Environmental Studies

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INDEX

ENVIRONMENTAL STUDIES

Module 1. Multidisciplinary nature of environmental studies

Lesson 1
DEFINITION, SCOPE, AND IMPORTANCE OF ENVIRONMENTAL STUDIES

'There is a sufficiency in the world for man's need but not for man's greed' ~Mohandas K. Gandhi

1.1 Introduction

Environment consists of surroundings which includes abiotic and biotic environment. Environment refers to sum of all i.e. water, air and land, along with their inter-relationships among themselves and also other living organisms. Environment can be studied by interpreting the knowledge from all the disciplines. Global environment constitutes important segment i.e. atmosphere, hydrosphere and lithosphere. Nitrogen, oxygen and argon are major gases which account for 99% of air. Hydrosphere consist of sea, ocean, rivers, glaciers, lakes, reservoirs, polar ice caps, and shallow water ground bodies and about 70% of earth's surface covered with water . In the modern era, human beings have exploited natural resources making the use of latest techniques in fields of information technology, genetic engineering, and others technologies for enhancing productivity and income which may lead to brighten our future. Over exploitation of natural resources may lead to starvation for resources and can create an environment which is not suitable for living organisms. So there is a need to keep the balance to sustain production level and maintain environment. Polluted air, water, and soil have negative impact on health and economic opportunities for the humans. Polluted environment gives birth to harmful biological and chemical agents which have direct or indirect threats to human health. To face these threats, there is a growing realization at national and international that proper utilization of environmental endowments of life support systems such as air, water and soil is a must for sustainable development. Environmental problems created by large population of human beings may due to individual or collective actions influence the environment greatly, so there is need to identify environment problems and to find solution .Individuals should be involved in the process of improving the environment.

Academic disciplines are created to help us understand the universe better. While nature can be understood using the disciplines, but not be '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 study about the environment. Environment cannot be studied from the point of view of any one particular discipline, but understanding of the interlinks between the complex ways in which one phenomenon; how one action is connected to another, how the same thing can be understood from different perspectives, perspectives often rooted in different disciplines.

There is need to create an consensus at national level to give emphasis to environment science involving the application of scientific and technical information to understand, manage and

conserve the environment and its resources.

1.2 Definitions

Some of the frequently used terms in study of environment are defined as follows:

1.2.1 Environment

- The word environment is derived from the French word 'environner', which means surrounding. Thus, Environment can be defined as the combined interaction of physical, chemical and biological conditions affecting an individual or community in the complex of social and cultural conditions.

1.2.2 Environmental science

- Environmental science is a systematic study of our environment under different micro climatic conditions and it is multi disciplinary in nature.
- Environmental science can also be defined as the application of scientific principles to understand environmental issues by studying the impact of interaction between different parameters of environment. Many times, environmental science is related to other sciences like ecology, environmental education and engineering.
- A relatively new field, environmental science has evolved from integrated use of many disciplines which include important topics of modern civilization and applied aspects of environmental science need the basic knowledge of physics, chemistry, biology, mathematics, engineering, anthropology, sociology, economics, management, ecology, etc.
- Environmental science integrates natural sciences, social sciences with environmental ethics, environmental impact and planning.
- Environmental science has emerged as a multi-disciplinary field of study to access the impact of interaction of living beings and micro environments in which they live.

1.3 Environmental Science As a Multi Disciplinary Field

Environmental Science is interconnected to many branches of sciences. Some of these are:

1.3.1 Environmental science and biology

- Biology mainly deals with life and environment factors have affect on living organisms. Interaction between living things and different components of environment will affect the efficiency and combined effect can be known as environmental biochemistry.
- Biological processes in nature profoundly influenced by chemical species existing and these processes will determine the nature of species, their degradation, and synthesis, both in the aquatic and soil environments. Study of such phenomena are the basis of biochemistry of environment

1.3.2 Environmental science v/s chemistry

- Chemistry deals with chemical processes occurring in nature. When these processes are studied in the shape of reaction which affects the existence of different species, with special reference to air, soil and water environment, this relationship is termed as environmental chemistry.

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

1.3.3 Relationship between environment and economics

- Economic environment refers to all factors or forces, which contribute to economic impact on the man, his activities and his region.
- Resources such as agriculture, dairying, fisheries poultry, horticulture, floriculture and machinery help to improve economic condition. Economic conditions, internal and external factors such as export and import balances create favourable economic environment for fast development of the country.

1.3.4 Social system and environment

- Social environment of the society indicate the mental makeup of man's activities and helps the individual to decide his occupation and use of resources for his development. Infrastructure such as roads, buildings, settlements, communication setup plantation of horticulture and cropped fields are major component which helps to create social environment.
- Using the combination of tools of modern technology indigenous technical knowledge (ITK) can help to fasten the change of physical environment into cultural environment.

1.3.5 Impact of population on environment

- Work force is a major factor to fasten the role of individual in socio-economic environment of a country. Population density can have significant effect on natural environment. It can be observed that high population density have negative effects on environment.
- The world population, which is growing at alarming rate (annually 1.7 %) has damaged the environment significantly. The growing trend which is likely to continue for another three to four decades, which may further damage physical, social and economic environment at both global and national level. On the other hand, negative growth rate of population in developed countries is likely to hamper the development. Many policy makers are considering the availability of young work force in India asset for development in this changed scenario.

1.3.6 Political climate and environment

Main political institutions such as Legislature, executive and judiciary which constitutes the political setup of any country can help to provide visionary leadership. Political decisions by policy makers can have a direct effect on development and control of various human activities, which includes formulation of laws related to increase the productivity, income and town planning. The executives are pillars of policy implementation decided by legislature. A stable and dynamic political setup is pre requisite for development of the nation. Stable government can guide the nation by taking firm decisions. In a democratic setup, the executive should function in public interest and within the boundaries of the constitution.

1.4 Importance

Earth's living components establish equilibrium with their environment. Environmental science helps to understand the scientific basis to establish different standards which help to keep the equilibrium in the ecosystem.

Majority of environmental scientists are of the view that if environmental pollution i.e. air, water and soil continued at the present rate the change will be irreversible and may cause damage to ecological cycles and balances in the ecosystem which is may harm the life of living organisms on the earth.

To maintain the ecological balance in the ecosystems, drastic changes have to be inculcated in the human behaviour .There is well known fact that universe does not have infinite resources to support the future generation. Earth's limited resources must be conserved and reused where ever possible. Policy makers at global level must devise new strategies to protect natural ecosystem, keeping balance with economic growth. 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.

An environmental study is the subject in which we examine important issues relating to environment as they affect our lives. It is an exploratory description of issues. Each issue can be probed more deeply.

Many a time development and economic growth cannot go hand on hand. Development activities are inversely related to environment because development leads to industrialisation for employment which leads to depletion of natural resources and affect the standard of living of the citizens. Developing nations are compromised with environment for fast growth in different sectors to produce goods for domestic use and export which in turn pollute the environment at the expense of development.

It is hard fact that consumption levels of the consumer life-style of humans is directly related to environmental problems. Therefore, living habits attitude and ethical standards are the areas of concern to keep the ecological balance intact.

The government and their agencies, the non-governmental organizations, the judiciary and now the corporate sector also express a great concern on matters relating natural environment and ecosystem. Many environmental problems such as depletion of ozone layer, global warming, destruction and extinction of species, decreasing water table, contamination and depletion of ground water and problem of increasing population can be solved by educating the future generations about the impact of development activities on environment.

1.5 Objectives of Environment Education

The objectives of Environmental Education are classified as follows:

- Knowledge: to help social groups and individuals, gain a variety of experiences and acquire a basic understanding of the environment and its associated problems.
- Awareness: to help social groups and individuals acquire an awareness of and sensitivity to the total environment and its allied problems.
- Attitudes: to help social groups and individuals to acquire a set of values and promote a feeling of concern for the environment and provide motivation for actively participating in environmental improvement and protection.
- Participation: to provide social groups and individuals with an opportunity to be actively involved at all levels, working towards the resolution of environmental problems.
- Skills : to help social groups and individual to acquires the skills for identifying and solving environmental problems

- Evaluation Ability: to evaluate environmental measures and education programs in terms of ecological, economic, social and aesthetic factors.

The overall goal of environmental education can be expressed in another form as three principal objectives (UNESCO, 1977a).

1. To foster clear awareness and concern about economic, social, political and ecological interdependence in urban and rural areas.
2. To create new patterns of behaviors of individuals, groups and society as a whole towards the environment.
3. To provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment

1.6 Scope

The wide spread use of chemicals in agriculture and industry has introduced new dimensions to sustain eco balance in the system. This possesses potential threat to human health through the spread of pollutants through water and soil, as well as through food chain. The need for use of environment science is drawing the intention of policy makers for pollution control to sustain the life and nature. Study of environmental science helps us to understand the various components of environment and disturbing factors and helps to find solution to overcome the negative effect of these factors. The industrial waste which contains highly toxic elements like lead, mercury and arsenic is discriminately discharged into the rivers. The water used for drinking, irrigation and other purposes from these contaminated sources is a serious threat to the human health. Study of environment science has helped in manufacturing pollution control equipment, sewage and effluent treatment plants, and biomedical waste treatment. The essence of environmental science is multidisciplinary in nature and helps to identify environmental issues which are directly or indirectly concerned with environment. College and university students, corporate houses can prove leaders to protect the environment and conservation of natural resources by understanding the multidisciplinary nature of environment studies. Policy makers from various government organisations can play an important role to protect and conserve environment by understanding the nature of environmental issues facing the country. Natural resources of any country are either renewable or non renewable. Most countries are exploiting their resources at fast rate. Increased population is creating stress on these resources. India, being in the phase of development is exploiting its resources at a fast rate. Increasing industrialisation, deforestation, soil erosion, increased mode of transformation and adoption of high intensity agriculture has contributed to degradation of environment .Our ecosystem which is constituted of air, soil and water cannot survive for long, unless efforts are made to protect the environment from pollutants. Without suitable habitat, living organisms cannot survive. With increased level of living standards, rate of consumption and disposal of waste has created problems due to enhanced activities for product manufacturing, marketing, and management, etc. Changed environment doesn't affect only the poor but also affects the rich people. Environmental studies has lot of scope in the areas like control of environment pollution, conservation and management of natural resources, balance disturbance in ecology and biodiversity ,control and education of human population and systematic development with keeping eye on environment pollution .Environmental science is problem oriented and seeks knowledge about the natural environment and its impact on living organisms. So there is a need of best idea and information to deals success fully with environmental problems

1.7 Need for Awareness

Life on earth emerged approximately 2.6 billion years ago and since then planet is being affected by number of species of organisms which flourished and died. Men acquired the capacity to change the environment faster than any other organisms on this planet. For his comfort he has exploited soil for agriculture industry, for manufacturing goods , transport and communication, which has lead to disturbing the ecological balance due to degradation of life supporting system including air ,water and land. It is the need of the hour that humans are educated about the effect of degraded environment on human health. Degraded environment is going to affect both developed and developing countries alike. Following steps can be initiated to educate the masses about the pathetic state of environment and to improve the environment for future generations.

1. Environmental science knowledge should be used to educate the masses about the problems being faced by present generation as well as the problems to be faced by future generation. Government of India, particularly ministry of agriculture in cooperation with ministry of environment and forest can launch campaigns, so that people can be educated about the importance of environment healthy plantation. State governments should activate the machinery to generate awareness about the impact of forest in maintaining ecological balance. At global level world environment day celebrated on 5th June every year which can be undertaken as plantation day.
2. Multimedia can play leading role for dissemination of information by using different tools like advertisements, group discussion, feature films, video conferencing, and website and internet services.
3. Printing media can initiate the campaigns regarding impact of degraded environment on living organisms by publishing articles through newspapers, magazines, newsletters.
4. Awareness campaign can be launched through displaying several holdings, posters at prominent places and organising exhibitions, face to face interaction, online e-mail service, SMS service throughout the country.
5. Individual actions can inspire large number of people. Therefore individual efforts can significantly influence the environment. Individuals can involve themselves in different activities for improving environment.
6. Social and political movement, environmentalism (code of conduct for achieving better environmental management) can have significant effect to save the ecosystem for future generations.

Lot of people talk about degradation of environment and preach for clean environment, but only selective people have clear vision about this scope and need of safe guarding the interest to keep balance between development and degradation of environment. There is a need to use the experience of experts to implement the developmental projects. Many times environment awareness campaign have been exploited for political propaganda rather than educational programmes to educate the people about actual impacts of the project, for example 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.

Awareness regarding the state of environment is must for every human being living on this planet. Already world is surrounded 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 those from the developed ones.

Looking at the present pathetic state of environment and the knowledge people have about it,

it has become evident for every country to educate their masses, so that they could start understanding the problems that they are facing at present and would have to face in future. In fact, almost all nations of world have geared up in creating awareness in their people.

The 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 to be telecasted on the video media. Newspapers and other magazines are publishing out lot of articles on this subject.

Government with its separate ministry - Ministry of Environment and Forest has also launched many campaigns like displaying several hoardings, posters etc. throughout the country. The state ministries are also playing important roles in generating awareness in masses.

Plantation of several trees on various occasions, especially on World Environment Day which falls on 5th June is undertaken on large scale.

The complex link between human activities and the loss of biodiversity is rapidly coming to light. Loss of habitats and poaching of wildlife is more obvious now a day. But more complex and unsuspected links are being thrown up as scientists go deeper into the subject. For example, the recent study suggest that rapid decline of species of vultures in South Asia could be result of a veterinary drug given to cattle which is eventually passed on to vultures when they feed one of the carcasses of these animals. This particular observation and many much more complex observations are based on deep study that is being done in field of Environment Sciences.

Similarly, while atmospheric science and chemistry may seem distantly related subjects, it was the study of CFCs (chloro fluoro carbon) and their impact on ozone that finally led to an understanding of the ozone 'hole' and the Montreal Protocol (a commitment by governments to phase out the use of CFCs), which has been one of the success stories of a global response to a global problem.

Fig. 1.1 Montreal protocol meeting

ENVIRONMENTAL STUDIES

Module 2. Natural resources

Lesson 2
FOREST RESOURCES

'A nation that destroys its soils destroys itself. Forests are the lungs of our land, purifying the air and giving fresh strength to our people'- **Franklin D. Roosevelt**

2.1 Introduction to Natural Resources

Any material which can be transformed in a way that it becomes more valuable and useful can be termed as resource. In other words, it is possible to obtain valuable items from any resources. Resource, therefore, are the means to attain given ends. The aspect of satisfaction is so important that we consider a thing or substance a resource, as so long it meets our needs. Life on this planet depends upon a large number of things and services provided by the nature, which are known as Natural Resources. Thus water, air, soil, minerals, coal, forests, crops and wild life are all examples of natural resources.

