed by Gujarat (more than 250) and Madhya Pradesh (130). The highest one is Tehri dam, on river Bhagirathi in Uttarakhand and the largest in terms of capacity is Bhakra dam on river Satluj in Himachal Pradesh.

Big dams have been in sharp focus of various environmental groups all over the world, because of several ecological problems including deforestation and socio-economic problems related to tribal or native people associated with them.

The Silent Valley Hydro-Electric Project was one of the first such projects situated in the tropical rain forest area of Western Ghats, which attracted much concern of the people.

The crusade against the ecological damage and deforestation caused due to Tehri dam was led by Shri Sunderlal Bahaguna, the leader of Chipko Movement. The cause of Sardar Sarovar Dam related issues taken up by the environmental activitist Medha Patkar, joined by Arundhati Roy and Baba Amte.

For building big dams, large-scale devastation of forests takes place which breaks the natural ecological balance of the region. 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 (particularly, the tropical rain forests), we are going to lose these species even before knowing them. These species could have marvelous economic or medicinal value and deforestation results in loss of this storehouse of species which have evolved over millions of years.

2. Water Resources

Water is an indispensable natural resource on this earth on which all life depends. About 97 per cent of the earth's surface is covered by water and most of the animals and plants have 60-65 per cent water in their body.

Water is characterized by certain unique features which make it a marvelous resource. These are as follows:

- It exists as a liquid over a wide range of temperature, i.e., from 0 to 100ºC.
- It has the highest specific heat, due to which it warms up and cools down very slowly without causing fluctuations in temperature, thereby protecting the aquatic life.
- It has high latent heat of vapourization. Hence, it takes huge amount of energy for getting vapourized. That is why it produces a cooling effect as it evaporates.
- It is an excellent solvent for several nutrients. Thus, it can serve as a very good carrier of nutrients, including oxygen, which are essential for life. It can also easily dissolve various pollutants and become a carrier of pathogenic micro-organisms.
- Due to high surface tension and cohesion, it can easily rise through great heights, through tree trunks even in the tallest of the trees like Sequoia.
- It has an anamolous expansion behaviour, i.e., as it freezes it expands instead of contracting and thus becomes lighter. It is because of this property that even in extreme cold, lakes freeze only on the surface. Being lighter, the ice keeps floating, whereas the bottom water remains at a higher temperature and therefore, can sustain aquatic organisms even in extreme cold.

The water we use keeps on cycling endlessly through the environment. This is known as the hydrological cycle. We have enormous resources of water on earth amounting to 1404 million km^3. The water from various moist surfaces evaporates and again falls on the earth in the form of rain or snow and passes through living organisms and ultimately returns to the ocean. Every year about 1.4 inch thick layer of water evaporates from the oceans, more than 90 per cent of which returns to the oceans through the hydrological cycle. Solar energy drives the water cycle by evaporating it from various bodies, which subsequently return through rainfall or snow. Plants too play a very vital role by absorbing the groundwater from the soil and releasing it into the atmosphere by the process of transpiration.

Global distribution of water resources is quite uneven depending upon several geographic factors. Tropical rain forest areas receive maximum rainfall, while the major world deserts occur in zones of dry, descending air (20-40° N and S) and receive very little rainfall.

Water Use and Overexploitation

Due to its unique properties, water has multiple uses for all living organisms. Water is absolutely essential for life. Most of the life processes take place in water contained in the body. Uptake of nutrients, their distribution in the body, regulation of temperature, and removal of wastes are all mediated through water.

Water is used by humans in the two following ways:

1. **Water withdrawal**: This involves taking water from groundwater or surface water resource.
2. **Water consumption**: Here, the water which is taken up is not returned for reuse.

Water: A Precious Natural Resource

Although water is very abundant on earth, yet it is very precious. Out of the total water reserves of the world, about 97 per cent is salt water (marine) and only 3 per cent is fresh water. Even this small fraction of fresh water is not available to us; most of it is locked up in the polar ice caps and just 0.003 per cent is readily available to us in the form of groundwater and surface water.

Overuse of groundwater for drinking, irrigation and domestic purposes has resulted in rapid depletion of groundwater in various regions leading to lowering of water table and drying of wells. Pollution of many of the groundwater aquifers has resulted in making these wells unfit for consumption.

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

Groundwater: About 9.86 per cent of the total fresh water resources is in the form of groundwater and it is about 35-50 times that of surface water supplies.

Effects of groundwater usage: 1. Subsidence 2. Lowering of water table and 3. Waterlogging

Surface water: When the water formed through precipitation (rainfall, snow) does not percolate down into the ground or does not return to the atmosphere through evaporation or transpiration loss, it assumes the form of streams, lakes, ponds, wetlands or artificial reservoirs known as surface water. The surface water is largely used for irrigation, industrial use, public water supply and navigation. As you know, a country's economy is largely dependent upon its rivers.

The problems arising out of water resources are floods and droughts. Apart from these, there are conflicts over water. Indispensability of water and its unequal distribution has often led to inter-state or international disputes. Issues related to sharing of river water have been largely affecting our farmers and also shaking our governments. Some major water conflicts are: a) Water conflict in the Middle East-countries involved are Sudan, Egypt, Turkey—it also affects countries who are water starved, viz., Saudi Arabia, Kuwait, Syria, Israel and Jordan, b) The Indus Water treaty is dispute between India and Pakistan, c) The Cauvery water dispute-involves two major southern states of India, viz. Tamilnadu and Karnataka. Similarly, the Satluj-Yamuna Link canal dispute also involves two northern states, viz. Punjab and Haryana. Affected states include UP, Rajasthan as well as Delhi.

In traditional water management, innovative arrangements ensure equitable distribution of water. The 'gram sabhas' approve these plans publicly. While water disputes between states and nations often resume battle-like situations, our traditional water managers in villages prove to be quite effective.

Big Dams: Benefits and Problems

The benefits and problems of big dams are mentioned below:

Benefits

River valley projects with big dams have usually been considered to play a key role in the developmental process due to their multiple uses. India has the distinction of having the largest number of river valley projects. These dams are often regarded as a symbol of national development. Such projects result in providing employment, raising the standard of living and improving the quality of life. Such projects have tremendous potential for economic upliftment and growth. It can check floods and famines, generate electricity and reduce water and power shortages, provide irrigation water to lower areas, provide drinking water in remote areas and bring about overall development of the region.

Environmental problems

The environmental impact of big dams are also too many, due to which very often, big dams become an issue of controversy. The impacts can be at the upstream as well as the downstream levels.

Upstream problems:

- Displacement of tribal people
- Loss of forests, flora and fauna
- Changes in fisheries and the spawning grounds

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- Siltation and sedimentation of reservoirs
- Loss of non-forest land
- Stagnation and waterlogging near reservoir
- Breeding of vectors and spread of vector-borne diseases
- Reservoir induced seismicity (RIS) causing earthquakes
- Growth of aquatic weeds
- Microclimatic changes

Downstream impacts:

- Waterlogging and salinity due to overirrigation
- Micro-climatic changes
- Reduced water flow and silt deposition in rivers
- Flash floods
- Salt water intrusion at river mouths
- Loss of land fertility along the river since the sediments carrying nutrients get deposited in the reservoir
- Outbreak of vector-borne diseases like malaria

Thus, dams are built to serve the society with multiple uses, but it has several serious side-effects. That it why, now there is a shift towards construction of small dams or mini-hydel projects.

3. Mineral Resources

Minerals are naturally occurring, inorganic, crystalline solids having definite chemical composition and characteristic physical properties. There are thousands of minerals occurring in different parts of the world. However, most of the rocks we see everyday are just composed of few common minerals like quartz, feldspar and biotite. These minerals, in turn, are composed of some elements like silicon, oxygen and iron.

Minerals are generally used for the development of industrial plants, generation of energy, construction, equipment and armament for defence, transportation, medical system, communication, jewellery–gold and silver.

Environmental impacts of mineral extraction are devegetation and defacing of landscape, subsidence of land, groundwater contamination, surface water pollution, air pollution and occupational health hazards.

Environmental Effects of extracting and using Mineral Resources

Much of the impact of mining and quarrying is obvious. The disruption of land otherwise suitable for agricultural, urban or recreational use; the deterioration of the immediate environment through noise and airborne dust; and the creation of ore of the most dangerous environments for workers and potentially hazardous for the public are all environmental problems associated with mining.

Water passing through the mines or dumps becomes acidified, later finding its way into rivers, streams or the local groundwater system. Many streams can be affected by abandoned mine works.

Remedial measures include adoption of eco-friendly technology, microbial leaching technique, restoration of mined areas by re-vegetating them with appropriate plant species, stabilization of the mined lands and gradual restoration of flora.

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Case Example: Tracking Health and Well-being in Goa's Mining Belt

New tools promote the sustainable development of mining

The Indian state of Goa is better known for its beaches and as a mecca for backpackers than as the backbone of India's iron ore industry. Yet, the mining belt that stretches across the middle of this tiny state, accounts for 60 per cent of the nation's iron ore exports. The contrast between the picture-perfect beaches of the coast and the pockmarked landscape of the interior is stark. Open pit mining operations have left an indelible mark on the region: hills have been flattened, forests razed, and fields blanketed in silt run-off from waste sites and processing plants. Look beyond the fractured landscape, however, and you will see that jobs have been created, health and education standards have improved, and money spent locally has brought a measure of material wealth.

Goa's story is one that has been repeated in mineral-rich regions the world over, where economic imperatives have pushed environmental concerns aside. Where this story differs, though, is in the steps being taken to change the narrative.

The search for balance

'Closing the mines because of their environmental impact is not an option for Goa,' says Dr Ligia Noronha of the Western Regional Centre of the Tata Energy Research Institute (TERI). 'But there is a need to bring about some balance between the economic gains and the environmental losses to ensure greater sustainability for the region and local communities….'

Building local trust

'Early on, we understood that we needed a broad perspective for understanding well-being and its determinants, as well as a means of addressing the various realities of the people living and working in mining areas,' says Dr Noronha. 'We chose an ecosystem approach because it places an equal emphasis on concerns related to the environment, the economy, and the community in assessing the significance of an economic activity to human well-being. For us, it seemed the best way to go….'

The common set of core issues to emerge from this process were:

- **Land:** its availability for mining operations and issues of compensation to farmers
- **Environmental quality:** concerns about the degradation of air, water, lands, and forests
- **Post mine-closure:** issues of unemployment, income potential, migration rates, alcoholism, and environmental cleanup
- **Human and physical investment in the region:** education, basic amenities, rent-sharing with locals, training opportunities, and health care facilities
- **Social and community relations:** nongovernmental organizations' interference, political interference, media under-reporting of problems, cosmetic attention to problems, and consultation
- Effective administration: rule enforcement, goals achieved, and accountability

Working from this core set of issues, the TERI researchers developed three tools for measuring the impact of mining activities and their effect on well-being: (i) a

set of environmental and social performance indicators to measure the economic, environmental, and social costs of mining; (ii) a 'quality of life' instrument to assess the well-being of people in mining areas over time; and (iii) an income-accounting tool to gauge the long-term economic viability of mining activities.

Assessing change

The purpose of environmental and social performance indicators is to measure trends. … The TERI team developed indicators for each of the stakeholder groups. For mining companies, for example, whether wastewater was treated and tailings water was recycled served as indicators of environmental performance. In villages, water levels in wells and rivers served as indicators of environmental quality. Because monitoring was done by government agencies, they also served as indicators of good environmental governance….

Monitoring quality of life

In developing the quality of life (QOL) instrument, the TERI team worked with focus groups of ten to twelve people who represented a cross-section of the community and included members of the three stakeholder groups. …

… In Goa, the QOL instrument will provide stakeholders with a snapshot of how quality of life changes over time and at different levels of economic activity depending on whether mining is new to the area, well established, or in the process of closing down. This panoramic picture of changes over time can 'suggest policies and promote improved industry and government practices that will lead to improved health and well-being of people', says Dr Noronha.

Promoting sustainable development

The role of mining in sustainable development is one issue that decision makers and resource managers have wrestled with for decades. With the development of their income-accounting tool, the TERI researchers have attempted to show how mining activities, which have a finite life span, can be integrated with social and environmental concerns in a way that promotes long-term community development.

The approach adopted by the TERI team places a monetary value on the effects of mining, such as air and water pollution, loss of forests, groundwater depletion, mineral resource use, and reduced agricultural productivity. It also takes into account the direct and indirect benefits to society. In the case of forests, for example, this would include the economic benefits gained from the generation of marketable products and the indirect benefits from watershed protection and other services. These environmental costs can be seen as an additional amount that should be contributed by the mining company to finance environmental rehabilitation using the 'polluter pays' principle.

The team used similar accounting practices to place values on the health and social costs of mining. To ensure the economic viability of communities after the resource has been exhausted, money would be set aside to finance human and community development. This could help offset one of the main problems associated with mine closures: the lack of skills and resources for alternate economic development.

A step forward

The tools, the TERI team have developed are not a panacea. For one thing they do not address the skewed power relationship so common in mining areas. 'In Goa, mining is big business and mine owners are politically powerful,' says Dr Noronha. 'Mining is causing serious environmental problems, but few questions are asked.'

She sees the development of these tools as a step forward in redressing this imbalance. 'Mining companies are now aware and, more importantly, acknowledge that they have to act responsibly, that their activities are being monitored and assessed,' states Dr Noronha. 'Communities have information, both positive and negative, about the activity and its impact in relation to certain societal goals or standards, if they want to act toward improved conditions for themselves. And government officials know there is access to information if they want to use it to improve governance in mining regions.'

This, she believes, can promote increased accountability and transparency in resource development.

Source: Adapted from the Case Study written by Kevin Conway, a writer in Canada's International Development Research Centre's (IDRC) Communications Division.

For more information

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4. Food Resources

There are thousands of edible plants and animals in the world over, yet only about three dozen types constitute the major food of humans. The main food resources include wheat, rice, maize, potato, barley and oats and about twenty or so common fruits and vegetables, milk, meat, fish and seafood.

World food problems: Every year food problem is killing as many people as were killed by the atomic bomb dropped on Hiroshima during World War II. This shows that there is a drastic need to increase food production, equitably distribute it and also to control population growth. Although, India is the third largest producer of staple crops, an estimated 300 million Indians are still undernourished. India has only half as much land as USA, but it has nearly three times the population to feed. Our food problems are directly related to population.

Because of overgrazing, the agricultural land gets affected as follows:

- Land degradation
- Soil erosion
- Loss of useful species

Agriculture also makes an impact on the usage of land as follows:

- Deforestation
- Soil erosion
- Depletion of nutrients

The impact of modern agriculture is as follows:

- Impact related to high yielding varieties (HYV).
- Fertilizers related problems include micronutrient imbalance, nitrite pollution and eutrophication.
- Pesticide-related problems include creating resistance in pests and producing new pests, death of non-target organisms, biological magnification.
- Some other problems include waterlogging and salinity problems.

Food Resources: Water Logging and Salinity

'Waterlogging' is defined as the state of land in which the subsoil water table is located at or near the surface with the result that the yield of crops commonly grown on it is reduced well below for the land, or, if the land is not cultivated, it cannot be put to its normal use because of the high subsoil water table.

'Salinity control' is defined as the physical control, management, and use of water and related land resources in such a way as to maintain or reduce salt loading and concentrations of salt in water supplies. Drainage of irrigated land is required to reduce waterlogging and soil salinization that inevitably accompanies waterlogging in arid zones. At present, about 20-30 million hectares of irrigated land are seriously affected by salinity.

Case Example: Statement by the Advisory Group on Nutrition on The World Food Problem, Hunger and Malnutrition

In the two decades since the World Food Conference of 1974, the questions of how much food the world grows and how that food is distributed have rightly remained at the centre of international debate and concern. For most of that time, the main emphasis has been on access to food and on distribution, rather than on supply. We believe that emphasis was correct. It directed discussion to questions of food entitlement, household and individual food security and matters related to the quality and safety of food for human consumption. These concerns have been prominent in international statements, most recently the International Conference on Nutrition in 1992. International policy commitments have in turn been associated with modest increases in resource flows to nutrition and related fields, not just to save lives in famines, but also to help achieve food and nutrition goals in the longer term.

Recently, an alternative set of concerns has re-emerged, which has begun to direct attention back to food supply. Rising population, increasing urbanization, doubts about the sustainability of intensive farming and irrigation systems and an apparent slow-down in the rate of increase of yields of the major food staples, are factors which have led some observers to argue for a higher priority to be given to agricultural research and to investments designed to increase agricultural productivity and production. The case is said to be strengthened by structural changes in the world economy, including the changes in Eastern Europe and the former Soviet Union and the effect of the GATT agreement on world food trade.

Our continuing concern about under nutrition and household food security leads us to conclude that agricultural research and investment will have their

greatest impact on reducing hunger if they are planned specifically to take account of the changing geographical and socio-economic characteristics of hunger in the world, and of poor people's perceptions of their malnutrition-related problems. In the immediate future, this will mean increased attention to the production potential of poor people living in resource-poor areas, to the promotion of secure and sustainable livelihoods in Africa, to the needs of female-headed households and semi-urban populations and to measures which will mitigate the appalling effects of severe drought and conflict on food supply, food prices and the command over food by poor people.

Because it is imperative to assure a sustainable and sufficient world food supply, it is necessary to keep under review investments in agricultural research, agriculture and other components affecting supply. We believe that increased investments in these areas are entirely in concert with the massive programmes of action required to achieve the goals set by the International Conference on Nutrition. At the same time, and in a world where aid resources are increasingly scarce, the additional resources required to address issues related to world food supply should not be sought at the expense of those needed to strengthen the effective demand of the deprived for food, health and household care. In our analysis of the world food problem, household access to food remains one of the most urgent food problems for the foreseeable future.

Source: *Report on the Twenty-First Session of the Sub-Committee on Nutrition,* UNICEF, New York, 7–11 March 1994.

5. Energy Resources

Energy consumption of a nation is usually considered as an index of its development. This is because almost all the development activities are directly or indirectly dependent upon energy. There are wide disparities in per capita energy use between the developed and the developing nations.

The original form of energy based technology probably was fire, which produced heat and the early man used it for cooking and heating purposes. Wind and hydropower has also been used. Invention of steam engines replaced the burning of wood by coal and coal was further replaced by oil.

Energy resources are primarily divided into two categories, viz. renewable and non-renewable sources.

Renewable energy resources must be preferred over the non-renewable resources. This will seek to end the energy crisis which the world is facing today. It is inevitable truth that now there is an urgent need of thinking in an terms of alternative sources of energy, which are also termed as non-conventional energy sources. These include: 1. solar energy, 2. wind energy 3. hydropower, tidal energy, ocean thermal energy, geothermal energy, biomass, biogas and biofuels.

The non-renewable energy sources include coal, petroleum, natural gas and nuclear energy.

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6. Land Resources

Land as a Resource

Land is a finite and valuable resource upon which we depend for our food, fibre and fuel wood—the basic amenities of life. Soil is also a valuable resource.

Land Degradation

Because of increase in population, the demands for arable land for producing food and fuel wood is also increasing. Hence, there is more and more pressure on the limited land resources which are being depleted due to overexploitation. Soil erosion, waterlogging, salinization and contamination of the soil with industrial wastes like fly ash, press mud or heavy metals all cause degradation of land.

Soil erosion: Soil erosion means wearing away of soil. It is defined as the movement of soil components, especially surface-litter and top soil from one place to another. It results in the loss of fertility.

It is basically of two types, viz, normal erosion or geological erosion and accelerated erosion. The agents that cause such erosions are climatic agents and biotic agents. Wind is also responsible for land erosion through saltation, suspension and surface creep.

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

- Conservational till farming
- Contour farming
- Terracing
- Strip cropping
- Alley cropping
- Wind breaks or shelterbelts
- Waterlogging

Man-induced Erosions

In order to provide food and shelter, man has cut down forests indiscriminately, allowed grazing of grasses excessively and ploughed the land and exposed it to nature with the result that erosion of soil has been faster than it was formed.

This is man - made erosion and is a result of bad land management. The worst form of cultivation is shifting cultivation. The practice is common with tribal communties. They fell the forest and burn all vegetation and cultivate the cleared areas for two to three years and then abandon them for some years. This accelerates erosion and many good hill slopes have been denuded of vegetation and top soil, making them barren.

Landslides: Various anthropogenic activities like hydroelectric projects, large dams, reservoirs, construction of roads and railway lines, construction of buildings and mining are responsible for clearing of large forested areas.

Desertification: It is a process whereby the productive potential of arid or semiarid lands falls by ten per cent or more. Desertification is characterized by devegetation and loss of vegetal cover, depletion of groundwater, salinization and severe soil erosion. The causes of desertification are deforestation, overgrazing and mining and quarrying.

1.3.3 Role of an Individual in Conservation of Natural Resources

Different natural resources like forests, water, soil, food, mineral and energy resources play a vital role in the development of a nation. With our small individual efforts we can help in conserving our natural resources to a large extent. The following are some of the ways:

Conserve Water

1. Do not keep water taps running while brushing, shaving, washing or bathing.
2. In washing machines, fill the machine only to the level required for your clothes.
3. Install water-saving toilets that use not more than six litres per flush.
4. Check for water leaks in pipes and toilets and repair them promptly.
5. Reuse the soapy water of washing from clothes for gardening, driveways, etc.
6. Water the plants and the lawns in the evening when evaporation losses are minimum. Never water the plants in mid-day.
7. Install a system to capture rain water.

Conserve Energy

1. Turn off lights, fans and other appliances, when not in use.
2. Obtain as much heat as possible from natural sources. Dry the clothes in sun instead of using dryers.
3. Use solar cooker for cooking which will make the food more nutritious and will save your LPG expenses.
4. Build your house with provision for sunspace which will keep your house warmer and will provide more light.
5. Drive less, make fewer trips and use public transportations whenever possible. Share a car-pool, if possible.
6. Control the use of air conditioners.
7. Recycle and reuse glass, metals and paper.
8. Use bicycle or just walk down small distances instead of using an automobile.

Protect the Soil

1. Grow different types of ornamental plants, herbs and trees in your garden. Grow grass in the open areas which will bind the soil and prevent its erosion.

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2. Make compost from your kitchen waste and use it for your kitchen-garden.
3. Do not irrigate the plants using a strong flow of water as it would wash off the soil.
4. Better use sprinkling irrigation.

Promote Sustainable Agriculture

1. Do not waste food; Take only as much as you can eat.
2. Reduce the use of pesticides.
3. Fertilize your crops with organic fertilizers.
4. Use drip irrigation.
5. Eat local and seasonal vegetables.
6. Control pests.

CHECK YOUR PROGRESS

6. Define natural resources.
7. Enlist the categories of natural resources.
8. What are the ecological benefits of forests?
9. What is our role as an individual in the conservation of water?
10. The rich have gone richer and the poor have become poorer. Can there be a balanced distribution of resources and wealth?

1.4 SUMMARY

- Environmental science, in its broadest sense, is the science of complex interactions that occur among the terrestrial, atmospheric, living and anthropological environments.
- Economic environment refers to all those factors or forces which contribute to the economic impact on the man, his activities and his region.
- The cultural environment is the imprint of man's activities, his occupation and utilization of the physical resources for his own benefit. All manmade features such as buildings, settlements, roads and plantation are called cultural features.
- Political environment refers to the influence exerted by the three main political institutions, viz. legislature, executive and judiciary. It helps to shape, direct, develop and control many of the human activities including the business antipollution laws.
- The scope of environmental science and its management has increased from manufacturing pollution control equipment, sewage and effluent treatment plants, biomedical waste treatment and fly ash management.

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- To safeguard a healthy environment that is essential to life, humans must learn that Earth does not have infinite resources. Earth's limited resources must be conserved and, where possible, reused. Furthermore, humans must devise new strategies that combine environmental progress with economic growth.
- Environmental studies is an important but neglected body of knowledge. It concerns itself with life support system and is closely related with development and economic growth.
- The basic ecological variables—energy, space, time and diversity are sometimes together called natural resources. These natural resources maintain the ecological balance among themselves. Man is the only organism who has disrupted this delicate balance.
- Resources that can be replenished through rapid natural cycles are known as renewable resources.
- The resources that cannot be replenished through natural processes are known as non-renewable resources.
- Resources which are not changed or exhausted by man's activities and are abundantly available are said to be inexhaustible.
- These resources are limited in nature and they are non-maintainable, e.g., coal, petrol and some minerals.
- About one-third of the world's land area is forested, which includes closed as well as open forests.
- The forested area in India seems to have stabilized since 1982 with about 0.04 per cent decline in deforestation annually between 1982-90.
- Mining Engineering is a field that involves many of the other engineering disciplines as applied to extracting and processing minerals from a naturally occurring environment.
- For building big dams, large-scale devastation of forests takes place which breaks the natural ecological balance of the region. Floods, droughts and landslides become more prevalent in such areas.
- Water is an indispensable natural resource on this earth on which all life depends.
- Although water is very abundant on earth, yet it is very precious. Out of the total water reserves of the world, about 97 per cent is salt water (marine) and only 3 per cent is fresh water.
- Minerals are naturally occurring, inorganic, crystalline solids having definite chemical composition and characteristic physical properties. There are thousands of minerals occurring in different parts of the world.
- There are thousands of edible plants and animals the world over, yet only about three dozen types constitute the major food of humans. The main food resources include wheat, rice, maize, potato, barley and oats and about twenty or so common fruits and vegetables, milk, meat, fish and seafood.

- Energy consumption of a nation is usually considered as an index of its development. This is because almost all the development activities are directly or indirectly dependent upon energy.
- Energy resources are primarily divided into two categories, viz. renewable and non-renewable sources.
- Land is a finite and valuable resource upon which we depend for our food, fibre and fuel wood—the basic amenities of life. Soil is also a valuable resource.
- Because of increase in population, the demands for arable land for producing food and fuel wood is also increasing.
- Soil erosion means wearing away of soil. It is defined as the movement of soil components, especially surface-litter and top soil from one place to another. It results in the loss of fertility.

1.5 KEY TERMS

- **Environment:** It is the sum total of water, air and land, the inter-relationships among them and also with human beings, other living organisms and property.
- **Environmental Studies:** It is the study of environment. Not the environment from the point of view of any one particular discipline, but a study and understanding of the interlinkages—the complex ways in which one phenomenon, one action, is connected to another, how the same thing can be understood from different perspectives, perspectives that are often rooted in different disciplines.
- **Environmental Science:** In its broadest sense, it is the science of complex interactions that occurs among the terrestrial, atmospheric, living and anthropological environments. It includes all the disciplines such as chemistry, biology, sociology and government that affect or describe these interactions.
- **Environmental Chemistry:** It may be defined as the study of the sources, reactions, transport, effects and fates of chemical species in water, soil, and air environments and the effects of technology thereon.
- **Economic Environment:** It refers to all those factors or forces which contribute to the economic impact on the man, his activities and his region. Resources, industrial production, population, agriculture, infrastructure and the various stages in the economic development like economic conditions, economic policies, economic planning, economic philosophy, economic system and trade cycle are major internal and external factors which make up the total economic environment.
- **Political Environment:** It refers to the influence exerted by the three main political institutions, viz. legislature, executive and judiciary. It helps to shape, direct, develop and control many of the human activities including the business antipollution laws.

1.6 ANSWERS TO 'CHECK YOUR PROGRESS'

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1. Environment is the sum total of water, air and land with an inter-relationship among human beings, other living organisms and property.
2. Environmental science may be defined as the study of the earth, air, water and living environments and the effects of technology thereon. This discipline of natural history in recent times has evolved into ecology, the study of environmental factors that effect organisms and how organisms interact with these factors and with each other.
3. Natural ecosystem includes both physical and natural resources.
4. Global warming, population problems, depletion of ozone layer, habitat destruction and species extinction, energy production, groundwater depletion and contamination, are the problems that are being solved by using environmental studies.
5. Media is playing a major role in creating awareness among people by telecasting Various advertisements, documentaries, feature films, etc. Also newspaper and other magazines are publishing a lot of articles on the environment to create awareness.
6. Natural resources are defined as a form of energy which is essential for the functioning of organisms, populations and ecosystems.
7. Forest resources, water resources, mineral resources, food resources, energy resources and land resources are the categories of natural resources.
8. The ecological benefits of forests are as follows: Trees produce oxygen by photosynthesis which is so vital for life on earth. The greenhouse gas carbon dioxide is absorbed by the forest as a raw material for photosynthesis, thereby reducing the problem of global warming caused by CO_2.

   It provides shelter to wild animals and helps in binding soil particles tightly to their roots and prevents soil erosion. Forests can absorb many toxic gases and can help in keeping the air pure and clean.
9. Our small individual efforts can together help in conserving the natural resources. Some of the ways to conserve natural resources are as follows:
   - Do not keep water taps running while brushing, shaving, washing or bathing.
   - In washing machines, fill water only to the level required for our clothes.
   - Install water-saving toilets that use not more than six litres per flush.
   - Check for water leaks in pipes and toilets and repair them promptly.
10. Yes, there can be a balanced distribution of resources and wealth. Rich countries will have to lower their consumption levels and the minimum needs of the poor must be satisfied by providing them resources. Fair sharing of resources between the rich and the poor will bring about sustainable development for all.

1.7 QUESTIONS AND EXERCISES

Short-Answer Questions

1. 'If you plan for one year, plant rice; if you plan for ten years, plant trees; and if you plan for 100 years, educate people.' Comment on this statement.
2. Do you agree that both underdeveloped and developing countries and developed countries create damages, depletion and pollution? Give reasons for your answer.
3. What is the major challenge faced by environmental chemistry?
4. What are renewable and non-renewable resources? Give examples.

Long-Answer Questions

1. What is the need for studying environment issues?
2. What is the scope of environmental education?
3. How would environmental awareness help to protect our environment?
4. Discuss the major uses of forests. How would you justify that ecological uses of forest surpass its commercial uses?
5. What are the major causes and consequences of deforestation?
6. What are major causes for conflicts over water? Discuss one international and one interstate water conflict.
7. What are the uses of various types of minerals?
8. What are the major environmental impacts of mineral extraction?

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UNIT 2 ECOSYSTEMS AND BIODIVERSITY CONSERVATION

Structure

2.0 INTRODUCTION

It is essential to first grasp the fundamentals of ecology in order to understand the environment. The word ecology comes from the Greek word Oikos, meaning a house or place to live. Taken literally, ecology refers to the study of organisms in their natural habitat. Ecology is concerned with the study of organisms in various habitats, viz. land, oceans, fresh water and air. Ecology can also be defined as the study of the structure and functions of nature. Ecologists try to predict what will happen to organisms, population, or communities under a particular set of habitat.

For practical purposes, we can consider ecology as the study of organisms and their environment. In other words, it is the study of the interrelations between living organisms and their environment. Ecology proceeds at three levels: (1) the

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individual organism (2) the population (consisting of individuals of the same species) and (3) the community (consisting of number of populations).

At the level of the organism, ecology deals with how individuals affect the ecosystem and vice versa. For example, the greenhouse effect is a real danger, and the implications on human life as the earth heats up further are dangerous. At the level of population, ecology deals with the presence or absence of a particular species and with trends and fluctuations in their numbers. To understand population fluctuation, the changes that are happening to individuals making up the population are analysed. Community ecology deals with the composition or structure of communities, and the natural resources affected by them. Communities are not constant but are continually changing because of interactions among the population and because of disturbances caused by climatic and geological events as well as human activities.

Ecology is a branch of science that deals with the inter-relationship between biotic (living) and abiotic (non-living) components of nature as well as with the relationship among the individuals, population and community of the biotic components.

Ecology has been defined in a number of ways. According to Woodbury (1954), 'Ecology is a science which investigates organisms in relation to their environment'. E.P. Odum (1969) defined ecology as 'the study of structure and function of nature'. The most acceptable definition of ecology was proposed by Charles Krebs (1985), *Ecology is the scientific study of the interaction that determines the distribution and abundance of organisms*.

In ecology, the term 'habitat' is used to denote the place where an organism's or species' population lives, for example pond. A pond is the habitat of zooplankton and fish. 'Niche' is the fundamental unit of an organism's or species' population in the community. Whereas 'habitat' is the place where an organism lives, 'niche' is the activity (functional) aspect of the organism. 'Population' is used to denote groups of individuals of any one kind of organism and 'community' or biotic community includes all the populations of a given area, called habitat.

Ecology plays a significant role in our day-to-day life. It is concerned with agriculture, horticulture, conservation of soil, forest, wildlife, water resources, etc.

This unit will also talk about the concept of biodiversity. If we divide the whole earth into 10 billion parts, it is only one part where life exists and the 50 million species are all restricted to just about a kilometre-thick layer of soil, water and air. It is indeed wonderful to see that so much diversity has been created by nature on this earth from so little physical matter.

Biodiversity refers to the variety and variability among all groups of living organisms and the ecosystem complexes in which they occur.

In the Convention of Biological Diversity, 1992, biodiversity has been 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 a part of.

Biodiversity means the variety and variability of all living organisms. Biodiversity constitutes the biological wealth. Biodiversity is at three levels genetic diversity, species diversity and ecosystem diversity.

2.1 UNIT OBJECTIVES

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After going through this unit, you will be able to:

- Discuss the concept of ecosystem
- Describe the structure and functions of an ecosystem
- Identify the energy flow in an ecosystem
- Explain the concept of ecological succession
- Learn the concept of biodiversity
- Assess the various types of biodiversity

2.2 CONCEPT OF AN ECOSYSTEM

An organism is a form of life. A wide range and variety of organisms are present on earth from the single-celled amoeba to huge sharks, from microscopic blue-green algae to massive banyan trees. It includes all plants and animals.

Species

Group of organisms that resemble one another in appearance, behaviour, chemistry and genetic structure form a species. Organisms of the same species can breed with one another and produce fertile offspring under natural conditions. For instance, all human beings (Homo sapiens) resemble one another in their body structure, body systems and they all have similar genetic structure. They are thus grouped together under the species and sapiens.

Population

Population is a group of individuals of the same species occupying a given area at a given time. For example, the Asiatic lions in the Gir National Park, Gujarat, make a population. Group of individual organisms of the same species living within an area is called population.

Communities

Groups of various species occupying a particular area and interacting with each other make up a community. For instance, when we say 'the community of the Gir National Park', we refer to the lion population, the deer population, the cattle population, the grass population and populations of all kinds of life forms present there. Thus, community comprises several species interacting with each other.

Any assemblage of populations living in a prescribed area or physical habitat that has characteristics in addition to its individual and population components can be called a community.

Cycles

The circulation of the chemical elements in the biosphere, from the environment to organisms and back to the environment, is called cycle.

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Food Chain

The transfer of food energy from its source in plants through a series of organisms where eating and being eaten is repeated a number of times is called food chain.

Carrying Capacity

The maximum population of a particular species that a given habitat can support over a given period of time is known as the carrying capacity of the habitat.

Ecosystem: An ecosystem is a community of organisms involved in a dynamic network of biological, chemical and physical interactions between themselves and with the non-living components. Such interactions sustain the system and allow it to respond to changing conditions. Thus, an ecosystem includes the communities, the non-living components and their interactions. The Gir ecosystem will thus include the various life forms found in the park (the community) and also the non-living components of the park like the soil, rocks and water and even the solar energy that is captured by the plants.

The sum total of all the ecosystems on planet Earth is called the biosphere, which includes all living organisms on earth, interacting with the physical environment as a whole, to maintain a steady-state ecosystem.

The community of organisms and populations that are interacting with one another and with the chemical and physical components of their environment is called 'ecosystem'.

The term ecosystem was first proposed by A.G. Tansley (1935) who defined ecosystem as follows: 'Ecosystem is defined as a self-sustained community of plants and animals existing in its own environment.'

Odum (1971) defined ecosystem as any unit that includes all the organisms in a given area interacting with the physical environment, so that a flow of energy gives rise to a clearly defined tropic structure, biotic diversity and material cycles within the system.