2.1.1 Classification of natural resources

Depending upon availability of natural resources can be divided into two categories such as (1) renewable and (2) Non renewable resources.

1.Renewable resources

Renewable resources are in a way inexhaustible resources. They have the ability to replenish themselves by means such as recycling, reproduction and replacement.Examples of renewable resources are sunlight, animals and plants,soil,water,etc.

2. Non-Renewable Resources

Non renewable resources are the resources that cannot be replenished once used or perished. Examples of non renewable resources are minerals, fossil fuels, etc.

Resources can also be classified as biotic or abiotic.

a)Biotic resources

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

b)Abiotic resources

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

2.1.2 Problems associated with natural resources

1. The unequal consumption of natural resources

A major part of natural resources today are consumed in the technologically advanced or 'developed' world, usually termed 'the west'. The 'developing nations' of 'the east', including India and China, also over use many resources because of their greater human population. However, the consumption of resources per capita (per individual) of the developed countries is up to 50 times greater than in most developing countries. Advanced countries produce over 75% of global industrial waste and greenhouse gases.

2. Planning land use

Land is a major resource, needed for not only for food production and animal husbandry, but also for industry and growing human settlements. These forms of intensive land use are frequently extended at the cost of 'wild lands', our remaining forests, grasslands, wetlands and deserts. This demands for a pragmatic policy that analyses the land allocation for different uses.

3. The need for sustainable lifestyles

Human standard of living and the health of the ecosystem are indicators of sustainable use of resources in any country or region. Ironically, both are not in concurrence with each other. Increasing the level of one, usually leads to degradation of other. Development policies should be formulated to strike a balance between the two.

2.2 Forest Resources

Forest is important renewable resources. Forest vary in composition and diversity and can contribute substantially to the economic development of any country .Plants along with trees cover large areas, produce variety of products and provide food for living organisms, and also important to save the environment.

It is estimated that about 30% of world area is covered by forest whereas 26% by pastures. Among all continents, Africa has largest forested area (33%) followed by Latin America (25%), whereas in North America forest cover is only 11%. Asia and former USSR has 14% area under forest. European countries have only 3% area under forest cover. India's Forest Cover accounts for 20.6% of the total geographical area of the country as of 2005.

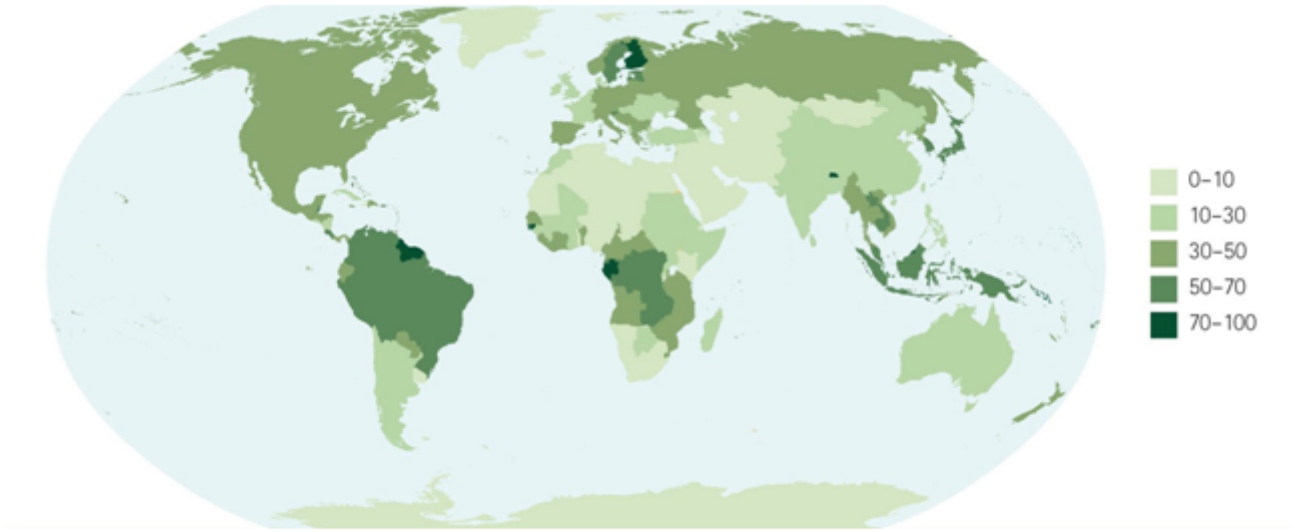

Fig 2.1 Forest area in percent of land area by country (courtesy : FAO, 2012)

2.2.1 Significance of forests

Forest can provide prosperity of human being and to the nations. Important uses of forest can be classified as under

- Commercial values
- Ecological significance
- Aesthetic values
- Life and economy of tribal

Fig. 2.2 Uses of the forest

2.2.1.1 Commercial values

- Forests are main source of many commercial products such as wood, timber, pulpwood etc. About 1.5 billion people depend upon fuel wood as an energy source. Timber obtained from the forest can used to make plywood, board, doors and windows, furniture, and agriculture implements and sports goods. Timber is also a raw material for preparation of paper, rayon and film.
- Forest can provide food , fibre, edible oils and drugs.
- Forest lands are also used for agriculture and grazing.

- Forest is important source of development of dams, recreation and mining.

2.2.1.2 Life and economy of tribal

Forest provide food, medicine and other products needed for tribal people and play a vital role in the life and economy of tribes living in the forest.

2.2.1.3 Ecological uses

Forests are habitat to all wild animals, plants and support millions of species. They help in reducing global warming caused by green house gases and produces oxygen upon photosynthesis.
Forest can act as pollution purifier by absorbing toxic gases. Forest not only helps in soil conservation but also helps to regulate the hydrological cycle.

2.2.1.4 Aesthetic values

All over the world people appreciate the beauty and tranquillity of the forest because forests have a greatest aesthetic value. Forest provides opportunity for recreation and ecosystem research.

2.2.2 Over exploitation of forests

Forests contribute substantially to the national economy. With increasing population increased demand of fuel wood, expansion of area under urban development and industries has lead to over exploitation of forest .At present international level we are losing forest at the rate of 1.7 crore hectares annually. Overexploitation also occurs due to overgrazing and conversion of forest to pastures for domestic use.

2.2.3 Deforestation

1. Forest are burned or cut for clearing of land for agriculture ,harvesting for wood and timber , development and expansion of cities .These economic gains are short term where as long term effects of deforestation are irreversible
2. Deforestation rate is relatively low in temperate countries than in tropics If present rate of deforestation continues we may losses 90% tropical forest in coming six decades
3. For ecological balance 33% area should be under forest cover but our nation has only 20.6% forest cover.

2.2.3.1 Causes of deforestation

Forest area in some developed area has expanded. However in developing countries area under forest is showing declining trend particularly in tropical region. Main causes of deforestation are

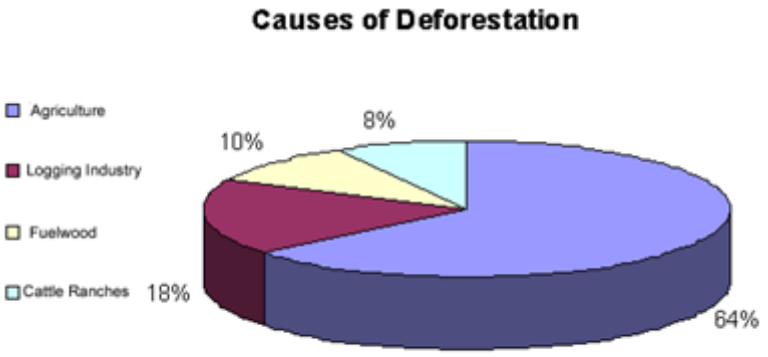

Fig. 2.3 Causes of deforestation

a) Shifting cultivation or jhum cultivation

This practise is prevalent in tribal areas where forest lands are cleared to grow subsistence crops. It is estimated that principle cause of deforestation in tropics in Africa, Asia and tropical America is estimated to be 70, 50, and 35% respectively. Shifting cultivation which is a practice of slash and burn agriculture are posses to clear more than 5 lakh hectares of land annually. In India, shifting cultivation is prevalent in northeast and to limited extent in M.P, Bihar and Andhra Pradesh and is contributing significantly to deforestation.

b) Commercial logging

It is a important deforestation agent. It may not be the primary cause but definitely it acts as secondary cause, because new logging lots permits shifting cultivation and fuel wood gatherers access to new logged areas.

c) Need for fuel wood

Increased population has lead to increasing demand for fuel wood which is also acting as an important deforestation agent, particularly in dry forest.

d) Expansion for agribusiness

With the addition of cash crops such as oil palm, rubber, fruits and ornamental plants, there is stress to expand the area for agribusiness products which results in deforestation.

e) Development projects and growing need for food

The growing demand for electricity, irrigation, construction, mining, etc. has lead to destruction of forest. Increased population needs more food which has compelled for increasing area under agriculture crops compelling for deforestation.

f) Raw materials for industrial use

Forest provides raw material for industry and it has exerted tremendous pressure on forest. Increasing demand for plywood for backing has exerted pressure on cutting of other species such as fir to be used as backing material for apple in J&K and tea in northeast states.

2.2.3.2 Major effects of deforestation

Deforestation adversely and directly affects and damages the environment and living beings .Major causes of deforestation are

- Soil erosion and loss of soil fertility
- Decrease of rain fall due to affect of hydrological cycle

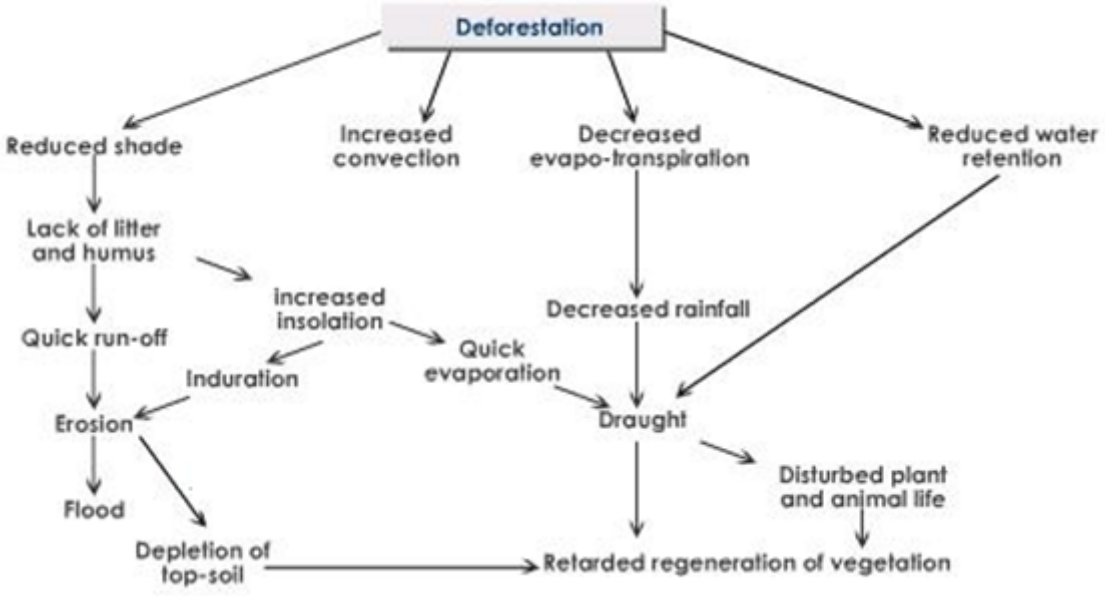

Fig 2.4 Effects of deforestation (courtesy :tutorvista)

- Expansion of deserts
- Climate change and depletion of water table
- Loss of biodiversity ,flora and fauna
- Environmental changes and disturbance in forest ecosystems

2.2.4 Case studies

1.Jhum cultivation

Jhum Agriculture or shifting agriculture has destroyed large number of hectare of forest tracts in North-Eastern states and Orissa. Jhum agriculture is subsidence agriculture in which tract of forest land is cleared by cutting trees and it is used for cultivation. After few years, when productivity of the land decreases, cultivators abandon the land and clear next tract. As a result of this practise, combined with increasing population there is rapid deforestation as more and more cultivators clear forest to cultivate land. Also, with increase in population there is cultivators are forced to return to previous tracts of land in relatively shorter durations, not allowing the land to regain its productivity.

2.Chipko movement

The Chipko movement or Chipko Andolan is a social-ecological movement that practised the Gandhian methods of satyagraha and non-violent resistance, through the act of hugging trees to protect them from being felled. The modern Chipko movement started in the early 1970s in the Garhwal Himalayas of Uttarakhand,with growing awareness towards rapid deforestation. The landmark event in this struggle took place on March 26, 1974, when a group of peasant

women in Reni village, Hemwalghati, in Chamoli district, Uttarakhand, India, acted to prevent the cutting of trees and reclaim their traditional forest rights that were threatened by the contractor system of the state Forest Department. Their actions inspired hundreds of such actions at the grassroots level throughout the region. By the 1980s the movement had spread throughout India and led to formulation of people-sensitive forest policies, which put a stop to the open felling of trees in regions as far reaching as Vindhyas and the Western Ghats.

3.Western himalayan region.

Over the last decade, there has been widespread destruction and degradation of forest resources in Himalayas, especially western Himalayas. This has resulted in various problems such as erosion of top soil, irregular rainfall, changing weather patterns and floods. Construction of roads on hilly slopes, have not only undermined their stability, but also damaged protective vegetation and forest cover. Tribes in these areas are increasingly facing shortage of firewood and timber, due large scale tree cutting. Increased traffic volumes on these roads leads to increased pollution in the area.

2.2.5 Timber extraction

There has been unlimited exploitation of timber for commercial use. Due to increased industrial demand; timber extraction has significant effect on forest and tribal people.

2.2.5.1 Logging

- Poor logging results in degraded forest and may lead to soil erosion especially on slopes.
- New logging roads permit shifting cultivators and fuel wood gatherers to gain access to the logging area.
- Loss of long term forest productivity
- Species of plants and animals may be eliminated
- Exploitation of tribal people by contractor.

2.2.6 Mining

Major effects of mining operations on forest and tribal people are:

- Mining from shallow deposits is done by surface mining while that from deep deposits is done by sub-surface mining. It leads to degradation of lands and loss of top soil. It is estimated that about eighty thousands hectare land is under stress of mining activities in India
- Mining leads to drying up perennial sources of water sources like spring and streams in mountainous area.
- Mining and other associated activities remove vegetation along with underlying soil mantle, which results in destruction of topography and landscape in the area. Large scale deforestation has been reported in Mussorie and Dehradun valley due to indiscriminating mining.
- The forested area has declined at an average rate of 33% 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 50000 ha of forest land. Coal mining in Jharia, Raniganj and Singrauli areas has caused extensive deforestation in Jharkhand.

- Mining of magnetite and soapstone have destroyed 14 ha of forest in hilly slopes of Khirakot, Kosi valley and 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, chromites, bauxite and magnetite.

2.2.7 Effects of dams on forests and tribal people

Pandit Jawaharlal Nehru referred dam and valley projects as "Temples of modern India". These big dams and rivers valley projects have multi-purpose uses. However, these dams are also responsible for the destruction of forests. They are responsible for degradation of catchment areas, loss of flora and fauna, increase of water borne diseases, disturbance in forest ecosystems, rehabilitation and resettlement of tribal peoples.

- 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 Uttaranchal 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, which is mainly because of several ecological problems including deforestation and socio-economic problems related to tribal or native people associated with them.
- The Silent valley hydroelectric 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. Sunder Lal Bahaguna, the leader of Chipko Movement.
- The cause of Sardar Sarovar Dam related issues have been taken up by the environmental activitist Medha Patkar, joined by Arundhati Ray 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 be having marvellous economic or medicinal value and deforestation results in loss of this storehouse of species which have evolved over millions of years in a single stroke.

2.2.8 Forest conservation and management

Forest is one of the most valuable resources and thus needs to be conserved. To conserve forest, following steps should be taken.

1. Conservation of forest is a national problem, thus it should be tackled with perfect coordination between concerned government departments.
2. People should be made aware of importance of forest and involved in forest conservation activities.
3. The cutting of trees in the forests for timber should be stopped.
4. A forestation programmes should be launched
5. Grasslands should be regenerated.
6. Forest conservation Act should be strictly implemented to check deforestation.
7. Awards should be instituted for the deserving.

References

http://www.earthwatch.org/rcc_india
http://www.youtube.com/watch?v=CHE1oUFO_-U&feature=related

Module 2. Natural resources

Lesson 3
WATER RESOURCES

'Water is the driver of Nature' - **Leonardo daVinci**

3.1 Introduction

Water is an indispensable resource for life on earth. Approximately 70.8 % surface of earth is covered with water in the form of oceans. Out of this, about 97% is not fit for human consumption, about 2% is locked as a glacier and only less than 1% available as fresh water that can be used for human consumption and other uses.

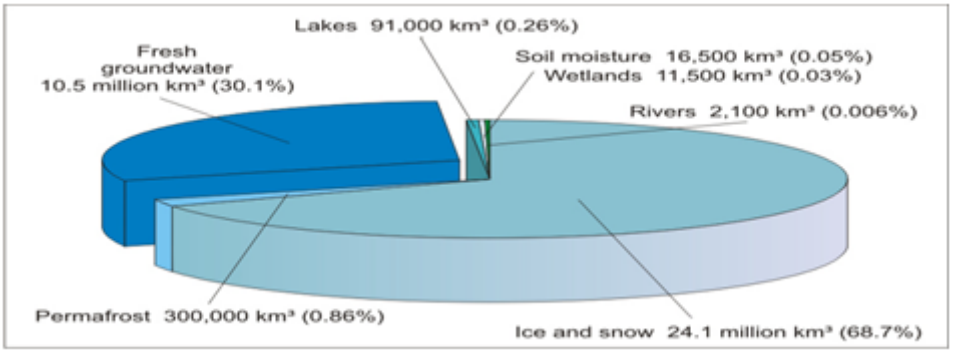

Fig. 3.1 Water resources in world

Water is a very important source and essential for life because it has very unique characteristic such as

1. Water exists as liquid over a wide range of temperature 0-100^{0}C with highest specific heat and latent heat of vaporizations.
2. Water is excellent solvent and act as carrier of nutrient and helps to distribute them to the cells in the body, regulates the body temperature and support structure and can dissolve various pollutant and can act as carrier of large number of microorganisms
3. It is responsible for hydrological cycle which acts as resource of water to the earth. It is estimated that about 1.4 inch thick layer of water evaporates and majority of water returns to earth through hydrological cycle.

3.2 Water Use

More than 99% of earth water is unavailable for use; only 1% water is available for people, animal, plants and earth. There is an uneven distribution of water resources, tropical rainforest are receive maximum rainfall where as desert receive only little rainfall.

Due to its unique properties water is of multiple uses for all living organisms. Water is absolutely essential for all the living organisms. One can survive for weeks without food but cannot survive more than a few days without water. Since the earliest days of mankind water availability was the major factor to decide the place of human settlements. Water dissolves nutrients and distributes them in different parts of plants and regulates the temperature and removes the waste.

3.2.1 Fresh water crisis

On global scale water availability is not a problem itself, but it's availability in right form, right time and right place is a problem. Irregularities in duration and intensity of rainfall cause floods and droughts. Out of the total water reserves of the world, about 97% is salty water (marine) and only 3% is fresh water.

Due to increased demands overuse of groundwater for drinking, irrigation and domestic purposes has lead to rapid depletion of groundwater in various regions leading to lowering of water table.

Pollution of many of the groundwater aquifers has made them unfit for consumption. Rivers and streams have long been used for discharging the wastes. due to industrialization river water are being polluted because industrial residues are pushed into the river .Civilizations have grown and flourished on the banks of rivers, but being over populated due to fast growth are polluting the natural resources of water.

3.2.2 Problems associated with water resources

These are some problems associated with use of water

- **Water Scarcity** (precipitation/evapotranspiration balance, temporal availability, per capita availability)
- **Floods and droughts** (spatio-temporal distribution; regular floods related to heavy winter or spring rains, increasing damage level due to shifting land use (settlements in flood zones) recurrent summer droughts coinciding with peak demand periods for agriculture and tourism)
- **Groundwater availability and quality** (aquifer size and access, yield, saltwater intrusion, pollution of shallow aquifers)
- **Watershed degradation** (deforestation, land use, increasing impervious (sealed) areas due to urbanization the main concern here is land use change (primarily deforestation and urbanization) and its effects on runoff patterns (flooding) and water quality including erosion/sediments with subsequent problems such as reservoir siltation/capacity loss)
- **Coastal interaction** (salinity intrusion in groundwater and estuaries, coastal pollution due to pollution runoff)

3.3 Over-Exploitation of Water

3.3.1 Groundwater

About 9.86% of the total fresh water resources are in the form of groundwater and it is about 35-50 times that of surface water supplies.

Effects of extensive and reckless groundwater usage:

1. Subsidence
2. Lowering of water table
3. Water logging

3.3.2 Surface water

Surface water mainly comes directly from rain or snow covers. The various surface sources are natural lakes and ponds, rivers and streams, artificial reservoirs. Availability of surface water decides the economy of the country. On one side surface water availability affects the productivity, but on the other side water sources may cause floods and drought. Due to unequal distribution, water may lead to national (interstate) or international disputes. Sharing of surface water due to these disputes is affecting productivity of different agro eco-zone and creating problems for government.

Recently many water conflicts at national and international levels relating to sharing of surface water are catching the headlines of newspaper.

3.3 Major Water Conflicts

Some of the major water conflicts that have become thorn in relations between states and countries are

3.3.1 Water conflict in the middle east

Countries involved are Sudan, Egypt and Turkey. It also affects countries which are water starved viz. Saudi Arabia, Kuwait, Syria, Israel and Jordan.

Fig. 3.2 Water conflict in the middle-east (courtesy :furmen.edu)

3.3.2 The Indus water treaty

This Indus water treaty dispute between India and Pakistan is lingering since long.

Fig. 3.3 The Indus water treaty (Courtesy-Indian Express)

3.3.3 The Cauvery water dispute

It involves two major states of India viz. Tamilnadu and Karnataka.

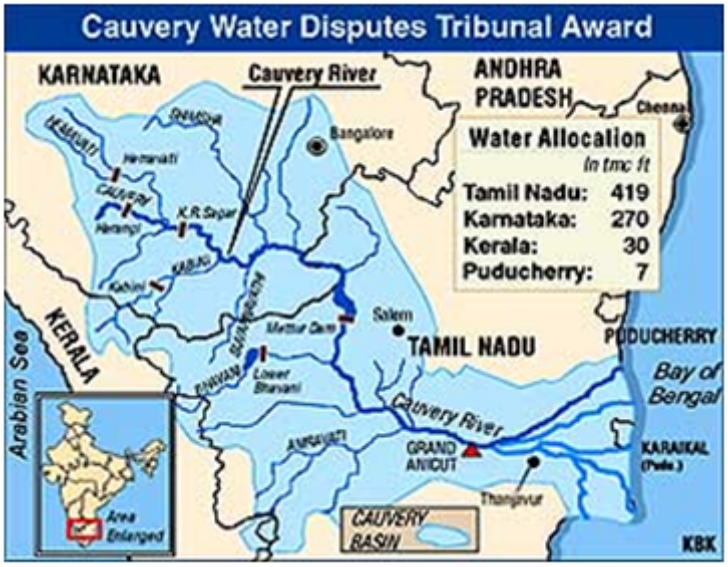

Fig 3.4 The Cauvery water dispute (Courtesy-KBK)

3.3.4 The Satluj-Yamuna link canal dispute

The dispute is between two Northern states viz. Punjab and Haryana and UP, Rajasthan as well as Delhi has also interest in it .

Fig. 3.5 the Satluj-Yamuna link canal Dispute (Courtesy-DEEP)

In traditional water management, innovative arrangements ensure equitable distribution of water, which are democratically implemented. These disputes can be solved amicably through 'Gram Panchayats", if transparency is maintained. But disputes between countries or states sometimes attain war like situation and are difficult to solve.

3.4 Dams - Benefits and Problems

Water is a precious resource and its scarcity is increasing at global level. There is a pressure to utilise surface water resources efficiently for different purposes. According to

World Commission on Dam Report -2001 there are 45000 large dams spread over 140 countries

3.4.1 Major benefits of dams

The major benefits of dams are

1. Hydroelectricity generation
2. Year round water supply to ensure higher productivity
3. Equal water distribution by transferring water from area of excess to area of deficit
4. Helps flood control and protects soil
5. Assure irrigation during dry periods
6. River valley projects provide inland water navigation ,employment opportunities and can be used to develop fish hatcheries and nurseries
7. River valley projects have tremendous potential for economic upliftment and will help to raise the standard of living and can help to improve the quality of life

3.4.2 Disadvantages/problems

Although dams have proved very useful over the centuries but recent past big dams has created lot of human as well as environmental issues

1. Submergence of large areas may lead to loss of fertile soil and displacement of tribal people
2. Salt left behind due to evaporation increase the salinity of river water and makes it unusable when reaches down stream
3. Siltation and sedimentation of reservoirs not only makes dams use less but also is responsible for loss of valuable nutrients
4. Loss of non-forest land leads to loss of flora and fauna
5. Changes in fisheries and the spawning grounds
6. Stagnation and water logging near reservoir leads to breeding of vectors and spread of vector-borne diseases
7. Growth of aquatic weeds may lead to microclimatic changes.

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Module 2. Natural resources

Lesson 4
MINERAL RESOURCES

'God sleeps in the minerals, awakens in plants, walks in animals, and thinks in man' **-Arthur Young**

4.1 Introduction

Minerals are essential for the formation and functioning of organisms, plant animals and human beings. In the modern era, human life needs variety of minerals to sustain industry based civilization. Mineral resources are broadly defined as elements, chemical compounds, and mixtures which are extracted to manufacture sustainable commodity. India has rich mineral resource base to provide suitable base for industrial development in the country. Sufficient reserve of nuclear energy minerals is available in India.
India's reserves, as well as production are adequate in petroleum, ores of copper, lead, zinc, tin, graphite, mercury, tungsten, and in the minerals required for fertilizer industry such as sulphur, potassium and phosphorus.

4.1 Exploitation of Minerals

Depending on their use, mineral resources can be divided into several broad categories such as elements for metal production and technology, building materials, minerals for the chemical industry and minerals for agriculture. When usually we think about mineral resources we often think of metals but the predominant mineral resources are not metallic. The picture of annual world consumption of some elements is as under:

- Sodium and iron are used at a rate of about 0.1 to 1.0 billion metric tons per year.
- Nitrogen, sulphur, potassium and calcium are primarily used as fertilizers at a rate of about 10 to 100 million metric tons per year.
- Zinc, copper, aluminium and lead are used at a rate of about 3 to 10 million metric tons per year;
- Gold and silver are used at a rate of about 10 thousand metric tons per year.
- Out of all the metallic minerals, iron consumption is 95% of the metals consumed

Thus, with the exception of iron, the non-metallic minerals are consumed at much greater rates than the elements used for their metallic properties.

4.3 Uses of Minerals

Due to increased population, there is increased demand of minerals by the industry, transport, agriculture and defence preparation. Depletion of almost all known and easily accessible deposits is anticipated in near future. Moreover, there may be shortage of some crucial elements such as mercury, tin, copper, gold, silver and platinum. The limited resource of phosphorus, which is an essential component of chemical fertilizers, is another area of concern.

Fig. 4.1 Mineral and metal source of India (courtesy: Indian mirror)

Table 4.1 Uses of minerals

S.No	Mineral	Uses
	A. Metallic	
1	Aluminium	Building materials, electrical wiring, utensils, aircraft, rockets
2	Beryllium	Refractories, copper alloys
3	Chromium	Refractory, metallurgy, chemicals
4	Cobalt	Alloys, radiography, catalysts, therapeutics
5	Columbium	Stainless steel, nuclear reactors
6	Copper	Alloys, electrical products
7	Gold	Monetary purposes, jewellery, dentistry
8	Iron	Steel, building materials, numerous industrial uses
9	Lead	Batteries, paints, alloys, public health fittings, gasoline
10	Magnesium	Structural refractories
11	Manganese	Alloy steels, disinfectants
12	Uranium	Nuclear bombs, electricity generation, tinting glass
	B. Non-Metallic	
1	Asbestos	Roofing, insulation, ceramics, textiles, gasoline, solid propellants.
2	Corundum	Abrasives
3	Feldspar	Ceramic flux, artificial teeth
4	Fluorspar	Flux, refrigerants, propellants, acid
5	Nitrates	Fertilizers, chemicals
6	Phosphates	Fertilizers, chemicals
7	Sulphur	Fertilizers, acid, iron and steel industry

4.4 Environmental Impacts of Mineral Extraction

Extracting and use of mineral resources can affect the environment adversely. Environmental affect may depend on factors such as mining procedures, ore quality, climate, size of operation, topography, etc. Some of major environmental impacts of mining and processing operations are as under

1. Degradation of land.
2. Pollution of surfaces and ground water resources.
3. Effect on growth of vegetation due to leaching out effect of minerals.
4. Surface water pollution and groundwater contamination lead to occupational health hazards etc.
5. Air pollution due to emission of gases.
6. Deforestation affects flora and fauna.
7. Rehabilitation of affected population.