Michael Allaby (1983) defined ecosystem as a community of interdependent organisms together with the environment.

The term ecosystem is made up of two words: eco and system. Eco means ecological sphere or a region of space where living things can exist, while system mean interacting organisms living in a particular habitat (living space). Thus, the system resulting from the integration of all the living and non-living factors is called ecosystem.

An ecosystem may be defined as a dynamic entity composed of a biological community and its associated abiotic environment. Often, the dynamic interactions that occur within an ecosystem are numerous and complex. Ecosystems are always undergoing alterations in their biotic and abiotic components. Some of these alterations first begin with a change in the state of one component of the ecosystem, which then cascades and sometimes, amplifies into other components because of relationships.

Thermodynamically, a system is any part of the universe separated from the rest by a well-defined boundary. Likewise, a living organism has a boundary, the skin.

Thermodynamically, systems can be of three types:

- **Isolated system:** There is neither an exchange of energy nor matter with the environment.
- **Closed system:** There is an exchange of energy but not matter.
- **Open system:** There is an exchange of both energy and matter.

Open systems are not in thermodynamic equilibrium but in a dynamic steady state. Living systems are considered to be open.

In case of an ecosystem, the boundary is not rigidly defined. The ecological system or ecosystem is defined as a system where the biotic community (living organisms) and the non-biotic (non-living organisms) environment function together as one complete unit. Thus, an ecosystem includes both the living organisms and their non-living counterparts, the environment, each influencing the characteristics of the other and both are necessary for the survival and maintenance of life. An ecosystem has both structure and function. The structure tells about the diversity of species, as function involves the flow of energy and cycling of materials through the structural components. The earth as a whole, is thus a vast ecosystem and the portion of the earth in which the biotic components, i.e., the living matters are present is called 'biosphere' or 'ecosphere'. Relative to the volume of the earth, the biosphere is only a very thin surface layer that extends from 11,000 metres below sea level to 15,000 metres above.

Types of Ecosystem

Ecosystem is of two types: (1) Natural ecosystems (2) Artificial ecosystems.

Natural ecosystems: Ecosystems like ponds, lakes, oceans, forests, grasslands and deserts, which are self regulating systems, without much direct human interferences or manipulations are called natural ecosystems. The natural ecosystem is thus, of two types: (*a*) terrestrial ecosystem (land based ecosystem) (*b*) aquatic ecosystem (water-based ecosystem).

Artificial ecosystems: The town, city and agricultural ecosystems are man-made ecosystems and are therefore, called artificial ecosystems.

2.2.1 Ecosystem Resources

For many years, Indian villagers have been dependent on forests for fuel-wood to cook food. Deforestation was not vehement when the population was less. However, with growing needs of the ever-increasing population, the situation has changed over the last few decades. Forests and the animals they sheltered have disappeared. The disruption of this ecosystem has negatively affected the social system. Increase in the human population, deforestation, fuel shortage, decreased food production

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have adversely affected our ecosystem. Several human activities have impacted the ecosystems and its components in a way that achieving sustainability has become a distant reality.

Development is conventionally reconciled with the economists' view of maximizing wealth for better quality of life for the people. The notion of economic development was challenged when the ill effects of overexploitation surfaced and paved way for sustainable development as a cherished goal that rests on mutually reinforcing relationship between ecology, economic development and social justice. Sustainable development can be defined as meeting present needs without compromising the ability of future generations to meet their needs. It is about leaving a cleaner earth for the future generations. Ecologically sustainable development is about keeping ecosystems healthy. It is about interacting with ecosystems in ways that allow them to maintain sufficient functional integrity to continue providing humans and all other creatures in the ecosystem the food, water, shelter and other resources that they need.

The sustainability of our planet depends on the respect we show to the ecological systems. On this rests the well-being of all organisms including the human race. Of late, ecosystems have been affected by: climate change; large-scale shifts in the ranges of species, timing of the seasons and animal migration; deeply stressed coastal areas; threat to certain important benefits provided by ecosystems; frequency and aggressiveness of disasters like tsunami. Natural ecosystems benefit humans by providing clean drinking water, and processes that help decompose dead plants and animals.

Land

The delineable part of the earth not covered by water is known as land. Land resources provide various functions or services including provisioning, regulating and supporting. However, the quality of the services reached its threshold as communities started exploiting land resources in the name of meeting their own needs. It is important to note that the renewal of land resources is a slow process. The rate of degradation of land is much faster than the natural rate of generation. This means that land that is lost due to degradation will not be naturally replaced within a human time frame. This will lead to a loss of opportunities for the future generations. Deforestation, farming, damming of rivers, industrialization, mining, urbanization, etc., have seriously stressed land resources.

Recent studies conducted worldwide show that land resources have been overexploited by man. The traditional land resource management is no longer appropriate and technology is not always available or affordable. Figure 2.1 provides a snapshot of the causes of land resource degradation of the world.

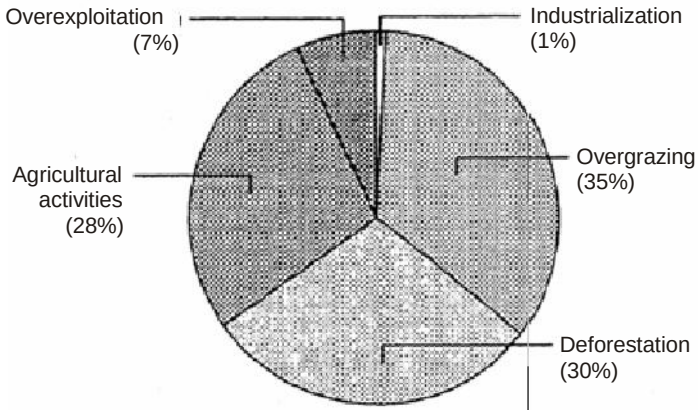

Fig. 2.1 *Causes of Land Resource Degradation*

Source: http://www.env.go.jp/en/wpaper/1996/eae250008000002.gif

Degradation of land resources has resulted in serious variance in the energy balance. The aftermath of this has been made evident through the erratic change in the climate patterns and has posed an alarming threat of food insecurity for the growing population. The need of the hour is to promote the role of ecosystem facilitators rather than exploiters, charged with the responsibility of safeguarding the rights of unborn generations and of conserving land as the basis of the global ecosystem.

Water

After air, no other ecosystem resource holds greater significance than water. Water is a fundamental resource for development and is vital for the survival, health and dignity of human population. About 97.5 per cent of global water resource is saline in nature and found in the seas and oceans. The other 2.5 per cent of water resources provide fresh water to support 86 per cent of the world's population through glaciers, groundwater, permafrost and surface and atmospheric water. Figure 2.2 provides a comparison of worldwide water resource availability over a range of thirty years.

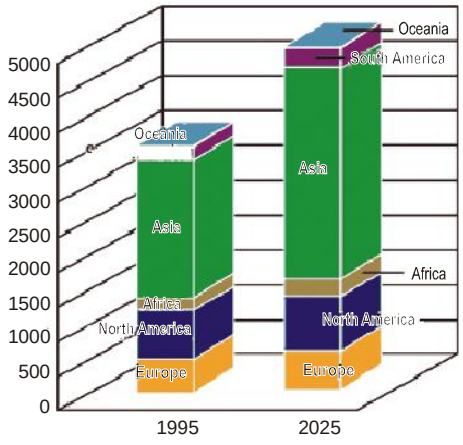

Fig. 2.2 *Comparison of Water Availability*

Source: http://www.mlit.go.jp/english/2006/c_l_and_w_bureau/01_worldwater/images/c_001_2_zu.gif

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The freshwater reserves throughout the world are rapidly declining. An estimated 3 billion people will be living in water poverty by 2025. Urbanization, overpopulation and wastage of groundwater, contribute towards an increase in per capita domestic consumption. As a result, India, China, Africa and Europe will face acute shortage of freshwater by 2025. India will face acute scarcity of water by 2050.

Sustainability of water resources in India is fast becoming a necessity. The increasing population and the high rate of development have led to an increase in pollution, over-exploitation and degradation of the environment. Weak government policies and economic incentives have led to inappropriate use of water resources in the last few years. Management of water resources should be carried out using a holistic approach that addresses the pressures arising from various sources such as the agricultural, industrial and domestic sectors.

Air

Understanding the relationship between air pollution and ecosystem services is vital for achieving sustainable development of the communities. Air is a precious resource that supplies us with oxygen, which is essential for us. Air quality primarily influences the atmosphere in which people live and breathe.

Several researches conducted globally on air pollution suggest that developing nations are the most affected by it. Air pollutants such as nitrogen oxides (NO_x), ammonia (NH_3) and sulphur dioxide (SO_2) have major effect on the ecosystem services. These range from substantial reductions in food provisioning due to crop yield impacts (O_3) to changes in the ecosystem functioning. It is likely that these impacts represent a barrier to providing sufficient crop growth to reduce hunger and maintaining diverse natural ecosystems.

Energy

Understanding the links between energy, poverty and ecosystem services is important for attaining sustainable development. Increased access to energy for the poorest part of the world's population will help in holistic, sustainable development. The current energy use of the poor is neither sufficient to attain the sustainable development nor is it sustainable in terms of maintaining important ecosystem services that can facilitate a transition out of poverty. Meeting the basic energy needs of the poor with minimized impacts on the ecosystem services needed for other aspects of sustainable development attainment such as food production and livelihood support is thus vital.

Other Resources

Another important ecosystem resource which is important to discuss in the present scenario is biodiversity. Biodiversity provides both tangible and intangible benefits like food, fodder, fiber, fuel, climate regulation, flood and drought control, nutrient recycling, cultural and recreational benefits.

Development processes like industrialization and urbanization have brought about loss and degradation of biodiversity throughout the world. Today, several species of organisms, plants and animals are at the threshold of extinction and their conservation is the need of the hour. Identifying the importance of biodiversity, attempts are being made through following various approaches and different strategies, to conserve it. One of the prominent organizations in this area is International Union for Conservation of Nature (IUCN) which has been doing remarkable work in conservation of endangered species.

2.2.2 Human–Ecosystem Interactions

Ecosystems are strongly affected by human activities which are a simple manifestation of society where human beings live. In a simple human–ecosystem interaction, the ecosystem provides services to the human social system by the way of moving materials, energy and information to meet people's needs. The ecosystem resources, both natural and artificial, play a very vital role in the discharge of ecosystem services of provisioning, regulating, supporting and recreating. Like ecosystems, human social system affects the ecosystem through use of ecosystem resources for their survival needs. This relationship has been displayed in Figure 2.3.

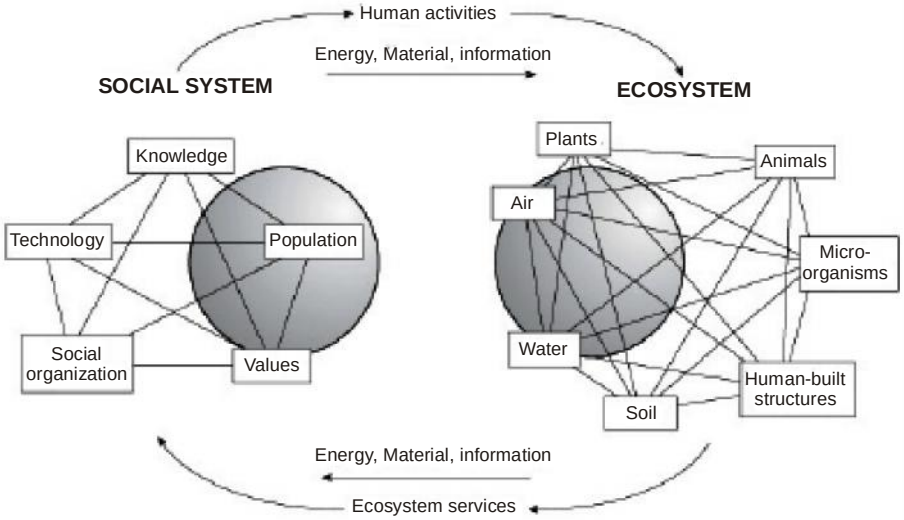

Fig. 2.3 *Human–Ecosystem Interaction*

Source: http://www.gerrymarten.com/human-ecology/images/01-1-english.jpg

Human-ecosystem interaction may be explained through the concepts of common property resources, coexistence and adaptive development.

Common Property Resources

Common Property Resources (CPR) include all such resources which are meant for common use of the villagers but not for individual possession. These resources are an indispensable aspect of the social and institutional arrangements made to meet the everyday requirements of village communities. They are particularly

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important to the landless, the agricultural labours and rural artisans. Usually, common property resources are identified by three factors—access, common use and communal purpose. These two characteristics distinguish it from a private good, which is subject to exclusive use and possession by individuals. These resources are community pastures and forests, wastelands, common dumping and threshing grounds, watershed drainages, village ponds, rivers and other common pool water bodies.

CPRs perform a major role as a life support system. In developing countries like India, CPRs are an important component of the resource base of both the rural as well as urban communities. They contribute to the production and consumption needs of the people in these communities, as well as beyond. When properly managed, CPRs ensure the sustainability of agro-ecological systems providing basic needs and sustenance for the poor.

Nearly everywhere, common property resources have been steadily reduced in extent and importance in modern times. Activities like encroachment as well as privatization and government appropriation are the main processes that have taken resources out of communal control. Increasing pressures on what is left have generally led to its progressive degradation, encouraging further expropriation. The need of the hour is therefore to resort to a more successful common property resources management that has:

- Social groups with rights to a clearly defined resource.
- Ability to exclude others from using the resource.
- Set of use rules that limit the seasonality, extent, or ways in which the resource is extracted by individuals.
- Capacity to monitor use and enforce rules.

Coexistence

Coexistence is a common architectural feature of ecosystems where autotrophs and heterotrophs exist together in a mutually interdependent, compulsory relationship that ensures the flow of energy and the constant recycling of vital chemical nutrients through the ecosystem. Constant energy and nutrient flows are important if the system has to carry on as a self-sustaining collection of components and relationships within a certain physical environment.

Coexistence in relation to human–ecosystem interaction could be used to explain the respectful and non-violent relationship between human beings and different species living in a given place at any given time. The example that follows is that of coexistence of urban ecosystem in chaparral of southern California.

Adaptive Development

Understanding the concept of adaptive development paves way for understanding the notion of resilience and its relationship with sustainable development.

The capability of an ecosystem to endure disturbances like storms, fire and pollution, without changing its form, is known as ecosystem resilience. If a resilient

ecosystem is damaged, it has the ability to repair itself. In a resilient ecosystem, the procedure of repairing facilitates renewal and innovation. Without resilience, ecosystems become more prone to the effects of disturbances, which could have previously been absorbed.

Clean and clear lakes can turn into dirty, oxygen-depleted pools; grasslands can be converted into shrub-deserts, and coral reefs into algae-covered rubble. All these are a result of a combination of disturbance patterns caused by human alteration in nature, and due to reduced social and ecological resilience of ecosystems. Coral reefs, mangrove forests and other coastal wetlands shelter human settlements from coastal storms. Forests and wetlands help in absorbing floodwaters. Sadly, our activities have depleted resilience in many natural systems to such an extent that their ability to protect us from disturbances has declined. Furthermore, the resilience of many social systems to natural calamities has been decreased as the increase in the human population growth has forced people to settle down and conduct economic activities in vulnerable areas.

2.2.3 Ecological Balance or Ecosystem Stability

Ecological balance or ecosystem stability implies a balance between the production and consumption of each component in the ecosystem.

According to T.D. Brock, 'Steady state condition in nature ecosystem is a time independent condition in which production and consumption of each constituent in the system is exactly balanced, the concentration of all constituents within the system remains constant, even though there occurs a continual change'.

There are a number of theories, mechanisms and models to explain the stability of ecosystem. The important ones are as follows:

(i) Theory of Diversity or Stability

If there is diversity of food webs, it will lead to an increase in the number of links in the food web and if community succession operates in an ecosystem, the stability will increase.

(ii) Homeostatic Mechanism

Inbuilt, self-regulating mechanism is known as homeostatic mechanism. If within an ecosystem the population of a species increases significantly, the result will be scarcity of food, leading to competition for food. Most species will die of starvation and the species population will be brought back to its original value and the stability will be restored.

(iii) Models

The equilibrium, as well as non-equilibrium model can explain stability. Thus, if the ecosystem is disturbed by external factors, it may quickly return to its original state by some adjustments, restoring the stability. However, if it does not return to its original state, the disordered arrangement might lead to cross-relationships and make the system stable.

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Ecological Instability

When an ecosystem is unable to adjust to the environmental changes, it is said to be unstable. The instability occurs due to a number of natural and anthropogenic activities such as destruction of natural vegetation and animal species, partly or completely or by replacing them by other vegetations and animals, introduction of toxic substances like insecticides and pesticides and toxic gases like SO_2 and NO_2.

Importance of Ecology

During the past decades, due to rapid increase in technology and population, humans have far more influenced their own environment than any other ecosystem.

Some quoted examples of ecological crisis are as follows:

- *Permian*: Triassic extinction over 25 million years ago.
- *Cretaceous*: Tertiary extinction over 65 million years ago.
- Global warming related to greenhouse effect could involve flooding of the Asian deltas, multiplication of extreme weather phenomena and changes in the nature and quality of the food resources.
- Ozone layer hole issue.
- Deforestation and desertification, resulting in disappearance of many species.
- The nuclear meltdown at Chernobyl in 1986, caused the death of many people and animals due to cancer and caused mutation in large number of people and animals.

The study of ecology helps us to understand the various primitive factors responsible for the existence of life on earth. The survival and well-being depend entirely on the ecological relationships. Although, ecology is considered a branch of biology, ecology deals with many other branches of science, such as chemistry, physics, geology, geography, meteorology, pedology, etc. Thus, the study of ecology gives a reactive insight into the universe and helps to take proper care of the environment for overall survival.

Case Exhibit: Natural Resources Being Depleted at Record Rates

The annual Vital Signs report by the WorldWatch Institute identified fourty-four trends that indicate that the world is on a path toward irrevocable and damaging global warming, and that climate change is not the only serious environment issue confronting the global community. 'The world is running out of time to head off catastrophic climate change, and it is essential that Europe and the rest of the international community bring pressure to bear on U.S. policymakers to address the climate crisis,' Erik Assadourian, Vital Signs Project Director, said in a statement made available to the press. 'The United States must be held accountable for its emissions, double the per capita level in Europe, and should follow the EU lead by committing to reducing its total greenhouse gas emissions by 80 per cent by 2050.' The United States accounted for over 21 per cent of global carbon emissions from fossil fuel burning in 2005. Raging fires in Greece, flooding in England and intense heat waves across southeastern Europe are

early warning signs of climate change that should be headed, the non-profit group said. Here are some of the facts presented in the report:

- More wood was removed from forests in 2005 than ever before.
- Steel production grew 10 per cent to a record 1.24 billion tons in 2006, while primary aluminum output increased to a record 33 million tons. Aluminum production accounted for roughly 3 per cent of global electricity use.
- Meat production hit a record 276 million tons (43 kilograms per person) in 2006.
- Meat consumption is one of several factors driving rising soybean demand. Rapid expansion of soybean plantations in South America could displace 22 million hectares of tropical forest and savanna in the next twenty years.
- The rise in global seafood consumption comes even as many fish species become scarcer: In 2004, 156 million tons of seafood was eaten, an average of three times as much seafood per person than in 1950.
- The warming climate is undermining biodiversity by accelerating habitat loss, altering the timing of animal migrations and plant flowerings, and shifting some species toward the poles and to higher altitudes.
- The oceans have absorbed about half of the carbon dioxide emitted by humans in the last 200 years. Climate change is altering fish migration routes, pushing up sea levels, intensifying coastal erosion, raising ocean acidity, and interfering with currents that move vital nutrients upward from the deep sea.

Source: http://www.thedailygreen.com/environmental-news/latest/6628

CHECK YOUR PROGRESS

1. Where did we derive the word ecology from?
2. What is an ecosystem?
3. Name the two types of ecosystem.
4. What do you understand by coexistence in an ecosystem?
5. Define Common Property Resources (CPR).
6. State the significance of homeostatic mechanism.

2.3 STRUCTURE AND FUNCTION OF AN ECOSYSTEM

A system is an arrangement of matter related to form a whole (unit). The living organisms (biotic community) of an area and their non-living environment function together as one unit called ecological system or ecosystem. The term ecosystem was first introduced in 1935. In the ecosystem, the living organisms and its environment each influences the properties of the other and both are necessary for the survival and maintenance of life. Some examples of natural ecosystems are ponds, lakes,

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oceans, grasslands, forests, deserts, and so on. The largest ecosystem of the earth is the biosphere, which is self sufficient and balanced. Each ecosystem has two components, i.e., biotic and abiotic substances. In short, ecosystem can be described as 'Life Support System'.

2.3.1 Components of Ecosystem

Before we move on to define an ecosystem, we must understand some concepts related to it.

Biosphere—The biosphere is the biological component of earth systems. It consists of all the living organisms on earth, along with the dead organic matter produced by them. The concept was introduced by geologist Eduard Suess in 1875 and is central to many significant disciplines. According to him it meant 'the place on Earth's surface where life dwells'.

Biome—Another important concept that finds place in this context is that of a biome. A biome is nothing but a large area comprising similar flora, fauna and microorganisms. Biomes categorize the biological communities on the earth according to similarities found in the dominant vegetation, climate, geographic location and various other characteristics. Each of these categories contains species, which have adapted to varying conditions of water, heat and soil. A biome consists of many similar ecosystems throughout the world grouped together. Ecologists have identified at least five major categories of biomes namely, aquatic, desert, forests, grasslands and tundra. A biome is characterized by a unique set of abiotic factors, particularly climate, and encompasses an ecological community.

An ecosystem is much smaller than a biome and can be of varying sizes. The term ecosystem comprises two words—'eco' which means 'habitat' and 'system' referring to a set of connected things or parts which link together to make the system work. An ecosystem comprises the biological community, which is found in some locale, as well as the physical and chemical factors that make up its non-living or abiotic environment. It can be defined as a dynamic complex of plants, animals, microbes, and physical environmental features that interact with one another. Regional ecosystems are referred as biomes, while the largest of all the possible ecosystems is called a biosphere. Figure 2.4 provides the levels of organization in ecology.

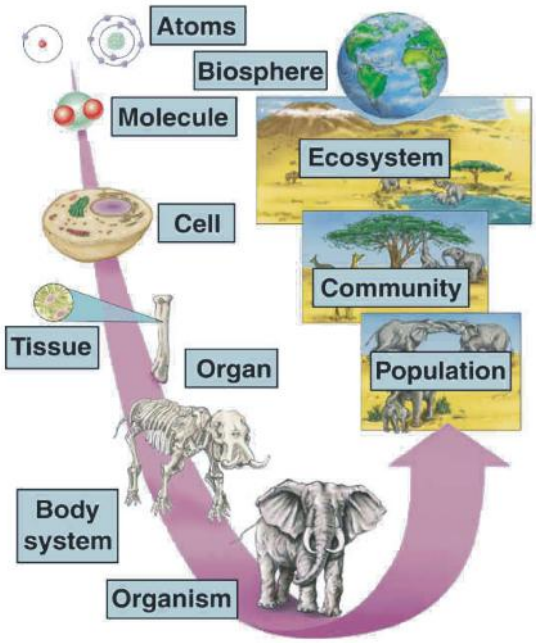

Fig. 2.4 *Levels of Organization in Ecology*

Source: http://www.ux1.eiu.edu/~cfruf/images/bio3002/els_le2.jpg

2.3.2 Structure of an Ecosystem

However, all ecosystems consist of components that can be categorized into two main types, namely, abiotic components, consisting of chemical substances and physical conditions that support life in the ecosystem, and biotic components, which include all living organisms. There is also some source of energy and interaction that takes place in all ecosystems. Figure 2.5 illustrates the components of an ecosystem.

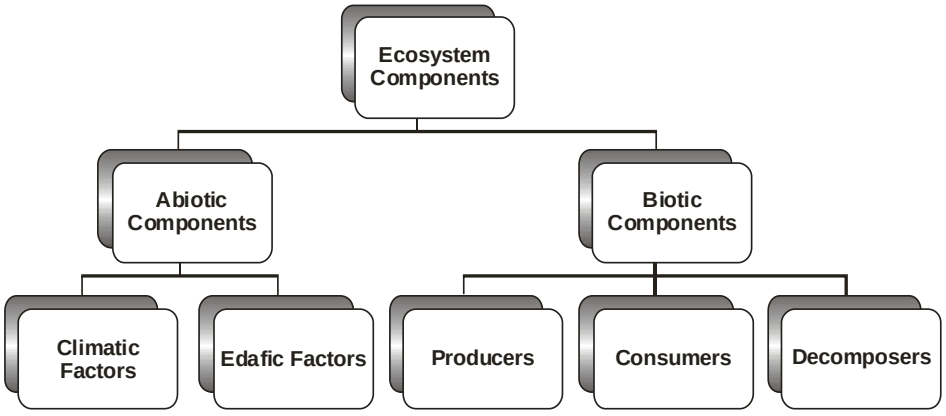

Fig. 2.5 *Components of an Ecosystem*

1. **Abiotic components:** Abiotic components that are responsible for creating the physical environment of an ecosystem consist mainly of elements like energy, inorganic elements and compounds, dead organic matter and climate.

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2. **Biotic components:** The biotic components of an ecosystem include plants, animals and microbes, i.e., the complete living community. The biotic components can be further classified to include **autotrophs** or producers, **heterotrophs** or consumers and **saptotrophs** or reducers. Heterotrophs or consumers obtain energy and nutrients by feeding directly or indirectly on the autotrophs. Animals are the primary heterotrophs. Plants and animals provide organic matter to the soil by shedding skins as well as through death. Saprotrophs or decomposers are those organisms that consume this organic matter, which is called **detritus**. The organic matter that is consumed by these organisms ultimately transforms back into inorganic nutrients in the soil. The plants can utilize these nutrients to produce organic compounds.

Autotrophs: Green plants are generally considered as the autotrophs.

(auto means '*self*', trophic means '*nourishing*')

The autotrophic components include green plants, photosynthetic bacteria, chemosynthetic microbes, etc. The autotrophic components are known as **producers**. The main function of these is to absorb energy from non-living organisms and make it available to all living organisms. The main producers are, of course green plants. These plants possess a green pigment called 'chlorophyll', which transduces solar energy. Such producers absorb solar energy through the light trapping pigments, chlorophylls and convert it to chemical energy with the help of inorganic substances such as water and carbon dioxide, as well as organic substances such as enzymes. Such a process is known as 'photosynthesis', carbon assimilation or primary biological productivity. These autotrophs are known as 'photo-autotrophs', as they utilize light energy. The biochemical formula that describes photosynthesis is:

$$\underset{\text{Lower Energy}}{6CO_2 + 6H_2O} + \text{Solar Energy} \xrightarrow{\text{Chlorophyll}} \underset{\text{Higher Energy}}{C_6H_{12}O_6 + O_2}$$

The oxygen thus evolved, is used for respiration by the living organisms.

The other type of autotrophs called 'chemo-autotrophs', use the energy generated in an oxidation–reduction process. The microorganisms like *beggiatoa* and sulphur bacteria are some examples of chemo-autotrophs. However, the importance of chemo-autotrophs as producers is minimal in an eco-system.

Heterotrops

(Hetero means '*different*', trophic means '*nourishing*')

Heterotrophic components are the living organisms that are unable to prepare their own food like autotrophs, but consume or decompose the complex food material prepared by the autotrophs or producers. Heterotrophs, are thus of two types:

(*a*) Consumers

(*b*) Decomposers and transformers

(a) Consumers

Consumers are the living organisms that consume food prepared by producers. On the basis of dependency on food habits, consumers can be of four types:

(*i*) Primary consumers, (*ii*) Secondary consumers, (*iii*) Tertiary consumers, (*iv*) Decomposes and transformers.

(*i*) *Primary consumers*: Those that feed directly on green plants and are purely herbivorous animals, e.g., cow, dove, buffalo, deer, elephants, and insects like butterfly.

(*ii*) *Secondary consumers*: Those that feed on primary consumers and can be purely carnivorous (flesh eating) as well as omnivorous (plants and flesh eating), e.g., small birds, toad, lizard, small fish.

(*iii*) *Tertiary consumers*: Those that feed on secondary consumers and are the top carnivores. They can feed on primary consumers also. Thus, the tertiary consumers feed on other carnivores, omnivorous as well as herbivorous animals, e.g., lion, tiger, hawk, vulture, snake, peacock, large fish, etc.

(b) Decomposers and Transformers

Decomposers are also heterotrophic organisms, but they depend upon dead organisms for their food. They are chiefly microorganisms like bacteria, fungi, etc. Some invertebrate animals like *protozoa* (*amoeba*, *entamoeba*, *euglena*), as well as earthworms, decompose dead organisms to derive food from them and can therefore, be classified as decomposers. The decomposers attack the dead bodies of producers and consumers, degrading the complex organic substances like cellulose, semi-cellulose, proteins and fats into simple substances. The transformers then convert these simple organic substances into the inorganic form, suitable for reuse by the producers. The decomposers and transformers are very important microorganisms which maintain the dynamic equilibrium in the eco-system.

2.3.3 Functions of an Ecosystem

An ecosystem has got two main functions, which are (1) Productive, and (2) Distributive. In its productive function, it produces energy, which in its distributive function is further passed on to the members in the ecosystem. Autotrophs (producer) produce energy through chlorophyll by trapping solar energy through a process called photosynthesis. These autotrophs are then consumed by heterotrophs (consumer) and hence energy is passed on from producer to consumer.

Case Exhibit: Groundwater Resource In India, Depleting At An Alarming Rate, Says World Bank

According to Pawan Kumar Bansal, Minister for Water Resources, extensive exploitation of India's groundwater resources without keeping a check on the regeneration options, is the main reason for its depletion. As per a report published by the World Bank, called 'Deep well and prudence: towards pragmatic action for addressing groundwater overexploitation in India', in order to preserve groundwater resources in India, 'water pricing measures' like 'incentives' should be adopted.

The report suggests 'Pricing measures, including volumetric charges, taxes and user fees, can act as incentives to conservation and more efficient allocation of water resources, provided they address concerns of equity and affordability to the poor.'

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Bansal said that the depletion of groundwater is a threat to the long-term sustainability of this important resource. The World Bank report was introduced with an aim of determining appropriate strategies for the management and conservation of the groundwater resource in India. In a statement issued by the World Bank with the report, said 'The approach was to look for pragmatic models that have demonstrated potential for success.'

Bansal also said that due to the predictable effects of climate change and global warming on the groundwater resource, it has become necessary to reconsider the methods of managing the groundwater resources.

As per the World Bank report, the groundwater resources are declining at a very fast rate. Currently, 29 per cent of the total groundwater blocks are semi-critical, critical or overexploited and the situation is getting even worse, everyday.

In Uttar Pradesh, the government is slowly realizing the intensity of this problem. Members of the Legislative Assembly, recently, expressed their concern over this matter and appealed to the government to take an action. The government has admitted that it is an important issue and will be dealt with on a priority basis. According to the government, a legislation is, at the moment, being considered, which will keep a check on the exploitation of groundwater. If this legislation is passed, it will ensure that any intrusion on the water bodies is punished. The legislation will also make it compulsory for all the development authorities and housing corporations to construct water bodies in the new housing societies.

According to Paras Nath, Minister for Ground Water in Uttar Pradesh, out of the total 820 blocks in Uttar Pradesh, 215 are in a critical situation. Out of the 215, seventy-six development blocks belonging to twenty-five districts, which consist of Lucknow, Rae Bareli, Agra, JP Nagar, Bareilly and Kanpur, are acutely critical. There has been a drastic reduction in the underground water level, in these districts. Nath also stated that from the remaining 139 blocks, thirty-two are in a critical condition, while 107 are under the sensitive category, however, these also need instant action.

The reason for this situation is over-exploitation of the groundwater resources. Almost 80 per cent of the underground water was used for agricultural purposes, while the remaining 20 per cent was used for drinking. It is extremely important to put an end to the overuse of the groundwater resources. Nath further added that this can be ensured through a legislation and by creating an awareness among the people about the depleting groundwater.

About the Bundlekhnad region, Nath said that the government had decided to boost the number of dams for water harvesting to 415 this year from the 265 last year. Members of the legislative assembly asked Yadav the reason for the decrease in the underground water level. According to him, the intrusion on the ponds is one of the main causes of the depleting groundwater resources as these are an important source for water recharge.

Ambika Chaudhary, the Revenue Minister, intervened at this point and said that the revenue department will conduct an investigation to find out how many water bodies have been disturbed and also find a way to bring them back to their original shape. Returning back to the report of the World Bank on underground water depletion, it has forecasted that by the year 2025, approximately 60 per cent of India's groundwater blocks will fall under the critical category. It further

added that climate change will also affect groundwater resources. Sanjay Pahuja, the lead author of the groundwater resources report as well as the senior Water Resources specialist of World Bank, said that Andhra Pradesh has shown an excellent example of the self-regulation of groundwater in areas where there is drought.

Source: Adapted from http://zeenews.india.com/news/eco-news/india-s-groundwater-resource-depletion-alarming-world-bank_608895.html and http://articles.timesofindia.indiatimes.com/2012-06-09/lucknow/32139750_1_water-bodies-underground-water-excessive-exploitation

2.3.4 Energy Flow in the Ecosystem

The transformation of energy between the different components of an ecosystem is known as 'energy flow'. This is very important, as it determines the density and diversity of organisms as well as their development and functional status. The energy flow in an ecosystem is always uni-directional in nature.

To prepare food and to store it in the form of chemical energy, green plants, with the help of their green pigments known as 'chlorophyll', trap solar energy and convert carbon dioxide (CO_2) and water (H_2O) into complex food materials with the help of other nutrients. This is done through the process of photosynthesis and is referred to as primary production.

The total amount of solar energy converted into chemical energy by green plants is called Gross Primary Production (GPP). Some part of the gross primary production (GPP) is utilized by plants for their various metabolic activities, (mainly respiration [M_A]) and the remainder is called the Net Primary Production (NPP). Thus,

$$GPP = NPP + M_A$$

When, (*i*) $GPP = M_A$, there is no change in energy content (NPP = 0).

(*ii*) $GPP < M_A$, NPP becomes negative, *i.e.*, bio-mass undergoes degradation.

(*iii*) $GPP > M_A$, NPP becomes positive, *i.e.*, accumulation of biomass.

The grains, straws and roots, harvested after a growing season, comprise the NPP. Primary production is of special importance in ecology, since it is the energy fixed by plants by converting solar energy into chemical energy of food stuff that support life in other trophic levels.

When herbivores consume autotrophic plants as food, part of the food is assimilated and the rest is ingested. Some parts of the assimilated food, the potential energy stored as chemical energy of food, get oxidized through respiration, the carbon-carbon bonds are broken and carbon combines with oxygen to form carbon dioxide, releasing kinetic energy. Some parts of the energy is used by the organism to do work and the rest dissipates as heat.

$$C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O + \text{Kinetic energy}$$

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The efficiency of energy utilization varies from organism to organism and within similar organisms it varies with the physical structure of the organism and its age. The remaining part of the assimilated food (energy) is stored in somatic and reproductive tissues for growth and reproduction.

The production of organic matter by heterotrophic organisms is known as 'Secondary Production'. The total quantity of plant material ingested and stored (assimilated) in the body of heterotrophic organisms (herbivore) is known as 'Gross Secondary Production' and the remaining part of the assimilated food (energy) after metabolic processes (mainly respiration), is known as 'Net Secondary Production'.

When herbivores are consumed by carnivores (secondary consumers), further degradation of energy occurs.

Similarly, when carnivores (secondary consumers) are consumed by top carnivores (tertiary consumers) again, energy is degraded further. Thus, at each level of the system there is degradation of energy.