4.5 Conservation of Minerals

Conservation of minerals can be done in number of ways and these are as follows,

- Industries can reduce waste by using more efficient mining and processing methods.
- In some cases, industries can substitute plentiful materials for scarce ones.
- Some mineral products can be recycled. Aluminum cans are commonly recycled. Although bauxite is plentiful, it can be expensive to refine. Recycling aluminum products does not require the large amounts of electric power needed to refine bauxite.
- Products made from many other minerals, such as nickel, chromium, lead, copper, and zinc, can also be recycled.
- Strict laws should be made and enforced to ensure efficient management of mining resources.

4.6 Case Study

Aravilli mountains which covers about 10% of geographical area is rich source of minerals wealth .This mountain range play important role in control of climate and act as mini water shed. On the request of environmentalist, Honourable Supreme Court has passed the order to stop these mines in Rajasthan

Marble mining near Rajsamant Lake has lead to drying up of lake. Marble mining was stopped on December 2002.

Recently, mining in Goa has attained the attention of the press and media and ultimately government has to take the decision to stop this mining.

Module 2. Natural resources

Lesson 5
FOOD RESOURCES

'A house is not a home unless it contains food and fire for the mind as well as the body'--
Benjamin Franklin

5.1 Introduction

Food is essential for growth and development of living organisms. These essential materials are called nutrients and these nutrients are available from variety of animals and plants. There are thousands of edible plants and animals over the world, out of which only about three dozen types constitute major food of humans.

5.1.1 Food sources

The majority of people obtain food from cultivated plants and domesticated animals. Although some food is obtained from oceans and fresh waters, but the great majority of food for human population is obtained from traditional land-based agriculture of crops and livestock.

Table 5.1 Indian food production in 2010-11

Food items	Production (Million tonnes)
Rice	94.5
Wheat	83
Maize	30
Pulses	17.2
Oilseeds	30.2
Milk	117

5.1.2 Food crops

It is estimated that out of about 2,50,000 species of plants, only about 3,000 have been tried as agricultural crops. Under different agro-climatic condition, 300 are grown for food and only 100 are used on a large scale.

Some species of crops provide food, whereas others provide commercial products like oils, fibres, etc. Raw crops are sometimes converted into valuable edible products by using different techniques for value addition .At global level, only 20 species of crops are used for food. These, in approximate order of importance are wheat, rice, corn, potatoes; barley, sweet potatoes, cassavas, soybeans, oats, sorghum, millet, sugarcane, sugar beets, rye, peanuts, field beans, chick-peas, pigeon- peas, bananas and coconuts. Many of them are used directly, whereas other can be used by changing them by using different techniques for enhancing calorific value.

5.1.3 Livestock

Domesticated animals are an important food source. The major domesticated animals used as food source by human beings are 'ruminants' (e.g. cattle, sheep, goats, camel, reindeer, llama, etc.).
Ruminants convert indigestible woody tissue of plants (cellulose) which are earth's most abundant organic compound into digestible food products for human consumption. Milk, which is provided by milking animals, is considered to be the complete food. Other domestic animals like sheep, goat, poultry and ducker can be used as meat.

5.1.4 Aquaculture

Fish and seafood contributes 17 million metric tonnes of high quality protein to provide balance diet to the world. Presently aquaculture provides only small amounts for world food but its significance is increasing day by day.

5.2 World Food Problems

As per estimates of Food and Agriculture Organization (FAO), about 840 million people remain chronically hungry and out of this 800 million are living in the developing world. In last decade, it is decreasing at the rate of 2.5 million per year, but at the same time world's population is increasing. Target of cutting half the number of world's chronically hungry and undernourished people by 2015 will difficult to meet, if the present trend continues. Due to inadequate purchasing power to buy food, it is difficult to fulfil

minimum calorific requirement of human body per day .Large number of people are in India are poor which can be attribute to equitable distribution of income .

Food insufficiency can be divided into two categories into under-nourishment and malnourishment. Both of these insufficiencies are global problems.

5.2.1 Under-nourishment

The FAO estimates that the average minimum daily caloric intake over the whole world is about 2,500 calories per day. People who receive less than 90% of their minimum dietary intake on a long-term basis are considered undernourished. Those who receive less than 80% of their minimum daily caloric intake requirements are considered 'seriously' undernourished. Children in this category are likely to suffer from stunted growth, mental retardation, and other social and developmental disorders. Therefore, Under-nourishment means lack of sufficient calories in available food, resulting in little or no ability to move or work.

5.2.2 Malnourishment

Person may have excess food but still diet suffers from due to nutritional imbalance or inability to absorb or may have problem to utilize essential nutrients. If we compare diet of the developed countries with developing countries people in developed countries have processed food which may be deficient in fibre, vitamins and other components where as in the diet of developing countries, may be lack of specific nutrients because they consume less meat ,fruits and vegetables due to poor purchasing power .

Malnourishment can be defined as lack of specific components of food such as proteins, vitamins, or essential chemical elements.

The major problems of malnutrition are:

- **Marasmus**: a progressive emaciation caused by lack of protein and calories.
- **Kwashiarkor**: a lack of sufficient protein in the diet which leads to a failure of neural development and therefore learning disabilities.
- **Anemia:** it is caused by lack of iron in the diet or due to an inability to absorb iron from food.
- **Pellagra**: it occurs due to the deficiency of tryptophan and lysine, vitamins in the diet.

Every year, food problem kill as many people as were killed by the atomic bomb dropped on Hiroshima during World War II. This shows that there is 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, it is estimated that about 300 million Indians are still undernourished. India has only half as much land as USA, but it has nearly three times population to feed. Our food problems are directly related to population.

5.2.3 Balanced diet

Supply of adequate amount of different nutrient can help to improve malnutrition and its ill effects. Cereals like wheat and rice can supply only carbohydrate which are rich in energy supply, are only fraction of nutrition requirement. Cereal diet has to be supplemented with other food that can supply fat, protein and minor quantity of minerals and vitamins. Balanced diet will help to improve growth and health.

5.3 Changes Caused by Agriculture and Overgrazing

From centuries, agriculture is providing inputs to large number of industries involved in production, processing and distribution of food. Accordingly, agriculture has significant effect on environment. The effects of agriculture on environment can be classified as local, regional, and global level. The agriculture also makes impact on the usage of land generally as follows:

1. Deforestation
2. Soil Erosion
3. Depletion of nutrients
4. Impact related to high yielding varieties (HYV)
5. Fertilizers related problems include micronutrient imbalance, nitrite pollution and eutrophication.
6. Pesticide related problems include creating resistance in pests and producing new pests, death of non-target organisms, biological magnification.
7. Some other problems include water logging, salinity problems and such others.

The carrying capacity of land for cattle depends upon micro climate and soil fertility. If carrying capacity is exceeded than land is overgrazed. Because of overgrazing the agricultural land gets affected as follows,

- Reduction in growth and diversity of plant species
- Reduce plant cover leads to increased soil erosion

- Cattle trampling leads to land degradation

5.4 Effects of Modern Agriculture

For sustainable production modern techniques are used to enhance productivity of different cropping systems under different agro-eco-zones. Adoption of modern agricultural practises has both positive and negative effects on environment. Effects of modern agriculture are briefly discussed under different heads as under:

5.4.1 Soil erosion

Raindrops bombarding bare soil result in the oldest and still most serious problem of agriculture. The long history of soil erosion and its impact on civilization is one of devastation. Eroded fields record our failure as land stewards.

5.4.2 Irrigation

Adequate rainfall is never guaranteed for the dry land farmer in arid and semiarid regions, and thus irrigation is essential for reliable production. Irrigation ensures sufficient water when needed and also allows farmers to expand their acreage of suitable cropland. In fact, we rely heavily on crops from irrigated lands, with fully one-third of the world's harvest coming from that 17% of cropland that is under irrigation. Unfortunately, current irrigation practices severely damage the cropland and the aquatic systems from which the water is withdrawn.

5.4.3 Agriculture and the loss of genetic diversity

As modern agriculture converts an ever-increasing portion of the earth's land surface to monoculture, the genetic and ecological diversity of the planet erodes. Both the conversion of diverse natural ecosystems to new agricultural lands and the narrowing of the genetic diversity of crops contribute to this erosion.

5.4.4 Fertilizer-pesticide problems

For photosynthesis apart from water, sunshine and CO_2, plants need micro and macro nutrients for growth. These nutrients are supplied in the shape of fertilizers. There is lot of potential to increase food productivity by increasing fertilizer use. On one hand application of artificial chemical fertilizers increases the productivity at faster rate as

compare to organic fertilizers, on the other hand application of fertilizers can be a serious problem of pollution and can create number of problems. Excessive level of nitrates in ground water has created problems in developed countries. These are:

a. Accumulated phosphorous as a consequence of use of phosphoric fertilizer are posing serious threat as residues in domestic water supply and for ecology of river and other water bodies. Increased level of phosphates in different water results in eutropication.
b. Effect of chemical fertilizer is long term, therefore leads to net loss of soil organic matter.

To control insects, pests, diseases and weeds which are responsible for reduction in productivity different chemicals are used as insecticides, pesticides and herbicides. Successful control of insects, pests and weeds increases productivity and reduces losses and provide security for harvest and storage. Applications of these synthetic chemicals have great economic values and at the same time cause number of serious problems such as:

a. Affects human health which includes acute poisoning and illness caused by higher doses and accidental exposes
b. As long term effect, cause cancer, birth defects, Parkinson's disease and other regenerative diseases.
c. Long term application of pesticides can affect soil fertility.
d. Danger of killing beneficial predators.
e. Pesticides resistance and pest resurgence

5.5 Water Logging

High water table or surface flooding can cause water logging problems .Water logging may lead to poor crop productivity due to anaerobic condition created in the soil. In India, deltas of Ganga, Andaman and Nicobar Islands and some areas of Kerala are prone to frequent water logging.

5.6 Salinity

Due to adoption of intensive agriculture practices and increased concentration of soluble salts leads to salinity. Due to poor drainage, dissolved salts accumulate on soil surface and affects soil fertility. Excess concentration of these salts may form a crust on the surface which may injurious to the plants. The water absorption process is affected and uptake of

nutrient is disturbed. According to an estimate, in India, 7 million hectare of land is saline and area is showing in increasing trends due to adoption of intensive agriculture practises.

5.7 Case Studies

1. A study on birth defects in water birds, in Kesterson wildlife refuge in California, indicated that these defects where due to high concentration of selenium.
2. Recent reports from cotton growing belt of Punjab which covers Abohar, Fazalka and part of Bathinda indicates that over use of pesticides for control of insect pest in cotton to enhance productivity has not only affected soil health, but also caused cancer in human being.
3. Diclofenac is the drug for veterinary use to treat the livestocks which have strong residual nature, which leads to high persistence throughout the foodchain .Due to biomagnification it becomes more dangerous to the vultures as they are consumers of diclofenac treated cattle. Diclofenac is responsible for bringing three South Asian species of *Gyps* vultures to the brink of extinction. It has been banned in India since 2006.

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ENVIRONMENTAL STUDIES

Module 2. Natural resources

Lesson 6
ENERGY RESOURCES

6.1 Growing Energy Needs

Energy consumption of a nation is usually considered as an index of its development, because almost all the development activities are directly or indirectly dependent upon energy. Power generation and energy consumption are crucial to economic development as economy of any nation depends upon availability of energy resources. There are wide disparities in per capita energy use of developed and the developing nations. With increased speed of development in the developing nations energy needs are also increasing.

- The very original form of energy technology probably was the fire, which produced heat and the early man used it for cooking and heating purposes.
- Wind and hydropower has also been used. Invention of steam engineers replaced the burning of wood by coal and coal was further replaced by oil.
- The oil producing has started twisting arms of the developed as well as developing countries by dictating the prices of oil and other petroleum products.
- 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.
- It is inevitable truth that now there is an urgent need of thinking in terms of alternative sources of energy, which are also termed as non-conventional energy sources which include:

  1. Solar energy needs equipments such as solar heat collectors, solar cells, solar cooker, solar water heater, solar furnace and solar power plants .
  2. Wind energy
  3. Hydropower, Tidal energy, ocean thermal energy, geothermal energy, biomass, biogas, biofuels etc.

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

6.2 Energy Scenario

Energy is a key input in the economic growth and there is a close link between the availability of energy and the future growth of a nation. Power generation and energy consumption are crucial to economic development.

In India, energy is consumed in a variety of forms such as fuel wood; animal waste and agricultural residues are the traditional sources of energy. These non-commercial fuels are gradually getting replaced by commercial fuels i.e. coal, petroleum products, natural gas and electricity.

Out of total energy, commercial fuels account for 60% where as the balance 40% is coming from non-commercial fuels. Of the total commercial energy produced in the form of power or electricity,

- 69% is from coal (thermal power),
- 25% is from hydel power,
- 4% is from diesel and gas,
- 2% is from nuclear power, and
- Less than 1% from non- conventional sources like solar, wind, ocean, biomass, etc.

Petroleum and its products are the other large sources of energy. In a developing country like India, in spite of enhanced energy production, there is still shortage due to increased demand of energy. In spite of the fact that there is a phenomenal increase in power generating capacity, still there is 30% deficit of about 2,000 million units.
Policy makers are in the process of formulating an energy policy with the objectives of ensuring adequate energy supply at a minimum cost, achieving self-sufficiency in energy supplies and protecting environment from adverse impact of utilizing energy resources in an injudicious manner. The main features of this policy are

1. Accelerated exploitation of domestic conventional energy resources, viz., oil, coal, hydro and nuclear power;
2. Intensification of exploration to achieve indigenous production of oil and gas;
3. Efficient management of demand of oil and other forms of energy;
4. To formulate efficient methods of energy conservation and management;
5. Optimisation of utilisation of existing capacity in the country
6. Development and exploitation of renewable sources of energy to meet energy requirements of rural communities;
7. Organisation of training for personnel engaged at various levels in the energy sector.
8. Government private partnership to exploit natural energy resources

6.3 Renewable Resources

- The resources that can be replenished through rapid natural cycles are known as renewable resource.
- These resources are able to increase their abundance through reproduction and utilization of simple substances.
- Examples of renewable resources are plants (crops and forests),and animals who are being replaced from time to time because they have the power of reproducing and maintain life cycles.
- Some examples of renewable resources though they do not have life cycle but can be recycled are wood and wood-products, pulp products, natural rubber, fibres (e.g. cotton, jute, animal wool, silk and synthetic fibres) and leather.
- In addition to these resources, water and soil are also classified as renewable resources. Solar energy although having a finite life, as a special case, is considered as a renewable resource in as much as solar stocks is inexhaustible on the human scale.

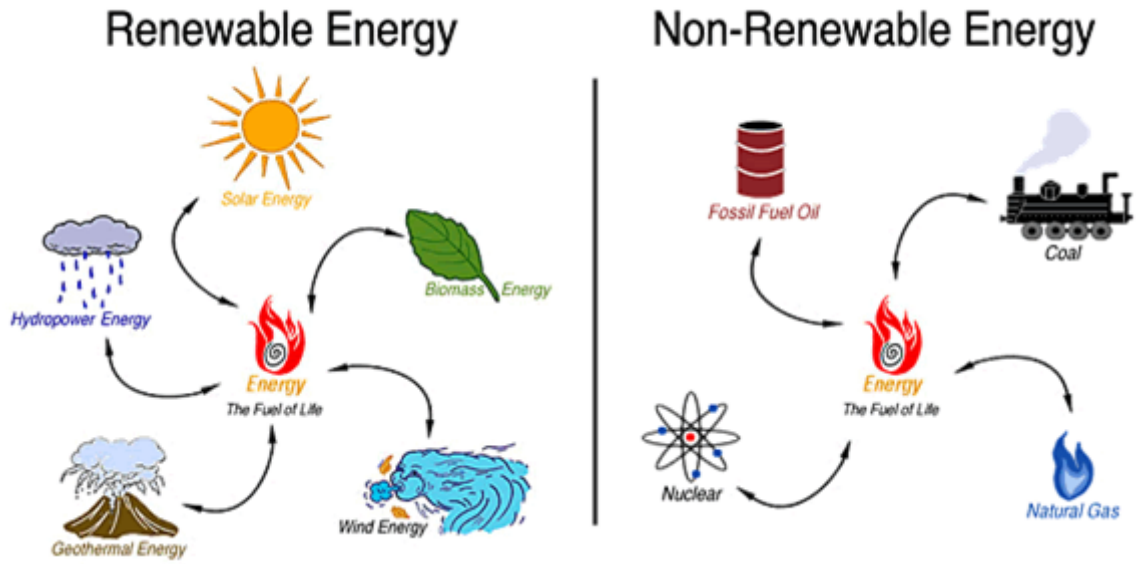

Fig 6.1 Renewable & non-renewable resources

6.4 Non-Renewable Resources

- The resources that cannot be replenished through natural processes are known as non-renewable resources.
- These are available in limited amounts, which cannot be increased. These resources include fossil fuels (petrol, coal etc.), nuclear energy sources (e.g. uranium, thorium, etc). metals (iron, copper, gold, silver, lead, zinc etc.), minerals and salts (carbonates, phosphates, nitrates etc.).
- Once a non-renewable resource is consumed, it is gone forever. Then we have to find a substitute for it or do without it.
- Non-renewable resources can further be divided into two categories, viz. Recyclable and non-recyclable

6.4.1 Recyclable resources

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, mercury etc.) and deposits of fertilizer nutrients (e.g. phosphate sock and potassium and minerals used in their natural state (asbestos, clay, mica etc.)

6.4.2 Non-recyclable resources

These are non-renewable resources, which cannot be recycled in any way. Examples of these are fossil fuels and nuclear energy sources (e.g. uranium, etc) which provide 90 per cent of our energy requirements.

6.5 Use of Alternate Energy Sources

There is a need to develop renewable energy sources which are available and could be utilized (solar or wind) or the sources which could be created and utilized (bio-mass). The main renewable energy sources for India are solar, wind, hydel, waste and bio-mass. Bio-mass are resources which are agriculture related like wood, bagasse, cow dung, seeds, etc.

6.5.1 Hydel energy

India has a total hydro energy potential of about 1.5 lakh MW, of which only about 20 % is installed. Small hydro plant potential is about 15000 MW and most of it is in the northern and eastern hilly regions.

6.5.2 Wind energy

The wind power potential of India is about 45,000 MW out of which capacity of 8748 MW has been installed in India till 2008. India is one of the leading countries in generating the power through wind energy.

Gujarat, AP, Karnataka, MP and Rajasthan are states having more than 5000 MW potential each. These potentials could be improved if the technology of putting turbines in sea is embraced. There are wind farms on sea generating as high as 160 MW of power.

6.5.3 Geothermal energy

Geothermal energy is thermal energy generated and stored in the Earth. Thermal energy is the energy that determines the temperature of matter. Earth's geothermal energy originates from the original formation of the planet (20%) and from radioactive decay of minerals (80%). Geothermal power is cost effective, reliable, sustainable, and environmentally friendly, but has historically been limited to areas near tectonic plate boundaries. Recent technological advances have dramatically expanded the range and size of viable resources, especially for applications such as home heating, opening a potential for widespread exploitation. Geothermal wells release greenhouse gases trapped deep within the earth, but these emissions are much lower per energy unit than those of fossil fuels. As a result, geothermal power has the potential to help mitigate global warming if widely deployed in place of fossil fuels.

6.5.4 Ocean thermal energy conversion (OTEC)

Ocean Thermal Energy Conversion (OTEC) uses the difference between cooler deep and warmer shallow or surface ocean waters to run a heat engine and produce useful work, usually in the form of electricity. A heat engine gives greater efficiency and power when run with a large temperature difference. In the oceans the temperature difference between surface and deep water is greatest in the tropics, although still a modest 20 to 25 °C. It is therefore in the tropics that OTEC offers the greatest possibilities. OTEC has the potential to offer global amounts of energy that are 10 to 100 times greater than other ocean energy options such as wave power

6.5.5 Biomass energy

Biomass is the oldest means of energy used by humans along with solar energy. As soon as the fire was discovered, it was used widely among humans mainly for heat and light. Fire was generated using wood or leaves, which is basically a biomass. The biomass could be used to generate steam or power or used as a fuel. Power is generated using rice husk in Andhra Pradesh, while several bagasse based plants are there. India has a potential of 3500 MW from bagasse. Other fast growing plants could be planned over a huge area, so that it provides biomass for generating power.

Organic waste such as dead plant and animal material, animal dung, and kitchen waste can be converted by the anaerobic digestion or fermentation into a gaseous fuel called biogas. Biogas

is a mixture of 65% methane (CH_4) and of 35% CO_2 and may have small amounts of hydrogen sulphide (H_2S), moisture and siloxanes. It is a renewable energy resulting from biomass. Biogas can be used as a fuel in any country for any heating purpose, such as cooking. It can also be used in anaerobic digesters where it is typically used in a gas engine to convert the energy in the gas into electricity and heat. Biogas can be compressed, much like natural gas, and used to power motor vehicles.

6.5.6 Bio-fuels

India has more than 50 million hectare of wasteland, which could be utilized for cultivating fuel plants. Jatropha is one of the options which can be planted on arid lands and be used for production of bio fuels.

6.5.7 Solar energy

India being a tropical country has potential to use solar energy on commercial bases. According to estimates, 35 MW of power could be generated from one sq km. With such potential, solar energy has bright future as energy source for the development of the country. Initial cost is the biggest limitation which has led to the low realization of its potential. For solar energy to become one of the front runners, it will require lot of research, cheap technology and low capital.

6.6 Problems Relate To the Use of Energy Resources

6.6.1 Fossil fuel:

• Global warming
• Acid rains
• Dangers posed by leaded fuels ,Oil spills
• Water pollution caused by poorly managed coal mines
• Air pollution.

6.6.2 Alternate energy resources:

• The initial cost of establishment of alternate energy generation is costlier than conventional resources.
• Maintenance of these structures is difficult.
• It requires more space.
• Energy supply is unpredictable during natural calamities.

6.7 Case Study

Importance of the energy resources in present economy and as a base for our future can be underlined by the fact that recent confrontations between some powerful nations of the world have primarily been attributed driven by objective to secure their energy supplies. Examples of this have been the two gulf wars. It was the hunger for energy resources that drove Iraq to lead an offensive over Kuwait and also reason for second Gulf war has been attributed to energy security by defence experts. In recent times, world has witnessed a confrontation at South China Sea between India, Vietnam and China over the issue of exploring natural gas and petroleum under the sea bed.

ENVIRONMENTAL STUDIES

Module 2. Natural resources

Lesson 7
LAND RESOURCES

'A nation that destroys its soils destroys itself'- **Franklin D. Roosevelt**

7.1 Land as a Resource

Land area constitutes about 1/5 of the earth surface. To meet out the challenging demand of food, fibre and fuel for human population, fodder for animals and industrial raw material for agro based industries, efficient management of land resources will play critical role. Soil, water, vegetation and climate are basic natural resources for agricultural growth and development.

7.2 Land Degradation

Due to increasing population, the demands for arable land for producing food, fibre and fuel wood is also increasing. Hence there is more and more pressure on the limited land resources which are getting degraded due to over-exploitation. Nearly 56% of total geographical area of the country is suffering due to land resource degradation. Out of 17 million hectare canal irrigated area, 3.4 million hectare is suffering from water logging and salinity. Soil erosion, water logging, salinization and contamination of the soil with industrial wastes like fly-ash, press mud or heavy metals all cause degradation of land.

7.3 Soil Erosion

Soil erosion refers to loss or removal of superficial layer of soil due to the action of wind, water and human factors. In other words, it can be defined as the movement of soil components, especially surface-litter and top soil from one place to another. It has been estimated that more than 5000 million tonnes topsoil is being eroded annually and 30% of total eroded mass is getting loosed to the sea .It results in the loss of fertility. It basically is of two types, viz. geologic erosion and accelerated erosion. Various factors which affect soil erosions include soil type, vegetation cover, slope of ground, soil mismanagement and intensity and amount of rainfall. Wind is also responsible for the 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 and Terracing
- Strip cropping and alley cropping
- Wind breaks or shelterbelts

Fig. 7.1 Terracing

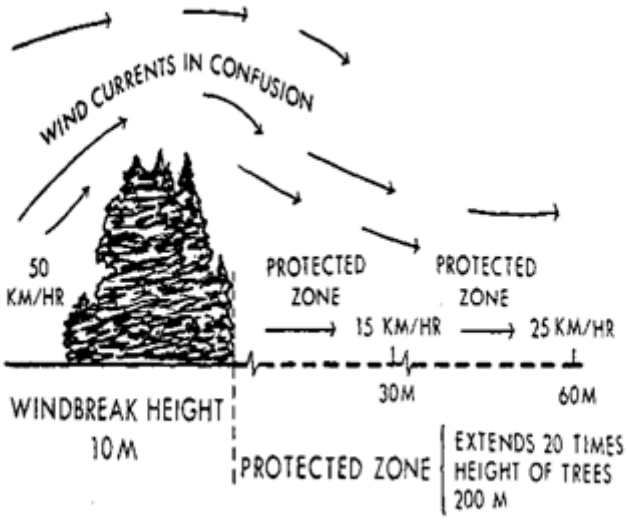

Fig. 7.2 Shelterbelts

Fig. 7.3 Conservational tillage (USDA,2007)

7.4 Salinization

It refers to accumulation of soluble salts in the soil. Concentration of soluble salts increases due to poor drainage facilities. In dry land areas, salt concentration increases where poor

drainage is accompanied by high temperature. High concentration of salts affects the process of water absorption hence affects the productivity.

7.5 Water Logging

Excessive utilization of irrigation may disturb the water balance which can lead to water logging due to rise of water table .Anaerobic condition due to poor availability of oxygen in water logged soils may affect respiration process in plants which will ultimately affect the productivity of water logged soil.

7.6 Desertification

Desertification is a process whereby the productive potential of arid or semiarid lands falls by ten percent or more. Desertification is characterized by devegetation and depletion of groundwater, salinization and severe soil erosion.

7.6.1 Causes of desertification

- Deforestation
- Overgrazing
- Mining and quarrying

7.7 Shifting Cultivation

Shifting cultivation is a practice of slash and burn agriculture adopted by tribal communities and is a main cause for soil degradation particularly tropical and sub tropical regions. Shifting cultivation which is also popularly known as 'Jhum Cultivation' has lead to destruction of forest in hilly areas .It is responsible for soil erosion and other problems related to land degradation in mountainous areas.

7.8 Man induced Landslides

Human race has exploited land resources for his own comfort by constructing roads, railway tracks, canals for irrigation, hydroelectric projects, large dams and reservoirs and mining in hilly areas. Moreover productive lands under crop production are decreasing because of development activities. These factors are affecting the stability of hill slopes and damage the protective vegetation cover. These activities are also responsible to upset the balance of nature and making such areas prone to landslides.

ENVIRONMENTAL STUDIES

Module 2. Natural resources

Lesson 8
CONSERVATION AND EQUITABLE USE OF NATURAL RESOURCES

8.1 Role of an Individual

Natural resources like forests, water, soil, food, minerals and energy resources play an important role in the economy and development of a nation. Humans can play important role in conservation of natural resources. A little effort by individuals can help to conserve these resources which are a gift of nature to the mankind. Brief description of role of individual to conserve different types of natural resources is given below:

8.1.1 Roles to conserve water

- To minimise the evaporation losses irrigate the crops, the plants and the lawns in the evening, because water application during day time will lead to more loss of water due to higher rate of evapo-transpiration.
- Improve water efficiency by using optimum amount of water in washing machine, dishwashers and other domestic appliances, etc.
- Install water saving toilets which use less water per flush.
- Check for water leaks in pipes and toilets and repair them promptly.
- Don't keep water taps running while they are not in use.
- Recycle water of washing of cloths for gardening.
- Installing rainwater harvesting structure to conserve water for future use.

8.1.2 Energy conservation for future use

- Turn off all electric appliances such as lights, fans, televisions, computers, etc when not in use.
- Clean all the lighting sources regularly because dust on lighting sources decreases lighting levels up to 20-30%
- Try to harvest energy from natural resources to obtain heat for example drying the cloths in sun and avoid drying in washing machine.
- Save liquid petroleum gas (LPG) by using solar cookers for cooking.
- Design the house with provision for sunspace to keep the house warm and to provide more light.
- Avoid misuse of vehicles for transportation and if possible share car journey to minimise use of petrol/diesel. For small distances walk down or just use bicycles.
- Minimise the use air conditioner to save energy

8.1.3 Protect soil health

- Use organic manure/compost to maintain soil fertility
- To avoid soil erosion does not irrigate the plants by using fast flow of water.

- Use sprinkler irrigation to conserve the soil.
- Design landscape of lawn in large area which will help to bind soil to avoid erosion.
- Provide vegetation cover by growing of ornamental plant, herbs and trees in your garden.
- Use vegetable waste to prepare compost to use in kitchen gardening.