The decomposers ultimately, get food and energy by decomposing the dead organisms of all the trophic levels.

The energy flow through various components of ecosystem can be depicted through Figures 2.6 and 2.7.

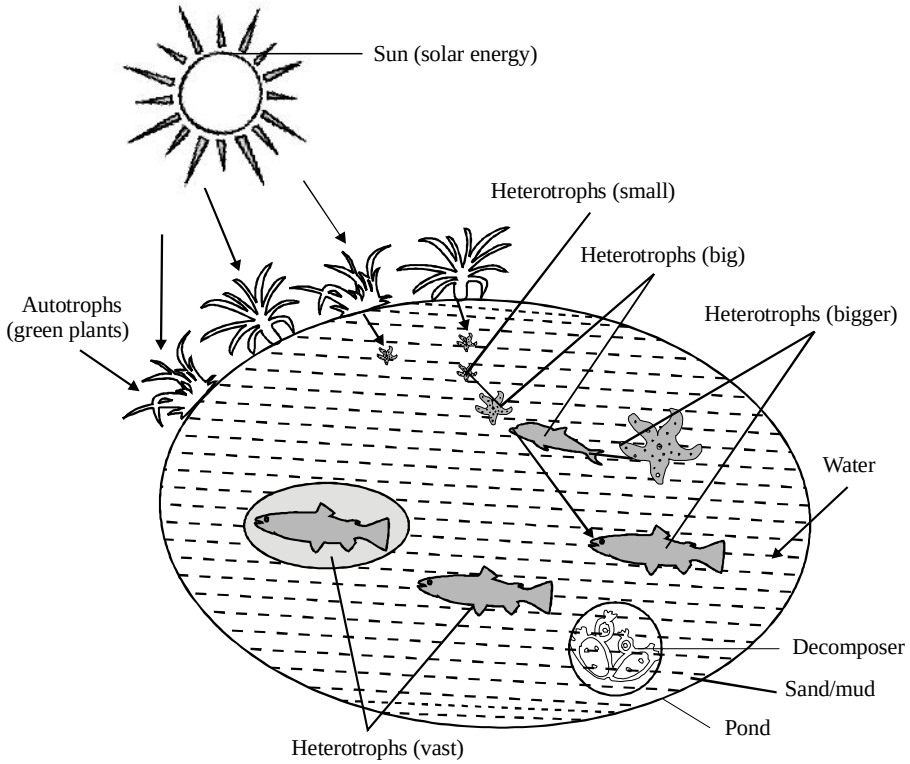

Fig. 2.6 *Passage of Energy in Ecosystem*

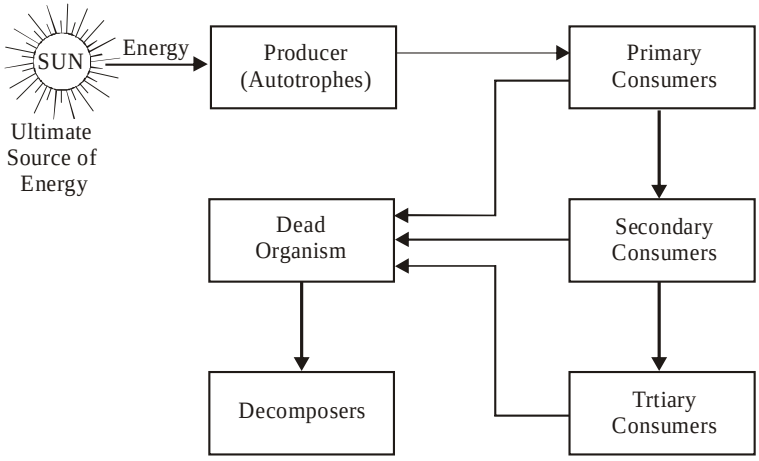

Fig. 2.7 *Energy Flow Chart*

2.3.5 Ecological Succession

Ecological succession is the gradual process by which ecosystems change over time. Habitats are constantly changing. To give you an example, a bare patch of ground will not stay bare for long. It will be quickly colonized by a variety of plants, ants, pests and other living creatures. In the process of succession, the species present in an area will gradually change. Succession occurs because the environmental conditions prevalent in a particular place change over time. Each species is adapted to thrive and compete best against other species under a very specific set of environmental conditions. If these conditions change, then the existing species will be replaced by a new set of species which are better adapted to the new conditions.

Ecological succession is the observed process of modification in the species structure of an ecological community over time. Within a community, some species may become less abundant over time, or they may even disappear from the ecosystem altogether. Similarly, other species within the community may become more abundant, or new species may invade to the community from adjacent ecosystems.

There are specific environmental conditions under which specie will grow and reproduce most optimally. Given an ecosystem's set of environmental conditions, those species that can best survive and grow and produce the most viable offspring will, in all probability, become the most abundant living things. As long as the ecosystem's set of environmental conditions remains unchanged, the species that are most suited to those conditions will flourish. The cause behind changes in an ecosystem is the impact that species have upon the environment. In the process of living, organisms alter their environment over a period of time. While the original environment may have been ideal for a certain species of plant or animal, the new environment is often optimal for some other species. Under the modified conditions, the erstwhile dominant species are likely to dwindle and another species may become ascendant.

Ecological successions can be short-term, usually due to changes in season. For instance in summer, the open ground in your locality is dry and may be home to

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rodents, ants and other small insects. But in the rainy season, it gets filled with water and becomes home to another set of plants and animals—algae, mosquitoes, small fish and so on. Once the rains end, the ground may again turn dry and the original species may return to their habitat. Ecological succession may also take place when conditions of an environment are altered suddenly and drastically. Floods, forest fires, wind storms and human activities like agriculture all greatly modify the conditions of an environment. These devastating forces may also eradicate some species and thus introduce non-reversible changes in the dynamics of the community, kick-starting a struggle for dominance among the species that have survived.

CHECK YOUR PROGRESS

7. Name the abiotic components of an ecosystem.
8. Define 'energy flow'.
9. What is Gross Primary Production (GPP)?

2.4 FOOD CHAINS, FOOD WEBS AND ECOLOGICAL PYRAMID

Let us discuss food chains, food webs and ecological pyramid in detail in the following section.

Food Chain

A food chain shows the movement of food energy through an ecosystem. The organisms belonging to each category of autotrophs, heterotrophs and saprotrophs are related to each other in terms of food. For example, green plants are consumed by herbivores, which are eaten by carnivores. This simply forms a food chain through the eater and eaten relationship. Within any ecosystem, two major types of food chains can be distinguished. They are the grazing food chains and detritus food chains. Figure 2.8 illustrates a simple grazing food chain.

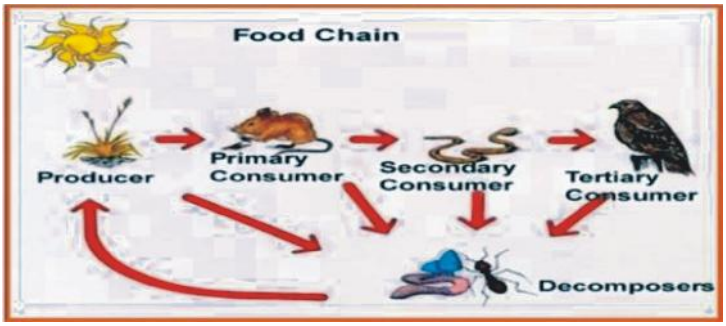

Fig. 2.8 *A Grazing Food Chain*

Source: http://www.bcgrasslands.org/SiteCM/i/upload/4D9BB688B89B4092F9D10BDAEF83EC41E762FBDB.jpg

Grazing food chains are sequential. They begin with the green plants as major sources of energy for primary consumers, i.e., herbivores. The herbivores are then eaten by carnivores. Detritus food chains start from the dead and decaying organic matter of animal and plant bodies known as detritus. This acts as the source of energy for the primary consumers, in this case known as detritus consumers.

The green plants (autotrophs) convert solar energy to chemical energy with the help of inorganic substances such as water, carbon dioxide, as well as other nutrients, and store it as food material. This is utilized by the plants for their survival, which are then consumed by herbivores. The herbivores are consumed by carnivores and carnivores by top carnivores. Through this process, one form of life is supported by another. Thus, food from one trophic level reaches the other trophic level and a chain is established which is known as 'food chain'.

In other words, the transfer of food energy from the producers, through a series of organisms (herbivores, carnivores and decomposers) with repeated eating and being eaten, is known as food chain.

The arrangement in a food chain can be depicted as:

Plant → Herbivore → Carnivore → Top Carnivore
(carnivore 1) (carnivore 2)

Example: Grasshopper grazes grass, but in turn is eaten by toads, which are eaten by snakes.

Grass → Grasshopper → Toad → Snake

Examples of the food chain of different ecosystems can be: grassland ecosystem, forest ecosystem and pond ecosystem.

Grassland ecosystem

Grass→ Grasshopper → Bird → Man → Tiger

Grass → Goat → Man → Lion

Forest ecosystem

Plant → Deer → Lion

Plant → Goat → Tiger

Pond ecosystem

Phytoplankton → Zooplankton → Small fish → Big fish → Crocodile

It is estimated that only about 10 per cent of the potential energy of the previous trophic level is made available to the next trophic level. The efficiency of the food chain is therefore, dependent upon the number of trophic levels or their links present. Thus, shorter the food chain more is the available energy.

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Types of Food Chain

Food chains are of four types:

(*i*) Predator food chain: Such type of food chain starts from producer and ends with higher consumer level. In every trophic level, the size of the organism increases while its number decreases.

(1) Grass → Grasshopper → Toad → Snake

(2) Grass → Grasshopper → Small fish → Big fish → Crocodile

(*ii*) Parasitic food chain: This type of food chain starts from big hosts and ends with the parasitic organisms.

Cow → Worm → Protozoa

(*iii*) Saprophytic food chain: This type of food chain starts from dead organisms and ends with decomposers such as bacteria. It is, however, less efficient as major portion of the energy is lost to the environment without being used properly.

Dead organism (plant/animal) → Fungi → Bacteria

(*iv*) Detritus food chain: Detritus food chain begins with dead organic matter into microorganisms and subsequently to organisms feeding on detritus (detrivores) and their predators.

Such food chains are not much dependent on solar energy, but on the influx of organic matter produced in other systems.

Detritus food chains are prominent in mangrove ecosystems. Some part of the leaves of mangrove trees are consumed by grazing insects and the rest fall into warm, shallow water and are decomposed by saprotrophs like bacteria, fungi, protozoa and colonized algae and subsequently eaten and re-eaten by some small animals. The animals include nematods, amphipods, crabs, insect larvae (detritus consumer).

These animals are in turn consumed by some small fish, minnows which becomes the source of large fish and fish eating birds.

Food Web

Simple food chains rarely exist in nature. The sharing of food by consumers in natural ecosystems leads to food chains being interconnected with one another forming a network. The resulting complex network of interlinked food chains is referred to as a **food web**. Figure 2.9 illustrates a sample food web.

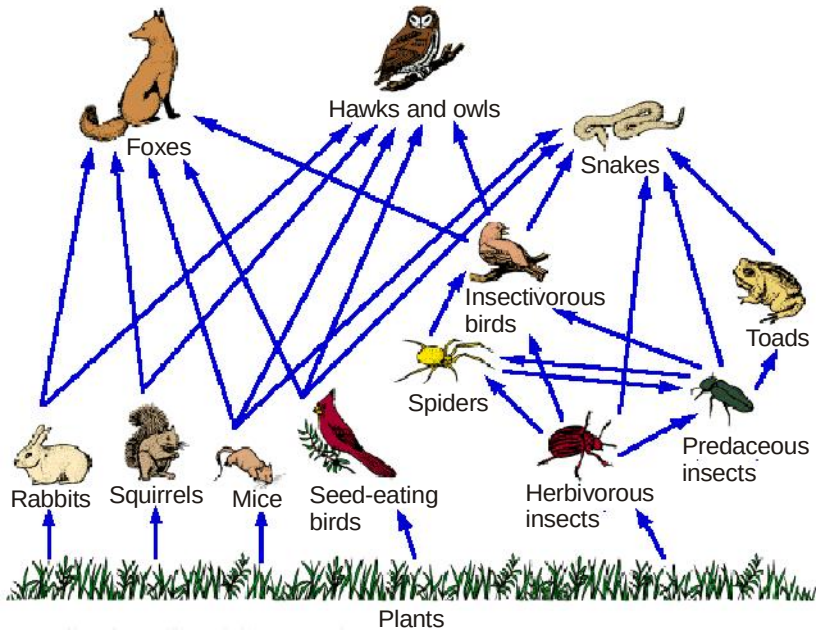

Fig. 2.9 *A Food Web*

Source: http://www.kirksville.k12.mo.us/khs/teacher_web/alternative/Foodweb2.gif

In nature, food chain relationships are very complex. They never operate as isolated sequences, as one organism may form the food source of many organisms and so on. Thus, instead of a food chain, a number of food chains are interconnected with each other and form a web-like structure known as 'food web'.

For example, grass may be grazed by grasshoppers as well as cattle, rabbits and each of these may be eaten by different type of carnivores, such as birds, toads, snakes, foxes, depending on their food habit. Thus, a particular organism may not occupy the same trophic level in every food chain, it may simultaneously behave as secondary, tertiary or a top consumer.

Organisms, whose food is obtained from plants by the same number of steps are said to belong to the same trophic level. Thus, green plants occupy the first trophic level or the producer level. The plant grazers occupy the second trophic level or primary consumer or herbivore level (all plant-grazing insects, cattle, deer, rabbits, etc.). Flesh-eaters, that eat herbivores, form the third trophic level or the secondary consumer or carnivore level-1 (frogs and small fish). The third trophic level is the tertiary consumer or carnivore level-2, which eats the flesh of herbivores and secondary consumers. In a similar fashion, trophic levels can be expanded based on the food habits of organisms.

Charles Elton, a British ecologist, however, concluded that the number of links in a food chain rarely exceeds five, because in the process of energy transfer there is always the loss of energy to the environment. It is the energy transfer mechanism which determines the number of links in a food chain.

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Man and many other animals who are omnivores occupy different trophic levels in food chains in relation to pure carnivores.

The food web maintains the stability of the ecosystem. For example, green land can be grazed by different organisms like insects, rabbits, rodents, etc. The insects then can be eaten by frogs which can be eaten by snakes. Snakes can either be eaten by hawks or can take rodents or rabbits as their preys which only consume grass. Thus, nature has sufficient alternatives and greater the number of alternative pathways, the more stable will be the community of living things.

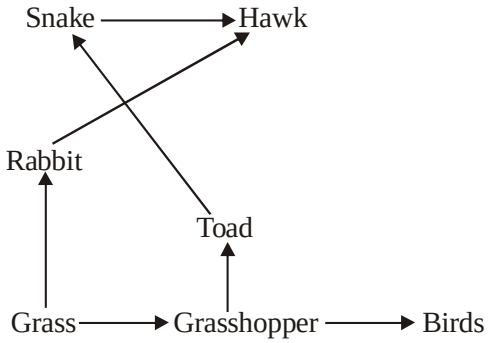

Fig. 2.10 *Food Web*

Examples of some food webs in a grassland ecosystem can be:

(1) Grass → Grasshopper → Toad → Snake → Hawk

(2) Grass → Mouse → Snake → Hawk

(3) Grass → Mouse → Hawk

Significance of Food Chains and Food Webs

Food chain studies help us to understand the feeding relationships and the interaction between organisms in any ecosystem. They help us to understand the energy flow mechanism and matter circulation, such as circulation of toxic substances in the ecosystem and the problem of biological magnification.

Biological magnification is the tendency of pollutants to get concentrated in successive trophic levels. Large concentration of pollutants could be detrimental; if they are toxic.

Bio-magnification occurs when organisms at the bottom of the food chain accumulate the toxic materials greater than that available in the environment around it. As DDT, heavy metals and other toxic metals resemble essential inorganic nutrients these will also be taken up by plants along with the essential nutrients. If there is a shortage of essential nutrients, accumulation of these toxic materials will be more and more. This is the first step of bio-magnification and is known as 'bio-accumulation'.

The second step of bio-magnification occurs when the producers are eaten by consumers. It is known, that energy availability decreases from one trophic level to the other. Thus, successive trophic levels consume more and more biomass and accumulate more and more toxic materials. Since, these toxic substances are not

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broken down in the body or excreted easily, they quickly get accumulated in the tissues. The case is severe for toxic materials soluble in fat such as DDT. When producers containing DDT get digested by the consumers, the DDT solubilizes in fat and gets stored. When this consumer is eaten by another consumer, its fat is digested and the pollutants move to the fat of the new consumer. In this way, the toxic substances are built up in fatty tissues of consumers. For water-soluble toxic materials, bio-magnification however, cannot occur as they are dissolved in the body fluids of consumers and get excreted easily. Since, man is an omnivore and has access to all trophic levels for food, he receives the toxic substances in his body in large amounts. Secondary and tertiary consumers located on top of the food chain also accumulate toxic materials in their body.

The bio-magnification of pollutants can be estimated with the help of Biological Concentration Factor (BCF).

$$BCF = \frac{\text{Concentration of toxic material in organism}}{\text{Concentration of toxic material in environment}}$$

Ecological Pyramids

The concept of ecological pyramid was developed by Charles Elton in 1972.

Ecological pyramids are the diagrammatic representations of data of each trophic level in an ecosystem. In pyramids, the producer level forms the base and successive levels form the tiers, which make up the apex. The higher the steps in the ecological pyramid the lower the number of individuals and larger their size.

Ecological pyramids are of three types:

1. Pyramid of Number
2. Pyramid of Biomass
3. Pyramid of Energy

Pyramid of Number

It depicts the relationship between the producers and different orders of consumers at successive trophic levels in terms of their number. The shape of the pyramid varies from one ecosystem to another. There are two types of pyramid of numbers — upright and inverted.

In aquatic and grassland ecosystems, the pyramid is always upright, but in case of parasitic food chain the pyramid is always inverted.

In a grassland ecosystem, the producers are large number of tiny grasses (tiny autotrophs). The number then, decreases towards the apex as the primary consumers (herbivore) like grasshopper, rabbits and rodents are lesser in number than the grasses. The secondary consumers like snakes, lizards are lesser in number than the primary consumers. Finally, the tertiary consumers (top in the trophic level) like birds, hawks are least in number. Hence, the pyramid becomes upright.

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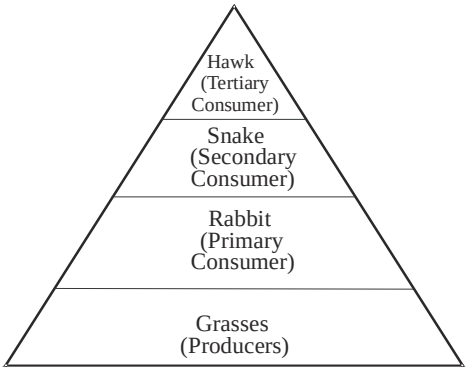

Fig. 2.11 *Upright Pyramid*

In parasitic food chain, inverted pyramid structure is observed. In this case, one primary producer may support numerous tiny parasites, which in turn may support many more hyper-parasites.

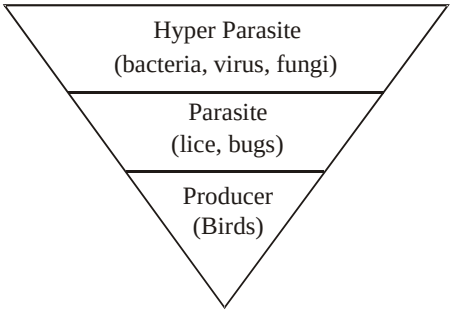

Fig. 2.12 *Inverted Pyramid*

Pyramid of Biomass

Biomass is the total living material (dry weight) of an organism. The pyramid of biomass describes the qualitative relationship between the producers and consumers. There is a gradual decrease of biomass from one trophic level to the next. The total biomass of the producer is more than that of the primary consumer (herbivore), which in turn is more than that of the secondary consumer (carnivore), and so on.

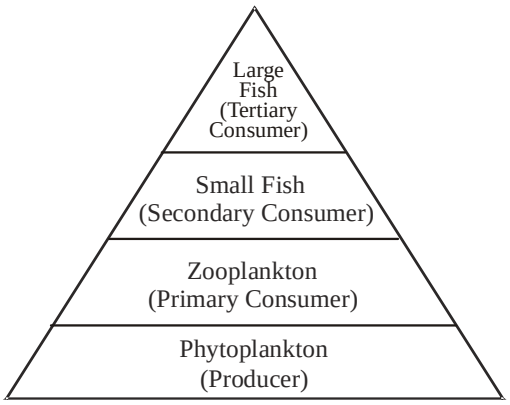

Fig. 2.13 *Pyramid of Biomass*

Pyramid of Energy

Pyramid of energy describes the energy utilization by successive trophic levels. Since, the energy passes from lower trophic level (producers) to higher trophic level (consumer), only about 10 per cent of the potential energy gets transferred and the rest is lost as heat. Energy pyramid in any ecosystem will always be upright.

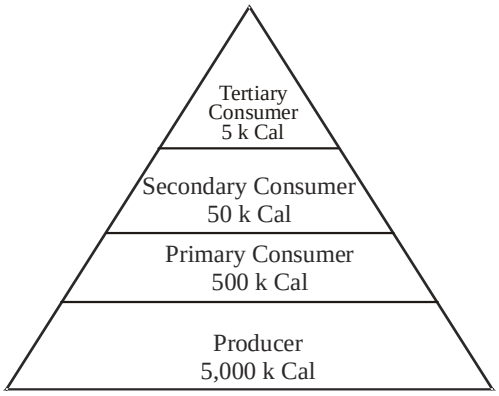

Fig. 2.14 *Pyramid of Energy*

Two important conclusions can be drawn from the pyramid of energy:

1. Energy flow is unidirectional and irreversible.
2. There is a gradual decrease of energy in successive trophic levels, due to energy dissipation as heat released in metabolic activities.

2.4.1 Forest Ecosystems: Structure and Function

Forests are community of plants structurally defined by its trees, shrubs, climbers and ground cover. Forests occupy about 40 per cent of land and in India, it is about one tenth of the total land area. The forest ecosystems consist of two components: the abiotic component and biotic component.

Abiotic component: The type of forests depends upon the abiotic conditions at the site. The type of forests depending on the abiotic factors such as climate and soil characteristics can be coniferous forests, evergreen forests, deciduous forests, mangrove forests, etc. The abiotic components are both inorganic as well as organic substances present in the soil and in the atmosphere. The inorganic substances are CO_2, water, oxygen, nitrogen and inorganic salts of calcium and magnesium such as their phosphates, sulphates and nitrates. There are trace elements like iron, cobalt, copper, molybdenum, etc. present in the soil; the organic components are the carbohydrates, proteins, lipids found in the dead organic debris which form a part of the soil. The physical components are sunlight, heat, rainfall, pH of the soil, etc.

Biotic component: The living organism or the biotic components are (*i*) producers (*ii*) consumers and (*iii*) decomposers.

(*i*) **Producers:** They are mainly trees which show much species diversity and greater degree of stratification especially in tropical moist deciduous forests.

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The diversity of tree depends upon the climatic condition of the site. Besides trees there are shrubs, climbers, epiphytes and ground vegetation. In India, the coniferous forests grow in the Himalayan Mountain Region where temperature is low. The trees have needle like leaves and downward sloping branches. The evergreen forests grow in the high rainfall regions. The trees overlap with each other and form continuous canopy. The forests are rich in orchids and ferns. Deciduous forests are found in regions with a moderate amount of seasonal rainfall. These forests have a thick undergrowth as light penetrates easily. Thorn forests are found in the semi-arid regions. Thorny plants called xerophytic species are found here. The mangrove forests grow along the coast especially in the river deltas.

(*ii*) **Consumers:** Consumers are of three types:

(*a*) *Primary consumers*: These are herbivores such as ants, flies, bugs feeding on tree leaves, larger animals grazing on shoots and fruits of producers, such as elephant, nilgai, deer, squirrel, flying fox, mongoose, etc.

(*b*) *Secondary consumers*: These are carnivores freeding on herbivores. Some common examples are snakes, birds, frogs, lizards, etc.

(*c*) *Tertiary consumers*: These are top carnivores like lion, tiger, hyaena, etc.

(*iii*) **Decomposers:** These are wide variety of microorganisms including fungi (species of coprinus, polyporus, fusarium, etc.) bacteria (species of bacillus, clostridium, angiococcus, etc.) and actinomytes like species of streptomyces. These microorganisms actively participate in bio-geo-chemcial nutrients cycling.

Functions of Forest Ecosystem

The functions of the forest ecosystem are very crucial to life on earth. Let us have a look at the important functions served by the forests.

The biggest utility of forests for the environment is its function as a lifeline. Forests induced life into lifeless rock. The new area of land is first colonized by a few plants which were very strong and could live on bare rock. Slowly other plants and animals followed. Then the trees and forest develop.

The forests ecosystem has a very important function in the production of the soil. The soil on the land is nothing but the remains of the old broken-down rock mixed with the dead plants of the forest. The resultant soil supports many life forms including many small animals and bacteria and plants. Not only do forests aid the production of soil but also protects the soil though its roots. If heavy rains come and there are no trees, soil erosion will take place as the soil will get muddy and wash away, polluting streams, rivers and the sea.

The forest shelters the gardens against erosions. When strong winds and heavy rains come the trees protect the gardens by acting like an anchor. Strong

winds can hurt crops and dry out the soil. Near the coast, salt spray can poison the soil or harm the crops without the shelter of trees. The forests also help protect homes and villages from strong winds by acting as a natural boundary.

The forest holds water. This storage function is beneficial in times of little or no rain. The forest controls the flow of water over the land too by trapping the water in the soil during heavy rains. They hold water in their branches, trunks, roots and leaves. The greenery of the forests helps in preventing the land from going dry and barren.

When the wind blows over the land it moves through the trees and the interaction between the wind and the trees help in the release of water into the wind. When the wind goes through the trees, the trees also put excess heat from the sun into the wind. The heated, wet air then lifts up because hot air rises. When the hot, wet air hits the cooler wind above the land, it becomes clouds. Thereby, helping in further regulating the temperature.

The forest also helps in providing material benefits through products like wood for construction of homes, creation of tools, boats, carvings and wood as a fuel for cooking. The forest also houses many plants which are of great economic value. Not just trees, forests also are important for products like foods, spices and medicines.

The forests have universal as well as local value, they form a part of the heritage for local people. They provide plenty of benefits for humans and we must do the same by protecting it.

2.4.2 Biodiversity: Definition, Genetic, Species and Ecosystem Diversity

Let us discuss the concept of biodiversity in detail in the following section.

Definition of Biodiversity

'Biological diversity', as defined by the Convention on Biodiversity, 1992, means 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.

Biodiversity functions in three levels: genetic biodiversity, species biodiversity, and ecosystem biodiversity.

Genetic Biodiversity

It is the basic source of biodiversity. 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. When the genes within the same species show different versions, due to new combinations, it is called genetic variability. For example, all rice varieties belong to the species Oryza sativa, but there are thousands of wild and cultivated varieties of rice which show variations at the genetic level and differ in their colour, size, shape, aroma and nutrient content of the grain. This is genetic diversity of rice.

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Genetic biodiversity means the variation of genes within a species. In a species, each variety has its own genes or genetic make-up. Diversity of genes within a species increases its ability to adapt to diseases, pollution and other changes in the environment. When a variety of a species is destroyed, genetic diversity gets diminished.

Species Biodiversity

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.

Till now, only about 1.5 million living and 300000 fossil species have been actually described and given scientific names. It is quite likely that a large fraction of these species may have become extinct even before they were discovered and enlisted.

Species biodiversity means a variety of species within a region. Such diversity can be measured on the basis of species in a region. More the species biodiversity means more the biological wealth.

Ecosystem Biodiversity

This is the diversity of ecological complexity showing variations in ecological niches, tropic structure, food webs, nutrient cycling, etc. Ecosystems also show variations with respect to physical parameters like moisture, temperature, altitude and precipitation. Thus, there occurs tremendous diversity within the ecosystems, along these gradients.

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

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 replace the diversity of one ecosystem with 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.

Ecosystem biodiversity refers to the variety of ecosystem in a particular region or zone, for example, various ecosystems include forests, wetlands, arid zones and deserts. All these have their own fauna and flora (biodiversity).

CHECK YOUR PROGRESS

10. What is a food chain?
11. What is a biotic component?
12. List the major ecosystems.
13. What are the types of terrestrial ecosystems on the basis of habitat conditions?
14. How did the Convention of Biological Diversity, 1992 define biodiversity?
15. What are the three levels of biodiversity?

2.5 VALUE OF BIODIVERSITY

Biodiversity in terms of its commercial utility, ecological service, social and aesthetic value has enormous importance. We are benefited by other organisms in innumerable ways. Sometimes, we come to know and appreciate the value of an organism only after it is lost from this earth. Very small, insignificant, useless looking organism may play a crucial role in the ecological balance of the ecosystem or may be a potential source of some invaluable drug for dreaded diseases like cancer or AIDS. The multiple uses of biodiversity is classified as follows:

Consumptive Use Value

These include direct use values where the biodiversity product can be harvested and consumed directly, e.g., fuel, food, drugs and fibre.

Food: A large number of wild plants and shrubs are consumed by human beings as food. About 80,000 edible plants species have been reported from the wild. About 90 per cent of present day food crops have been domesticated from wild tropical plants. Even now, our agricultural scientists make use of the existing wild species of plants that are closely related to our crop plants for developing new hardy strains. Wild relatives usually possess better tolerance and hardiness. A large number of wild animals are also our sources of food.

Drugs and medicines: About 75 per cent of the world's population depends upon plants or plant extracts for medicines. The wonder drug penicillin used as an antibiotic is derived from a fungus called penicillium. Likewise, we get tetracyclin from a bacterium. Quinine, the cure for malaria is obtained from the bark of cinchona tree, while digitalin is obtained from foxglove (digitalis) which is an effective cure for heart ailments. Recently, vinblastin and vincristine, two anti-cancer drugs, have been obtained from periwinkle (catharanthus) plant, which possesses anti-cancer alkaloids. A large number of marine animals are supposed to possess anti-cancer properties which are yet to be explored systematically.

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Fuel: Our forests have been used since ages for fuel wood. The fossil fuels coal, petroleum and natural gas are also products of fossilized biodiversity. Firewood collected by individuals are not normally marketed, but are directly used by tribals and local villagers; hence, falls under constructive value.

Productive Use Values

These are the commercially usable values, where the product is marketed and sold. It may include lumber or wild gene resources that can be traded for use by scientists for introducing desirable traits in the crops and domesticated animals. These may also include animal products like tusks of elephants, musk from musk deer, silk from silkworm, wool from sheep, fur of many animals and lac from lac insects, all of which are traded in the market. Many industries are dependent upon the productive use of values of biodiversity, e.g., paper and pulp industry, plywood industry, railway sleeper industry, silk industry, textile industry, ivory-works, leather industry, pearl industry, etc.

Despite international ban on trade in products from endangered species, fur, hide, horns, tusks, live specimen, etc., worth millions of dollars are being sold every year. Developing countries in Asia, Africa and Latin America are the richest biodiversity centres and wildlife products are smuggled and marketed in large quantities to some rich western countries and also to China and Hong Kong, where export of animal skins and snake skins is a booming business.

Social Value

These are the values associated with the social life, customs, religion and psycho-spiritual aspects of the people. Many of the plants are considered holy and sacred in our country like tulsi(holy basil), peepal, mango, lotus and bael. The leaves, fruits or flowers of these plants are used in worship or the plant itself is worshipped. The tribal people are closely linked with the wildlife in the forest. Their social life, songs, dances and customs are closely woven around the wildlife. Many animals like cow, snake, bull, peacock and owl, also have a significant place in our psycho-spiritual arena and thus, hold special social importance. Thus, biodiversity has distinct social value, attached with different societies.

Ethical Value

It is also sometimes known as existence value. It involves ethical issues like 'all life must be preserved'. It is based on the concept of 'live and let live'. If we want our human race to survive, then we must protect all biodiversity, because biodiversity is valuable.

Ethical value means that we may or may not use a species, but knowing the fact that these species exists in nature gives us pleasure. We all feel sorry when we learn that 'passenger pigeon' or 'dodo' is extinct. We are not deriving anything directly from the kangaroo, zebra or giraffe, but we all strongly feel that these species should exist in nature. This means, there is an ethical value or existence value attached to each species.

Aesthetic Value

Great aesthetic value is attached to biodiversity. None of us would like to visit vast stretches of barren lands with no signs of visible life. People from far and wide spend a lot of time and money to visit wilderness areas, where they can enjoy the aesthetic value of biodiversity and this type of tourism is now known as ecotourism. The 'willingness to pay' concept on such ecotourism gives us even a monetary estimate for aesthetic value of biodiversity. Ecotourism is estimated to generate about 12 billion dollars of revenue annually, this roughly gives the aesthetic value of biodiversity.

Option Value

These values include the potential of biodiversity that are presently unknown and need to be explored. There is a possibility that we may have some potential cure for AIDS or cancer existing within the depths of a marine ecosystem or a tropical rainforest.

Thus, option value is the knowledge that there are biological resources existing on this biosphere that may one day prove to be an effective option for something important in the future. Thus, the option value of biodiversity suggests that any species may prove to be a miracle species someday. Biodiversity is like precious gifts of nature presented to us. We should not commit the folly of losing these gifts even before unwrapping them.

Option value also includes the values, in terms of the option to visit areas where a variety of flora and fauna, or specifically some endemic, rare or endangered species exist.

Ecosystem Service Value

Recently, a non-consumptive use value related to self maintenance of the ecosystem and various important ecosystem services has been recognized. It refers to the services provided by the ecosystems like prevention of soil erosion, prevention of floods, maintenance of soil fertility, cycling of nutrients, fixation of nitrogen, cycling of water, their role 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 the biodiversity will lead to huge economic, ecological and socio-cultural losses.

2.5.1 Hotspots of Biodiversity

Areas which exhibit high species richness as well as high species endemism are termed as hot spots of biodiversity. Species which are restricted only to particular areas are known as **endemic**. India shows a good number of endemic species. About 62 per cent of amphibians and 50 per cent of lizards are endemic to India. Western Ghats are the site of maximum endemism. The term 'Hot spots' was introduced by Myers (1988). There are twenty-five such hot spots of biodiversity on a global level, out of which two are present in India, namely the Eastern Himalayas and the Western Ghats.

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These hot spots covering less than 2 per cent of the world's land area are found to have about 50 per cent of the terrestrial biodiversity. According to Myers, an area is designated as a hot spot when it contains at least 0.5 per cent of the plant species as endemics.

(a) **Eastern Himalayas**: They display an ultra-varied topography that fosters species diversity and endemism. Recent studies have shown that North East India along with its contiguous regions of Burma and Chinese provinces of Yunnan and Schezwan is an active centre of organic evolution and is considered to be the cradle of flowering plants. Out of the world's recorded flora, 30 per cent are endemic to India of which 35000 are in the Himalayas.

(b) **Western Ghats**: It extends along a 17,000 km² strip of forests in Maharashtra, Karnataka, Tamilnadu and Kerala and has 40 per cent of the the total endemic plant species. The major centres of diversity are Agastyamalai Hills and Silent Valley– the new Amambalam Reserve Basin. It is reported that only 6.8 per cent of the original forests are existing today, while the rest have been deforested or degraded, which raises a serious cause of alarm, because it means we have already lost a huge proportion of the biodiversity.