8.1.4 Promote sustainable agriculture

- Diversify the existing cropping pattern for sustainability of agriculture
- Cultivate need based crop
- Maintain soil fertility
- Make optimum use of fertilizers, pesticides and other chemicals for production and processing of agriculture products
- Save grains in storage to minimise the losses
- Improve indigenous breeds of milch animals for sustainable dairy production systems.
- Adopt post harvest technologies for value addition

8.2 Equitable Use of Resources for Sustainable Life Style

In last 50 years, the consumption of resource in the society has increased many folds. There is a big gap in the consumers lifestyle between developed and developing countries.Urbanisation has changed the life style of middle class population in developing countries creating more stress on the use of natural resources. It has been estimated that More Developed Countries (MDC) of the world constitute only 22% of world's population but they use 88% of natural resources. These countries use 73% of energy resources and command 85% of income and in turn they contribute very big proportion of pollution. On the other hand less developed countries (LDCs) have moderate industrial growth and constitute 78% of world's population and use only 12% of natural resources, 27% of energy and have only 15% of global income.

There is a huge gap between rich and poor. In this age of development the rich have gone richer and the poor is becoming more poorer.. This has lead to unsustainable growth. There is an increasing global concern about the management of natural resources. The solution to this problem is to have more equitable distribution of resources and income. Two major causes of unsustainability are over population in poor countries and over consumption of resources by rich countries. A global consensus has to be reached for balanced distribution of natural resources.

For equitable use of natural resources more developed countries/rich people have to lower down their level of consumption to bare minimum so that these resources can be shared by poor people to satisfy their needs. Time has come to think that it is need of the hour that rich and poor should make equitable use of resources for sustainable development of mankind.

ENVIRONMENTAL STUDIES

Module 3. Ecosystem

Lesson 9
INTRODUCTION, STRUCTURE AND FUNCTION OF AN ECOSYSTEM

9.1 Introduction

The term ecosystem is defined as the system resulting from the integration of all the living and non-living factors of the environment. The terms biocoenosis, microcosm, biocoenosis or geobiocoenosis, holocoen, biosystem, bioinert body and ecocosm, respectively are used to express similar ideas. However, the term ecosystem is most preferred, where eco refers the environment, and system implies an interacting and interdependent complex. The organisms of any community besides interacting among themselves always have functional relationship with the environment. This structural and functional system of communities and environment is called ecological system or ecosystem. It is the basic functional unit in ecology, since it includes both biotic and abiotic environment, influencing each other for maintenance of life.

An ecosystem may, in its simplest form, be defined as a self-sustained community of plants and animals existing in its own environment. An ecosystem may be as small as a drop of pond water (microecosystem) or as large as ocean. It can be of temporary nature, e.g., a fresh pool or a field of cultivated crops, or permanent e.g., a forest or an ocean. A balanced aquarium may be thought of as an artificially established self-sustained ecosystem.

9.2 Characteristics of Ecosystem

According to Smith (1966), the ecosystem has the following general characteristics:

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

9.3 Kinds of Ecosystems

Artificially ecosystems may be classified as follows:

9.3.1 Natural ecosystems

These operate under natural conditions without any major interference by man. On the basis of the type of habitat these may be further divided as:

a) Terrestrial

Forest, grassland, desert, etc.

b) Aquatic

1. Fresh water - which may be lotic (e.g., running water as spring, stream or rivers) or lentic (e.g., standing water as lake, pond, pools, puddles, ditch, swamp, etc.).
2. Marine - such deep bodies as ocean or shallow ones as seas or an estuary, etc.

9.3.2 Artificial (Man - engineered) ecosystems

These are maintained artificially by man whereby addition of energy and planned manipulation, natural balance is disturbed regularly, e.g. cropland ecosystem.

In addition to above types, some other types such as spacecraft and microecosystem have also been recognised.
An outline of classification of the ecosystems is as follows:

A detailed account of the various major ecosystems may follow in the later part of this chapter.

9.4 Structure of the Ecosystem

All ecosystems, whether terrestrial, fresh water, marine or man-engineered, consist of following major components:

1. Species components
2. Stratification
3. Trophic organisation—relationship of food between various layers
4. Nutrients—required for living organisms

9.4.1 Biotic (living) components

This comprises of all the living organisms. On the nourishment (or trophic) standpoint, they may be divided into two categories:

The autotrophs (autotrophic = self nourishing)

These are green plants and certain photosynthetic or chemosynthetic bacteria which can convert the light energy of sun into potential chemical energy in the form of organic compounds needed by plants for their own growth and development. Oxygen is produced as a

by-product of photosynthesis, needed by all living organisms for respiration. These green plants are also known as producers because they produce food for all the other organisms.

The heterotrophs (heterotrophic = other nourishing)

They are dependent directly or indirectly upon the autotrophs for their food. The organisms involved are also known as consumers because they consume the materials built up by producers. These may be subdivided into two kinds:

Macroconsumers (or Phagotrophs, Phago = to eat)

These are organisms which ingest food and digest it inside their bodies. They may be herbivores (plant eating), carnivores (= animal eating), or omnivores (= eating all kind of food). The herbivores are primary consumers. For example, insects like grass hopers, chew up stems and leaves, animals like goat, cow, deer and rabbit eat up entire aerial portion of green plants, and man eats up plant products, are all primary consumers. Frog, a carnivore, is a secondary consumer as it eats the herbivores, the snake that eats the frog is a tertiary consumer, there is also a class of top consumers, which are not killed and eaten by any other animals e.g. lion, tiger, leopard, vulture, etc.

Microconsumers (Saprotrophs, sapro = to decompose, or osmotrophs, osmo = to pass through a membrane)
These are the organisms which secrete digestive enzymes to breakdown food into simpler substances and then absorb the digested food. They are mostly parasitic and saprophytic bacteria, actinomycetes and fungi. They are also known as decomposers because of their role in decomposition of dead organic matter. However, the parasites are not decomposers and also some consumers (e.g. insects and such small animals) also which help in decomposition by breaking down the organisms into small bits. Keeping this in view, Wiegert and Owens (1970) suggested the classification of heterotrophs into two categories, biophages (= feeding on living organisms) and saprophages (= feeding on dead organic matter). Decomposers breakdown the complex compounds of dead or living protoplasm, absorb some of the decomposition products and release inorganic nutrients which are cycled back to the soil and the atmosphere from where they are once again made available to the primary producers.

Such a division of organisms based on the type of nutrition gives rise to the trophic structure of the ecosystem and the energy source used which is one kind of producer-consumer arrangement, where each food level is known as trophic level. The amount of living material in different trophic levels or in a component population is known as the standing crop, a term applicable to both, plants as well as animals. The standing crop may be expressed in terms of organism's mass, which can be measured as living weight, dry weight, ash-free dry weight or carbon weight or calories or any other convenient unit suitable for comparative purposes.

In nature simple food chains occur only rarely. There are several food chains linked together, and intersecting each other to form a network known as food web.

9.4.2 Abiotic components

Structurally abiotic components include -

1. Climate regime: Precipitation, temperature, light, and other physical factors.
2. Inorganic substances: Elements such as C, N, H, O, P, S, etc., involved in material cycles.

3. Organic Compounds: Carbohydrates, proteins, lipids and humic substances that link the abiotic components with the biotic components (for details see any elementary book on ecology).

The minerals and atmospheric gases keep on cycling. They enter into biotic systems and after the death and decay of organisms return to the soil and atmosphere. This is known as biogeochemical cycle. This circulation of materials involves trapping of the solar energy by the green plants which are ultimately lost by the organisms in several ways. The amount of abiotic materials present in an ecosystem is called standing stage.

9.5 Functions

The function of the ecosystem is to allow flow of energy and cycling of materials which ensures stability of the system and continuity of life. These two ecological processes including interaction between the abiotic environment and the communities. For the sake of convenience, the ecosystem dynamics may be analysed in terms of the following: (i) food chains, (ii) food pyramids, (iii) energy flow, (iv) nutrient cycles, (v) development and evolution of ecosystem, and (vi) homeostasis and stability of ecosystem.

ENVIRONMENTAL STUDIES

Module 3. Ecosystem

Lesson 10
ENERGY FLOW IN THE ECOSYSTEM AND ECOLOGICAL SUCCESSION

10.1 Ecosystem Functioning

To understand clearly the nature of the ecosystem, its function must be thoroughly investigated. The function of the ecosystem is to allow flow of energy and cycling of materials which ensures stability of the system and continuity of life. These two ecological processes including interaction between the abiotic environment and the communities may be considered as the 'heart' of the ecosystem functioning. For the sake of convenience, the ecosystem dynamics may be analysed in terms of the following: (i) food chains, (ii) food pyramids, (iii) energy flow, (iv) nutrient cycles, (v) development and evolution of ecosystem, and (vi) homeostasis and stability of ecosystem.

10.2 Ecological Energetics

In ecological energetics one is mainly interested in the (i) quantity of solar energy reaching an ecosystem, (ii) quantity of energy used by green plants in the process of photosynthesis and (iii) the quantity and path of energy flow from producers to consumers.

In the earth's atmosphere about 15 X 10^8 calories m^{-2} yr^{-1} of solar energy is received (Phillipson, 1966). The fate of solar radiations upon its incidence on earth's surface is shown in Fig. 10.2. About 34% of the solar radiations reaching the earth's atmosphere is reflected back into space by clouds and the suspended dust particles in the atmosphere; 9% is further held by ozone, water vapour and other atmospheric gases. Remaining 47% reaches the earth's surface. In fact, only 1 to 5% of the energy reaching the ground is converted by green plants to chemical energy, and 42 to 46% is absorbed as heat by ground, vegetation or water. Water budget showed that 45% of the incoming

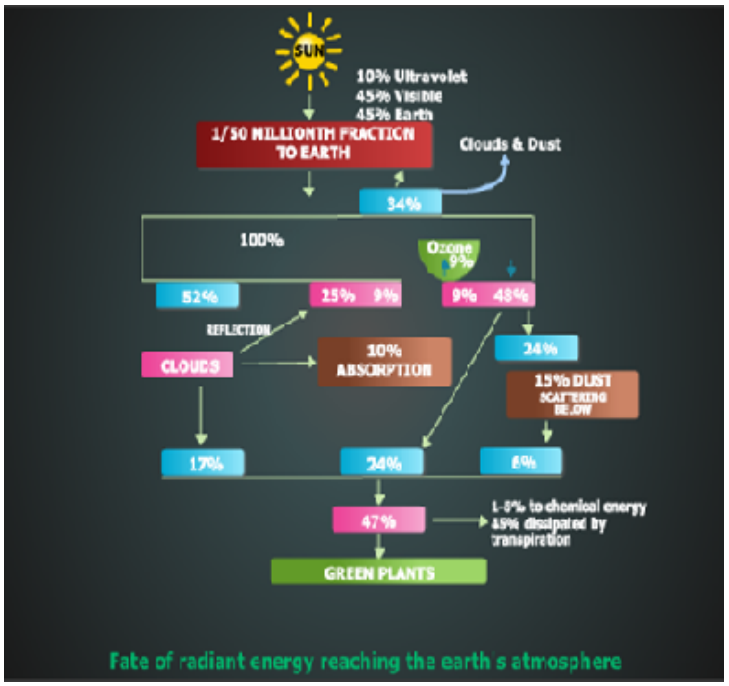

Fig. 10.1

radiation was dissipated by transpiration of 370 t ha^{-1} of water from the crop. The quantity of solar radiation received at any place not only depends upon the clarity of the atmosphere, but also on the latitude of the area. The equatorial region receives maximum solar radiation followed by other regions of the tropics. The quantity of energy goes on decreasing with increase in latitude both in the northern and southern hemispheres (fig.10.1).

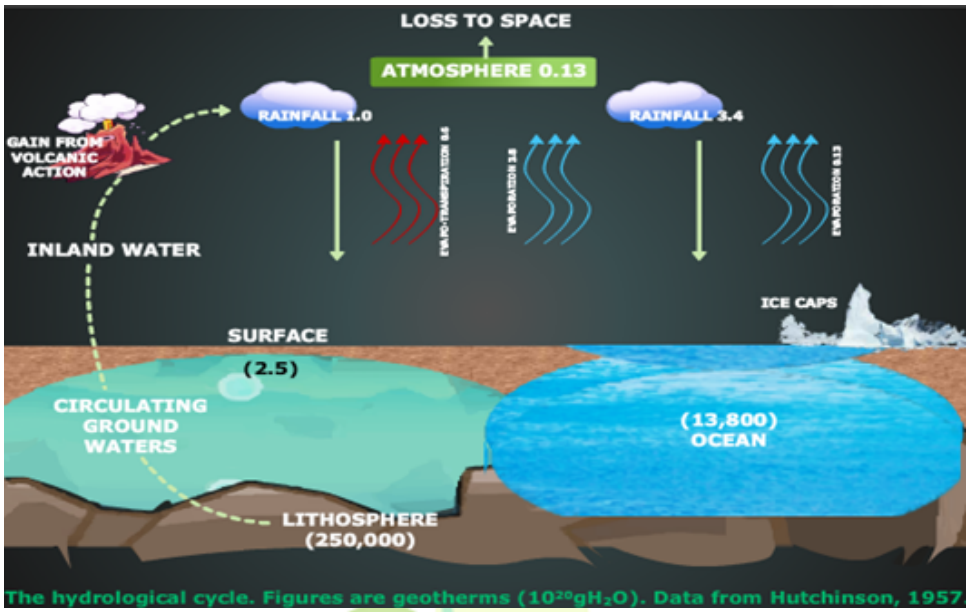

Fig. 10.2

10.2.1 Energy flow in the ecosystem

The behaviour of energy in ecosystem can be conveniently termed as energy flow because of unidirectional energy transformations. Total energy flow that constitutes the energy environment has already been dealt in detail, and now we take up the study of that portion of the total energy flow that passes through the biotic components of the ecosystem. Entrance of energy, its retention within the ecosystem and dissipation into space, are governed by two laws of thermodynamics. According to the first law, the law of conservation of energy, in a closed system, no energy comes in or escapes out and not created or destroyed but may be altered from one form to another. The second law of thermodynamics, the law of entropy, states that there is always a tendency for increase in entropy or degradation from a concentrated (non-random) to a dispersed (random) form leading to dissipation of heat. All the energy entering the earth's surface can be accounted for. Some energy is used in photosynthesis; the rest is used in converting the water into vapours or heating the soil and air. Ultimately the energy reflected back to outer space as heat. The light energy fixed by green plants in the process of photosynthesis may be represented by the following equation:

$$6CO_2 + 18\ ATP + 12\ NADPH_2 \text{ ----> } C_6H_{12}O_6 + 18\ ADP + 18\ Pi + 12\ NADP + 6H_2O$$

Assimilatory power of photochemical reaction 673 Kcal of solar energy

Out of the amount of energy so fixed by green plants, some is released again in respiration. The fixed energy, in the form of food, then passes from plant source through herbivores to carnivores. At each stage of food transfer, potential energy is released, resulting in further loss of a large part of energy. The energy flow, thus follows the second law of thermodynamics.

10.3 Biogeochemical Cycles

The absorption and utilization of elements by organisms is compensated by their recycling and regeneration back into the environment by the breakdown of these organic compounds again. The more or less cyclic paths of these elements in the biosphere from environment to organisms and into the environment back are called biogeochemical cycles (Bio - living organisms, Geo - rock, soil, air, water).

Many elements enter living organisms in the gaseous state from the atmosphere or as water soluble salts from the soil. As the flux of these elements through an ecosystem gives some measure of its continuity and productivity, the analysis of exchange of various components of the biosphere is essential. Furthermore, society depends upon this life-support system of the earth for sustained and increased production of food, fodder, fibre and fuel.

These biogeochemical cycles may be categorized into three global types:

1. The hydrological cycle, involving the movement of water.
2. The gaseous cycle of carbon, oxygen and nitrogen
3. The sedimentary (non-gaseous) cycle of remaining nutrient elements e.g. phosphorus, calcium and magnesium. Sulphur is to extent intermediate, since H_2S or SO_2, formed under some circumstances, adds a gaseous component to its normally sedimentary cycle. These elements normally do not cycle through the atmosphere in the absence of a gaseous phase. The elements concerned in the sedimentary cycle are earthbound and follow a basic pattern of flow through erosion, sedimentation, mountain building, volcanic activity and biological transport (e.g. through the excreta of marine birds). Sedimentary cycles are much less perfect than gaseous in that some of the element may get stuck in certain phase of the cycle.

10.3.1 Hydrologic (Water) cycle

The important cycle among all the materials is that of water. Water is by far the most important substance necessary for life. It is very important ecological factor that determines the structure and function of the ecosystem, and regulates the plant environment to a large extent. The cycling of all other elements is also dependent upon water as it provides the solvent medium for their uptake. It provides H^+ for reduction of CO_2 in photosynthesis. It has moderating effect on the temperature of the surrounding area by virtue of its heat absorbing ability. Protoplasm the very basis of life is made up of 85 to 95% of water. The content varies in different tissues of the organism and in different plants and animals. Human blood is 90% water. Water cycle involves an exchange of water between the earth's surface and the atmosphere via precipitation and evapo-transpiration. Water covers about 75% of the earth's surface, occurring in lakes, rivers, seas, oceans, etc. The ocean occupies 70% of the surface and contains 97% of all the water on earth. Much of the remainder is frozen in the ice caps and glaciers. The water in rivers and lake is comparatively small. Less than 1% is in the form of ice-free fresh waters in rivers, lakes and aquifers. Yet this relatively negligible portion of the planet's water is crucially important to all forms of terrestrial and aquatic life. There is also a large underground supply of water. Soils near the surface also serve as reservoirs for enormous quantities of water. Based on the data from Hutchinson (1957) (Table 10.1), prepared a diagram of hydrologic cycle (Fig.10.2).

Every year 4.46 G of water comes in the form of rainfall of which 3.47 G precipitates over the ocean's surface. About 1 G rainfall occurs over land mass of which 0.2 G runs away and 0.6 G evaporates again, and only a small quantity (0.2 G) is stored as underground water. 0.13 G water moves in the form of water vapour and clouds from ice caps present on South and North poles and on the top of high mountains. Only about 0.004% (~10 G) of the total water is all the time moving in the cycle as much of earth's water is in cold storage. Glaciers and the ice caps cover 11% of the world's land area; permanent frozen ground holds another 10% area in its grip, while 30 to 50% of the land is covered with snow at any given time. Icebergs and pack ice occupy 25% of the ocean area. Therefore of all fresh water is locked up as ice, mostly in Antarctica and Greenland.

Table 10.1 Data on water cycle from Hutchinson, 1957

Water in the rocks (lithosphere)	250000.00 G
Water in sedimentary rocks	2100.00 G
Water in the oceans	13800.00 G
Water in rivers and lakes	0.25 G
Water in atmosphere as vapours	0.13 G
Water in mountainous and polar ice caps	167.00 G
Circulating ground water	2.50 G
Total quantity of water on the earth	**266069.88 G** **Geogram (G) = 10^{20}g**

10.3.2 Carbon cycle

Carbon is present in atmosphere, mainly in the form of carbon dioxide, and thus it cycles in this gaseous phase. Though it is a minor constituent of the atmosphere (0.032% v/v), as compared to oxygen (~21% v/v) and nitrogen (~79% v/v), yet without carbon dioxide no life could exist, for it is vital to the production of carbohydrates through photosynthesis in plants, the basic building blocks for other organic compounds needed in metabolic synthesis and incorporation of the carbon with the protoplasm. Fig. 10.3 illustrates the global carbon cycle. Carbon from atmospheric pool moves to green plants (producers), then to animals (consumers), and finally from these to bacteria, fungi and other microorganisms (decomposers) that return it to the atmosphere, through decomposition of dead organic matter. Some of this is also returned to the atmosphere through respiration at various levels in the food chain. It is estimated that half of the carbon fixed is subsequently returned to the soil in the form of decomposing organic matter. Fig. 10.3 illustrates the global cycle of carbon indicating the quantities involved at various levels. The atmospheric pool (711 X 10^9 tons) is very small as compared to that of carbon in ocean (39,000 X 10^9 tons) and in fossil fuels (12,000 X 10^9 tons). Before the onset of industrial revolution flows among atmosphere, continents and oceans were balanced, but with industrialization and urban development this equilibrium appears to be disturbed. Fossil fuel burning, forest fire, deforestation and agriculture are some of the important sources of new input. On the contrary, forests are important carbon "sinks" as forest biomass is estimated to contain 1.5 times and forest humus 4 times the amount of carbon in the atmosphere.

There are two main sources of carbon in the abiotic world:

1. The rocks containing carbonates such as lime stone in the earth's crust.
2. The carbon dioxide of the air and that dissolved in water.

In addition, there is present large amounts of carbon in fossil fuel (coal, petroleum, natural gas, etc.) but this is not available to the plants until and unless it is burned to produce carbon dioxide

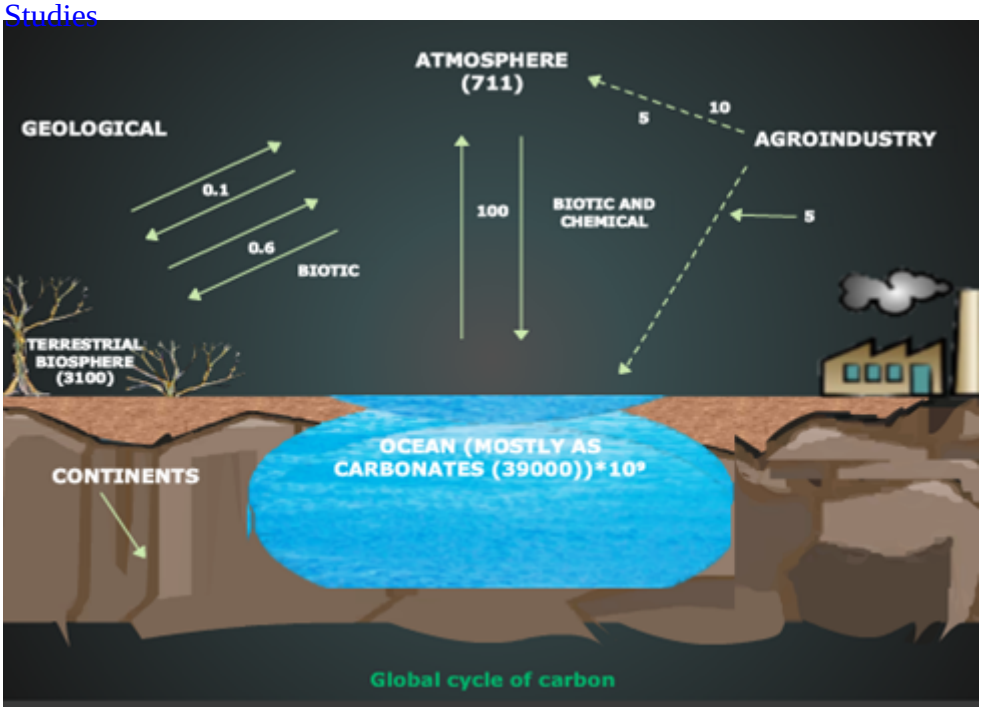

Fig. 10.3

Carbon dioxide is released from carbonate rocks by acids resulting from geological action and also by acids formed during fermentation and by bacteria that produce nitric acid and sulphuric acid. An insignificant amount of carbon dioxide is also produced by activity by bacterium Carboxydismonas oligocarbophila which oxidizes carbon monoxide to carbon dioxide. Carbon monoxide (a poisonous gas for aerobic organisms including man) is not of common occurrence in nature but may be produced due to partial combustion of fossil fuel. When carbon dioxide dissolves in water, some of it reacts to form carbonic acid (H_2CO_3) which immediately produces carbonate ($CO^{2-}{}_3$) and bicarbonate ($HCO\text{-}_3$) ions.

$$H_2O + CO_2 \text{ ----> } H_2CO_3$$

$$H_2CO_3 \text{ ----> } H^+ + HCO^-_3$$

$$HCO^-_3 + H_2O \text{ ----> } H_3O^+ + CO^{2-}_3$$

The richest source of stored carbon today is in the ocean, and in the form of these ions. The oceans contain about 50 times more carbon dioxide than in the atmosphere. This regulates atmospheric carbon dioxide than in the atmosphere. This regulates atmospheric carbon dioxide content level to 0.03% despite photosynthetic uptake. Thus, there is a continuous exchange of carbon dioxide between the atmosphere and organisms on the one hand and between the atmosphere and sea on the other hand. However, the majority of ocean-dissolved CO_2 ($HCO\text{-}_3$) is below the thermocline and inaccessible for rapid exchange with the atmosphere. The immediate source of CO_2 for exchange is thus restricted to relatively small quantity of epilimnic CO_2. The sea water being rich in calcium and being alkaline (NaOH) helps in accelerating the process of carbonate decomposition. About 48 ml l^{-1} CO_2 occurs as carbonate in sea water. Such deposits in the form of coral reefs and calcium carbonate rocks are common in the tropical regions of the oceans. In warm climates, high temperatures and greater salinity and alkalinity favour the process of carbonate decomposition, and it is also reflected in thicker, shells of moluscs.

The carbon dioxide has the unique property of absorbing infra-red radiations. While the small quantities of carbon dioxide are helpful in keeping the earth warm, the enhanced atmospheric carbon dioxide results in rise in the temperature of the atmosphere much in the same way as glass houses do (i.e. they permit the radiations to pass through and strike the earth, but once converted into heat and reflected upwards, the heat waves are absorbed by carbon dioxide rich atmosphere and cause rise in temperature) and in turn, causes rise in ocean level. Fig. 10.4 shows the carbon cycle in an ecosystem.

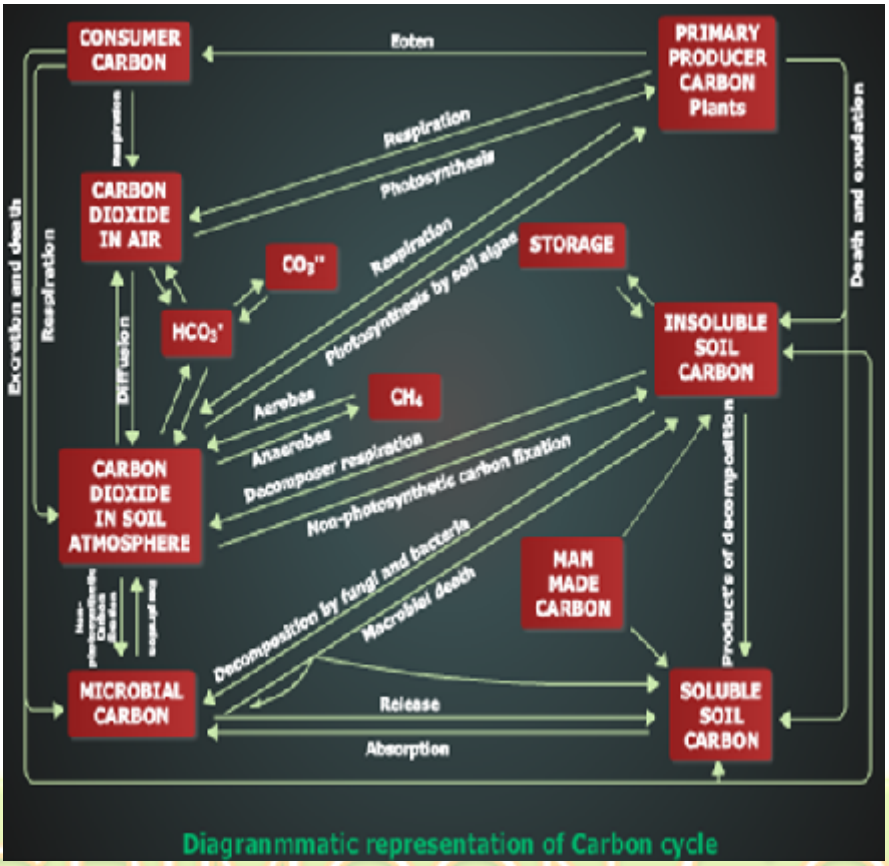

Fig. 10.4

10.3.3 Oxygen cycle

Oxygen which is in abundance (20.9476% v/v) in the atmosphere is another indispensable material for life. According to Broecker (1970), each square metre of the earth's surface is covered by 60,000 moles (about a ton) of oxygen gas. Terrestrial, aquatic and marine plants, during photosynthesis release about 8 moles of oxygen annually for each square metre of the earth's surface. Nearly all of this gaseous oxygen is utilized in the process of respiration by plants, animals and bacteria with the result that the amount of oxygen consumed is almost equal to that of released in the atmosphere. However, there is a small net addition of oxygen to the atmosphere (about 1 part in 15 million parts of the oxygen present), which probably does not bring about any change in the oxygen content, as much of this is utilized in the oxidation of carbon, iron, sulphur and other minerals during the normal process of weathering.

Oxygen in bound state, occurs as oxides of carbonates in rocks, and in water. Oxygen dissolved in water is the main source of oxygen for aquatic plants, which may act as one of the limiting factors in their growth and development. Another important phase of oxygen is the ozone layer (oxygen acted on by short-wave radiation to produce ozone), of the outer atmosphere, which by shielding out the deadly ionizing short-wave ultraviolet radiations, protects the life. Oxygen is thus present in atmosphere in sufficiently large quantities and there is no possibility of oxygen deficiency on global scale even if all the earth's organic matter including the fossil fuel is burnt.