CHECK YOUR PROGRESS

16. What is the ethical value of biodiversity?
17. What are the two hot spots of biodiversity in India?

2.6 THREATS TO BIODIVERSITY AND CONSERVATION OF BIODIVERSITY

Extinction or elimination of a species is a natural process of evolution. In the geologic period, earth has experienced mass extinctions. During evolution, species have died and have been replaced by others. However, the rate of loss of species in the geologic past has been a slow process, keeping in view the vast span of time going back to 444 million years. The process of extinction has become particularly fast in the recent years of civilization. In the recent times, the human impact has been so severe that thousands of species and varieties are becoming extinct annually. One of the estimates puts the figure of extinction at 10,000 species per year or twenty-seven per day. These figures raise an alarm regarding the serious threat to biodiversity. Over the last 150 years, the rate of extinction has escalated more dramatically. If the present trend continues, we would lose one-third to two-third of our current biodiversity by the middle of the twenty-first century.

2.6.1 Threats to Biodiversity

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The following are the major causes and issues related to threats to biodiversity:

Loss of Habitat

Destruction and loss of natural habitat is the single largest cause of losing own biodiversity. Billions of hectares of forests and grasslands have been cleared over the past 10,000 years for conversion into agricultural lands, pastures, settlement areas or development projects. These forests and grasslands were the homes of thousands of species, which perished due to loss of their natural habitat. Severe damage has been caused to wetlands, thinking them to be useless ecosystems. The unique and rich biodiversity of the wetlands, estuaries and mangroves are under serious threat today. The wetlands are destroyed due to draining, filling and pollution, thereby causing huge loss of biodiversity.

The habitat is divided into small and scattered patches, so that the complete loss of habitat can be put at bay. This phenomenon is known as habitat fragmentation. There are many wildlife species such as bears and large cats that require large territories to subsist. They are threatened as they breed only in the interiors of the forests. Due to habitat fragmentation, many song birds are becoming extinct.

There has been a rapid disappearance of tropical forests in our country, at the rate of about 0.6 per cent per year. With the current rate of loss of forest habitat, it is estimated that 20-25 per cent of the global flora would be lost within a few years. Marine diversity is also under serious threat due to large-scale destruction of the fragile breeding and feeding grounds of fish and other species.

Poaching

Illegal trade of wildlife products by killing prohibited endangered animals, i.e., poaching is another threat to wildlife. Despite international ban on trade in products from endangered species, smuggling of wildlife items like furs, hides, horns, tusks, live specimens and herbal products worth millions of dollars per year, continues. The developing nations in Asia, Latin America and Africa are the richest source of biodiversity and have enormous wealth of wildlife. The rich countries in Europe and North America and some affluent countries in Asia like Japan, Taiwan and Hong Kong are the major importers of wildlife products or wildlife itself.

The trading of such wildlife products is highly profitable for the poachers who smuggle them to other countries mediated through mafia. The worst part is that for every live animal that actually gets into the market, about fifty additional animals are caught and killed.

If you are fond of rare fishes or birds, please make sure that you are not going to harm the **endangered species** or wild-caught species. Doing so will help in checking further decline of these species. Also, do not purchase fur coat, purse or bag, or items made of crocodile skin or python skin. You will certainly help in preserving biodiversity by doing so.

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Man and wildlife conflict

Conflict between people and animals is one of the main threats to the continued survival of many species in different parts of the world, and is also a significant threat to local human populations. If solutions to conflicts are not adequate, local support for conservation also declines.

As human populations expand and natural habitats shrink, people and animals are increasingly coming into conflict over living space and food.

People lose their crops, livestock, property, and sometimes their lives. The animals, many of which are already threatened or endangered, are often killed in retaliation or to 'prevent' future conflicts.

The solutions are often specific to the species or area concerned, and are often creative and simple.

An important aspect of the work is that it benefits both the animals and local human communities, and actively involves these communities. This is about finding solutions that lead to mutually beneficial co-existence.

The work has also often led to people being more enthusiastic and supportive of conservation, and has demonstrated that people can live alongside wildlife while developing sustainable livelihoods.

Endangered, Endemic and Exotic Species of India

Endangered Species of India

Critically endangered is the highest risk category assigned by the IUCN (International Union for Conservation of Nature) to wild species.

A taxon is critically endangered when the best available evidence indicates that it meets any of the following criteria:

I. Populations have declined or will decrease, by greater than 80 per cent over the last ten years or three generations.
II. Have a restricted geographical range.
III. Small population size of less than 250 individuals and continuing decline at 25 per cent in three years or one generation.
IV. Very small or restricted population of fewer than fifty mature individuals.
V. High probability of extinction in the wild.

Examples of endangered species in India include birds like Jerdon's Courser (Rhinoptilus bitorquatus), Forest Owlet (Heteroglaux blewitti), White-bellied Heron (Ardea insignis) etc.; mammals include Pygmy Hog (Porcula salvania), Andaman White-toothed Shrew (Crocidura andamanensis), Namdapha Flying Squirrel (Biswamoyopterus biswasi) etc.; reptiles like Gharial (Gavialis gangeticus), Hawksbill Turtle (Eretmochelys imbricata) etc.

Endemic Species of India

Endemic species refers to species of plants and animals which exist naturally only in a particular geographical region. The region can be as small as an island or as large as a continent. They are unique and indigenous to their location.

Examples of endemic species in India include South Indian Tree Shrew, Lion-tailed Macaque, Nilgiri Langur, Nicobar flying fox, Madras hedgehog among others.

Exotic species

Animals and plant species introduced whether intentionally or accidently from other countries, which are not otherwise found locally are termed exotic species. These introduced or exotic species can adversely affect the ecosystem by acting as invasive species affecting the local endemic population.

The biggest problem of exotic species is when they turn into weeds and multiplying incredibly fast adversely affecting the ecosystem, for e.g. water hyacinth and lantana.

The reason for the growth and spread of exotics is that they are invariably introduced without their natural enemies that should control and balance their spread in their native land, and hence, unhindered the exotic species grow and flourish, leaving bad consequences to the local ecosystem.

While the exotic species are selected specifically for their quality of adaptability in the long run, they commonly outnumber the native species and compete with them for the resources. This is bad for the native species who now because of additional competition suffer and ultimately decline in numbers.

But the negative or positive effect of the introduction of an exotic species differs from species to species. Examples of exotics introduced in India include vegetables like chillie and the onion, which have been brought from South America and Persia (modern day Iran) respectively.

Some quick growing plant species were brought from Australia for afforestation programmes such as the acacia and the eucalyptus. The demand for wood in different industries led to a growth of forest area under these species. the introduction of these species has caused more harm than good to the forests and the soil in general.

Some weeds have not been intentionally introduced but have come accidentally, for instance the Mexican weed came along with American wheat that came as PL480 aid from the USA in the 1960s when quarantine rules were not so strict.

A measure to control the effect of exotic species on native species is through the process of quarantine. All the plants and seeds that come from another country should be quarantined to ensure that no other foreign material has come with it. Quarantine facilities must be made available at all entry and exit points, at the airports, border crossing on land and the harbours. This will prevent further damage, and the existing plants and animals can then and should be allowed to flourish in their natural surroundings and habitat.

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2.6.2 Conservation of Biodiversity

Due to the tremendous importance of biodiversity it is considered an asset of a region or a nation. Due to its multiple advantages of commercial value, consumption value, medicinal value, social, cultural, religious and optional values, biodiversity needs to be conserved. The need for its protection and conservation has become more important due to overexploitation and the subsequent depletion. There are two types of methods of conservation of biodiversity:

1. Ex-situ
2. In-situ

Ex-situ conservation means off-site protection of biodiversity. It is the process of protecting an endangered species of plant or animal by removing it from an unsafe or threatened habitat and placing it under human care.

While Ex-situ conservation comprises some of the oldest and best-known techniques known to and created by man, it also involves newer techniques like laboratory method.

Methods of Ex-Situ Conservation

Creation of zoos, botanical gardens, culture collection centres are the most conventional and traditional methods of ex-situ conservation, all of which house and protect specimens for breeding and reproduction of wild life animals and plants. Endangered plants may also be preserved in part in such botanical garden through seed banks and germplasm banks.

Endangered animals are preserved using similar techniques through preservation in gene bank.

In the gene banks, which consist of cryogenic facilities, live sperms, eggs or embryos can be stored. Some countries have established frozen zoos to store such samples from more than 366 species, which consist of mammals, reptiles and birds.

Drawbacks of ex-situ conservation

Ex-situ conservation although is helpful to man's effort to sustain and protect biodiversity, is rarely enough to save a species from extinction. It can be used as a last resort or as a supplement to in-situ conservation. It cannot re-create a habitat. Furthermore, ex-situ conservation techniques are often costly.

In-situ Conservation

In-situ conservation means to conserve the biodiversity within the habitat and on site. It is a process of protecting an endangered species of plant or animal in its natural habitat, either by protecting or preventing the habitat itself from being depleted.

The benefit of in situ conservation is that it maintains the natural surroundings of the population of the animals or plant in its natural distinctive property.

In situ conservation should be preferred to ex situ conservation, the latter opted only in case where in situ conservation is either too difficult or impossible.

Wildlife conservation is mostly based on in situ conservation through protection and recreation of the wildlife habitat.

Wildlife Protection Act

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The major activities and provisions in the Act can be summed up as follows:

1. It defines the wildlife 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 wildlife species was done for the first time and prohibition of hunting of the endangered species was mentioned.
4. Protection to some endangered plants.
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 stated 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 wildlife 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.

Forest Conservation Act

This Act deals with the conservation of forests and related aspects. Except for 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 government 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 the 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).

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2. It makes a 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 activities (e.g. fencing, making water-holes, trench, pipelines, check-posts, wireless communication, etc.) Penalties include a fine of up to ₹ 500 per offence and imprisonment of up to six months.

The 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 the central government, These activities are the setting of transmission lines, seismic surveys, exploration, drilling and hydroelectric projects. The last activity involves large-scale destruction of forests, 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 the central government, 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 government. 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 the same as described earlier.
7. Mining is a non-forestry activity and prior approval of the central government is mandatory. The Supreme Court in a case T.N.Godavarman Thirumulkpad Vs. Union of India (1997) directed all on-going mining activities to be ceased immediately in any forest area of India, if it has not obtained prior approval of the central government.
8. Removal of stones, *bajri*, boulder, etc., from riverbeds located within the forest area fall under non-forest activity.

9. Any proposal sent to the central government 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 preventing deforestation.

CHECK YOUR PROGRESS

18. What is habitat fragmentation?
19. Name the two types of methods of conservation of biodiversity.
20. Enlist the five quantitative criteria to determine whether a taxon is critically endangered.
21. Define exotic species.

2.7 SUMMARY

- The word ecology comes from Greek word Oikos, meaning house or place to live. Ecology is concerned with the study of organisms in various habitats, e.g., land, ocean, fresh water and air. The term ecosystem was first proposed by A.G. Tansley (1935) who defined ecosystem as follows: 'Ecosystem is defined as a self-sustained community of plants and animals existing in its own environment.'
- The term ecosystem is made up of two words: eco and system. Eco means ecological sphere or a region of space where living things can exist, while system means interacting organisms living in a particular habitat. In the ecosystem, the living organisms and their environment each influence the properties of the other and both are necessary for the survival and maintenance of life. Thus, in short, ecosystem can be described as the 'life support system'.
- Group of organisms that resemble one another in appearance, behaviour, chemistry and genetic structure form a species. Organisms of the same species can breed with one another and produce fertile offspring under natural conditions. For instance, all human beings (Homo sapiens) resemble one another in their body structure, body systems and they all have similar genetic structure. They are thus grouped together under the species, sapiens.
- Population is a group of individuals of the same species occupying a given area at a given time. For example, the Asiatic lions in the Gir National Park, Gujarat, make a population. Group of individual organisms of the same species living within an area is called population.
- The sum total of all the ecosystems on planet Earth is called the biosphere, which includes all living organisms on earth, interacting with the physical environment as a whole, to maintain a steady-state ecosystem.

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- The biosphere is the biological component of earth systems. It consists of all the living organisms on earth, along with the dead organic matter produced by them. The concept was introduced by geologist Eduard Suess in 1875 and is central to many significant disciplines. According to him it meant 'the place on Earth's surface where life dwells'.
- Another important concept that finds place in this context is that of a biome. A biome is nothing but a large area comprising similar flora, fauna and microorganisms. Biomes categorize the biological communities on the earth according to similarities found in the dominant vegetation, climate, geographic location and various other characteristics.
- The delineable part of the earth not covered by water is known as land. Land resources provide various functions or services including provisioning, regulating and supporting. However, the quality of the services reached its threshold as communities started exploiting land resources in the name of meeting their own needs. It is important to note that the renewal of land resources is a slow process.
- Understanding the relationship between air pollution and ecosystem services is vital for achieving sustainable development of the communities. Air is a precious resource that supplies us with oxygen, which is essential for us. Air quality primarily influences the atmosphere in which people live and breathe.
- Understanding the links between energy, poverty and ecosystem services is important for attaining sustainable development. Increased access to energy for the poorest part of the world's population will help in holistic, sustainable development. The current energy use of the poor is neither sufficient to attain the sustainable development nor is it sustainable in terms of maintaining important ecosystem services that can facilitate a transition out of poverty.
- Ecosystems are strongly affected by human activities which are a simple manifestation of society where human beings live. In a simple human–ecosystem interaction, the ecosystem provides services to the human social system by way of moving materials, energy and information to meet people's needs. The ecosystem resources, both natural and artificial, play a very vital role in discharge of ecosystem services of provisioning, regulating, supporting and recreating.
- According to T.D. Brock, 'Steady state condition in nature ecosystem is a time independent condition in which production and consumption of each constituent in the system is exactly balanced, the concentration of all constituents within the system remains constant, even though there occurs a continual change'.
- Genetic biodiversity means the variation of genes within a species. In a species, each variety has its own genes or genetic make-up. Diversity of genes within a species increases its ability to adapt to disease, pollution and other changes in environment.

- About 75 per cent of the world's population depends upon plants or plant extracts for medicines. The wonder drug penicillin used as an antibiotic is derived from a fungus called penicillium.
- Ethical value means that we may or may not use a species, but knowing the fact that these species exists in nature gives us pleasure.
- The term 'Hot spots' was introduced by Myers (1988). There are twenty-five such hot spots of biodiversity on a global level, out of which two are present in India, namely the Eastern Himalayas and the Western Ghats.
- Extinction or elimination of a species is a natural process of evolution. In the geologic period, earth has experienced mass extinctions. During evolution, species have died and have been replaced by others.
- Destruction and loss of natural habitat is the single largest cause of losing own biodiversity.
- Illegal trade of wildlife products by killing prohibited endangered animals, i.e., poaching is another threat to wildlife.
- Due to the tremendous importance of biodiversity it is considered an asset of a region or a nation. Due to its multiple advantages of commercial value, consumption value, medicinal value, social, cultural, religious and optional values, biodiversity needs to be conserved.
- There are two types of methods of conservation of biodiversity:
  1. Ex-situ
  2. In-situ

2.8 KEY TERMS

- **Abiotic Component:** Non-living components of an ecosystem including all the physical and chemical factors that influence living organisms like air, water, soil and rocks
- **Biotic Component:** It includes all living organisms of the environment
- **Ecology:** It is concerned with the study of organisms in various habitats, viz., land, oceans, fresh water and air, i.e., the study of the structure and functions of nature
- **Ecosystem:** It is a community of organisms involved in a dynamic network of biological, chemical and physical interactions between themselves and with the non-living components
- **Population:** It refer to a group of individuals of the same species occupying a given area at a given time, for example, the Asiatic lions in the Gir National Park, Gujarat, make a population
- **Species:** It refer to a group of organisms that resemble one another in appearance, behaviour, chemistry and genetic structure

- **Community:** It is the groups of various species occupying a particular area and interacting with each other
- **Cycle:** It is the circulation of the chemical elements in the biosphere, from the environment to organisms and back to the environment
- **Food chain:** It refers to the transfer of food energy from its source in plants through a series of organisms where eating and being eaten is repeated a number of times
- **Carrying Capacity:** It refers to the maximum population of a particular species that a given habitat can support over a given period of time
- **Biodiversity:** Biodiversity refers to the variety and variability among all groups of living organisms and the ecosystem complexes in which they occur.
- **Ecosystem Biodiversity:** This is the diversity of ecological complexity showing variations in ecological niches, tropic structure, food webs, nutrient cycling, etc.

2.9 ANSWERS TO 'CHECK YOUR PROGRESS'

1. The word ecology comes from Greek word Oikos, meaning house or place to live.
2. An ecosystem is a community of organism involved in a dynamic network of biological, chemical and physical interactions between themselves and with the non-living components.
3. The two types of ecosystems are:
   (i) Natural
   (ii) Artificial
4. Coexistence is a common architectural feature of ecosystems where autotrophs and heterotrophs exist together in a mutually interdependent, compulsory relationship that ensures the flow of energy and the constant recycling of vital chemical nutrients through the ecosystem. Constant energy and nutrient flows are important if the system has to carry on as a self-sustaining collection of components and relationships within a certain physical environment.
5. Common Property Resources (CPR) include all such resources which are meant for common use of the villagers but not for individual possession. These resources are an indispensable aspect of the social and institutional arrangements made to meet the everyday requirements of village communities.
6. Inbuilt, self-regulating mechanism is known as homeostatic mechanism. If within an ecosystem the population of species increases significantly, the result will be scarcity of food, leading to competition for food. Most species will die of starvation and the species population will be brought back to its original value and the stability will be restored.

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7. Abiotic components of an ecosystem consist of energy, inorganic elements and compounds dead organize matter and climate.
8. The transformation of energy between the different components of an ecosystem is known as 'energy flow'.
9. The total amount of solar energy converted into chemical energy by green plants is called Gross Primary Production (GPP).
10. The transfer of food energy from its source in plants through a series of organisms, where eating and being eaten is repeated a number of times is known as food chain.
11. Biotic component includes all living organisms of the environment. The biotic component can be divided into two major groups: a) Autotrophs (producers)- food producing organisms, b) Heterotrophs (consumers) -These are the organisms, mostly animals, that cannot utilize sunlight directly like autotrophs for their food preparation, because they do not have chlorophyll.
12. The major ecosystems are: terrestrial – grassland ecosystem, forest ecosystem, desert ecosystem and aquatic – estuarine ecosystem, marine ecosystem.
13. On the basis of habitat conditions, terrestrial ecosystems can be:

    (a) Grassland ecosystem, (b) Forest ecosystem, (c) Desert ecosystem
14. In the Convention of Biological Diversity, 1992, biodiversity has been 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 a part of.
15. Biodiversity means the variety and variability of all living organisms. Biodiversity constitutes the biological wealth. Biodiversity is at three levels genetic diversity, species diversity and ecosystem diversity.
16. It is also sometimes known as existence value. It involves ethical issues like 'all life must be preserved'. It is based on the concept of 'live and let live'. If we want our human race to survive, then we must protect all biodiversity, because biodiversity is valuable.
17. There are twenty-five of such hot spots of biodiversity on a global level, out of which two are present in India, namely the Eastern Himalayas and the Western Ghats.
18. The habitat is divided into small and scattered patched, so that the complete loss of habitat can be put at bay. This phenomenon is known as habitat fragmentation.
19. The two types of methods of conservation of biodiversity are as follows:
    - Ex-situ
    - In situ

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20. A taxon is critically endangered when the best available evidence indicates that it meets any of the following criteria:
    I. Populations have declined or will decrease, by greater than 80 per cent over the last ten years or three generations.
    II. Have a restricted geographical range.
    III. Small population size of less than 250 individuals and continuing decline at 25 per cent in three years or one generation.
    IV. Very small or restricted population of fewer than fifty mature individuals.
    V. High probability of extinction in the wild.
21. Animals and plant species introduced whether intentionally or accidently from other countries, which are not otherwise found locally are termed exotic species.

2.10 QUESTIONS AND EXERCISES

Short-Answer Questions

1. Define ecology and ecosystems.
2. What are the biotic and abiotic components of an ecosystem?
3. What do you understand by adaptive development?
4. State the reasons for the degradation of land resources.
5. What are different biotic components in a desert ecosystem?
6. What are different types of food chain?
7. What are the major threats to biodiversity?
8. What are hot spots of biodiversity? Which are the hot spots found in India? Discuss their salient features.

Long-Answer Questions

1. What is a food chain? Give examples and discuss their significance.
2. Describe the biotic and abiotic components of an ecosystem. Analyse the role of each component in maintaining the ecological balance.
3. Discuss the important theories of ecological balance or ecosystem stability.
4. Describe the various aspects of human-ecosystem interactions.
5. Explain the basic features of pond as an ecosystem.
6. Highlight the role of abiotic and biotic components in a grassland ecosystem.
7. What do you mean by consumptive use value, productive use value, social value, ethical value and option value of biodiversity?
8. What are the main causes of man-wildlife conflicts? Discuss the remedial steps that can curb the conflicts.
9. What is meant by in-situ and ex-situ conservation of biodiversity?

2.11 FURTHER READINGS

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UNIT 3 ENVIRONMENTAL DEGRADATION AND MANAGEMENT

Structure

3.0 INTRODUCTION

According to the Environment Protection Act, 1986, environment includes water, air, land and their interrelationship with human beings, other living creatures, plants and micro-organisms. Pollution refers to the presence of substances in air, water and land, whether they result from human activity or occur naturally, which has adverse effects on human-life and on the environment. Air pollution, is thus, the state of environment in which the outer atmosphere gets contaminated with gases and other materials in concentration, which are harmful to man and environment. The contamination of air occurs because the contaminants cannot be absorbed by natural environmental cycles.

The atmosphere is polluted by the discharge of emissions originating from industrial plants, domestic sources, vehicles and thermal power plants. Both in the developed and developing countries, the urban areas in particular are exposed to such high levels of atmospheric pollution that causes serious hazard to public health. The presence of sulphur oxides, nitrogen oxides, carbon monoxide, hydrocarbons and toxic particulate substances in the atmosphere cause harmful influence on man and other living things.

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Pollution refers to the substances (pollutants) which are released into the environment because of anthropogenic (human) activities that can be either deliberate or accidental (e.g., Bhopal gas leak or radioactive material released from Chernobyl nuclear power plant is accidental). The reference point of pollution is the ambient quality of the environment which means environment in its natural state. Human activities, whether industrial production or other like sewage, and their impact on air, water and land, results in the change in the ambient quality of the latter. In the production process, certain substances (wastes) are recycled or produced in the form of emissions/effluents and they impact the environment leading to damages to humans and ecosystem.

It may be worthwhile to note that there are natural sources of pollution too. These are substances released from the volcanic eruptions or forest fires. But, these natural pollutants do not stay long in the atmosphere since they can be recycled in the biological or chemical cycles. Hence, they pose only a short-term problem and that too localized.

In this unit, you will learn about all of these environmental pollution as mentioned above, with addition to that you will also get to know about the role of the Tripura Control Board (TSPCB) in managing these environmental pollution.

3.1 UNIT OBJECTIVES

After going through this unit, you will be able to:

- Discuss the definition, causes and effects of various types of pollutions
- Evaluate the problem of pollution and understand the various remedies
- Ascertain the need for disaster management
- Assess the need for solid management, water resource management, etc.
- Analyse different environmental related acts and regulations.

3.2 ENVIRONMENTAL POLLUTION

In this section, we will discuss the various types of environmental pollution. They are mentioned as below:

1. Air Pollution

The Air (Prevention and Control of Pollution) Act, 1981 defines 'air pollutant' and with reference to them defines air pollution. 'Air pollutant' means any solid, liquid or gaseous substance (including noise) present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment. Air pollution means the presence in the atmosphere of any air pollutant. In this connection, the definition of 'emission' is also relevant. 'Emission' means any solid, liquid or gaseous substance coming out of any chimney, duct or any other outlet. There are 'standards' and legislation that exist for emissions.

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Approximately 95 per cent of earth's air occurs in the lower levels, the troposphere. In the natural state, air contains 78 per cent nitrogen, 21 per cent oxygen, 0.4 per cent carbon dioxide plus small amounts of other gases and water vapour. The remaining 0.5 per cent of the planet air occurs in the upper levels, the stratosphere together with gases like ozone.

Air pollutants can be primary or secondary. Primary pollutants are carbon dioxide, nitrogen oxides, sulphur dioxide, carbon monoxide (all formed from the combustion of fossil fuels), CFC and particulate matter. Secondary pollutants are acid rain and ozone. Sulphur dioxide and nitrogen dioxide combine with water in the atmosphere and react with sunlight forming acid droplets. These acid droplets constitute acid rain.

Sources of Air Pollution

The sources of air pollution are both natural and man-made (anthropogenic).

Natural sources: The natural sources of air pollution are volcanic eruptions, forest fires, sea salt sprays, biological decay, photochemical oxidation, extraterrestrial bodies, pollen grains of flowers, etc. Radioactive minerals present in the earth crust are the sources of radioactivity in the atmosphere.

Man-made: Man-made sources include thermal power plants, industrial units, vehicular emissions, burning of fossil fuel, agricultural activities, etc. Thermal power plants have become the major sources for generating electricity in India. The main pollutants emitted are fly ash and SO_2. Metallurgical plants also consume coal and produce similar pollutants. Fertilizer plants, smelters, textile mills, chemical industries, paper and pulp mills are other sources of air pollution.

Automobile exhaust is another major source of air pollution.

Indoor air pollution: The most important indoor air pollutant is radon gas. This is responsible for a large number of lung cancer deaths each year. These could be emitted from building materials like bricks, concrete and tiles. Many houses in the underdeveloped countries including India, use fuels like coal, dung-cakes, wood and kerosene in their kitchens. Complete combustion of fuel produces carbon dioxide which may be toxic; however, incomplete combustion produces the toxic gas, carbon monoxide.

Effects of Air pollution

1. **Effects on human health**: Years of exposure to air pollutants including cigarette smoke adversely affect the natural defenses of the body and can result in lung cancer, asthma, chronic bronchitis, etc. Many other pollutants may have toxic metals which can cause mutations, reproductive problems or even cancer.
2. **Effects on plants**: Air pollutants affect plants by entering the cells through stomata. The damage results in the death of the plant.
3. **Effects on aquatic life**: Air pollutants mixing up with rain can cause high acidity in fresh water lakes, which affects aquatic life especially fish. Some of the freshwater lakes have experienced total death of fishes.

4. **Effects on materials**: Because of their corrosiveness, particulates can cause damage to exposed surfaces.

Control of Air Pollution

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Air pollution can be minimized by the following methods:

1. Setting up of industries after proper environmental impact assessment studies.
2. Using low sulphur coal in industries.
3. Removing sulphur from coal (by washing or with the help of bacteria).
4. Removing NOx during the combustion process.
5. Removing particulate from stack exhaust gases by employing electrostatic precipitators, bag-house filters, cyclone separators, scrubbers, etc.
6. Vehicular pollution can be checked by regular tune-up of engines, converters, by engine modification to have fuel effective (lean) mixtures to reduce CO and hydrocarbon emissions and slow and cooler burning of fuels to reduce NOx emission (Honda Technology).
7. Using mass transport system, bicycles, etc.
8. Shifting to less polluting fuels (hydrogen gas).
9. Using non-conventional sources of energy.
10. Using biological filters and bio-scrubbers.
11. Planting more trees.
12. Through the Air Pollution Control Act

2. Noise Pollution

We hear various types of sounds everyday. Sound is a form of mechanical energy emitted from a vibrating source. A type of sound may be pleasant to someone and at the same time unpleasant to others. The unpleasant and unwanted sound is called noise.

The CPCB (Central Pollution Control Board) has recommended permissible noise levels for different locations.

Effects of Noise

1. **Interferes with man's communication**: In a noisy area, communication is severely affected.
2. **Hearing damage**: Noise can cause temporary or permanent hearing loss. It depends on the intensity and duration of sound level. Auditory sensitivity is reduced with noise levels over 90 dB in the mid-high frequency, for more than a few minutes.
3. **Physiological and psychological changes**: Continuous exposure to noise affects the functioning of various systems of the body. It may result in hypertension, insomnia (sleeplessness), gastro-intestinal and digestive disorders, etc.

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Control of Noise Pollution

1. Reduction in the sources of noise.
2. Noise making machines should be kept in containers with sound absorbing media. The noise path will be interrupted and will not reach the workers.
3. Proper oiling will reduce the noise from machinery.
4. Use of sound absorbing silencers. Silencers can reduce noise by absorbing sound. For this purpose, various types of fibrous material can be used.
5. Planting more trees that have broad leaves.
6. Through Law. Legislation can ensure that sound production is minimized at various social functions. Unnecessary blowing of horn should be restricted especially, in vehicle-congested areas.

3. Water Pollution

Water pollution can be defined as an alteration in the physical, chemical or biological characteristics of water, making it unsuitable for the designated use in its natural state.

Sources of Water Pollution

Water is an essential commodity for survival. We need water for drinking, cooking, bathing, washing, irrigation and for all industrial operations. Water has the property to dissolve many substances in it. Therefore, it can easily get polluted. Pollution of water can be caused by point sources or non-point sources. Major point sources of water pollution are industries, power plants, underground coal mines, offshore oil wells, etc.

Groundwater Pollution and Surface Water Pollution

Groundwater pollution

Groundwater forms about 6.2 per cent of the total water available on planet earth, and is about thirty times more than surface water, i.e., streams, lakes and estuaries. Septic tanks, industry (textile, chemical, tanneries), deep-well injection, mining, etc., are mainly responsible for ground water pollution which is irreversible. Ground water pollution with arsenic, fluoride and nitrate pose serious health hazards.

Surface water pollution

The major sources of surface water pollution are as follows:

1. Sewage
2. Industrial effluents
3. Synthetic detergents
4. Agrochemicals
5. Oil
6. Waste heat

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Effects of Water Pollution

The following are some of the important effects of various types of water pollutants:

1. Oxygen-demanding wastes
2. Nitrogen and phosphorus compounds (nutrients)
3. Pathogens
4. Toxic compounds
5. Waterborne diseases
6. Reduction in dissolved oxygen in water resources

Pesticides in drinking water ultimately reach humans and are known to cause various health problems. DDT, aldrin, dieldrin, etc., have therefore, been banned. Recently, in Andhra Pradesh, people suffered from various abnormalities due to the consumption of endosulphan contaminated cashew nuts.

Control of Water Pollution

It is easy to reduce water pollution from point sources by legislation. However, due to the absence of any defined strategies it becomes difficult to prevent water pollution from non-point sources. The following points may help to reduce water pollution from non-point sources:

1. Judicious use of agrochemicals like pesticides and fertilizers which will reduce their surface run-off and leaching. Avoid the use of these on sloped lands.
2. Use of nitrogen-fixing plants to supplement the use of fertilizers.
3. Adopting integrated pest management to reduce reliance on pesticides.
4. Prevent run-off of manure. Divert such run-offs to basin for settlement. The nutrient rich water can be used as fertilizer in the fields.
5. Separate drainage of sewage and rain water should be provided.
6. Plantation of trees would reduce pollution and will also prevent soil erosion.
7. Industrial affluents to be allowed only after treatment.

Case Example: Pollution in the Rio Grande (Rio Grande)

In 1965, Mexico initiated the Border Industrialization Programme, now widely as the maquiladora programme. Under this programme, foreign companies (primarily from the US and Asia) could construct factories in Mexico and import parts and materials to those factories duty-free. With the growth of this system, however, the potential for water pollution has increased. Several factors have contributed to pollution on the Rio Grande. These include inadequate sewage treatment in many communities on both sides of the border, oxygen-demanding substances and pathogenic micro-organisms and pesticide contamination from farming regions around the Rio Grande valley. Finally, there is a threat of toxic chemical contamination due to the operation of the maquiladoras and other industries located on both sides of the border.

In February 1992, the United States and Mexico issued the Integrated Environmental Plan for the Mexican-US Border Area (First Stage, 1992–94). The

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plan calls for the two countries to work together to solve environmental problems in the border area, specifically, to identify areas where any trans-boundary water source or potential trans-boundary water source is contaminated or where there is an identifiable threat of contamination.

The North American Free Trade Agreement (NAFTA), signed in 1993 between the two countries, has also contributed to greater environmental awareness. Part of the public debate surrounding NAFTA centred on the environment, especially the implications of increased US-Mexico economic integration for the border environment. To address these concerns, NAFTA was accompanied by environmental 'side agreements' setting up new binational and trinational agencies to deal with environmental issues. These included: (i) the lack of waste water treatment and drinking water systems; (ii) problems tracking and accounting for hazardous waste generated by maquiladora plants and (iii) concerns about industrial air and water pollution associated with maquiladora plants.

To deal with these issues more effectively, both the US Environmental Protection Agency (EPA) and the Texas Natural Resource Conservation Commission (TNRCC), in conjunction with their Mexican counterparts, have strengthened their border-related operations. The Rio Grande begins in the San Juan Mountains of southern Colorado and follows a 1,885-mile course before it empties into the Gulf of Mexico. Along the way the river and its tributaries drain a land area more than twice the size of California. This drainage area, or basin, covers widely varied landscape in the US and Mexico including mountains, forests, and deserts. The basin is home to diverse native plants and wildlife as well as some 10 million people. For approximately two-thirds of its course, the river also serves as the boundary between the countries.

The river is an important natural resource for industry, agriculture, domestic water supply, recreation and aesthetic enjoyment, and wildlife and aquatic habitat. Most of the major tributaries, and some of the lesser ones, are also of significance in these respects. Substantial agricultural areas are irrigated by the waters of the Rio Grande. The river is the primary source of drinking water for up to 98 per cent of the population in both countries.

NAFTA has brought with it not only the potential for greater economic growth but also a larger population and increased industrialization on the border, and according to a biennial report authorized by the Texas Clean Rivers Act (1991), increased population and industrialization creates greater risk to the quality and quantity of the water that is available.

Population growth has occurred on both sides of the border in the last ten years. NAFTA and the previous Border Industrialization programme have facilitated this growth. The increased population has not only brought with it increased job opportunities, it has also created greater environmental hazards in the form of inadequate sewage treatment, pesticide contamination and chemical contamination.

With respect to waste water treatment, greater priority will be given to projects that deal with water pollution, wastewater treatment and municipal solid waste. A study found that the cost of constructing wastewater treatment plants for Mexican border towns would be about $ 2 billion, but this funding could be the single most important factor in the effort for improved water quality in the basin.

Second, in order to better track waste movements across the border and to conduct monitoring of air and water quality in the region, in 1993 the Texas Natural Resource Conservation Commission established an office of Border Affairs and Environmental Equity. This office coordinates the Texas Natural

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Resource Conservation Commission's efforts and tracks federal activities with respect to border environmental issues and works with state environmental departments in the four Mexican states that border Texas.

Finally, to address the problem of pollution caused by the Maquiladora system more effectively, the biennial report from the Texas Clean Rivers Act suggests utilizing local steering committees to encourage public input about the specific problems or concerns they have regarding their communities. Examples of this include the Dia del Rio, a citizen-led event organized by the Rio Grand/Rio Bravo Basin in October 1995 and the Clean Rivers Program Water Quality Issues Meeting in January 1996.

Source: Adapted from Patrick Sanders, 'Pollution in the Rio Grande', TED Case Studies No. 382, 18 December 96.

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4. Thermal Pollution

Thermal pollution can be defined as the presence of excessive heat in the water which can cause undesirable changes in the natural environment.

Heat producing industries like thermal power plants, nuclear power plants, refineries and steel mills are the major sources of thermal pollution.

Effects of Thermal Pollution

1. The dissolved oxygen content of water is decreased as the solubility of oxygen in water is decreased at high temperature.
2. High temperature becomes a barrier for oxygen penetration into deep cold waters.
3. Toxicity of pesticides, detergents and chemicals in the effluents increases with the increase in temperature.
4. The composition of flora and fauna changes because the species which are sensitive to increased temperature due to thermal shock, will be replaced by temperature tolerant species.
5. Metabolic activities of aquatic organisms increase at high temperatures and require more oxygen.

6. Discharge of hot water near the shores can disturb spawning and can even kill young fishes.
7. Fish migrations are affected due to the formation of various thermal zones.

Control of Thermal Pollution

The following methods can be employed for the control of thermal pollution:

1. Cooling ponds
2. Spray ponds
3. Cooling towers

5. Marine Pollution

The main sources of marine pollution are: 1) rivers, which bring pollutants from their drainage basins 2) catchment areas, and, coastlines where human settlements in the form of hotels, industry, agricultural practices have been established and 3) oil drilling and shipping.

Most of the rivers join the ocean. The pollutants which these rivers carry, from their drainage basins, are finally poured into the sea. These include sewage sludge, industrial effluents, synthetic detergents, agrochemicals, solid wastes, plastics, metals and waste heat released by industries.

In the sea, the pollutants get diluted and the organic matter is further broken down as in river water. Still, many pollutants, especially the recalcitrant ones, remain unchanged or are partially degraded causing marine pollution.

Tankers and other shipping means, industries like petroleum, refinery, lubrication oil using industry, metal industry and paint industry, automotive wastes refineries, ship-accidents and offshore production add to marine pollution.

Oil in sea water can spread over a large area of the sea and remain dispersed or get adsorbed by sediments. It can cause adverse effects on marine life.

Control of Marine Pollution

1. Toxic pollutants from industries and sewage treatment plants should not be discharged in coastal waters.
2. Run-offs from non-point sources should be prevented from reaching coastal areas.
3. Sewer overflows should be prevented by keeping separate sewer and rain water pipes.
4. Dumping of toxic, hazardous wastes and sewage sludge should be banned.
5. Developmental activities on coastal areas should be minimized.
6. Oil and grease from service stations should be processed for reuse.
7. Oil from ballasts should not be dumped into the sea.
8. Ecologically sensitive coastal areas should be protected by not allowing any drilling.

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6. Soil Pollution

Soil is the upper layer of the earth's crust which is formed by weathering of rocks. Organic matter in the soil makes it suitable for living organisms to thrive. Dumping of various types of materials, especially domestic and industrial wastes, causes soil pollution.

Domestic wastes include garbage, rubbish material like glass, plastics, metallic cans, paper, fibres, cloth rags, containers and paint varnishes. Leachates from dumping sites and sewage tanks are harmful and toxic which pollute the soil.

Thermal power plants generate a large quantity of 'fly ash'. Huge quantities of these wastes are dumped on soil, thus contaminating them.

Industrial wastes also contain some organic and inorganic compounds that are refractory and non-biodegradable.

Soil also receives excreta from animals and humans. The sewage sludge contains many pathogenic organisms, bacteria, viruses and intestinal worms which cause pollution in the soil.

Effects of Soil Pollution

Sewage and industrial effluents which pollute the soil ultimately affect human health. Various types of chemicals like acids, alkalis, pesticides and insecticides found in the industrial discharges affect soil fertility by causing changes in its physical, chemical and biological properties.

Some of the persistent toxic chemicals accumulate in the food chain and ultimately affect human health. Sewage sludge has many types of bacteria, viruses and intestinal worms which may cause various types of diseases.

Control of Soil Pollution

1. Effluents should be properly treated before discharging them into the soil.
2. Solid wastes should be properly collected and disposed off by appropriate methods.
3. From the wastes, useful products should be recovered.
4. Biodegradable organic waste should be used for the generation of biogas.
5. Cattle dung should be used for methane generation. Night soil can also be used in the biogas plant to produce methane gas.
6. Microbial degradation of biodegradable substances is also one of the scientific approaches for reducing soil pollution.

7. Nuclear Hazards

Radioactive substances are present in nature. They undergo natural radioactive decay, in which unstable isotopes spontaneously give out fast moving particles, high energy radiations or both, at a fixed rate, until a new stable isotope is formed.

These particles and rays pass through paper and wood but can be stopped by concrete wall, lead slabs or water. Damage caused by the different types of radiations

depends on the penetration power and the presence of the source inside or outside the body.

Control of Nuclear Pollution

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1. Setting up of nuclear power plants should be carefully done after studying both long-term and short-term effects.
2. Proper disposal of wastes from laboratories using radioisotopes should be done.

8. Solid Waste Management

Higher standard of living of ever increasing population has resulted in an increase in the quantity and variety of waste generated. It is now realized that if waste generation continues indiscriminately, then very soon it would be beyond rectification.

Management of solid waste has, therefore, become very important in order to minimize the adverse effects of solid wastes. Solid waste (waste other than liquid or gaseous) can be classified as municipal, industrial, agricultural, medical, mining waste and sewage sludge.

Sources of Urban and Industrial Wastes

These wastes consist of medical waste from hospitals, municipal solid waste from homes, offices, markets (commercial waste) small cottage units, and horticulture waste from parks, gardens and orchards.

The urban solid waste materials that can be degraded by micro-organisms are called biodegradable wastes. For example, vegetable wastes, stale food, tea leaves, egg shells, peanut shells, dry leaves, etc., are solid wastes.

Wastes that cannot be degraded by micro-organisms are called non-biodegradable wastes, e.g., polyethylene bags, scrap metal, glass bottles, etc.

Industrial waste consists of a large number of materials, including factory rubbish, packaging material, organic waste and acids. There are large quantities of hazardous and toxic materials which are also produced during industrial processing.

Effects of Solid Wastes

Municipal solid waste heap up on the roads due to improper disposal system. People clean their own houses and litter their immediate surroundings which affect the community including themselves. This type of dumping allows biodegradable materials to decompose under uncontrolled and unhygienic conditions. This produces foul smell and breeds various types of insects and infectious organisms, besides spoiling the aesthetics of the site.

Industrial solid wastes are sources of toxic metals and hazardous wastes, which may spread on land and can cause changes in the physicochemical and the biological characteristics, thereby affecting the productivity of soils. Toxic substances may leach or percolate and contaminate the ground water.

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Management of Solid Waste

For waste management we must focus on three 'Rs'- Reduce, Reuse and Recycle before destruction and safe storage of wastes.

1. Reduction in the use of raw materials
2. Reuse of waste materials
3. Recycling of materials

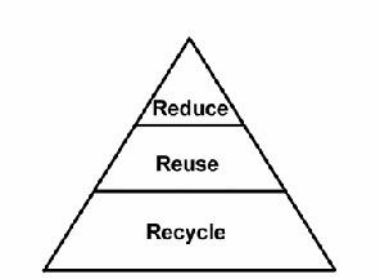

Fig. 3.1 *The Three Rs of Solid Waste Management*

For discarding wastes, the following methods could be used:

1. Sanitary landfill
2. Composting
3. Incineration

3.2.1 Role of Individuals in Preventing Pollution

The role of every individual in preventing pollution is of paramount importance, because if every individual contributes substantially the effect will be visible not only at the community, city, state or national level, but also at the global level as environment has no boundaries.

It is the responsibility of the human race which has occupied a commanding position on this earth to protect the earth and provide conducive environment for itself, and innumerable other species which are on this earth. A small effort made by each individual at his own place will have pronounced effect at the global level. It is appropriately said 'Think globally, act locally.'

Each individual should change his or her lifestyle in such a way so as to reduce environmental pollution. It can be done through the following suggestions:

1. Help more in pollution prevention than pollution control.
2. Use eco-friendly products.
3. Cut down the use of CFCs as they destroy the ozone layer. Do not use polystyrene cups that have CFC molecules in them, they destroy ozone layer.
4. Use the chemicals derived from peaches and plums to clean computer chips and circuit boards, instead of CFCs.
5. Use CFC free refrigerators.

The manufacture and operation of such devices should be encouraged that do not pollute the environment.

Air pollution can be prevented by using clean fuel, i.e., hydrogen fuel. Hydrogen for that matter, should not be produced by passing current in water, in the is case the environment will be polluted. So, solar hydrogen fuel is the need of the hour.

The following are the practical hints for an individual to prevent pollution:

- Reduce your dependency on fossil fuel, especially coal or oil.
- Save electricity by not wasting it when not required, because electricity saved is electricity generated without polluting the environment.
- Adopt and popularize renewable energy sources.
- Improve energy efficiency. This will reduce the amount of waste energy.
- Promote reuse and recycling whenever possible and reduce the production of wastes.
- Use mass transport system. For short visits, use bicycle or go on foot.
- Decrease the use of automobiles.
- Use pesticides only when absolutely necessary, that too in right amounts.
- Use rechargeable batteries, it will reduce metal pollution.
- Use less hazardous chemicals wherever possible.
- The solid waste generated during one manufacturing process can be used as a raw material for some other processes.
- Do not put pesticides, paints, solvents, oils or other harmful chemicals into the drain or ground water.
- Use only the minimum and required quantity of water for various activities.
- Plant more trees, as trees can absorb many toxic gases and can purify the air.
- Check population growth so that demand of materials is under control.

CHECK YOUR PROGRESS

1. What is environment?
2. What is pollution?
3. Name some primary pollutants.
4. What is acid rain?
5. What is water pollution?

3.3 MAJOR ACTS AND REGULATIONS RELATED TO THE ENVIRONMENT

In this section we will have a look at major acts related to the environment for e.g., air, water etc.

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3.3.1 Environmental Protection Act

The Act came into force on 19 November, 1986. The Act extends to the 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 interrelationship that exist 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 the 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 the environment, while the state government coordinate the actions. The most important function of central government under this act includes:

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 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 the industries and to carry on processes 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 samples, 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 is discharged or the area of emission.

3.3.2 Air (Prevention and Control of Pollution) Act

The salient features of the act are as follows:

1. It provides for prevention, control and abatement of air pollution.
2. 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 the Water (Prevention and control of pollution) Act, the boards perform similar functions related to the 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, power and function of pollution control boards, funds, accounts, audit, penalties and procedures.
6. Section 20 of the Act has provision for insuring emission standards for automobiles. Based upon it, the state government is empowered to issue instructions to the authorities in charge of registration of motor vehicles (under Motor Vehicle 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 the approved fuel in the area causing air pollution. No person shall without prior consent of the 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 the Water Act and Section 31 of the 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, the Governor is constituted to hear such appeals as filed by some aggrieved parties due to some order made by the state board within thirty 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.

Penalties include a fine of up to ₹5000 a day and/or imprisonment for up to one and a half to six years for first offence and fine of ₹10000 a day and imprisonment of one and a half to six years.

3.3.3 Water (Prevention and Control of Pollution) Act

It provides for maintaining and restoring the wholesomeness of water by preventing and controlling its pollution. Water 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

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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 the quality of all types of surface and groundwater.
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):

The board is supposed to:

1. Advise the Central Government in matters related to the prevention and control of water pollution.
2. Coordinate the activities of State Pollution Control Boards and provides them technical assistance and guidance.
3. Organize training programmes for prevention and control of pollution.
4. Organize comprehensive programmes on pollution-related issues through mass media.
5. Collect, compile and publish technical and statistical data related to pollution.
6. Prepare manuals for treatment and disposal of sewage and trade effluents.
7. Lay down standards for water quality parameters.
8. Plan nation-wide programmes for prevention, control or abatement of pollution.
9. Establish and recognize laboratories for analysis of water, sewage or trade effluent sample.

The State Pollution Control Boards also have similar functions to be executed at the state level and are governed by the directions of CPCB.

1. The board advises the state government with respect to the location of any industry that might pollute a stream or a well.

2. 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.
3. 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 the 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.
4. Every industry has to obtain consent from the Board (granted for a fixed duration) by applying on a prescribed proforma providing all technical details, along with a prescribed fee, following which analysis of the effluent is carried out.
5. The Board suggests efficient methods of 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 people. Installation and proper functioning of effluent treatment plants in all polluting industries is a must for checking the 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.

Penalties include a fine of up to ₹5000 a day for first offence and/or imprisonment from one to six years. On repeated offence, the penalty goes up to ₹ 10000 a day and/or imprisonment from one to six years.

CHECK YOUR PROGRESS

6. When did the Environmental Protect Act come into force?
7. Give any two salient features and provisions of the Water (Prevention and Control of Pollution) Act.

3.4 CLIMATE CHANGE AND GLOBAL WARMING

Let us discuss to concept of climate change and global warming in the following section.

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, for at least thirty years is called climate.

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The Intergovernmental Panel On Climate Change (IPCC) in 1990 and 1992 published the best available evidence about past climate changes, the greenhouse effect and recent changes in global temperature. It was 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 0.51°C over the 100 to 200 year period. We have relatively stable climate for thousands of years due to which we have practised agriculture and increased population. Even small changes in the climatic conditions may disturb agriculture that would lead to migration of animals including humans.

Anthropogenic activities are upsetting the delicate balance that has been established between various components of the environment. Greenhouse gases have increased in the atmosphere resulting in the increase in the average global temperature.

This may upset the hydrological cycle, resulting in floods and droughts in different regions of the world, causing sea level to rise, changes in agricultural productivity, famines and death of humans as well as livestock.

Global Warming

Troposphere, the lower most layer of the atmosphere, traps heat by natural processes due to the presence of certain gases. This effect is called greenhouse 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 upon the concentration of heat trapping or greenhouse gases and the length of time they stay in the atmosphere. The major greenhouse gases are carbon dioxide, ozone, methane, nitrous oxide, and water vapour.

The average global temperature is 15°C. In the absence of greenhouse gases, this temperature would have been 18°C. Therefore, greenhouse effect contributes to 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 vapour which is controlled by the 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 and nitrous oxide. Deforestation has further resulted in elevated levels of carbon dioxide due to the 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 droughts or floods following the rise in the average sea level.

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 absorbs infra-red light containing heat and results in the re-radiation of much of the outgoing thermal infra-red 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 include carbon dioxide, chlorofluorocarbons, methane and nitrous oxide. These are the greenhouse gases present in the troposphere which result in an increase in the temperature of air and earth.

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 inputs of greenhouse gases continues to rise at the present rate. Even at the lower value, earth would be warmer than it has been for the past 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 the 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 metres over the next 50-100 years.

   One metre 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. This 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 metres above the sea level is vulnerable. Some of the cities like Mumbai may be saved by heavy investment on embankments to prevent inundation.
   Life of millions of people who have build homes in the deltas of Ganges, the Nile, the Mekong, the Yangtze and the Mississippi rivers will be affected, by the sea level rise.

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 and elephantiasis.

   Areas which are presently free from diseases like malaria may become the breeding ground for the vectors of such diseases. The areas likely to be affected in this manner are Ethiopia, Kenya and Indonesia. Warmer

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temperature and more water stagnation will favour 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.

Measures to Check Global Warming

To slow down enhanced global warming the following steps will be important:

1. Cut down the current rate of use of CFCs and fossil fuel.
2. Use energy more efficiently.
3. Shift to renewable energy resources.
4. Increase in nuclear power plants for electricity production.
5. Shift from coal to natural gas.
6. Trap and use methane as a fuel.
7. Adopt sustainable agriculture.
8. Stabilize population growth.
9. Efficiently remove carbon dioxide from smoke stacks.
10. Plant more trees.
11. Remove atmospheric carbon dioxide by utilizing photosynthetic algae.

3.4.1 Rain and Wasteland Reclamation

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 oxidized 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 decomposition is the total wet acidic deposition (acid rain) and dry deposition.

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Rainwater turns acidic when its pH falls below 5.6. In fact, clean or natural rainwater has a pH of 5.6 at 20°C because of formation of carbonic acid due to the dissolution of CO_2 in water.

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.

Effects of Acid Rain

Acid rain causes a number of harmful effects below pH 5.1. The effects are visible even at pH less than 5.5.

1. 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.
2. It damages stone statues. Priceless stone statues in Greece and Italy have been partially dissolved by acid rain.
3. It damages metals and car finishes.
4. Aquatic life especially fish are badly affected by lake acidification.
5. 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.
6. It results in reproductive failure, and killing of fish.
7. It damages foliage and weakens trees.
8. 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.

Control of Acid Rain

1. Emission of SO_2 and NO_2 from industries and power plants should be reduced by using pollution control equipment.
2. Liming of lakes and soils should be done to correct the adverse effects of acid rain.
3. A coating of protective layer of inert polymer should be given in the interior of water pipes.

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-ridges, 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

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ha) is estimated to be wasteland, thus indicating the seriousness of the problem for a country like ours which has to support one-sixth of the world's population.

Maximum wasteland areas in our country lie in Rajasthan (36 million ha) followed by Madhya Pradesh and Andhra Pradesh. In Harayana, the wastelands cover about 8.4 per cent 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 and sandy areas or by anthropogenic (man-made) activities leading to eroded, saline or waterlogged lands.

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:

1. To improve the physical structure and quality of marginal soils
2. To improve the availability of good quality water for irrigating these lands
3. To prevent soil erosion, flooding and landslides
4. To conserve the biological resources of land for sustainable use

CHECK YOUR PROGRESS

8. What is the greenhouse effect?
9. Name some of the major greenhouse gases.

3.5 WATER CONSERVATION, RAIN WATER HARVESTING, WATERSHED MANAGEMENT

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 run-off 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.
   (a) Contour cultivation: Small furrows and ridges across the slopes, trap rainwater and allow more time for infiltration. Terraces constructed in deep soils have large water-storage capacity. On gentle slopes, trapped run off is spread over a large area for better infiltration.
   (b) Conservation-bench terracing: It involves construction of a series of benches for catching the run off water.
   (c) Water spreading is done by channeling or lagoon-levelling. In channelling, the water flow is controlled by a series of diversions with vertical intervals. In lagoon-levelling, small depressions are dug in the area so that there is temporary storage of water.

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(d) Chemical wetting agents (Surfactants): These seem to increase the water intake rates when added to normal irrigated soil.

(e) Surface crop residues, tillage, mulch, animal residues, etc., help in reducing run-offs by allowing more time for the water to penetrate into the land.

(f) 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 (hydrolyzed poyacrylonitrile).

(g) Water-storage structures like farm ponds, dug-outs, etc., built by individual farmers can be useful measures for conserving water through reduction of run-offs.

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 per cent. This is more effective on sandy soil but less effective on loamy sand soils.

   A co-polymer of starch and acrylonitrile called 'super slumper' has been reported to absorb water up to 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 the next season.

4. Reducing irrigation losses: a) Use of lined or covered canals to reduce seepage b) irrigation in early morning or late evening to reduce evaporation losses c) sprinkling irrigation and drip irrigation to conserve water by 30-50 per cent d) growing hybrid crop varieties with less water requirements and tolerance to saline water help conserve water.

5. Reuse of water: a) Treated wastewater can be used for ferti-irrigation b) 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. a) Closing taps when not in use b) repairing any leakage from pipes c) 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 the economic use of water by the consumers.

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 and check dams. 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.

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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 away run-offs 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 ground water contamination
6. To supplement ground water supplies during lean seasons

Rainwater can be mainly harvested by anyone of the following methods:

1. By storing in tanks or reservoirs above or below ground
2. By constructing pits, dug wells, lagoons, trench or check-dams on small rivulets
3. By recharging the ground water

Before adopting a rainwater harvesting system, the soil characteristics, topography, rainfall pattern and climatic conditions should be understood.

Traditional Rainwater 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 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 *taalaabs, baawaris, johars, hauz,* etc. in every city, village and capital cities which were used to collect rainwater and ensure adequate water supply in dry periods.

Modern Techniques of Rainwater 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, rocks, plants, loose rocks, wire nets, stones, slabs and sacks) are constructed for harvesting run-off from large catchment areas. Rajendra Singh of Rajasthan popularly known as 'waterman' has been doing a commendable job for harvesting rainwater by building check-dams in Rajasthan and he was honoured with the prestigious Magsaysay Award for his work.

Groundwater flow can be intercepted by building groundwater dams or storing water underground. As compared to surface dams, groundwater dams have several advantages like minimum evaporation loss, reduced chances of contamination, etc.

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In roof top rainwater harvesting, which is a low cost and effective technique for urban houses and buildings, the rainwater 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 well or by using a hand pump.

All these 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.

Watershed Management

The land area drained by a river is known as the river basin. 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 kilometres 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. They have mutual impacts on each other.

A watershed 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 basic functional units is extremely important and the first Integrated Watershed Management was adopted in 1949 by the Damodar Valley Corporation.

Watershed Degradation

Watersheds are very often found to be degraded due to uncontrolled, unplanned and unscientific land-use activities. Organizing, 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.

Objectives of Watershed Management

Rational utilization of land and water sources 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 regions.

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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 the resources.

The practices of conservation and development of land and water are taken up with respect to their suitability for people's benefit as well as sustainability. Various measures which are 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 agro-forestry**: In watershed development, afforestation and crop plantation play a very important role. They help in preventing soil erosion and retention of moisture. In high rainfall areas, woody trees are grown in between crops to substantially reduce the run-offs and loss of fertile soil. In Dehradun, trees like eucalyptus, leucaena and grasses like chrysopogon are grown along with maize or wheat to achieve the objectives. Woody trees grown successfully in such agro-forestry programmes include *sheesham*, teak and *keekar* which have been used in watershed areas of river Yamuna.
3. **Mechanical measures for reducing soil erosion and run-off losses**: Several mechanical measures like terracing, bunding, bench terracing, no-till farming, contour cropping, strip cropping, etc., are used to minimize run-offs and soil erosion, particularly on the slopes of watersheds. Bunding has proved to be a very useful method in reducing run-off, 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 one metre on overburdened dump, planting some soil binding plants, land 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 in 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 freshly planted areas and maintaining water harvesting structures implemented by the government or some external agency (NGO) independently or by involving the local people. 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.

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Watershed management in the Himalayan region is of vital importance since most of the watersheds of our country lie there. Several anthropogenic activities accelerate its slope instability which need to be prevented and efforts should be made to project the watershed by preventing overgrazing, terracing and contour farming to check run-offs and erosion. On steeper slopes with sliding faces, straw mulching tied with thin wires and ropes helps in establishing the vegetation and stabilizing the slopes.

CHECK YOUR PROGRESS

10. Give any two strategies that can be adopted to conserve water.
11. What is rainwater harvesting?
12. When was the first Integrated Watershed Management adopted?

3.6 VERMICOMPOSTING: DEFINITION, VERMICOMPOSTING SPECIES AND IMPORTANCE

Vermicomposting is basically a managed process of worms digesting organic matter to transform the material into a beneficial soil amendment. As per the USDA guidelines for compost practices (with effect from October 21, 2002), vermicomposts are defined as organic matter of plant and/or animal origin consisting mainly of finely-divided earthworm castings, produced non- thermophilically with biooxidation and stabilization of the organic material, due to interactions between aerobic microorganism and earthworms, as the materials pass through the earthworm gut.

Good quality compost production in ambient temperature can be accomplished in shorter time by the process of vermicomposting that involves the use of proper species of earthworms. The native cellulase activity of earthworms and microorganisms in the earthworm gut promotes faster decomposition of ingested organic material. The combined effect of enzymatic activity and grinding of organic materials to fineness by earthworms produces the vermicomposting and this is not observed in compost pits without earthworm.

The earthworms being voracious eaters consume the biodegradable matter and give out a part of the matter as excreta or vermi-castings. The vermi-casting containing nutrients is a rich manure for the plants. Vermicompost, apart from supplying nutrients and growth enhancing hormones to plants, improves the soil structure leading to increase in water and nutrient holding capacities of soil. Fruits, flowers and vegetables and other plant products grown using vermi- compost are reported to

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have better keeping quality. A growing number of individuals and institutions are taking interest in the production of vermicompost utilising earthworm activity. As the operational cost of production of this compost works out to less than ₹ 2.0/Kg., it is quite profitable to sell the compost even at:

₹ 4.00 to ₹ 4.50/Kg.

Process

The process of composting crop residues / agri wastes using earthworms comprise spreading the agricultural wastes and cow dung in gradually built up shallow layers. The pits are kept shallow to avoid heat built-up that could kill earthworms. To enable earthworms to transform the material relatively faster a temperature of around 300°C is maintained. The final product generated by this process is called vermicompost, which essentially consists of the casts made by earthworms eating the raw organic materials. The process consists of constructing brick lined beds generally of 0.9 to 1.5 m width and 0.25 to 0.3 m height are constructed inside a shed open from all sides. For commercial production, the beds can be prepared with 15 m length, 1.5 m width and 0.6 m height spread equally below and above the ground. While the length of the beds can be made as per convenience, the width and height cannot be increased as an increased width affects the ease of operation and an increased height on conversion rate due to heat built up.

Cow dung and farm waste can be placed in layers to make a heap of about 0.6 to 0.9 m height. Earthworms are introduced in between the layers at 350 worms per m3 of bed volume that weighs nearly 1 Kg. The beds are maintained at about 40-50 per cent moisture content and a temperature of 20–30° C by sprinkling water over the beds.

When the commercial scale production is aimed at, in addition to the cost of production, considerable amount has to be invested initially on capital items. The capital cost may work out to about ₹5000 to ₹6000 for every tonne of vermicompost production capacity. The high unit capital cost is due to the fact that large units require considerable expenditure on preparation of vermi beds, shed to provide shelter to these beds and machinery. However, these expenditures are incurred only once.

Under the operational cost, transportation of raw materials as also the finished product are the key activities. When the source organic wastes and dung are away from the production facility and the finished product requires transportation to far off places before being marketed, the operational cost would increase.

However, in most of the cases, the activity is viable and bankable. Following are the items required to be considered while setting up a unit for production of vermi-compost.

About the worms

Of about 350 species of earth worms in India with various food and burrowing habits, *Eisenia fetida, Eudrilus eugeniae* and *Perionyx excavatus* are some of the species that are reared to convert organic wastes into manure. A combination of epigeic species that form no permanent burrows and live on the surface, anecic that

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form semi-permanent and vertical burrows extending from the surface and endogeic that typically live throughout the deeper layers may be considered.

The worms feed on any biodegradable matter and vermicomposting units are ideally suited for locations/units with generation of considerable quantities of organic wastes. One earthworm reaching reproductive age of about six weeks lays one egg capsule (containing seven embryos) every 7-10 days. Three to seven worms emerge out of each capsule. Thus, the multiplication of worms under optimum growth conditions is very fast. The worms live for about two years. Fully grown worms could be separated and dried in an oven to make 'worm meal' which is a rich source of protein (70 per cent) for use in animal feed.

Location

Rural areas with predominance of agriculture, suburbs of cities and peri urban villages are considered ideal locations for setting up of vermicomposting units on a larger scale from the view point of availability of raw material and marketing of the produce. As use of the compost is said to have ameliorative effect more particularly on fruit, vegetable, plantation and ornamental crops, vermi- composting units may be located in areas with concentration of fruit and vegetable growers and floriculture units. Further, the nearness to a commercial dairy unit or large concentration of cattle population will have an added advantage of cheap raw material, i.e., cow dung.

Components of a Commercial Unit

Commercial units have to be developed based on the availability of cow dung locally. If some big dairy is functioning then such unit will be an associated activity. Commercial units must not be designed based on imported cow dung. The philosophy is in-situ development using 'natural resources'.

Sheds

For a vermi-composting unit, whether small or big, this is an essential item and is required for securing the vermi beds. They could be of thatched roof supported by bamboo rafters and purlins, wooden or steel trusses and stone/ RCC pillars. Locally available roofing materials or HDPE sheet may also be used in roofing to keep the capital investment at reasonably lower level. If the size is so chosen as to prevent wetting of beds due to rain on a windy day, they could be open sheds. While designing the sheds adequate room/pathways has to be left around the beds for easy movement of the labourers attending to the filling and harvesting the beds.

Vermi-beds

Normally, the beds have 0.3 to 0.6 m height depending on the provision for drainage of excess water. Care should be taken to make the bed with uniform height over the entire width to avoid low production owing to low bed volumes. The bed width should not be more that 1.5 m to allow easy access to the centre of the bed.

Land

About 0.5-0.6 acre of land will be needed to set up a vermiculture production. The centre will have at least 6-8 sheds for convenience and a dedicated area for finished

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products. It should also have a bore well and pump set or watering arrangement and other equipments as described in the scheme economics. The land can be taken on lease for at least 10-15 years.

Buildings

When the activity is taken up on a large scale on commercial lines, considerable amount may have to be spent on buildings to house the office, store the raw material and finished product, provide minimum accommodation to the Manager and workers. The cost of the buildings along with the electrification of these buildings and the vermi-sheds may be included under this item.

Seed Stock

This is an important item requiring considerable expenditure. Though, the worms multiply fast to give the required numbers over a period of six months to a year, it may not be wise to wait till such a time having invested on the infrastructure heavily. Thus, worms at 1 kg per m^3 of bed volume should be adequate to start with and to build up the required population in about two or three cycles without unduly affecting the estimated production.

Fencing and Roads/Paths

The site area needs development for construction of structures and development of roads and pathways for easy movement of hand-drawn trolleys/wheel barrows for conveying the raw material and the finished products to and from the vermi- sheds. The entire area has to be fenced to prevent trespass by animals and other unwanted elements. These could be estimated based on the length of the periphery of the farm and the length and type of roads/paths required. The costs on fencing and formation of roads should be kept low as these investments are essential for a production unit, yet would not lead to an increase in production.

Water Supply System

As the beds have to be kept moist always with about 50 per cent moisture content, there is a need to plan for a water source, lifting mechanism and a system of conveying and applying the water to the vermi-beds. Drippers with round the clock flow arrangement would be quite handy for continuous supply and saving on water. Such a water supply system requires considerable initial investment. However, it reduces the operational cost on hand watering and proves economical in the long run. The cost of these items would depend on the capacity of the unit and the type of water supply chosen.

Machinery

Farm machinery and implements are required for cutting (shredding) the raw material into small pieces, conveying shredded raw material to the vermi-sheds, loading, unloading, collection of compost, loosening of beds for aeration, shifting of the compost before packing and for air drying of the compost, automatic packing and stitching for efficient running of the unit.

Transportation

For any vermi-composting unit, transport arrangement is a must. When the source of raw material is away from the production unit, an off-site transport becomes major item of investment. A large sized unit with about 1000 tonnes per annum capacity may require a three tonne capacity mini-truck. With small units particularly with the availability of raw material near the site, expending on transport facility may become infructuous. On-site transport facilities like manually drawn trolleys to convey raw material and finished products between the storage point and the vermi-compost sheds could also be included in the project cost.

Furniture

A reasonable amount could also be considered for furnishing the office-cum-stores including the storage racks and other office equipments. This will enhance the efficiency of operations.

Financial aspects

The following are the financial aspects:

Benefits

It is assumed that there will be around 2–3 cycles of production in the first year and 5 – 6 cycles in the subsequent years with a duration of each cycle at around 65–70 days. Further, taking into account various limitations and operational problems, the capacity utilization is further assumed at 50 per cent in the first year and 90 per cent from second year onwards. Benefits include the income from sale of vermi-compost at ₹4500 per MT and worm at ₹200/- per kg. The net income from the second year onwards would be about ₹6,48,000 annually.

Project Cost

Vermi-composting could be taken up on any scale starting from 10 MT per annum (TPA) to 1000 TPA and above. As the production is proportional to the vermi-bed space, it is advantageous to start with less capacities and later expand the unit after gaining production experience and developing assured market for the product.

A bed volume of 324 m3 spread over twenty-four beds - 15 m long, 1.5 m wide and 0.6 m high is estimated to produce vermi-compost of 200 TPA over 6 cycles/crops of 65–70 days each annually. Total of twenty-four such beds may be housed under two to four different open sheds.

The particulars of capitalised costs including mother stock of earthworms, cost of machinery and tools and operational cost/production cost of compost are set out in Annexure I and II. The costs and benefits of the unit are set out in Annexure III. As can be seen, the investment cost is ₹13,50,000/-, operational cost ₹3,42,000. Operational cost of two cycles amounting to ₹1,24,800/- has been capitalised.

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Margin

The margin money/down payment has been considered at 25 per cent in the present model, which works out to ₹3.375 lakh.

Bank loan

Bank loan considered in the model is 75 per cent which works out to ₹10.125 lakh.

Rate of interest

Banks are free to decide the rate of interest within the overall RBI guidelines issued from time to time. While the interest rate may vary from 13 to 15 per cent, for the purpose of financial analysis and bankability of the project, the ultimate lending rate has been assumed at 13 per cent.

Security

Banks are guided by RBI guidelines issued from time to time in this regard.

Financial analysis

The financial analysis are shown in Annexure IV. It indicates that the model is viable. The major financial indicators are given below:

NPV : ₹7.621 lakh BCR : 1.23 : 1

IRR : 34 per cent

Repayment

Based on the cash flow the detailed repayment schedule has been worked out and furnished in Annexure V. The loan outstanding can be repaid in 6 years.

CHECK YOUR PROGRESS

13. What is vermicomposting?
14. What are the ideal locations for setting up of vermicomposting units?

3.7 ROLE OF GOVERNMENT IN MANAGEMENT

We will look at disaster management and the role of Tripura State Polution Control Board in this section.

3.7.1 Disaster Management: floods and earthquakes

Geological processes like earthquakes, volcanoes, floods and landslides are normal natural events which have resulted in the formation of the earth that we have today. They are however disastrous in their impact when they affect human settlements. Human societies have witnessed a large number of such natural hazards in different parts of the world and have tried to learn to control these processes to some extent.

Table 3.1 Frequently occurring Natural Disasters in India

Sr. No.	Type	Location/Area	Affected Pollution (in million)
1.	Floods	Eight major river valleys spread over 40 million hectares in the entire country.	260
2.	Droughts	Spread in fourteen states.	86
3.	Earthquakes	Nearly 55 per cent of the total area of the country fall in the seismic zones IV and V.	400
4.	Cyclones	Entire 5700 km long coastline of southern Peninsular India covering nine states.	10
5.	Landslides	Entire sub-Himalayan regions and Western Ghats.	10

Major disasters include a devastating earthquake which hit the city Bhuj in Gujarat which caused massive damage. Earthquake generated water waves called Tsunamis caused tremendous damage in Tamil Nadu and Kerala.

Causes for Natural Disasters

There are several causes for such disasters which include the following:

1. Anthropogenic activities such as impounding huge quantities of water in lakes behind big dams, e.g., Koyna Dam in Maharashtra has created few incidence of minor and major earthquakes; underground nuclear testing, e.g., Pokharan II testing in the desert of Rajasthan, deep well disposal of liquid waste.
2. Heavy rainfalls or sudden snow melt can swell the rivers disproportionately causing great economic loss and health-related problems.
3. Landslides occur when coherent rock of soil masses move down a slope due to gravitational pull. Water and vegetation influence landslides. Chemical action of water gradually causes chemical weathering of rocks making them prone to landslides.

Earthquake

An earthquake is a phenomenon that occurs without warning and involves violent shaking of the ground and everything over it. It results from the release of accumulated stress of the moving lithospheric or crustal plates. The earth's crust is divided into seven major plates, that are about 50 miles thick, which move slowly and continuously over the earth's interior and several minor plates. Earthquakes are tectonic in origin; that is the moving plates are responsible for the occurrence of violent shakes. The occurrence of an earthquake in a populated area may cause numerous casualties and injuries as well as extensive damage to property.

The Earthquake Risk in India

India's increasing population and extensive unscientific constructions mushrooming all over, including multistoried luxury apartments, huge factory buildings, gigantic

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malls, supermarkets as well as warehouses and masonry buildings keep - India at high risk. Scientific publications have warned of the likelihood of the occurrence of very severe earthquakes in the Himalayan region, which could adversely affect the lives of several million people in India.

At one time regions of the country away from the Himalayas and other inter-plate boundaries were considered to be relatively safe from damaging earthquakes. However, in the recent past, even these areas have experienced devastating earthquakes, albeit of lower magnitude than the Himalayan earthquakes. The Koyna earthquake in 1967 led to revision of the seismic zoning map, resulting in deletion of the non-seismic zone from the map. The areas surrounding Koyna were also re-designated to Seismic Zone IV, indicating high hazard. The occurrence of the Killari earthquake in 1993 resulted in further revision of the seismic zoning map in which the low hazard zone or Seismic Zone I was merged with Seismic Zone II, and some parts of Deccan and Peninsular India were brought under Seismic Zone III consisting of areas designated as moderate hazard zone areas. Recent research suggests that as understanding of the seismic hazard of these regions increases, more areas assigned as low hazard may be re-designated to higher level of seismic hazard, or vice-versa.

The North-Eastern part of the country continues to experience moderate to large earthquakes at frequent intervals including the two great earthquakes mentioned above. Since 1950, the region has experienced several moderate earthquakes. On an average, the region experiences an earthquake with a magnitude greater than 6.0 every year. The Andaman and Nicobar Islands are also situated on an inter-plate boundary and frequently experience damaging earthquakes.

The increase in earthquake risk is due to a spurt in developmental activities driven by urbanization, economic development and the globalization of India's economy. The increase in use of high-technology equipment and tools in manufacturing and service industries has also made them susceptible to disruption due to relatively moderate ground shaking. As a result, loss of human life is not the only determinant of earthquake risk any more. Severe economic losses leading to the collapse of the local or regional economy after an earthquake may have long-term adverse consequences for the entire country. This effect would be further magnified if an earthquake affects a mega-city, such as Delhi or Mumbai.

Floods

India is highly vulnerable to floods. Out of the total geographical area of 329 million hectares (mha), more than 40 mha is flood prone. Floods are a recurrent phenomenon, which cause huge loss of lives and damage to livelihood systems, property, infrastructure and public utilities. It is a cause for concern that flood related damages show an increasing trend. The average annual flood damage in the last 10 years period from 1996 to 2005 was Rs. 4745 crore as compared to Rs. 1805 crore, the corresponding average for the previous 53 years. This can be attributed to many reasons including a steep increase in population, rapid urbanization growing developmental and economic activities in flood plains coupled with global warming.

An average every year, 75 lakh hectares of land is affected, 1600 lives are lost and the damage caused to crops, houses and public utilities is Rs.1805 crores due to floods. The maximum number of lives (11,316) was lost in the year 1977. The frequency of major floods is more than once in five years.

Floods have also occurred in areas, which were earlier not considered flood prone. An effort has been made in these Guidelines to cover the entire gamut of Flood Management. Eighty per cent of the precipitation takes place in the monsoon months from June to September. The rivers a bring heavy sediment load from catchments. These, coupled with inadequate carrying capacity of rivers are responsible for causing floods, drainage congestion and erosion of river-banks. Cyclones, cyclonic circulations and cloud bursts cause flash floods and lead to huge losses. It is a fact that some of the rivers causing damage in India originate in neighboring countries; adding another complex dimension to the problem. Continuing and large-scale loss of lives and damage to public and private property due to floods indicate that we are still to develop an effective response to floods. NDMA's Executive Summary Guidelines have been prepared to enable the various implementing and stakeholder agencies to effectively address the critical areas for minimising flood damage.

Measures for Disaster Management

The following measures should be taken as set of measures for disaster management:

1. Damage of property and life can be prevented by constructing earthquake resistant buildings in the earthquake prone zones. Wooden houses are preferred in earthquake prone areas as in Japan.
2. To check floods, effort needs to be made to restore wetlands, replace ground cover on water-courses, build check-dams on small streams, move buildings off the flood plains, etc. Flood plains should be used for wildlife habitat, parks, recreational areas, etc.
3. These landslides should be masked by many other exerting factors like earthquakes, vibrations, disturbances in resistant rock, etc. These landslides could be minimized by stabilizing the slope by draining the surface and surface water, providing slope support like gabions (wired stone blocks) and concrete support at the base of a slope.
4. It is difficult to stop the recurrence of cyclones. Long-term defence measures can help to protect us from devastation. Such measures include planting of more trees on the coastal belt, construction of dams, embarkments, storm shelter, wind breaks, proper drainage and wide roads for quick evacuation.

3.7.2 Role of Tripura State Control Board (TSPCB)

The following section will explain the various functions of TSPCB.

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Functions of Tripura State Pollution Control Board

Under The Water (Prevention and Control of Pollution) Act, 1974

(a) To plan a comprehensive programme for the prevention, control or abatement of pollution of streams and wells in the State and to secure the execution thereof;

(b) To advise the State Government on any matter concerning the prevention, control or abatement of water pollution;

(c) To collect and disseminate information relating to water pollution and the prevention. control or-abatement thereof;

(d) To encourage, conduct and participate in investigations and research relating to problems of water pollution and prevention, control or abatement of water pollution;

(e) To collaborate with the Central Board in organizing the training of persons engaged or to be engaged in programmes relating to prevention, control or abatement of water pollution and to organize mass education programmes relating thereto;

(f) To inspect sewage or trade effluents, works and plants for the treatment of sewage and trade effluents and to review plans, specifications or other data relating to plants set up for the treatment of water, works for the purification thereof and the system for the disposal of sewage or trade effluents or in connection with the grant of any consent as required by this Act;

(g) Lay down, modify or annul effluent standards for the sewage and trade effluents and for the quality of receiving waters (not being water in an inter-State stream) resulting from the discharge of effluents and to classify waters of the State;

(h) To evolve economical and reliable methods of treatment of sewage and trade effluents, having regard to the peculiar conditions of soils, climate and water resources of different regions and more especially the prevailing flow characteristics of water in streams and wells which render it impossible to attain even the minimum degree of dilution;

(i) To evolve methods of utilization of sewage and suitable trade effluents in agriculture;

(j) To evolve efficient methods of disposal of sewage and trade effluents on land, as are necessary on account of the predominant conditions of scant stream flows that do not provide for major pan of the year the minimum degree of dilution;

(k) To lay down standards of treatment of sewage and trade effluents to be discharged into any particular stream taking into account the minimum fair weather dilution available in that stream and the tolerance limits of

pollution permissible in the water of the stream, after the discharge of such effluents;

(l) To lay down effluent standards to be complied with by persons while causing discharge of sewage or sullage or both and to lay down, modify or annul effluent standards for the sewage and trade effluents;

(m) To advise the State Government with respect to the location of any industry the carrying on of which is likely to pollute a stream or well

(n) To perform such other functions as may be prescribed or as may, from time to time be entrusted to it by the Central Board or the State Government.

A. Under The Air (Prevention and Control of Pollution)Act,1981

(a) To plan a comprehensive programme for the prevention, control or abatement of air pollution and to secure the execution thereof;

(b) To advise the State Government on any matter concerning the prevention, control or abatement of air pollution;

(c) To collect and disseminate information relating to air pollution:

(d) To collaborate with the Central Board in organising the training of persons engaged or to be engaged in programmes relating to prevention control or abatement of air pollution and to organise mass-education programme relating thereto;

(e) To inspect, at all reasonable times, any control equipment, industrial plant or manufacturing process and to give, by order, such directions to such persons as it may consider necessary to take steps for the prevention, control or abatement of air pollution;

(f) To inspect air pollution control areas at such intervals as it may think necessary, assess the quality of air therein and-take step for the prevention, control or abatement of air pollution in such areas;

(g) To lay down, in consultation with the Central Board and having regard to the standards for the quality of air laid down by the Central Board standards for emission of air pollutants into the atmosphere from industrial plants and automobiles or for the discharge of any air pollutant into the atmosphere from any other source whatsoever not being a ship or an aircraft:

Provided that different standards for emission may be laid down under this clause for different industrial plants having regard to the quantity and composition of emission of air pollutants into the atmosphere from such industrial plants;

(h) To advise the State Government with respect to the suitability of any premises or location for carrying on any industry which is likely to cause air pollution;

(i) To perform such other functions as may be prescribed or as may, from time to time, be entrusted to it by the Central Board or the State Government;

Mandates of Tripura State Pollution Control Board

The Mandates of Tripura State Pollution Control Board are to implement the following Acts, Rules and Notifications framed thereunder.

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(A) Acts :

- The Water (Prevention and Control of Pollution) Act, 1975
- The Water (Prevention and Control of Pollution) Cess Act, 1977
- The Air (Prevention and Control of Pollution) Act, 1981
- The Environment (Protection) Act, 1986

(B) Rules :

- The Water (Prevention and Control of Pollution) Rules, 1975
- The Tripura State Pollution Control Board (Water Pollution Control) Rules, 1989
- The Water (Prevention and Control of Pollution) Cess Rules, 1978
- The Air (Prevention and Control of Pollution) Rules, 1982
- The Tripura State Pollution Control Board (Air Pollution) Rules, 1989
- The Environment (Protection) Rules, 1986

(C) Notifications

- The Hazardous Wastes (Management, Handling and Transboundary) Rules, 2008
- The Bio Medical Wastes (Management & Handling) Rules, 2000
- The Plastics Manufacture, Sale and Usage Rules, 1999
- The Noise Pollution (Regulation & Control) Rules, 2000
- The Batteries(Management and Handling) Rules, 2001
- The Municipal Solid Waste(Management & Handling) Rules, 2000
- The Manufacture, Storage & Import of Hazardous Chemical Rules, 1989
- The Environment Impact Assessment Notification, 2006

CHECK YOUR PROGRESS

15. Give any one cause for natural disasters.
16. How can we prevent damage of property and life? Suggest some measures.
17. Give any two functions of Tripura State Pollution Control Board under the Water (Prevention and Control of Pollution) Act, 1974.

3.8 SUMMARY

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- Air pollution means the presence of any air pollutant in the atmosphere.
- Air pollutants can be primary or secondary. Primary pollutants are carbon dioxide, nitrogen oxides, sulphur dioxide, carbon monoxide (all formed from the combustion of fossil fuels), CFC and particulate matter. Secondary pollutants are acid rain and ozone.
- Water pollution can be defined as an alteration in physical, chemical or biological characteristics of water, making it unsuitable for the designated use in its natural state.
- Pesticides in drinking water ultimately reach humans and are known to cause various health problems.
- Thermal pollution can be defined as the presence of excessive heat in the water which can cause undesirable changes in the natural environment.
- The main sources of marine pollution are: 1) rivers, which bring pollutants from their drainage basins, 2) catchment areas, and, coastlines where human settlements in the form of hotels, industry, agricultural practices have been established and 3) oil drilling and shipping.
- Sewage and industrial effluents which pollute the soil ultimately affect human health. Various types of chemicals like acids, alkalis, pesticides and insecticides found in the industrial discharges affect soil fertility by causing changes in its physical, chemical and biological properties.
- Climate is the average weather of an area. It is the general weather conditions, seasonal variations and extremes of weather in a region.
- Troposphere, the lower most layer of the atmosphere, traps heat by natural processes due to the presence of certain gases. This effect is called greenhouse effect, as it is similar to the warming effect observed in the horticultural greenhouses made of glass.
- The enhanced greenhouse effect will not only cause global warming, but will also affect various other climatic and natural processes.
- Water being one of the most precious and indispensable resources, needs to be conserved.
- 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 and check dams.
- The land area drained by a river is known as the river basin. Watershed is defined as the land area from which water drains under gravity to a common drainage channel.
- Watersheds are very often found to be degraded due to uncontrolled, unplanned and unscientific land-use activities.

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- Watershed management in the Himalayan region is of vital importance since most of the watersheds of our country lie there. Several anthropogenic activities accelerate its slope instability which needs to be prevented and efforts should be made to protect the watershed by preventing overgrazing, terracing and contour farming to check run-offs and erosion.
- Vermicomposting is a managed process of worms digesting organic matter to transform the material into a beneficial soil amendment.
- As per the USDA guidelines for compost practices (with effect from October 21, 2002), vermicomposts are defined as organic matter of plant and/or animal origin consisting mainly of finely-divided earthworm castings, produced non-thermophilically with biooxidation and stabilization of the organic material, due to interactions between aerobic microorganism and earthworms, as the materials pass through the earthworm gut.
- Geological processes like earthquakes, volcanoes, floods and landslides are normal natural events which have resulted in the formation of the earth that we have today. They are however disastrous in their impact when they affect human settlements.
- It is difficult to stop the recurrence of cyclones. Long-term defence measures can help to protect us from devastation. Such measures include planting of more trees on the coastal belt, construction of dams, embarkments, storm shelter, wind breaks, proper drainage and wide roads for quick evacuation.

3.9 KEY TERMS

- **Air Pollutant:** It means any solid, liquid or gaseous substance (including noise) present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment. Air pollution means the presence of any air pollutant in the atmosphere.
- **Acid Rain:** Sulphur dioxide and nitrogen dioxide combine with water in the atmosphere and reacts with sunlight forming acid droplets. These acid droplets constitute acid rain.
- **Pollution:** It refers to the substances (pollutants) which are released into the environment because of anthropogenic (human) activities that can be either deliberate or accidental (e.g., Bhopal gas leak or radioactive material released from Chernobyl nuclear power plant is accidental). The reference point of pollution is the ambient quality of the environment which means environment in its natural state.
- **Thermal Pollution:** It can be defined as the presence of excessive heat in the water which can cause undesirable changes in the natural environment.
- **Water Pollution:** It can be defined as an alteration in physical, chemical or biological characteristics of water, making it unsuitable for the designated use in its natural state.

- **Global Warming:** Troposphere, the lower most layer of the atmosphere, traps heat by natural processes due to the presence of certain gases. This effect is called greenhouse effect, as it is similar to the warming effect observed in the horticultural greenhouse made of glass.
- **Rainwater Harvesting:** It 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 and check dams.

3.10 ANSWERS TO 'CHECK YOUR PROGRESS'

1. Environment includes water, air, land and their inter-relationship with human beings, other living creatures, plants and micro-organisms.
2. Pollution refers to the presence of substances in air, water and land, whether they result from human activity or occur naturally, which has adverse effects on human-life and on the environment.
3. Primary pollutants are carbon dioxide, nitrogen oxides, sulphur dioxide, carbon monoxide (all formed from the combustion of fossil fuels), CFC and particulate matter.
4. Sulphur dioxide and nitrogen dioxide combine with water in the atmosphere and react with sunlight forming acid droplets. These acid droplets constitute acid rain.
5. Water pollution can be defined as an alteration in physical, chemical or biological characteristics of water, making it unsuitable for the designated use in its natural state.
6. The Environmental Protect Act came into force on 19 November, 1986.
7. The two salient features and provisions of the Water (Prevention and Control of Pollution) Act are as follows:
   (i) It provides for maintenance and restoration of the quality of all types of surface and ground water.
   (ii) It provides for the establishment of Central and State Boards for pollution control.
8. Troposphere, the lower most layer of the atmosphere, traps heat by natural processes due to the presence of certain gases. This effect is called greenhouse effect.
9. Some of the major greenhouse gases are carbon dioxide, ozone, methane, nitrous oxide, and water vapour.
10. The two strategies that can be adopted to conserve water are as follows:
    - Conservation-bench terracing: It involves construction of a series of benches for catching the run-off water.

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- Water spreading is done by channeling or lagoon-levelling. In channelling, the water flow is controlled by a series of diversions with vertical intervals. In lagoon-levelling, small depressions are dug in the area so that there is temporary storage water.

11. 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 and check dams. Rainwater, wherever it falls, is captured and pollution of this water is prevented.
12. The first Integrated Watershed Management was adopted in 1949 by the Damodar Valley Corporation.
13. Vermicomposting is a managed process of worms digesting organic matter to transform the material into a beneficial soil amendment.
14. Rural areas with predominance of agriculture, suburbs of cities and peri urban villages are considered ideal locations for setting up of vermicomposting units on a larger scale from the view point of availability of raw material and marketing of the produce.
15. Heavy rainfalls or sudden snow melt can swell the rivers disproportionately causing great economic loss and health-related problems.
16. Damage of property and life can be pretended by constructing earthquake resistant buildings in the earthquake prone zones.
17. The two functions of Tripura State Pollution Control Board under the Water (Prevention and Control of Pollution) Act, 1974 are as follows:
    (a) To plan a comprehensive programme for the prevention, control or abatement of pollution of streams and wells in the State and to secure the execution thereof.
    (b) To advise the State Government on any matter concerning the prevention, control or abatement of water pollution.

3.11 QUESTIONS AND EXERCISES

Short-Answer Questions

1. Define pollution. Name some common atmospheric pollutants.
2. Write a note on air pollution. How can we control it?
3. Differentiate between sound and noise.
4. Briefly describe the sources, effects and control of noise pollution.
5. Write a short note on water pollution.
6. Discuss the measures to conserve water.
7. What is rainwater harvesting? What are the purposes served by it?
8. What is a watershed? Critically discuss the objectives and practices of watershed management.

Long-Answer Questions

1. What are the adverse effects and measures to control water pollution?
2. What are the sources of soil pollution? How does soil pollution affect soil productivity? What are the remedies for the same?
3. How can you as an individual prevent environmental pollution? Why is such an effort necessary?
4. What are the various types of disasters? How can they be controlled? What are the steps to be borne in mind in disaster management?
5. What are greenhouse gases and greenhouse effect? How do they contribute to the global warming?
6. Discuss the major implications of enhanced global warming.

3.12 FURTHER READINGS

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Annexure I
Vermi-Composting (200 TPA)

Capital Cost

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Sr	Particulars of item	Amt (₹)	
		Year 1	Year 2 onwards
A.	**Land and Building**		
1.	Land (On lease)	----	----
2.	Levelling and earth filling for vermicompost sheds	7500	----
3.	Fencing and gate	25000	----
4.	Open Shed with brick lined bed bottom & platform with RCC / MS pipe post & truss and thatch /HDPE / locally available roof (@ 1000/m^2) for :		
a.	Vermicompost beds (15 m*1.5 m*24 nos = 540 m^2 + 20 m^2 pathways/utility = 560 m^2)	560000	
b.	For finished products 30 m^2	30000	----
5.	Godown / Store cum office 50 m^2 @ 5000/-per m^2	250000	----
	Sub total	**872500**	----
B.	**Implements and machinery**		----
1	Shovels, spades, crowbars, iron baskets, dung fork, buckets, bamboo baskets, trowel,	5000	----
2	Plumbing and fitting tools	1500	----
3	Power operated shredder	25000	----
4	Sieving machine with 3 wire mesh sieves- 0.6 m x 0.9 m size - power operated with motor	45000	----
5	Weighing scale (100 kg capacity)	2500	----
6	Weighing machine (platform type)	6000	----
7	Bag sealing machine	5000	----
8	Culture trays (plastic) (35 cm x 45 cm) - 4 Nos	1600	----
9	Wheel barrows - 2 Nos.	12000	----
	Sub total	**103600**	----
C.	**Water provision - Borewell with hand pump, pipe, dripper**	**75000**	----
D.	**Electrical installation**	**10000**	----
E.	**Furniture & fixtures**	**25000**	----
F.	**Earthworms (@1 Kg per m^3 and @` 300/Kg, total utilized bed volume = 324 m^3)**	**97200**	----
	TOTAL CAPITAL COST	**1183300**	

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Annexure II

Vermi-Composting unit (200 TPA)

Total operational cost for one year with 7 cycles of 65-75 days

Bed volume 324 m3

Recovery : 30 %

Operational Cost

Sr	Particulars of item	Amt (₹)	
		Year 1	Year 2 onwards
1.	Agricultural wastes (cost, collection and transportation) @ 320 kg per m^3 and Rs.200/MT (15*1.5*0.6*24*5*320*200/1000) [at 50% in 1st year]	51840	103680
2.	Cow dung (cost, collection and transportation) @ 80 kg/m3 and Rs.250/MT (15*1.5*0.6*24*5*80*250/1000) [at 50% in 1st year]	16200	32400
3.	Salary wages for 2 permanent skilled labourers @ Rs.6000/month	12000	12000
4.	Labour wages on day to day basis in formation of vermibed with agro-waste, cow dung and worms, watering, stirring, harvesting, sieving, packing, etc., including cost of bags (250 mds[@ Rs.200/md) [at 50% in 1st year]	25000	50000
5.	Electrical charges for pump, machinery, lighting etc. [at 50% in 1st year]	12000	24000
6.	Repair and maintenance [at 50% in 1st year]	30000	60000
7.	Cost of bags and marketing cost [at 50% in 1st year]	15000	30000
	Sub Total	**156040**	**312080**
8.	Lease rent, Miscellaneous etc.	30000	30000
	Total Operational Cost	**186040**	**342080**

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Annexure III
Vermi-Composting units (200 TPA)

Costs and Benefits

Sr	Cost	Amt (₹)	
		Year 1	Year 2 onwards
1.	Total Capital cost	1183300	---
2.	Total Operational cost	186040	342080
3.	Total cost	1369340	342080
4.	Benefit		
4a.	Sale of vermicompost (200 MT @ 30% conversion) [@ Rs.4500/MT at 60% in 1st year and 90% in 2nd year onwards]	405000	810000
4b.	Sale of worms [@ 5 Kg/MT of compost and @ Rs.200/Kg.]	90000	180000
4c.	Total benefit	495000	990000
5.	Net benefit	(874340)	647920

Annexure IV
Vermi-Composting unit (200 TPA)

Financial Analysis

Sr	Cost	Amt (₹)	
		Year 1	Year 2 onwards
1.	Total Capital cost	1183300	---
2.	Total Operational cost	186040	342080
3.	Total cost	1369340	342080
4.	Benefit		
4a.	Vermicompost	405000	810000
4b.	Sale of worms	90000	180000
4c.	Total benefit	495000	990000
5.	Net benefit	(874340)	647920
6.	Discounting rate - 15%		
7.	PVC - ₹2893538		
8.	PVB - ₹3655654		
9.	NPV - ₹762116		
10.	BCR - ₹1.226		
11.	IRR – 34%		

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Annexure V
Vermi-Composting (200 TPA)

Repayment Schedule

TFO (₹.) = 1338132 (Say ₹13.50 lakh)

(Capital cost + Operational cost for two cycles + lease rent for 1st year)

Bank Loan (₹.) = 1012500 337500

Rate of Interest = 13%

Year	Loan O/s	Net Income*	Principal	Interest	Total outgo	Net surplus
1	1012500	456584	75000	131625	206625	249959
2	937500	647920	160000	121875	281875	366045
3	777500	647920	180000	101075	281075	366845
4	597500	647920	200000	77675	277675	370245
5	397500	647920	220000	51675	271675	376245
6	177500	647920	177500	23075	200575	447345

** 1st year net income = 1st year total income -operational cost of 1 cycle + insurance and lease [As 2 operational cycle and lease rent are capitalized].*

UNIT 4 HUMAN POPULATION AND SOCIAL ISSUES

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Structure

4.0 INTRODUCTION

Environmental and social rights are major points for the subject of sustainability. Sustainability is derived from a discussion about the recognition of global ecological problems and globally increasing social problems of poverty as a result of economic development and its processes. It represents the extension of the concept of social responsibility and its relationship with the global development conditions of humanity and is based on the assumption that ecological, economical and social problems have to be solved by means of new integrated strategies involving guiding actions.

In this unit, you will learn about sustainable development, environmental ethics and environmental awareness. This unit will also deal with the Social Impact Assessment (SIA) and Cumulative Effects Assessment (CEA). At the end of this unit, you will learn about the demographic structure of India.

4.1 UNIT OBJECTIVES

After going through this unit, you should be able to:

- Explain the concept of sustainable development
- Identify environmental ethics and environmental awareness

- Describe the role of the Social Impact Assessment (SIA) and Cumulative Effects Assessment (CEA)
- Discuss the demographic structure of India

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4.2 SUSTAINABLE DEVELOPMENT

Sustainable development is such a concept that signifies that the rate of consumption or the use of natural resources should be approximate to the rate at which these resources can be substituted or replaced. It also requires that a nation or a society should be able to satisfy its requirements—social, economic and others, without undermining the interest of our future generations. Developed countries use too many natural resources and such practice cannot continue for long. Mother Nature has been making available its resources and services and it is also serving as a receptacle for absorbing wastes for too long a time. We have to realize now that nature today is very fragile. Nature is finite. And experts have warned that it has reached a critical threshold beyond which it would lead to ecological decline that would further lead to nothing but 'disaster'. These experts are strong advocates of 'limits to growth' philosophy.

This concept of sustainable development can be further extended to the principle of justice and equity (equal distribution) between the developed and underdeveloped countries of north and south. Therefore, national as well as international leaders and institutions have a major responsibility for sound developmental, economic and environmental issues. They should keep in view the principle of equity and those principles that determine the intergenerational inequities.

Another aspect of sustainable development is related to system analysis, that is to say, how economic, social and environmental systems interact at various scales of operation, to lead sustainable development that will strike optimal balance among the three subsystems. It must ultimately lead to reduced poverty in developing countries by minimizing resources depletion, environmental damage and social instability.

Thus, sustainable development should lead to:

- Protecting the environment
- Avoiding depletion of non-renewable resources
- Seek reliance on alternative sources
- Equal access to resources
- Intergenerational distribution of resources
- Systems thinking

Sustainable Global Governance

In the 1970s, it was realized that there were 'limits to growth'. If growth continued unbridled at the existing rates, it was asserted that it would exhaust the limited stock of natural resources of the earth. Although, technological innovations have contributed in pushing outwards the 'limits to growth', it is now being argued that the limits must be evaluated in terms of the 'carrying capacity' of the environment. There is a

consensus over the fact that growth without commensurate efforts at environmental protection will pose a global threat.

The international community has responded to this perceived threat and environmental protection and sustainable development concerns are now on a high priority of the international agenda. The last century has seen a proliferation of international legal instruments—declarations and agreements—aimed at environmental protection. Whereas declarations are more general in nature, containing a general commitment to environmental protection without being legally binding, agreements contain binding obligations for the member states and deal with specific issues relating to particular environmental problems.

On various occasions, the highest representatives of states and governments have got together in international conferences on environmental protection and development. The basic principles for environmental protection, such as the precautionary principle, the polluter pays principle and the principle of sustainable development, etc., have also taken shape. Moreover, an international structure has been put in place, which is devoted to further the objective of environmental protection. There are also talks of setting up a centralized world body—a World Environment Organization (WEO)—to address the problems of environment. However, despite the intensified efforts at the international level, there are numerous challenges that must be met in order to allow these initiatives to be successful in their endeavour.

Various environmental problems have been identified, some related to the conservation of natural resources and ecosystems, such as forests, wildlife, biodiversity, wetlands, migratory species, etc. These issues put a question mark on how much the earth can give. Other issues relate to ensuring that we stay within the limits of the 'carrying capacity' of the environment. These issues, mostly relating to ozone depletion, global warming, hazardous wastes, persistent organic pollutants (POPs), hazardous chemicals, genetically modified organisms (GMOs), atmospheric pollution and marine pollution relate to the basic question of how much the earth can take.

Because of the diversity of environmental problems, the legal regime at the international level is necessarily fragmented, with over 200 Multilateral Environmental Agreements (MEAs) each dealing with different environmental problems.

The basic principles of environment management are increasingly being incorporated into political constitutions since the Stockholm Conference on Human Environment held in 1972. Therefore, the Stockholm Conference has taken issues such as proper use of natural reserves, environmental development as well as ecological pollution into consideration and they found expression in constitutional form. These are often articulated in terms of obligations which are stated clearly to its citizens. Moreover, a duty is often imposed on citizens to safeguard the national environment. Most of the developing countries exhibit this constitutional trend.

Equitable Use of Resources for Sustainable Lifestyle

There is a big division in the world in the use of resources, viz., north and south, more developed countries (MDCs) and less developed countries (LDCs), haves and have-nots.

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It is observed that MDCs have only 22 per cent of world's population, but they use 88 per cent of natural resources, 73 per cent of energy and command 85 per cent of income; in turn, they contribute a big proportion to its pollution. On the other hand, LDCs have very low or moderate industrial growth and have 78 per cent of the world's population. They use only 12 per cent of natural resources, 27 per cent of energy and have only 15 per cent of global income. The rich have gone richer and the poor have become poorer. There is a huge gap between them. This is not sustainable growth.

The solution to this problem is to have better equitable distribution of resources and wealth. A global consensus has to be reached for balanced distribution. There are two major causes of unsustainability. These are as follows:

1. Overpopulation in poor countries
2. Overconsumption of resources by rich countries

The rich countries will have to lower their consumption levels and the minimum needs of the poor must be satisfied by providing them resources. The need of the hour is fairer sharing of resources between the rich and poor, which will bring about sustainable development for all.

Within the concept of sustainable development, industrial ecology plays a significant role in order to create a balance between industrial development and preservation of natural resources. It refers to the adoption of such industrial processes, technology, equipment and raw material where the products can be recycled after their life cycle is complete or can be put to alternative use or a byproduct can be made out of it. This not only reduces the pressure on raw materials and compensates them for producing afresh; it also reduces the costing impact. Advanced technology also reduces wastage and is more energy efficient.

Case Exhibit: Tackling Challenges for Sustainable Development

The United Nations Conference on Sustainable Development will be held on June 20–22, 2012, which is commonly known as Rio+20, treating 'green economy within the context of sustainable development and poverty eradication' and 'institutional framework for sustainable development' as its two themes. Under the two themes, Rio+20 will assess the progress and implementation gaps in meeting already agreed commitments, address new and emerging challenges, and secure renewed political commitment to sustainable development.

It is known that uneven development, severe regional environmental pollution, desertification, climate change, population growth, poverty, increased demand for natural resources and energy supply are among the challenges China, India and many other developing countries are facing for sustainable development.

China is committed to pursuing sustainable development as a national strategy. As a matter of fact, sustainable development is embodied in China's traditional values. Over 2,000 years ago, the great Chinese philosophers Mencius observed that 'refraining from over fishing will ensure fishing last forever' and 'cutting wood according to the season ensure the health of forest' are the means to achieve harmony between man and nature.

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China has achieved remarkable results in promoting sustainable development process and accumulated some experience. China has instituted the most stringent systems for managing farmland and water resources, and fed one fifth of the global population with less than 10 per cent of the world's farmland and only 28 per cent of the world's per capita water resources. In the past decade, China has implemented the policy of development-oriented aid to the rural poor and lifted around 70 million people out of poverty, making it the first country to meet the Millennium Development Goal. China has carried out afforestation for two decades, with coverage now reaching 620,000 square kilometres. It is also committed to the implementation of energy conservation, and increased the efforts in pollution control. Since 2005, while maintaining a robust economic growth, China has cut energy consumption per unit of GDP by 21 per cent, and emissions of major pollutants such as S02 and COD by 16 per cent and 14 per cent respectively. China also attaches great importance to people's livelihood and strives to promote the well-being of the people.

China cannot develop itself in isolation from the rest of the world, and global sustainability can not be maintained without China. China has taken the initiative to promote bilateral and multilateral cooperation. It has carried out cooperation with many countries in the fields of resources, environment, disaster prevention and mitigation, and a large number of demonstration projects on sustainable development with the United Nations agencies and other international organizations.

Meanwhile, China is also providing any possible assistance to other developing countries and least developed countries in accordance with the principles of equality, mutual benefit, and emphasis on practical results, utilization of diversified forms, and the pursuit of common development. As of the end of 2010, China had offered zero tariff treatment to more than 60% of the products from thirty-eight least developed countries, provided other developing countries with 287 billion yuan (USD 46 billion) of financial assistance, and written off 30 billion yuan (USD 4.76 billion) debt of fifty heavily indebted poor countries and least developed countries.

China is in the process of rapid industrialization and urbanization and its development has many constrains. First, China is poor in natural endowment, low in per capita share of resources, and it has a fragile eco-system and disparity in regional development. Second, it is facing the dual pressures to accelerate development while restructuring the economy. China is still a developing country with large population, weak economic foundation and low-level productivity. Measured by the newly-adjusted national poverty line, China still has 128 million poor people in rural areas. Each year, over 10 million people enter the labour market. The conflict between resources supply and demand is more prominent, the emissions of major pollutants continue to exceed the capacity of the environment. China thus faces a formidable task of growing the economy while protecting the environment. Third, economic and social structural problems are prominent in China. The industrial structure is not sound; the domestic and external demand as well as investment and consumption are not balanced; economic growth is too dependent on investment and exports; and domestic consumer demand is obviously insufficient.

China and India, as two emerging economies consisting of one-third of the population in the world, both want to eradicate poverty and achieve modernization. The Indian saying 'We produce to live, not to consume' and the ancient Chinese philosophy of 'unity between heaven and man' and 'the law of following the

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nature' are all examples of oriental wisdom. We look forward to the cooperation between China and India in Rio+20 to guarantee a sustainable development for both countries and other developing countries. We hope that the Rio+20 shall send a positive, clear and powerful message to reinvigorate international cooperation and inject new vitality into sustainable development.

Source: Adapted from http://www.indianexpress.com/news/tackling-challenges-for-sustainable-development/964069/0

Accessed on 20 June, 2012

4.2.1 Fundamentals of Environment and Sustainable Development

To evaluate the critical aspects of environment and development, some basic concepts need to be explained.

Population and its Implication

There are two aspects that affect environment: a) Population growth and b) economic development. The interaction between population growth, resource depletion/ environmental damage has been debated. High population growth causes stress on the environment, and there are thinkers, who feel that the blame has to be on economic development, industrial growth and unsustainable economic development are the matters of cause of concern especially in development.

It can be expressed by the following equation:

$$I = P \times A \times T$$

where I = Impact of environment

P = Population

A = Affluence (consumption)

T = Technology coefficient

More people means more pressure on resources, more consumption of energy, more production of wastes including greenhouse gases – all have adverse effects on the environment. India's population has crossed the hundred crores mark. The question is whether we have devised adequate developmental programmes that can match the increase in population. If not, population factor itself would be a sufficient contribution toward degradation of environment and resource depletion.

Sustainable development is about integrational equity. But, if the future equity is of great concern, it is not legitimate to ignore the equity occurring in the present populations in different parts of the globe. Sustainability should reflect equity, environmental concerns and social responsibilities vis-à-vis population regardless of time or location.

Limits to Growth

We will need to change attitudes, consumption patterns, manufacturing and marketing practices and get into a technological world that is less intensive in its use of materials and energy, to be able to manage the environmental crisis. Improvement of efficiency

alone is not going to be enough. Growth has been treated as an infinite variable. This is not a correct assumption. 'Earth's carrying capacity' is not seriously thought about. And such a world has to desperately try to keep pace with the environmental problems because of such incorrect assumptions.

For example, climate change (global warming), can be combated only if the world transits to a non-carbon energy economy, only after that, the limitations of the environmental concerns posed by a carbon energy economy would get lessened. The world needs an international mechanism that not only provides incentives to all nations to live within their entitled norms (amounts), but also helps to promote a rapid transition to a non-carbon energy economy.

There is considerable scope for dematerialization and de-energization without a decrease in the living standards. This will be possible only if it is promoted through changes in the fiscal system, which supports appropriate technological improvements. This can happen if the principle of sufficiency is ignored. We will need to set a level of sufficiency, i.e., this much and not beyond it.

Sufficiency will be possible only if one day the world is prepared to reach an international agreement on limits to growth and to say, that we have fixed our level of greed and no more. Global agreement is still a distant possibility.

For sustainable use of global common systems, a separate set of policies will have to be adopted. It has to be a system that provides for the establishment of equitable entitlements or property rights to provide economic incentives to those who use this environment space in a sustainable manner and disincentives to those who use it in an unsustainable manner.

The world faces an enormous challenge in the coming years.

Economy

Rate of Gross National Product (GNP) is one of the most important indicators of economic performance of any nation. Increase in GNP indicates the economic health of the country. Such an increase however, is based on high rate of consumption of natural resources, of which depletion of environmental resources is significant. Economic growth comes in conflict with issues of environmental concerns.

India had adopted the Economic Reforms Models via liberalization and globalization. There are significant advantages from this transition; however, the ecological disadvantages are required to be taken into account. Long-term ecological costs are to be taken into account. In our effort to increase the GNP, we may not like to liquidate ecological assets.

High economic growth results in high rate of extraction, transformation and utilization of non-renewable resources. It is important to also achieve good rate of regeneration of natural resources.

Economic growth cannot take place without sustaining ecological costs. Economic growth has to be environmentally sustainable. Developing countries have yet to undertake more developmental programmes and attain reasonable standards of living. Therefore, GNP must increase in these countries. Elements of resource

generation and positive approach to environment have to be incorporated in the developmental programmes.

Poverty

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In order to properly manage environment and resources, due consideration should be given to the fact that poor people directly depend upon natural resources for their livelihood. Sustainable development must address the issue of eradication of poverty which is linked with employment for women and youth and other income generation programmes.

Human Settlement Issues

The environmental implications of urban development and rural development (slums) must be recognized. It will be necessary to give priority to the needs of urban as well as rural poor. The human settlement programme should concentrate on the following aspects:

1. Providing shelter to all
2. Investment in infrastructure- water, sewage and solid waste
3. Promotion of sustainable energy and transport system
4. Promotion of sustainable land use management

Land Resources

Land not only includes a physical entity in terms of topography, but it also includes natural resources, soil, minerals and biota. These components provide varieties of services which are essential for life support system. Land is an infinite resource. Integrated approach is necessary for the management of land.

Forests

There should be a rational approach adopted for management of forests and forests lands. Sustainable forest development, production of forest products and forest services require institutional approach at the government level.

CHECK YOUR PROGRESS

1. Define sustainable development.
2. What are the two major causes of unsustainability?

4.3 ENVIRONMENTAL ETHICS: ISSUES AND POSSIBLE 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 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 about 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.

Anthropocentric Worldview

This view guides most industrial societies. It puts human beings at the centre giving them the highest status. Man is considered to be the most capable for managing the planet earth. The guiding principles of this view are as follows:

1. Man is the planet's most important species and is in charge of the rest of the nature.
2. Earth has an unlimited supply of resources and it all belongs to us.
3. Economic growth is very good and the more the growth, the better it is, because it raises our quality of life and the potential for economic growth is unlimited.
4. A healthy environment depends upon a healthy economy.
5. The success of mankind depends upon how good managers we are for deriving benefits for us from the nature.

Ecocentric Worldview

This is based on earth-wisdom. The basic beliefs are as follows:

1. Nature exists not for human beings alone, but for all the species.
2. Earth's resources are limited and they do not belong only to human beings.
3. Economic growth is good till it encourages earth-sustaining development and discourages earth-degrading development.
4. A healthy economy depends upon a healthy environment.
5. 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 in deciding what to do when faced with crucial situations. Some important ethical guidelines known as earth ethics or environmental ethics are as follows:

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- One should love and honour the earth, since it nurtures life.
- One should keep each day sacred on earth and celebrate the turning of its seasons.
- One should not hold one above other living things and has no right to drive them to extinction.
- One should be grateful to the plants and animals which provides food.
- One should limit the number of offsprings because too many people will overburden the earth.
- One should not waste resources on destructive weapons.
- One should not run after gains at the cost of nature rather should strive to restore its damaged majesty.
- One should not conceal from others the effects that have been caused by one's actions on earth.
- One should not steal from future generations, their right to live in a clean and safe planet by impoverishing or polluting it.
- One 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 these 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* also 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. Even various festivals envisaged by Hinduism also prescribe the participation of humans in the celebrations through nature. (Nisarga Pooja is what we perform during celebrations of our festivals, e.g., Satyanarayana Pooja, Vatapournitma, Baishakhi, Ganesh Festival, Dusshera).

The concept of ahimsa 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' ensure to put 'limits to growth', and thus, guide us to have an ecocentric lifestyle.

4.3.1 Environmental Awareness

Public awareness about environment is at the stage of infancy. Of late, some awareness has taken place related to environmental degradation and pollution, but incomplete knowledge 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 been often branded as antidevelopment. The wisdom lies in maintaining a balance between our needs and supplies so that the delicate ecological balance is not disrupted.

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Some of the main reasons responsible for widespread environmental ignorance can be detailed as follows:

1. Our courses in science, technology and economics have so far failed to integrate the knowledge in environmental aspects as an essential component of the curriculum.
2. Our planners, decision-makers, politicians and administrators have not been trained so as to consider the environmental aspects associated with their plans.
3. In a zeal to go ahead with some ambitious development projects, quite often, there is a purposeful concealment of information about environmental aspects.
4. There is greater consideration of economic gains and issues related to eliminating poverty by providing employment that overshadows the basic environmental issues.

Methods to Propagate Environmental Awareness

There is immense need for environmental awareness. It is 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.

The various stages and methods that can be useful for raising environmental awareness in different sections of the society are given as follows:

1. **Among students through education:** Such education should be imparted to the students right from childhood. These studies are now being incorporated at all stages in schools and colleges as per the directives of the Supreme Court.
2. **Among the masses through mass-media:** Media can play an important role to educate the masses through articles, rallies, campaigns, street plays, TV serials, etc. This will appeal all age groups at the same time.
3. **Among the planners, decision-makers and leaders:** It is very important to give these classes of people necessary orientation and training through specially organized workshops and training programmes.

Role of Non-government Organizations (NGOs)

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 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 creating awareness.

The Chipko Movement for conservation of trees by Dasholi Gram Swarajya Mandal in Gopeshwar or the Narmada Bachao Andolan organized by Kalpvariksh are some of the instances where NGOs have played a landmark role in the society for the conservation of environment.

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The Bombay Natural History Society (BNHS), the World Wide Fund for Nature-India (WWF-India), Kerala Sastra Sahitya Parishad, Center 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 all take up the task of environmental protection and conservation, we have to be environmentally educated and aware. It can therefore said 'If you want to act green, first think green.'

CHECK YOUR PROGRESS

3. What do you understand by environmental ethics?
4. Give any two important ethical guidelines.
5. Give examples of raising environmental awareness through mass media.

4.4 SOCIAL IMPACT ASSESSMENT (SIA)

In this section, we will discuss about the Social Impact Assessment (SIA) in detail.

1. The impacts of development projects occur in different forms. While significant benefits result for the society, the project area people may often bear the brunt of adverse impacts. This can happen, for example, when they are forced to relocate to make way for such interventions. There is now a growing concern over the fate of the displaced people. This has given rise to the need to understand beforehand the implications of adverse project impacts so that mitigation plans could be put in place in advance.
2. The National R&R Policy, issued in 2007, recognizes the need to carry out Social Impact Assessment (SIA) as part of the resettlement planning and implementation processes. Section 4.1 in Chapter IV Social Impact Assessment (SIA) of the Policy reads as follows:

   'Wherever it is desired to undertake a new project or expansion of an existing project, which involves involuntary displacement of 400 hundred or more families, *en masse* in plain areas, or two hundred or more families *en masse* in tribal or hilly areas, DDP blocks or areas mentioned in the Schedule V or Schedule VI to the Constitution, the appropriate Government shall ensure that a Social Impact Assessment (SIA) study is carried out in the proposed affected areas in such manner as may be prescribed.'
3. While an assessment of social impacts prior to the commencement of a new project or expansion of an existing is now obligatory under the new national R&R policy, the appropriate guidelines for the purpose do not yet exist. This Handbook on Conducting Social Impact Assessments aims to fill this gap. It

explains the basic concept of social impact assessment, the step-by-step process of conducting SIA, and the SIA methodology. In short, it aims to provide practical guidance on carrying out Social Impact Assessment, as envisaged in the national R&R policy, 2007.

4. There is going to be an increase in demand for a set of how-to-do guidelines on conducting social impact assessments, especially from government resettlement planning and implementation agencies.

Social Impacts and Social Impact Assessment

1. Planners and decision makers increasingly recognize the need for better understanding of the social consequences of policies, plans, programmes and projects (PPPPs). Social Impact Assessment (short form for Socio-economic Impact Assessment) helps in understanding such impacts.
2. Social Impact Assessment alerts the planners as to the likely benefits and costs of a proposed project, which may be social and/or economic. The knowledge of these likely impacts in advance can help decision-makes in deciding whether the project should proceed, or proceed with some changes, or dropped completely. The most useful outcome of a SIA is to develop mitigation plans to overcome the potential negative impacts on individuals and communities.
3. SIAs can assist advocacy groups as well. A Social Impact Assessment report, done painstakingly, showing the real consequences of the project on affected people and suggesting alternative approaches, gives credibility to their campaigns.

A Historical Overview

1. Social scientists have long been involved in doing impact assessment, almost since the dawn of their discipline. A canal study carried out by Condorcet in the 19th century is believed to be the first Social Impact Assessment. (Prendergast 1989) However, Social Impact Assessment, as it is known today, emerged much later.
2. The beginnings of social impact assessment can be traced to developments as recent as those during the1970's. By this time, 'development agencies began to use impact assessments – which were about predicting, before the start of a project, its likely environmental, social, and economic consequences – in order to approve, adjust, or reject it.' (Roche 1999: 18)
3. From the early 1980s, several new methods of enquiry emerged, including Rapid Rural Appraisal (RRA), Participatory Action Research (PRA), Participatory Rural Appraisal (PRA) (Chambers 1997; Oommen 2007). These sought to make people and communities active participants, rather than mere objects of assessment.
4. By the early 1990s, social science professionals were also able to develop an acceptable set of SIA guidelines and principles. (IOCPGSIA: 1994 and 2003, and IAIA: 2003) Around this time, the practice of SIA also got firmly

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established among development agencies as a way to assess the impacts of development projects before they go ahead. SIA is now part of the formal planning processes in most development organizations. In some countries, SIA is a legal requirement.

5. Social impact assessments have been carried out for a variety of projects, including projects in such diverse sectors as water, sanitation and health, coal sector, urban transport systems, pastoral development programmes, and livelihood support projects (Cernea and Kudat 1997; Roche 1999). But it is for resettlement projects that SIAs have been found particularly useful. Modak and Biswas (1999:209) observe:

   The subject has evolved basically to identify project-affected people and find measures to mitigate negative impacts, or compensate irreversible losses following a participatory process

6. In recent years, much has been written on applications and methodology of Social Impact Assessment. The subject is widely taught, often in conjunction with other professional and academic courses, and training programmes. Numerous consulting firms have come up to offer SIA expertise in project preparation, implementation, monitoring and evaluation. These firms, along with skilled practitioners and academics are regularly hired by projects to produce SIA reports that are required in advance of proposed new projects for their approval.
7. In the beginning, SIA was carried out as part of Environmental Impact Assessment (EIA). Increasingly, SIA is now carried out as an exercise independently of EIA, because these are two different kinds of assessments.

Current Scene in India

1. In India, SIA has been generally carried out as a part of the Environment Impact Assessment clearance process. As part of the EIA process, it has therefore not received the attention it deserves.
2. Social Impact Assessment has now become an important part of the project preparation process, especially for the preparation of Resettlement Action Plans (RAPs). In this process, SIA is carried out as socio-economic survey that identifies social and economic impacts on people and communities facing project-induced displacement. In addition, data thus generated is used in designing mitigation measures as well as in monitoring mitigation implementation.
3. Resettlement policies have lately made social impact assessment a major part of the resettlement planning process. In 2006, a provision was included for conducting SIA in the Orissa R&R Policy 2006. The National R&R Policy 2007 has made a provision for conducting SIA, whenever a new project or expansion of an existing project is undertaken. (See Annex IV) But this provision is limited to only those cases which involve displacement of 400 hundred or more families, *en masse* in plain areas, or two hundred or more families *en masse* in tribal or hilly areas, DDP blocks or areas mentioned in

the Schedule V or Schedule VI to the Constitution. Undoubtedly, these are good beginnings, but as yet the guidelines to give effect to these policy provisions do not exist.

4. The World Bank, ADB, IFC, UNDP, as well as most multilateral and private agencies, including commercial banks, require some kind of prior social impact assessment for all the projects that they finance.
5. The issue is no longer whether SIA should be carried out or not, but how it should be carried out so that the local people benefit from the project and not lose from it, certainly not those who are poor to begin with.

What are Social Impacts?

1. Social impacts are the changes that occur in communities or to individuals as a result of an externally-induced change. IOCPGSIA (2003: 231) defines social impacts as 'the consequences to human populations of any pubic or private actions that alter the ways in which people live, work, play, relate to one another, organize to meet their needs, and generally cope as members of society. The term also includes cultural impacts involving changes to the norms, values, and beliefs that guide and rationalize their cognition of themselves and their society.' Social impacts are both positive and negative.
2. Changes may effect: employment, income, production, way of life, culture, community, political systems, environment, health and well-being, personal and property rights, and fears and aspirations. These impacts can be positive or negative. In short, a social impact is a significant improvement or deterioration in people's well-being.
3. Examples of projects with significant social impacts include: dams and reservoirs (disruption due to relocation), power and industrial plants (influx of work force, pressure on infrastructure), roads and linear projects (dislocation of activity networks), and landfill and hazardous waste disposal sites (seen as health risks).

Differential Impacts

Projects affect different groups differently. Some people tend to benefit, others lose. Often, impacts are particularly severe for vulnerable groups: tribal people, women-headed households, elderly persons, landless persons, and the poor.

Types of Impacts

Not all projects cause similar impacts. For example, impacts that are commonly experienced in urban projects are different from those in hydropower projects. The common hydropower project impacts include the following:

- Submergence of vast areas, usually in hilly, sparsely populated regions, inhabited by agriculture-dependent rural and tribal communities
- Forced displacement (often resulting in impoverishment)
- Boomtowns (uncontrolled influx of construction workers, crime, social evils)
- Downstream adverse changes in agro-production systems

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On the other hand, there is no submergence in urban projects. People are affected by loss of jobs, not by loss of agricultural lands.

The following is an illustrative list of possible impacts:

Social/Cultural

- Break-up of community cohesion
- Disintegration of social support systems
- Disruption of women's economic activities
- Loss of time-honoured sacred places of worship
- Loss of archeological sites and other cultural property

Economic

- Loss of agricultural lands, tress, wells
- Loss of dwellings and other farm buildings
- Loss of access to common property resources
- Loss of shops, commercial buildings
- Loss of businesses/jobs
- Overall reduction in income due to above losses

Public Infrastructure and services

- Government office buildings
- School buildings
- Hospitals
- Roads
- Street lighting

Identifying Impoverishment Risks

1. Identifying impoverishment risks which projects often create is part of the exercise to identify adverse project impacts. The impoverishment risks analysis model adds substantially to the tools used for explaining, diagnosing, predicting, and planning for development. (WCD: 297) The eight most common impoverishment risks to the project area people, as described by Cernea (1996), are as follows:
   - *Landlessness*: Expropriation of land removes the main foundation upon which peoples' productive systems, commercial activities and livelihoods are constructed.
   - *Joblessness*: Loss of employment and wages occurs more in urban areas, but it also affects rural people, depriving landless labourers, service workers, artisans, and small business owners of their sources of income.
   - *Homelessness*: Loss of housing and shelter is temporary for the majority of displacees, but threatens to become chronic for the most vulnerable. Considered in a broader cultural sense, homelessness is also placenessness, loss of a group's cultural space and identity.

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- *Marginalization*: Marginalization occurs when families lose economic power and spiral downwards. It sets in when new investments in the area are prohibited, long before the actual displacement. Middle-income farm households become small landholders; small shopkeepers and craftsmen are downsized and slip below poverty thresholds. Economic marginalization is often accompanied by social and psychological marginalization and manifests itself in a downward mobility in social status, displaced persons' loss of confidence in society and in themselves, a feeling of injustice and increased vulnerability.
- *Food Insecurity*: Forced displacement increases the risk that people will undergo chronic food insecurity, defined as calorie-protein intake levels below the minimum necessary for normal growth and work. Sudden drops in food crops availability and income are endemic to physical relocation and hunger lingers as a long-term effect.
- *Increased Morbidity and Mortality*: The health of affected persons tends to deteriorate rapidly due to malnutrition, increased stress and psychological traumas. Unsafe water supply and waste disposal tend to proliferate infectious disease, and morbidity decreases capacity and incomes. The risk is highest for the weakest population segments – infants, children, and the elderly.
- *Loss of Access to Common Property*: Loss of access to commonly owned assets (forestlands, water bodies, grazing lands, and so on) is often overlooked and uncompensated, particularly for the assetless.
- *Social Disarticulation*: Community dispersal means dismantling of structures of social organization and loss of mutual help networks. Although, this loss of social capital is harder to quantify, it impoverishes and disempowers affected persons.

2. These adverse impacts must be identified by a SIA study. WCD (2000: 241) is emphatic that the impact assessment studies must identify and delineate various categories of adversely affected people in terms of the nature and extent of their rights, losses and risks. This signals a departure from the way that social impacts were assessed in the past and will empower the planners and stakeholders to incorporate the full extent of social impacts and losses in the decision-making process.

What is Initial Social Impact Assessment (ISIA)?

1. An Initial Social Impact Assessment (ISIA) is carried out if the project impacts are likely to be minor or limited, which can be easily predicted and evaluated, and for which mitigation measures can also be prescribed easily. Generally, information for ISIA is obtained during a field visit to areas that will be affected by the project and through discussions with people whom it may affect positively or otherwise. The ISIA is also done to confirm whether this indeed requires a full-scale Social Impact Assessment (SIA). Usually, a comprehensive SIA is required for large projects, which entails a more detailed study, time, and resources.

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What is Social Impact Assessment?

2. There is no generally agreed definition of Social Impact Assessment (SIA). It may be defined as a process that seeks to assess, in advance, the social repercussions that are likely to follow from projects undertaken to promote development, such as dams, mines, industries, highways, ports, airports, urban development and power projects. It is a tool that can help decision-makers to foresee the likely negative impacts of their actions so that steps necessary to prevent or at least to contain them could be taken in time. As an aid to the decision making process, SIA provides information on social and cultural factors that need to be taken into account in any decision that affects the lives of project area people.
3. Goldman and Baum (2000:7) define Social Impact Assessment (SIA) as a method of analyzing what impacts actions may have on the social aspects of the environment. It involves characterizing the existing state of such aspects of the environment, forecasting how they may change if a given action or alternative is implemented, and developing means of mitigating changes that are likely to be adverse from the point of view of the affected population.
4. The IOCPGSIA (2003: 231) defines SIA in terms of efforts to assess, appraise or estimate, in advance, the social consequences that are likely to follow from proposed actions. These include: specific government or private projects, such as construction of buildings, siting power generation facilities, large transportation projects…
5. Finsterbusch and Freudenburg (2002: 409) define the three terms in '*Socio-economic Impact Assessment*' '(socio-economic, impact, and assessment) as follows:

   Socio-economic: In essence, the *socio*-half of the term *socio-economic* can be seen as covering social and cultural impacts of development, and as incorporating the traditional subject matter of sociology, anthropology, and psychology, in particular, with input from other fields as well. The *economic*-half of the term is generally seen as including not only economics, but also demography and planning, again with input from other fields, as needed. These are emphases, rather than rigid distinctions.

   Impacts: The *impacts* are the direct as well as indirect 'effects' or 'consequences' of an action (such as constructing a dam, digging a coal mine, or building a highway). 'In short, impacts include all of the significant changes that take place because of what an agency does and that would not have occurred otherwise'.

   Assessment: In the SIA context, *assessment* tends to have an unusual meaning: The 'assessment' of impacts is carried out before the impacts actually occur. In other words, an SIA is often anticipatory rather than empirical. It attempts to assist the planning process by identifying the likely effects before they take place. The estimates of likely future impacts are based on the existing empirical knowledge of the impacts of similar actions in the past.

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Advantages of Doing Social Impact Assessment

1. The main advantages of doing a systematic Social Impact Assessment (SIA) include the following:
   - *Identifying Affected Groups*: SIA helps in identifying people and groups who affect or are affected by the project
   - *Allying Fears and Winning Trust*: SIA can help allay fears of affected groups and build a basis of trust and cooperation which is so essential for successful project implementation
   - *Avoiding Adverse Impacts*: SIA provides the basis for preparing mitigation measures to avoid, reduce or manage adverse impacts
   - *Enhancing Positive Impacts*: SIA preparation also helps identify measures to maximize/share project benefits
   - *Reducing Costs*: Addressing social impacts at an early stage helps to avoid costly errors in future
   - *Getting Approval Faster*: A well prepared SIA demonstrates that social impacts are taken seriously and helps in getting project clearance faster
2. Social impact assessment is predicated on the notion that decision makers should understand the consequences of their decisions before they act and that the people affected will not only be appraised of the effects, but have the opportunity to participate in designing their future. (IOCPGSIA 2003:248).

CHECK YOUR PROGRESS

6. What is the most useful outcome of a SIA?
7. What are social impacts?

4.5 CUMULATIVE EFFECTS ASSESSMENT (CEA)

The impact of human activity or a project on an environmental resource or eco-system may be considered insignificant when assessed in isolation, but may become significant when evaluated in the context of the combined effect of all the past, present, and reasonably foreseeable future activities that may have or have had an impact on the resources in question. The Council for Environmental Quality, established under the US National Environmental Policy Act of 1969 (NEPA), came to the view that a conventional project and site-specific approach to environmental assessment has its limitations when it comes to assessing potential cumulative effects on environmental resources.

Definition of Cumulative Impact

Cumulative impact is defined by the US Council on Environmental Quality as 'the impacts on the environment that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions (RFFA)

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regardless of what agency undertakes such other actions.' Thus, the practice of Cumulative Effects Assessment (CEA) of projects in a region began. Various aspects of CEA began to be studied.

There are several reasons why Cumulative Impact Assessments should be carried out i.e.,

(i) Conceptual reasons - For a group of projects, the environmental effects of primary concern tend to be cumulative and it will not be advisable to consider simply the effects of individual projects

(ii) Pragmatic reasons - CEA guidance and other EIA legislation of the 1990s requires that CEs be assessed.

(iii) Regulatory reasons - make 'room' for future developments

(iv) Idealistic reasons - minimize negative CEs, promote resource sustainability.

In India, so far, there is no law requiring the conduct of Cumulative Environmental Impact Assessment before a development project is given Environmental Clearance.

During 1980s and 1990s, it became the practice in many countries to include Cumulative Effects in Environmental Impact Statements. CEA processes were also developed. Litigation in courts also clarified some of the concepts. With the dawn of the present millennium, i.e., 2000s practice for project CEAs was improved; methods of analysis developed and existing methods expanded.

4.5.1 New Concepts in Cumulative Effects Assessment

The advances in the field of Cumulative Effects Assessment gave rise to several new concepts, some of which are briefly mentioned below:

(i) Valued Ecosystem Component (VEC)

Any part, component or resource of the environment that is considered important by the proponent, public, scientists and government involved in the assessment process is Valued Ecosystem Component. A VEC can be assessed using following parameters:

Indicator: It is a feature of the environmental setting that describes, measures, manages and reports on factors of value (VEC). It needs to be measureable.

Thresholds values of Indicators: Value at which change becomes unacceptable.

Cautionary Threshold Values of Indicators: When Standard Protection Measures would do.

Target threshold values of Indicators: Beyond which Enhanced Protection Measures are necessary.

Critical Threshold values of Indicators: When exceeded restrictions need to be proposed.

Irwing et al. (1986) divided the impacts of development on the environment in two categories:

Homotypic: These are the impacts of developments of the same type.

Heterotypic: These are combination of two or more developments or land uses.

Stakhiv (1988) suggested that Cumulative Effects Assessment provides a frame work for three vectors

- Direct-indirect or traceable cause effect sequence of impacts
- Collective or additive sequence
- Interactive or Synergetic Sequence

Specifically, there are three basic ways by which cumulative effects can occur. The first is additive or incremental impact in which the cumulative impact is the sum of the individual impacts.

A second way is supra-additive, also called synergetic in which the total cumulative impact on a species or resource is more than the sum of individual impacts. Finally, there are Infra additive, also called antagonistic, impacts occur when a species or resource is exposed to a series of impacts wherein the total impact is less than the sum of the individual impacts.

It was also realised that the impact of human activities including developmental and others on environment, health, social aspects and economy are a function of policies, activities carried out in a region, the activities undertaken in a sector, carrying capacity of the region, which may make them sustainable or unsustainable.

Strategic Environmental Analysis

Cumulative Impact Assessment also provides valuable and important inputs as an element of Strategic Environmental Analysis, particularly in the monitoring of environmental sustainability impacts of legislation, policies, programmes and projects and impact on health, social and economic aspects.

Now, an explicit assessment of cumulative effects is considered desirable in environmental assessment practice. It is also critical to incorporate cumulative effects analysis into the development of alternatives for an environmental assessment, since it is only by re-evaluating and modifying alternatives in the light of the projected cumulative effects that adverse consequences can be effectively avoided or minimized.

4.5.2 Cumulative Effects and the Environmental Assessment Process

The following section will deal with the cumulative effects and the environmental assessment process.

(a) In most cases, it will be beyond the scope of an environmental assessment to include a full-fledged cumulative impact assessment. However, it is important that environmental assessment, where appropriate, includes a preliminary assessment of the potential for cumulative effects and specific recommendations on the need for, and the conduct of, a cumulative impact assessment. The key issues in considering a cumulative impact assessment relate to:

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(i) Defining appropriate analytical boundaries in time and space.

(ii) Identifying and predicting future resource use and impacts, and

(iii) Evaluating the significance of cumulative effects that are predicted to take place.

It may be difficult to precisely estimate the spatial boundaries in which the impacts are likely and, therefore, they should be determined flexibly so that during the assessment adjustment of process, if needed, can be made. The time period for which the impact will be assessed needs to be set. It depends on data availability as well as the degree of uncertainty and confidence in prediction. A concern is to determine the minimum data requirements that will allow defensible and robust impact predictions. The criteria for judging significance of cumulative effects are not different from those for other types of environmental assessment, but threshold effects and irreversible changes in the use of critical resources will generally be key concerns.

A number of guidance documents have been prepared to facilitate conduct of CEA in different parts of the world

*A list is given below:

Country /Agency	Year	Remarks
USA	1997	The process involves 11 steps
Canada	1999	The process involves 12 steps
Brazil	2007	Deals with hydropower
USA FHWA	2005	
US Army	2007	
Canada	-	tool kit related to fish habitat and productivity
USA Corps of Engineers	-	Water Resources Projects
South Africa & Australia	-	

****Source:*** L. W. Canter, Professor Emeritus, University of Oklahoma

(b) Analysing Cumulative Effects

The process of analyzing cumulative effects is an enhancement of the traditional environmental assessment components and consists of:

(i) Scoping,

(ii) Describing the affected environment, and

(iii) Determining the environmental consequences.

(c) Breaking Down Components in to Steps

The above components are broken down to steps as below:

(i) Identifying the resources, ecosystems, namely, Valued Environmental Components (VECs) or human communities of concern that need to be considered in the cumulative impact analysis by gathering input from knowledgeable individuals and reliable information sources. This enables the selection of the environmental resources or components, ecosystems and human community concerns that are likely to be impacted.

(ii) Identifying important cumulative impact assessment issues.

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(iii) Identifying the Impact Zone, the boundaries of CIA or the Resource Study Area (RSA) of each VEC, i.e., zone in which this impact will take place. This helps to set appropriate time and geographical boundaries for analysis of each VEC.

(iv) Identify the set of the past, current and reasonably foreseeable future actions or projects that have cause-effect relationships with the resources, ecosystems, and human communities of concern (VEC). The purpose of this step is to identify stresses and stressors, historical reference points, trends and thresholds along with other current and reasonably foreseeable projects to be considered in the cumulative impact analysis. It involves evaluation of data of development projects proposed or are likely.

(v) Identify the direct and indirect impacts of the proposed project that might contribute to a cumulative impact on the identified resources.

(vi) Identify agencies among which cooperation is needed to identify agency plans and other actions whose effects may overlap with those of the proposed action.

(vii) Relevant data of the identified environmental components (VEC) to determine its health (baseline condition) that needs to be gathered to be able to study the impact. The health of a resource refers very broadly to its overall condition, stability, or vitality. For a species, health could refer to sustainability.

(viii) Assess the potential cumulative impacts on VECs. Rather than identifying the life cycle of projects, it is important to identify the life cycle of effects or environmental consequences.

Determining the cumulative environmental consequences of an action requires:

(a) Reporting of the results of the cumulative impact analysis.

(b) Assessing the need for mitigation and/or recommendations for actions by other agencies to address a cumulative impact.

(d) Other Items that need to be Addressed

The cumulative impact analysis should also address:

(i) Other regional initiatives that are in place and could be built on.

(ii) The loss of locally important resource and its functions and values.

(iii) The potential for successful compensatory mitigation.

(iv) The time required for compensatory mitigation.

(v) The potential for increased habitat fragmentation.

(vi) The potential to reverse a trend for the resource or related ecosystem restoration.

(vii) The potential for cumulative impacts to the resource to affect other resources in the area, such as animal or plant species that depend on healthy wetland habitat.

(viii) Determine trends in VECs from base line to the present and the future.

(ix) Look at other regional initiatives that are in place and could be built on.

(x) Apply adaptive management.

(e) Methods or Analytical Tool

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There are eleven types of useful methods as below:

(i) **Questionnaires, Interviews, and Panels:** Useful for gathering the wide range of information on multiple actions and resources (VECs) needed to address cumulative effects. Brainstorming sessions, interviews with knowledgeable individuals, and group consensus building activities can help identify the important cumulative effects issues in the study area or region.

(ii) **Checklists:** Useful for identifying potential cumulative effects by providing a list of common or likely effects and juxtaposing multiple actions and VECs.

(iii) **Matrices:** Use a tabular format to organize and quantify the interactions between human activities and resources of concern. Matrices can also be used to combine the values in individual cells in the matrix to evaluate the cumulative effects of multiple actions on individual resources, ecosystems, and human communities (typically referred to as VECs).

(iv) **Networks and System Diagrams:** Useful for delineating the cause- and effect relationships resulting in cumulative effects. Can be used to analyse the multiple, subsidiary effects of various actions, and trace indirect effects to resources that accumulate from direct impacts on other resources (VECs).

(v) **Modelling:** A potentially powerful technique for quantifying the cause- and effect relationships leading to cumulative effects. Modelling can take the form of mathematical equations describing cumulative processes such as soil erosion, the use of VEC-specific software, or an expert system that computes the effect of various project scenarios based on a program of logical decisions.

(vi) **Trends Analysis:** This methodology can be used to assess the status of VECs over time and to develop graphical projections of past or future conditions. Changes in the occurrence or intensity of stressors (contributing effects from other actions) over the same time period can also be determined. Trends can help the analyst identify cumulative effects problems, establish appropriate environmental baselines, and project future cumulative effects.

(vii) **Overlay Mapping and GIS:** These methods incorporate locational information into cumulative effects analysis and help set the boundaries of the analysis, analyse landscape parameters, and identify areas where effects will be the greatest. Map overlays can be based on either the accumulation of stresses in certain areas or on the suitability of each land unit for development.

(viii) **Carrying Capacity Analysis (a special method):** Carrying capacity analysis identifies thresholds (as constraints on development) and

provides mechanisms to monitor the incremental use of unused capacity. Carrying capacity in the ecological context is defined as the threshold of stress below which populations and ecosystem functions can be sustained. In the social context, the carrying capacity of a region is measured by the level of services (including ecological services) desired by the populace.

(ix) **Ecosystem Analysis (a special method):** Ecosystem analysis explicitly addresses biodiversity and ecosystem sustainability. The ecosystem approach uses natural boundaries (such as watersheds and eco-regions) and applies ecological indicators (such as indices of biotic integrity and landscape pattern). Ecosystem analysis entails the broad regional perspective and holistic thinking that are required for successful cumulative effects assessment.

(x) **Economic Impact Analysis (a special method):** This method is an important component of analysing cumulative effects, because the economic well being of a local community and region depends on many different actions. The three primary steps in conducting an economic impact analysis are (1) establishing the region of influence, (2) modelling the economic impacts, and (3) determining the significance of the impacts. Economic models play an important role in these impact assessments and range from simple to sophisticated.

(xi) **Social Impact Analysis (a special method):** Social impact analysis addresses cumulative effects related to the sustainability of human communities by (1) focusing on key social variables such as population characteristics, community and institutional structures, political and social resources, individual and family changes, and community resources; and (2) projecting future effects using social analysis techniques such as linear trend projections, population multiplier methods, scenarios, expert judgment, and simulation modelling.

(f) Choosing a Method or Analytical Tool

There are a variety of methods or analytic tools available as mentioned above. A method, with appropriate input as needed, that makes sense considering the condition of and anticipated impacts to the resource, the type and amount of available information, and the type and size of the proposed project should be selected.

Lary W. Canter and Kamath studied a number of projects and found that in preparing Environtal Impact Statements, the Checklist Methodology was used. They concluded that the methodology selected should desirably have the following features:

(i) It should enable multiple developments or land used practices to be addressed.

(ii) It should be practical with understandable results that would aid decision making process.

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(iii) It should be adaptable to allow for the large array of possible site resource impact combination.

(iv) Method should allow flexibility of spatial and temporal boundaries.

(v) It should enable aggregation or tallying of incremental and interactive impacts to give an estimate of over all impact to which a resource is exposed.

(vi) Allow for different levels of resolution (more genereal, extensive analysis of the cumulative impacts of all relevant developments or projects or land use practices while still allowing intensive, site and project specific analysis Information related to EIA methodology was reviewed (Lahlou and Canter 1993, Cockin et al 1992).

(vii) Lary and Canter felt that the most appropriate methodological approach should be one that would be simple and yet comprehensive enough to provide a broad perspective on Cumulative effects Assessment. They chose the Questionnaire Check List for identifying and/or summarising the Cumulative Impact of projects. This has been used for two decades for EIA studies. It could be used in conjunction with delineating the study boundaries for addressing cumulative impact assessment depending on the study area, site visits. Information gathering may be necessary before applying the checklist.

(g) Taking Precautions to Avoid Common Deficiencies

Care needs to be taken to pay attention to the following aspects:

(i) Environmental components need emphasis but economic and social components need even more.

(ii) Proper scoping must be done upfront.

(iii) Adequate consultation must precede selection of VEC.

(iv) Governance issues need to be identified and addressed.

(v) Focus should be on Cumulative Effects Assessment rather than on management.

(vi) There should be clarity of the roles of the proponent and that of the government.

(vii) Multi-stake holder organisations should distinguish between their interests and responsibilities for CEA and should reconcile any conflict.

(viii) CEA at sectoral level must consider, in addition to the impact of all the projects in that sector, the impact of other development projects in the region with in the spatial and time boundaries set.

(ix) The study on CEA could be unending unless it was focussed on issues that are carefully selected. It should focus on resource sustainability in the expanded geographic and time boundaries . The USEPA document says, 'A cumulative effects analysis should 'count what counts', not produce superficial analyses or a long laundry list of issues that have little relevance to the effect of the proposed action or the eventual decisions.'

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(h) Drawing Conclusions from CEA Analysis

In previous steps, the data and information are collected and method(s) applied to analyse it. Based on that analysis, conclusions are drawn about the cumulative impacts to resources by applying professional judgment to the results, and by coordinating with technical experts as warranted.

First, the question 'Is there a cumulative effect?' needs to be answered. If the results of the analysis indicate that the proposed project, in combination with other actions, would affect the health of the resource or a trend associated with a resource, it is reasonable to conclude that the proposed project will contribute to a cumulative effect (either beneficial or adverse).

Next, the results of the analysis are used to characterize the severity or magnitude of the cumulative effect. The following question is then answered: 'What do decision-makers need to know about the status of this resource within the RSA?' The following information is documented for each resource:

(i) The health, status or condition of the resource as a result of past, present and reasonably foreseeable impacts.

(ii) The contribution of the proposed project to the overall cumulative impact to the resource, in support of a significance determination,

(iii) Avoidance and Minimization. Any project design changes that were made, or additional opportunities that could be taken, to avoid and minimize potential impacts in light of cumulative impact concerns

(iv) Any alternatives to the proposed project. Once the cumulative impact analysis is complete, do a 'reality check': compare the results of the cumulative impact analysis with the results of the direct and indirect impact analyses of the proposed project. This comparison can test the soundness of the conclusions about each resource.

(i) Adaptive Management

The following text is an abstract from the Presentation 'Adaptive Management and Integrated Decision Making - An Emerging Tool for Cumulative Effects Management' by Larry Canter and Sam Atkinson.

Adaptive Management (AM) is being used as a follow-up tool within environmental impact assessment and cumulative effects assessment.

Typical AM processes incorporate:

(i) Management objectives,

(ii) Conceptual and or quantitative models,

(iii) Management choices, monitoring,

(iv) Systematic decision making, and

(v) Stakeholder collaboration.

Such processes can be used to reduce cumulative effects uncertainties, and inform decision making relative to local and regional operational practices to minimize the incremental effects of proposed actions, as well as the management of regional cumulative effects resulting from multiple past, current, and future contributors.

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Based on an analysis of fundamental concepts, practices, and case studies the following key lessons and needs have been identified: (1) Due to numerous uncertainties associated with CEA, AM can be a useful tool for increasing the cumulative effects knowledge base, as well as determining the effectiveness of project mitigation and regional management measures. (2) Decision flowcharts and AM decision matrices can facilitate the learning and necessary decisions associated with AM programs. Such flowcharts and matrices should be both understandable to a range of audiences, and integrative in relation to developing a holistic perspective on management choices and their environmental implications.

However, AM may turn out to be expensive in cost time and Central deterrents to AM include both additional budgetary and time requirements. Accordingly, there is a need to carefully delineate the actual benefits and costs of AM requirements in a series of case studies.

CHECK YOUR PROGRESS

8. Define cumulative impact.
9. What do you understand by Adaptive Management (AM)?

4.6 DEMOGRAPHIC STRUCTURE

Population is the biggest asset of a country. The social, economic and political factors within and outside a region greatly affect the decrease or increase in population growth. Population patterns can be traced back to 10,000BC, before which humans were sparsely scattered across the earth. It has been estimated that from 8,000BC up to the beginning of the Christian era, the population of the world increased at the rate of 0.06 per cent per annum.

By 1300, the world population increased to 400 million and from 1300 to 1650, there was a very small addition to this, only 1 million people. In the next fifty years, however, 1 million more people were added to the global population. It grew by yet another million during the period 1700 to 1750. From 1750, however, population increased by 2 million in the first fifty years and by 3 and 4 million respectively during the next fifty years. Therefore, we find that prior to 1650; the population growth was very slow, while after 1650, it increased rapidly.

In the 20th century, global population increased rapidly except for the period between 1940 and 1950. During 1900–1950, the average annual growth rate was 0.8 per cent. In 1920, the United Nations prepared an estimated population report of major regions of the world. The estimates given by Walter F. Wilcox and A.M. Carr Saunders for 1650–1920 are considered to be the most authoritative region-wise estimates of world population. During 1950–1970, the rate of population rose to 1.9 per cent. During the next twenty years however, the growth of population was very fast, registering an average annual growth of 2.22 per cent.

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According to the US Census Bureau, recent years have seen some downturn in population growth. According to the Bureau's study funded by the Agency for International Development, since 1970, the world's population has gone up by 1.9 per cent annually.

Samuel Baum, the Bureau's Chief of International Demographic Statistics, said in the mid-1970s, 'We didn't expect a downturn in the rate of increase until the early 1980s but its happening a decade earlier and it's very significant. The difference of a tenth of a percentage point is not a tremendous decline. But it is important because the numbers are so high and it represents a change in direction, which is more important'. He added that, 'The encouraging thing is that the direction has shifted in all regions of the world except Africa and even there a number of countries—Tunisia, South Africa, Mauritius and Reunion—have had substantial decline'. Baum noted that more people are being added to the world and predicted that a growth rate of zero will not be reached, at earliest until the years 2020 to 2025.

Baum said two trends account for the reduced rate of growth: a rapid decline in fertility and not-so-rapid decline in mortality. According to him, 'People are being born at a slower rate and deaths are not going down as rapidly.' According to the census report of 1966, the population growth rate declined in less developed and developed nations. It cited Sri Lanka, where in 1966 population growth rate was 2.3 per cent and it declined to 1.5 per cent in 1976. Thailand, Philippines and the Republic of Korea each witnessed a decline of 0.7 per cent; Colombia 0.6 per cent, South Africa 0.4 per cent and Turkey and China 0.3 per cent.

China's population was estimated to be 982.5 million, 23 per cent of the world's figure in 1976 and 1977. In India, the growth rate of population was 2.2 per cent in the same years.

In 1977, Asia alone accounted for 58 per cent (2.5 billion) of the world's total population. Because of the sheer size of its base population, its population growth accounted for two-third of the world's increase. In 1976 and 1977, the United State had a growth rate of 0.8 per cent compared to 1.1 per cent in the year 1966 and 1967. The annual growth rate of Africa's population was 2.8 per cent between 1975 and 1977.

According to the US Census Bureau, the actual annual growth in the number of humans fell from its peak of 88.0 million in 1989, to a low of 73.9 million in 2003, after which it rose again to 75.2 million in 2006. Since then, annual growth has declined. In 2009, the human population increased by 74.6 million, and it is projected to fall steadily to about 41 million per annum in 2050, at which time the population will have increased to about 9.2 billion. Every region of the globe has seen great reduction in growth rate in recent decades, though growth rates remained above 2 per cent in some countries of the Middle East and sub-Saharan Africa South Asia, Southeast Asia and Latin America.

According to the United Nations, some countries experienced negative population growth, especially in Eastern Europe (mainly due to low fertility rates and emigration). In Southern Africa, growth is slowing down due to the high number of

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HIV-related deaths. Some Western Europe countries, might also encounter negative population growth. Japan's population began to decline in 2005.

There are two main reasons for growth in the world population. The first is the continued positive growth rate itself leading to an upward growth curve. The second reason is that the growth rate increases as a result of a decline in the mortality rate. The annual growth rate doubled in the three centuries between 1650 and 1950. Although, the growth rate of the world population started to decline after the mid-1960s from 2.0 per cent per annum in the period 1965–1970 to 1.7 per cent per annum in the period 1990–1995, it is still higher than at any time before 1950.

Thus, the people of the world are experiencing unprecedented demographic change. World population today stands at 6.7 billion, 3 billion more than 1960. Another 3 billion will likely be added by 2050. According to the United Nations, despite substantial past declines in childbearing rates, world population size is projected to grow to 7.9 billion in 2025 and to 9.3 billion in 2050. Nearly, all of this future growth will occur in the developing countries where four-fifth of the world population lives.

Table 4.1 *Estimates for 2000 and Projection in 2025 of Population by Region*

	Africa	Asia	Latin America	Developing world	Developed world	World
Population size (billion)						
2000	0.8	3.7	0.5	4.9	1.2	6.1
2025	1.4	4.8	0.7	6.7	1.2	7.9

Source: United Nations (1999, 2000, and 2001).

Population growth in India

India is the world's second most populated country after China. India possesses 2.4 per cent of the total land area of the world, but at the same time also supports about 17 per cent of the total world population. This is still increasing and it has been estimated that by 2040 the country is expected to be the most populous.

According to the theory of demographic transition, every country passes through three stages of demographic transition. In the first stage, both birth and death rates are high. Hence, the population remains more or less stable. Even if there is some increase in the population because the birth rate is somewhat higher than the death rate, it does not pose any serious problems. This happens mostly in backward economies where agriculture is the main mode of living and per capita incomes are low. This inevitably results in low standard of living. The mass population in these countries is deprived of basic necessities.

Rapid growth of population happens in the second stage of demographic transition. In this stage, despite extensive reduction in the rate of mortality, there is no equivalent decline in the rate of birth as a result of which there is a population explosion. This is found in countries where the economy is not adequate to its population size and a certain percentage of the population always remains below the poverty line. This kind of situation is mostly found in developing countries. For instance, India has been experiencing a rapid growth of population since the last six decades.

It has been found that every year, India adds more people to the world than any other country.

Table 4.2 *Growth Rate of India's Population*

population	year	population	year	population	year	population	year
271306,0	1900	277175,0	1930	431463,0	1960	833929,0	1990
270183,0	1901	279115,0	1931	438800,0	c1961	843931,0	1991c
269064,0	1902	284102,0	1932	452378,0	1962	883473,0	1992
267950,0	1903	287902,0	1933	462196,0	1963	900453,0	1993
266840,0	1904	291753,0	1934	472305,0	1964	918570,0	1994
265735,0	1905	295666,0	1935	482706,0	1965	934228,0	e1995
264635,0	1906	299614,0	1936	493389,0	1966	945121,0	1996
263539,0	1907	303626,0	1937	504345,0	1967	962378,0	1997
262447,0	1908	307694,0	1938	515601,0	1968	979673,0	1998
261361,0	1909	311820,0	1939	527177,0	1969	997515,0	1999
260278,0	1910	316004,0	1940	539075,0	1970	1014003,8	e2000m
259201,0	1911	318826,0	1941	547900,0	c1971	1027015,2	c2001
258127,0	1912	324180,0	1942	563530,0	1972		2002
257058,0	1913	328255,0	1943	575887,0	1973		2003
255994,0	1914	332332,0	1944	588299,0	1974		2004
254934,0	1915	336562,0	1945	600763,0	1975	1094985,0	2005e
253878,0	1916	340796,0	1946	613273,0	1976		2006
252827,0	1917	345085,0	1947	630200,0	1977m		2007
251780,0	1918	349430,0	1948	644330,0	1978m		2008
250737,0	1919	353832,0	1949	658730,0	1979m		2009
249699,0	1920	350445,0	1950	688956,0	1980	1170014,0	2010e
251441,0	1921	363211,0	1951	685200,0	c1981		2011
254963,0	1922	369231,0	1952	703570,0	1982m		2012
257637,0	1923	375633,0	1953	719090,0	1983m		2013
260339,0	1924	382438,0	1954	734870,0	1984m		2014
263071,0	1925	395096,0	1955	749184,0	1985	1237985,0	2015e
265831,0	1926	397334,0	1956	767200,0	1986m	1304263,0	2020ep
268621,0	1927	405450,0	1957	783730,0	1987m	1370028,0	2025ep
271442,0	1928	414021,0	1958	797526,0	1988	1432181,0	2030ep
274293,0	1929	423053,0	1959	817490,0	1989m	1706951,0	2050ep

From Table 4.2 one can visualize the trend of population growth in India. Population figures have been taken right from 1901 to see how India's population grew over the years. Except for a slight fall in the total population in the early years of the decade, India's population has been growing steadily over the years. The growth rate has been very high after 1951.

The density of population per square kilometre increased from seventy-seven in 1901 to 221 in 1981. The sex-ratio has been generally adverse to women. The number of women per thousand men has deteriorated and is still deteriorating. The percentage of urban population has also increased with time. It was 11 per cent in 1901 which rose to 24 per cent in 1981.

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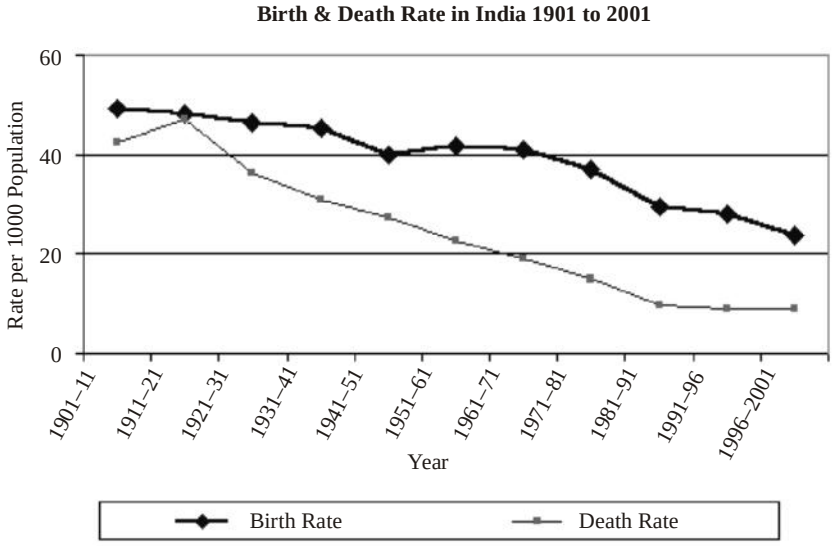

Source: Registrar General of India.

Fig. 4.1 *Birth and Death Rate in India between 1901 and 2001*

In terms of birth and death rate, there has been a rapid decline in the crude death rate in the past five decades. In 1951, the crude death rate was 25.1 per cent which decreased to 9.8 per cent in 1991. This trend of decline was also seen in crude birth rate. In 1951, it was 40.8 per cent which decreased to 29.5 per cent in 1991. During the 1990s, the annual population growth rate had fallen below 2 per cent. In terms of age and sex, India mostly has a young population which is mostly male.

The trend of population in India differs with respect to region. In Kerala, the mortality and fertility rates are similar to those of developed countries. On the other hand, in Uttar Pradesh, Bihar, Madhya Pradesh and Rajasthan, there is a high rate of infant mortality and high rate of fertility. As a result of this imbalance, the rate of population growth in these regions is also very high.

Today, it has been estimated that one sixth of the world's population lives in India. This trend is expected to increase further, as estimated that by 2025 India will be the most populated nation surpassing China.

4.6.1 Factors Influencing Population Growth in India

India's population has tripled since its independence in 1947. In the past, India's population grew slowly. It reached about 211 million by the first decennial census in 1871 and by 1921 the population reached 251 million. In each subsequent intercensal decade the scale of population addition rose, from 28 million during 1921–31 to 180 million during 1991–2001. This rapid increase in population has greatly affected the social and economic life of people in India. India's population has always been connoted with socio-economic travails such as poverty, employment, economic backwardness, low per capita income, environmental pollution, over-crowding and indebtedness, to name a few.

There are various factors that influence population growth in India. They are described as follows:

Fig. 4.2 *Factors of Population Growth in India*

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1. Decreased mortality rate

Decreased level of mortality is one of the major factors that influence the growth of population in India. According to 1995 estimates, the average Indian male born in the 1990s can expect to live 58.5 years and women can expect to live 59.6 years, which is slightly longer than the male. Till the first part of the 20th century, men enjoyed a slightly longer life expectancy compared to women. It was by 1990 that women had slightly surpassed men.

The death rate declined from 48.6 per 1,000 in the 1910-1920 period to 15 per 1,000 in the 1970s and improved thereafter, reaching 10 per 1,000 by 1990, a rate that held steady through the mid-1990s. The infant mortality rate in India was estimated to exceed seventy-six per 1,000 live births in 1995. 30 per cent of infants had low birth weight, and the death rate for children aged one to four years was around 10 per 1,000 of the population.

According to a 1989 National Nutrition Monitoring Bureau report, less than 15 per cent of the population was adequately nourished, although 96 per cent received an adequate number of calories per day. In 1986, the daily average intake was 2,238 calories as compared to 2,630 calories in China.

According to the findings by the United Nations, it has been seen that in India in 1989 the per day calorie intake fell to 2,229. According to some experts, it has been witnessed that the yearly nutritional standard statistics cannot be utilized to illustrate whether the ratio of poverty has actually fallen.

2. Conquest on diseases

The biggest factor that influences the growth of population in India is advances in medical science and eradication of diseases. This, in fact, is the biggest story of population growth in the last hundred years. The most helpful equipments for scientists

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in the conquest of disease are improved knowledge about vaccination, nutrition, improved public health practices and the advancement in medicines. Better knowledge of nutrition and good food habits make life healthier and longer. In many places of the world, people use traditional knowledge about better nutrition and food habits to stay healthy whereas in other places, due to the lack of such knowledge, people face high rates of infant and maternal mortality.

Another important factor in population growth is the provision of vaccination, which have reduced infections of smallpox, polio, influenza and rubella.

Improved public health practice is the third most significant factor that affects the growth of population. According to Louis Pasteur's Germ Theory of Disease, the health of a person is also important to a community. This thought led to the development of public health.

Today, in India, several health measures like treatment of wastes, purification of water, nutritional education as well as vaccination are considered to be of great importance. In addition, the nation also has expertise in modern medicine. With these advancements, the country's death toll has decreased and rate of birth has increased which together has led to population explosion in India.

3. Communicable and non-communicable disease

In India, a large number of endemic communicable diseases create a serious health problem among all age groups. To overcome this, the government has taken several efficient measures and has formulated a variety of national programmes over the years. All these efforts are mainly aimed at eradicating and controlling diseases, especially cholera, trachoma, diarrhoea, respiratory infections, sexually transmitted diseases and goiter.

In India, malaria is a persistent problem, although rate of infection has decreased. In the year 1975, India was declared free from smallpox.

In 1995, the National Filaria Control Programme was established to control and eliminate the filarial larvae in urban areas. In 1955, the National Leprosy Control Programme was established to control leprosy. The programme was slow when it was launched but received great priority after 1980. In 1982, it was redesigned and termed as the National Leprosy Eradication Programme.

The Indian Government has also taken steps to control several other forms of diseases such as tuberculosis, goiter, diarrheal disease, etc. This control has led to an increase in birth rate and decrease in death rate. The life expectancy of the average Indian has increased. As a result of this, the rate of population growth has tended to increase.

4. Migration

The population of a country also grows as a result of net migration, i.e., the number of people entering geographic areas and those leaving the geographic area. It has been found that in 2000; nearly 6,271,000 migrants were living in India, including 170,900 as refugees. This number is increasing fairly regularly. Most of them are from Sri Lanka, Bangladesh, Pakistan, Nepal and other neighbouring regions.

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5. Poverty

Poverty is another important factor that influences the growth of population in India. In 2005, the World Bank estimated that about 42 per cent of India's population falls below the international poverty line of US$ 1.25 a day.

Need and Measures of Population Control in India

According to the 2001 census, the total population of India was 1, 027,015,247, making India the second-most populated country in the world. It is expected that by 2025, India will become the most populated nation in the world, surpassing China. As a result, India faces an intense socio-economic and natural resource crisis. India is rich with resources, but has a number of poor people and the population growth is adversely affecting the growth and development of the country and its people. Therefore, it is essential to keep a check on population growth in India. The need for population control is necessary because that will enable the people of India to have a better standard of living and economic growth.

The Government of India has been making determined efforts through a series of planned programmes to control the population in India. The Planning Commission of India took a two-pronged approach.

- Department of Family Welfare under the Ministry of Health was created at the centre with counterparts in states for the task of educating Indian couples to adopt family welfare methods. Demographic and Action Research Centres were given financial assistance to carry on research on promotion of family planning practices.
- The working group on Vital and Health Statistics of the Planning Commission in its first meeting in March 1958 examined the question of obtaining reliable estimates of the natural rate of population growth since the rate, as obtained from the use of census data by actuaries, was considered to be less reliable. It recommended that the National Sample Survey obtain a reliable estimate of population increase rate in future years.

The programme of educating couples to practice family planning methods, as adopted by the Department of Health and Family Welfare in the 1960s and 1970s, did not reach the vast rural population who were mostly illiterate and were not exposed to the medical programme. In order to overcome this, the Government of India sought the advice of D.V. Glass of the London School of Economics and Political Science. He advised collection of live statistics through household sample surveys for identifying social variables which were significant for control of population growth.

In addition, the Indian Government also incorporated the goal of population control in the Five Year Plans. As part of this process, the government has formulated various agencies such as Family Planning Association of India and the New Population Plan.

- **Family Planning Association:** The main aim of the Family Planning Association is to encourage family planning and to take it as a basic human

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right. The Family Planning Association believes in the norm of a two-child concept. The association believes that families with two children will be able to maintain the balance between the population size and the resources that are available to the family.

The main role of the Family Planning Association is to make people become responsible regarding attitudes towards human sexuality and also provide other services and education in family planning methods to young people. The various family planning methods offered by the Family Planning Associations are conventional contraceptives such as condoms, diaphragms, jelly/cream tubes, foam tablets as well as tubectomy, IUD, oral pills and vasectomy. Besides this, the other family planning method available in the programme is induced abortion. This process is recognized by the government and is available free of charge in many institutions.

- **New Population Plan:** The main aim of the New Population Plan (NPP) is to improve and develop the reproductive health of the people of the country. To achieve this goal, the NPP allows general access to contraceptives and provides contraceptive education among locals. It also provides training programmes to people regarding safety aid at birth. In terms of certain legal aspects, the plan also stated that a formal registration of a birth of a child and marriage registration of a couple is very essential. It also maintains that the minimum age of marriage of a girl should be eighteen. Since, women play a significant role in the determination of family size, Attention needs to be diverted to the need to educate women. Participation in social and economic activities may help to promote small family size by meeting the necessary conditions of emotional and social fulfilment of women outside the family context. Adequate education for women in rural as well as urban areas can clarify choices to childbearing and facilitate women to understand the need for and use of contraception. Employment opportunities improve women's decision making power related to family through the acquirement of an alternative social and economic role, which may assist them to adopt birth control practices, space their children, and limit family size. Regarding abortion, the Medical Termination of Pregnancy (MTP) Act was passed by the Indian Government in 1971, under which pregnancy can be ended or aborted.

CHECK YOUR PROGRESS

10. What are the two main reasons for growth in the world population?
11. Name any two factors that influence population growth in India.
12. Why is population control a necessity in India?
13. What is the main aim of the Family Planning Association?

4.7 HUMAN, ENVIRONMENT AND SOCIAL ISSUES

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In this section, we will have a look at the important social issues that pertain to the human population. We will study environment and human health, human rights and HIV/AIDS and women and child welfare.

4.7.1 Environment and Human Health

Environmental health comprises those aspects of human health including quality of life that are determined by physical, biological, social and psychological factors in the environment. The relationship between the environment and its impact on human health is highly complex. Each of the effects is associated with a variety of aspects of economic and social development. Moreover, there is no single best way of organizing and viewing the development-environment-health relationship that reveals all important interactions and possible entry points for public health interventions. Human beings are exposed to a variety of chemicals including industrial chemicals, pesticides, air pollutants, natural and man-made toxicants etc. in the environment through the skin, respiratory system and gastrointestinal tract that can affect vital body systems such as pulmonary, reproductive and nervous and immune system. Dysfunction of these systems could have far-reaching consequences, which affect individuals and even their progeny from serious health ailments. To investigate possible effects of environmental pollutants on human health it is of prime importance that accurate exposure assessment techniques and validated biomarkers are available. It is, therefore, essential to have full-fledged and accurate Environmental Health Impact Assessment procedures in place, undertake application-oriented research such as occupational and environmental cohort studies to define single or mixture of pollutants and their impacts on health. This would help the implementing agencies to revise the environmental and industry specific actions. It is also very important to have collaborative approach among the industries and various technical/research centers together with the implementing agencies of the pollution control so as to deal with the Environment and Health issues properly.

4.7.2 Human Rights, Environment and HIV/AIDS

The Universal Declaration of Human Rights (UDHR) is a milestone document in the history of human rights. Drafted by representatives with different legal and cultural backgrounds from all regions of the world, the Declaration was proclaimed by the United Nations General Assembly in Paris on 10 December 1948 (General Assembly resolution 217 A) as a common standard of achievements for all peoples and all nations. It sets out, for the first time, fundamental human rights to be universally protected and it has been translated into over 500 languages.

Human Rights and Environment

More than 2 million annual deaths and billions of cases of diseases are attributed to pollution. All over the world, people experience the negative effects of environmental degradation ecosystems decline, including water shortage, fisheries depletion, natural

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disasters due to deforestation and unsafe management and disposal of toxic and dangerous wastes and products. Indigenous peoples suffer directly from the degradation of the ecosystems that they rely upon for their livelihoods. Climate change is exacerbating many of these negative effects of environmental degradation on human health and wellbeing and is also causing new ones, including an increase in extreme weather events and an increase in spread of malaria and other vector borne diseases. These facts clearly show the close linkages between the environment and the enjoyment of human rights, and justify an integrated approach to environment and human rights.

The Stockholm Declaration, and to a lesser extent the Rio Declaration, show how the link between human rights and dignity and the environment was very prominent in the early stages of United Nations efforts to address environmental problems. That focus has to some extent faded away in the ensuing efforts by the international community to tackle specific environmental problems, with more focus being placed on developing policy and legal instruments, both at the international and national levels, targeted at the environmental problems that were emerging, through a series of MEAs and other mechanisms. Although the foundation of developing such mechanisms laid on the considerations made at the time of the Stockholm Conference, the human rights dimension is not made explicit in most of these instruments.

The UN reform process also calls for the integration of human rights in all of the organization's work.

In a series of resolutions, the former United Nations Commission on Human Rights and the United Nations Human Rights Council have drawn attention to the relationship between a safe and healthy environment and the enjoyment of human rights. Most recently, the Human Rights Council in its resolution 7/23 of March 2008 and resolution 10/4 of March 2009 focused specifically on human rights and climate change, noting that climate change-related effects have a range of direct and indirect implications for the effective enjoyment of human rights. These resolutions have raised awareness of how fundamental the environment is as a prerequisite to the enjoyment of human rights.

Human Rights and HIV/AIDS

HIV/AIDS is one of a number of killer diseases, such as, malaria, tuberculosis, cancer and heart disease. What is different about HIV/AIDS is that it impacts not only the physical health of individuals, but also their social identity and condition. The stigma and discrimination surrounding HIV/AIDS can be as destructive as the disease itself. Lack of recognition of human rights not only causes unnecessary personal suffering and loss of dignity for people living with HIV or AIDS but it also contributes directly to the spread of the epidemic since it hinders the response… For example, when human rights are not respected, people are less likely to seek counselling, testing, treatment and support because it means facing discrimination, lack of confidentiality or other negative consequences. It also appears that the spread of HIV/AIDS is disproportionately high among groups that already suffer from a lack

of human rights protection, and from social and economic discrimination, or that are marginalised by their legal status.

4.7.3 Women and Child Welfare

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The overall condition of a nation can be found out by observing the status of women and children and the focus of the state on this section of our society. It is generally seen that the country on whose priority are women and children, are generally more developed than others. Women are the first link of education and development in a family, so an investment on women will indirectly transfer onto the betterment of the family.

Significance of Women and Child Care

(i) The whole domestic sphere in our Indian society is looked after by the women, who work hard for long hours without any pay.

(ii) Due to the hardship involved in the cooking and other household work, women subject themselves to long hours of work in dangerous environment of burning bio mass fuel.

(iii) Women are more influenced by environmental degradation than men.

(iv) Women, also require special provisions for sanitation and hygiene, which affects many other factors.

(v) Child labour is also rampant in our country. They are exposed to dangerous work environment and hazardous activities for money.

Objectives of Women and Child Welfare

(i) To focus on the improvement of overall status of women and children including the social, economic, health and nutritional status.

(ii) To provide for the physical, emotional and mental care of children.

(iii) To ensure that the women and children are provided constitutional protection and appropriate rights.

(iv) To aim for generating awareness about various government initiatives among the rural populace

Important Developmental Programmes for Women and Child Welfare

The government has initiated various programmes for the welfare of women and children in the society. These include training cum employment programmes in a variety of sector to increase employability attractiveness, financial and technical support through women development corporations, and government programmes, creating awareness of self-help groups, gender sensitization, advocacy; providing benefits through various government acts like Maternity Benefit Act, Dowry Prevention Act etc.; legal and constitutional protection through National Commission for Women and holistic development through head planning government wings like the Department for Women and Child Development.

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CHECK YOUR PROGRESS

14. What is environmental health?
15. When and where was the Universal Declaration of Human Rights proclaimed?
16. Give two examples of government acts providing benefits to women.

4.8 SUMMARY

- Sustainable development is such a concept that signifies that the rate of consumption or the use of natural resources should be approximate to the rate at which these resources can be substituted or replaced.
- Within the concept of sustainable development, industrial ecology plays a significant role in order to create a balance between industrial development and preservation of natural resources.
- Environmental ethics refers to the issues, principles and guidelines relating to human interactions with their environment.
- Environmental ethics can provide us the guidelines for putting our beliefs into action and help us in deciding what to do when faced with crucial situations.
- Public awareness about environment is at the stage of infancy.
- The impacts of development projects occur in different forms. While significant benefits result for the society, the project area people may often bear the brunt of adverse impacts.
- Social Impact Assessment alerts the planners as to the likely benefits and costs of a proposed project, which may be social and/or economic.
- SIAs can assist advocacy groups as well. A Social Impact Assessment report, done painstakingly, shows the real consequences of the project on affected people and suggests alternative approaches, and gives credibility to their campaigns.
- Social Impact Assessments have been carried out for a variety of projects, including projects in such diverse sectors as water, sanitation and health, coal sector, urban transport systems, pastoral development programmes, and livelihood support projects (Cernea and Kudat 1997; Roche 1999).
- In India, SIA has been generally carried out as a part of the Environment Impact Assessment clearance process.
- Social Impacts are the changes that occur in communities or to individuals as a result of an externally-induced change.
- There is no generally agreed definition of Social Impact Assessment (SIA). It may be defined as a process that seeks to assess, in advance, the social

repercussions that are likely to follow from projects undertaken to promote development, such as dams, mines, industries, highways, ports, airports, urban development and power projects.

- Cumulative impact is defined by the US Council on Environmental Quality as 'the impacts on the environment that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions (RFPA) regardless of what agency undertakes such other actions.'
- Population is the biggest asset of a country. The social, economic and political factors within and outside a region greatly affect the decrease or increase in population growth.
- China's population was estimated to be 982.5 million, 23 per cent of the world's figure in 1976 and 1977. In India, the growth rate of population was 2.2 per cent in the same years.
- According to the US Census Bureau, the actual annual growth in the number of humans fell from its peak of 88.0 million in 1989, to a low of 73.9 million in 2003, after which it rose again to 75.2 million in 2006.
- In 2009 the human population increased by 74.6 million, and it is projected to fall steadily to about 41 million per annum in 2050, at which time the population will have increased to about 9.2 billion.
- There are two main reasons for growth in the world population. The first is the continued positive growth rate itself leading to an upward growth curve. The second reason is that the growth rate increases as a result of a decline in the mortality rate.
- India is the world's second most populated country after China. India possesses 2.4 per cent of the total land area of the world, but at the same time also supports about 17 per cent of the total world population.
- India's population has always been connoted with socio-economic travails such as poverty, employment, economic backwardness, low per capita income, environmental pollution, over-crowding and indebtedness, to name a few.
- Decreased level of mortality is one of the major factors that influence the growth of population in India.
- The biggest factor that influences the growth of population in India is advances in medical science and eradication of diseases.
- In India, a large number of endemic communicable diseases create a serious health problem among all age groups. To overcome this, the government has taken several efficient measures and has formulated a variety of national programmes over the years.
- Poverty is another important factor that influences the growth of population in India.

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- The main role of the Family Planning Association is to make people become responsible regarding attitudes towards human sexuality and also provide other services and education in family planning methods to young people.
- The main aim of the New Population Plan (NPP) is to improve and develop the reproductive health of the people of the country. To achieve this goal, the NPP allows general access to contraceptives and provides contraceptive education among locals.
- Environmental health comprises those aspects of human health including quality of life that are determined by physical, biological, social and psychological factors in the environment. The relationship between the environment and its impact on human health is highly complex. Each of the effects is associated with a variety of aspects of economic and social development.
- To investigate possible effects of environmental pollutants on human health it is of prime importance that accurate exposure assessment techniques and validated biomarkers are available. It is, therefore, essential to have full-fledged and accurate Environmental Health Impact Assessment procedures in place, undertake application-oriented research such as occupational and environmental cohort studies to define single or mixture of pollutants and their impacts on health.
- The Universal Declaration of Human Rights (UDHR) was proclaimed by the United Nations General Assembly in Paris on 10 December 1948 (General Assembly resolution 217 A) as a common standard of achievements for all peoples and all nations. It sets out, for the first time, fundamental human rights to be universally protected and it has been translated into over 500 languages.
- Climate change is exacerbating many of these negative effects of environmental degradation on human health and wellbeing and is also causing new ones, including an increase in extreme weather events and an increase in spread of malaria and other vector borne diseases. These facts clearly show the close linkages between the environment and the enjoyment of human rights, and justify an integrated approach to environment and human rights.
- HIV/AIDS is one of a number of killer diseases, such as, malaria, tuberculosis, cancer and heart disease. What is different about HIV/AIDS is that it impacts not only the physical health of individuals, but also their social identity and condition. The stigma and discrimination surrounding HIV/AIDS can be as destructive as the disease itself. Lack of recognition of human rights not only causes unnecessary personal suffering and loss of dignity for people living with HIV or AIDS but it also contributes directly to the spread of the epidemic since it hinders the response
- The overall condition of a nation can be found out by observing the status of women and children and the focus of the state on this section of our society. It is generally seen that the country on whose priority are women and children, are generally more developed than others.

- **Objectives of Women and Child Welfare:** (i) To focus on the improvement of overall status of women and children including the social, economic, health and nutritional status., (ii) To provide for the physical, emotional and mental care of children, (iii) To ensure that the women and children are provided constitutional protection and appropriate rights, and (iv) To aim for generating awareness about various government initiatives among the rural populace.

4.9 KEY TERMS

- **Sustainable Development**: Sustainable development is the economic development that is conducted without depletion of natural resources.
- **Mortality Rate**: It is the number of deaths in a given area or period, or from a particular cause.
- **Human Migration**: Human migration is the movement by people from one place to another with the intentions of settling temporarily or permanently in the new location.

4.10 ANSWERS TO 'CHECK YOUR PROGRESS'

1. Sustainable development is such a concept that signifies that the rate of consumption or the use of natural resources should be approximate to the rate at which these resources can be substituted or replaced.
2. The two major causes of unsustainability are as follows:
   - Overpopulation in poor countries
   - Overconsumption of resources by rich countries
3. Environmental ethics refers to the issues, principles and guidelines relating to human interactions with their environment.
4. The two important ethical guidelines are as follows:
   - One should love and honour the earth, since it nurtures life.
   - One should keep each day sacred on earth and celebrate the turning of its seasons.
5. Environmental awareness can be spread through mass-media using articles, rallies, campaigns, street plays EV serials etc.
6. The most useful outcome of a SIA is to develop mitigation plans to overcome the potential negative impacts on individuals and communities.
7. Social impacts are the changes that occur in communities or to individuals as a result of an externally-induced change.
8. Cumulative impact is defined by the US Council on Environmental Quality as 'the impacts on the environment that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions (RFPA) regardless of what agency undertakes such other actions.'

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9. Adaptive Management (AM) is being used as a follow-up tool within environmental impact and cumulative effects assessment.
10. There are two main reasons for growth in the world population. The first is the continued positive growth rate itself leading to an upward growth curve. The second reason is that the growth rate increases as a result of a decline in the mortality rate.
11. The two factors that influence population growth in India are decreased mortality and migration.
12. The need for population control is necessary in India because that will enable the people of India to have a better standard of living and economic growth.
13. The main aim of the Family Planning Association is to encourage family planning and to take it as a basic human right.
14. Environmental health comprises those aspects of human health including quality of life that are determined by physical, biological, social and psychological factors in the environment.
15. The Universal Declaration of Human Rights (UDHR) was proclaimed by the United Nations General Assembly in Paris on 10 December 1948 (General Assembly resolution 217 A).
16. Two examples of government acts providing benefits to women are Maternity Benefit Act and Dowry Prevention Act.

4.11 QUESTIONS AND EXERCISES

Short-Answer Questions

1. What do you understand by sustainable development? What are the major measures to attain sustainability?
2. List the various types of impacts.
3. What is Initial Social Impact Assessment (ISIA)?
4. Why is it important to carry out Cumulative effects Assessment?
5. What are the various factors that influence population growth in India?
6. Write a short note on Family Planning Association and New Population Plan.

Long-Answer Questions

1. Discuss the two world-views in relation to environmental protection.
2. Explain what you understand by Social Impact Assessment (SIA).
3. Mention the various advantages of doing Social Impact Assessment.
4. Explain the three stages of demographic transition.
5. Describe the process of analysing cumulative effects.

4.12 FURTHER READINGS

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