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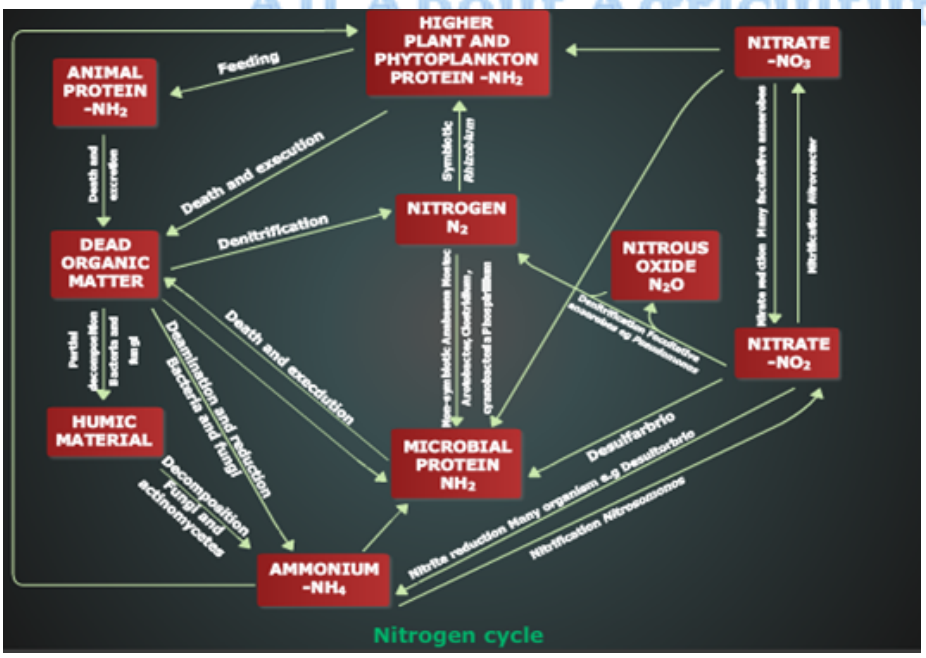
10.3.4 Nitrogen cycle

Gaseous nitrogen is the most abundant element of the atmosphere (78.084% v/v), and seems to have a highly complex nutrient cycle in the terrestrial and aquatic ecosystems. This substance is very important for plants and animals as an essential, constituent component of chlorophyll and proteins. Despite its immense value and indispensable nature it is never taken directly from the atmosphere by animals or higher plants. Atmospheric nitrogen is rather inert and does not readily participate in any reaction. A generalized nitrogen cycle is shown in Fig.10.5.

The chief sources of nitrogen for plants are nitrates in the soil. The atmospheric nitrogen is fixed symbiotically as well as asymbiotically by a variety of microorganisms. The chief nitrogen fixers are bacteria belonging to the genus Rhizobium found in root nodules of legumes. Asymbiotic nitrogen fixers are some blue green algae, like Anabaena and Nostoc, aerobic bacteria like Azotobacter, and anaerobic bacteria like Clostridium. Certain photosynthetic bacteria like Rhodospirillum are also nitrogen fixers. Some proportion of atmospheric nitrogen is fixed during lightening also. The fixed atmospheric nitrogen reaches the soil as nitrates, which are taken up by plants for manufacture of complex nitrogenous compounds which in turn, are eaten by animals. The dead organic matter formed due to death of plants and animals is decomposed by various types of bacteria, actinomycetes and fungi occurring in soil and water. This releases nitrogen either in free stage or as ammonia gas in the atmosphere. Ammonia gas may reach the soil as nitrates through the activity of nitrifying microbes, Nitrosomonas and Nitrobacter. Some nitrates of soil due to activity of denitrifying microbes, Pseudomonas, may also be converted to free nitrogen gas returning to the atmosphere. This inorganic nitrogen is again recycled into the organic system upon absorption by higher plants. It is presumed that the fixation of nitrogen by microorganisms is generally in equilibrium with denitrification.



But in recent years there has been high quantity of atmospheric nitrogen fixation by Industrial process (Haber's process). Nitrogen so fixed is not readily and fully denitrified so as to cause accumulation of nitrates or ammonia in water and soil. The accumulation of nitrates in water causes eutrophication. NO_2

from the incomplete combustion of fossil fuel in automobiles further pollute the environment. It appears that through photochemical and electrical fixation 2.5 x 107 ty^{-1} and through biological fixation 5-(6)x 10^9 ty^{-1} of nitrate is formed. Industrial nitrogen fixation including oxides of nitrogen formed during fossil fuel combustion is 8 x 10^7 ty^{-1}. Nitrogen fixed by microorganisms is 1-(2) x 10^8 ty^{-1}, which is presumed almost equal to that of denitrification. A tiny fraction of annual N-fixation is lost to fossilization in sediments because the anaerobic sedimentary environment is favourable to denitrifying bacteria.

10.3.5 Sulphur cycle

Sulphur is a component of sedimentary cycle. It is found in the gaseous forms (H2S, SO2, etc.) in the atmosphere, and as sulphates, sulphides and organic-sulphur in the soil. SO2 gas present in the atmosphere is produced volcanically, by burning of vegetation, and now in copious quantities by oxidation of sulphides and organo-S in fossil fuels. H_2S and dimethyl sulphide are commonly formed by the activity of anaerobic bacteria. The elemental and organic sulphur, and SO_4^{2-} are formed through oxidation of H2S. SO_2 and H_2S from the atmosphere are returned to the soil through precipitation. Sulphur in the form of sulphates (SO_4^{2-}) is the principal available form that is reduced and incorporated into proteins by autotrophs. Sulphur is an essential constituent of certain amino acids (cysteine, cystine, and methionine), the peptide glutathione and certain vitamins or enzyme cofactors (thiamine, biotine, and thiotic acid). It is the mercaptan, containing the thiol (-SH, or sulphydryl) group, and as the corresponding oxidized disulfide form that sulphur is most reactive in the plant.

The sulphur cycle links air, water and soil, where microbes play a key role. The sulphur is incorporated in the tissues of autotrophs as -SH in the proteins. It passes through the grazing food chain and excess of it is released through the faeces of animals. Within the detritus food chain the decomposition of proteins releases sulphur. Under aerobic conditions Aspergillus and Neurospora and under anaerobic conditions the bacteria like Escherichia and Proteus are largely responsible for the decomposition. In anaerobic soils and sediments H2S is formed by sulphate reducing bacteria like Desulphonovibrio desulfuricans which utilize the oxygen in the sulphate molecule to obtain energy and in turn reduce the sulphate in deep sediments to H2S gas:

$$CH_2NH_2COOH + H_2O + SO_4^{2-} \text{ ----> } H_2S + HS^- + HCO_3^- + NH_4^+$$

In iron-rich materials, much of this H2S is scavenged by ferrous iron to produce the very insoluble, black FeS. Many photosynthetic and chemosynthetic bacteria play an important role in sulphur metabolism. Chemoautotrophic colourless bacteria like Beggiatoa, Thiothrix and Thiobacillus occurring in H2S containing water oxidizes H_2S to S or S to SO_4^{2-} when the H_2S supply is exhausted.

$$H_2S + O \rightarrow H_2O + S + 32.5 \text{ Kcal}$$

$$S + 30 + H_2O \rightarrow H_2SO_4 + 141 \text{ Kcal}$$

Thiobacillus thiooxidans under highly acidic conditions (up to pH 0.6) may convert sulphur to sulphuric acid of 10% concentration and thus strongly acidify the soil. There are also green sulphur (e.g. Chlorobium) and purple-sulphur (e.g. Chromatium) photosynthetic bacteria that use the H2S as the source of hydrogen in reducing $CO^{2\cdot}$

Light

$$CO_2 + H_2S \xrightarrow{\text{Light}} (CH_2O) + S + H_2O + \text{Energy}$$

Green bacteria are able to oxidize H_2S only to elemental sulphur, whereas the purple one can carry oxidation to sulphate stage.

Sulphur cycle plays a key role in the metabolism of other nutrients like iron, copper, cadmium, zinc, cobalt etc. For example, when iron is precipitated as sulphide, phosphorus is converted from insoluble to soluble form and thus becomes available to organisms.

10.3.6 Phosphorus cycle

Like sulphur, phosphorus is also a component of sedimentary cycle. It is an essential component as in the form of ATP it acts as an energy carrier. It is comparatively less abundant in natural ecosystems, particularly in terrestrial ecosystems and occurs in meager amounts in aquatic ecosystems too. The phosphorus is made available to the plants form the phosphatic rocks by slow weathering process. The phosphatic (inorganic phosphates typically orthophosphate ions) are metabolised in the plant body and pass through the food chain to animals, and then to decomposers (as food as well as through death and decay) in the form of organic phosphate, which is subsequently made available in the soil for reutilization through mineralisation and decomposition. However, a major proportion of phosphorus becomes lost to this central cycle through run off to the deep sediments of the oceans and in biological processes, such as formation of teeth and bones. On the contrary some quantities of phosphates are returned back to the earth in the form of bird guana (excreta) and fishes. In recent years the excessive use of phosphate fertilizers and the detergents is a problem of global concern as it has been considered responsible for accelerated eutrophication of water bodies.

10.3.7 Calcium cycle

It is important element needed by plants for building their cell walls and by animals for bone formation. It is being regularly added to the soil pool through the weathering of rocks and through atmosphere. A large proportion of this is kept in a state of cycling by uptake from soil into the biotic pool of plants and animals and their return through litter fall, death and decay via detritus food chain. Only a small portion is lost out of the ecosystem through stream flow and this is replenished by weathering and precipitation.

10.3.8 Cycle of toxic elements

Several non-essential elements like mercury, lead, cadmium, arsenic and fluorine, despite their substantial toxicity are freely cycled through biological systems in well regulated and balanced manner. Growing industrial use, mining operations and other man's activities tended to perturb this equilibrium and upset the balance towards greater accumulation and lesser dispersion of toxic elements. A very significant role in the mobility and dispersion of these elements in the biosphere is played by microorganisms.

10.3.8.1 Mercury

It is one of the most important toxic elements which is now increasingly (about four-fold) discharged in soils and water as an unwanted by-product of certain industrial and agricultural activities. Mercury cycle is better known and the potential rate determining the role of biomethylation of mercury in an ecosystem involving lakes, rivers, coastal environment, soil, etc., is now well established. The natural level of mercury in soils is as high as 0.04 ppm, and in water 0.06 ppm. The amount of mercury found in the air depends on conditions of the environment. The element is poisonous in the metallic state, as inorganic salts of mercury or in the form of organic mercury compounds. It does not have to be ingested being poisonous. Metallic mercury gives off vapours at room temperature; some of the metal even vaporizes at the freezing point of water and

this being highly volatile gets dispersed into biosphere. Elemental mercury can exist in three alternative states, viz., $Hg2^{2+}$, Hg^{2+} and HgO and certain microorganisms are capable of interconverting the three forms. Naturally occurring methyl-vitamin B_{12} compounds can aid the synthesis of methyl mercury as well as dimethyl mercury in natural habitats. The bioaccumulation of mercury is greatly facilitated by the natural synthesis of stable alkylmercury compounds (Wood, 1974). About 25% of the world mercury production form chlorine plant, where mercury is used as in electrolyte electrode, escapes in fuel gases. Methyl mercury compounds formed probably in sulphide-rich sediments by the activity of Methanobacterium amelankis are also highly toxic and move in the ecosystem either in solution or as atmospheric volatiles. Methyl mercury chloride is particularly toxic to animals as it is easily passed across cell membranes. Dimethyl mercury, which is highly volatile, passes into the air and decomposes into CH_4, C_2H_6 and Hg_2O, thus causing air pollution.

The mercury cycle shows that the mercury in ecosystem passes through food chain or by inhalation of dust or ingestion of surface-contaminated food. Mercury pollution can be best assessed by measuring the concentration of total mercury in sediments and also the rate of uptake of methyl mercury by fish.

10.3.8.2 Arsenic

It also has a biological cycle in nature. It is an element that is intermediate between the metals and non-metals. It is more abundant in nature as compared to mercury. In drinking water it may occur at levels of upto 50 ppm, whereas mercury levels commonly do not exceed 1 ppm. Arsenic compounds are known as to accumulate through food chains (Summers and Silver, 1978), with the result that even small doses can be lethal. Severe poisoning of human can be caused by as little as 100 mg, and 130 mg found to be fatal. It occurs in rocks, soils and water at much higher levels than does in mercury. It is found in many vegetables and fruits. Some marine organisms, especially shellfish tend to concentrate arsenic within their bodies, which may contain more than 100 ppm. For example, 174 ppm in prawn, 42 ppm in shrimp, and 40 ppm in bass. In moist soils, it is present upto 500 ppm. It has also been detected at concentration of 10 to 70 ppm in several commonly marketed house hold detergents. It may often stimulate plant growth in very low concentrations, but is injurious in excessive quantities. Destruction of chlorophyll appears to be the main effect. As little as 1 ppm of arsenic trioxides in the water has caused injury into plants. U.S. Public Health Service in 1942 set a safe limit of 0.05 ppm, and in 1962 it recommended a maximum of 0.01 ppm in drinking water. There is also evidence that arsenic accumulates in the livers of mammals. Skin cancer has been found to be associated in several regions with arsenic intake in drinking water.

Arsenate is reduced to arsenite and then microbially methylated to form dimethylarsine and trimethylarsine. The conversion of arsenate through arsenite and methylarsenic acid occurs in lake sediments; di-and tri-methylarsines are released in water. These become oxidized in air to less toxic dimethylarsenic acid. The dimethylarsenic acid is thus cycled between air and sediment (Wood, 1974). Dimethylarsine is highly toxic to fish and other organisms.

10.3.8.3 Lead

The lead is prevalent in the natural environment. The earth's crust contains an average of about 10 to 15 ppm lead, though the content in rock, soil and water is extremely variable. Lead enters the environment in enormous quantities and particularly efficiently dispersed to the atmosphere by the use of tetraethyl and tetramethyl lead as antiknock additives to petrol (gasoline), which may contain about 2 g Pb gal^{-1}. About 2.5 X 108 kg y^{-1} Pb enters the oceans from this source and the mean sea-water concentration has increased almost seven fold during the past 50 years and is now about 0.07 μ g kg^{-1} (Goldberg, 1971).

Normally lead is not strongly absorbed from soil, by plants. The main toxicity hazard is therefore, from inhalation of dust or ingestion of surface-contaminated food. However, plants grown on heavily contaminated soil absorb several thousand $\mu g\ g^{-1}$ compared as the normal plant content of between 1 and 15 $\mu g\ g^{-1}$ (Johnston and Proctor, 1977).

10.3.8.4 Cadmium

Cadmium belongs to same family of elements as zinc and mercury. A major source of cadmium is zinc mining and smelting in addition to its release by other industries such as metal plating, and in making pigments, ceramics, photographic equipments, and nuclear reactors as well as those engaged in textile printing, lead mines and various chemical industries.

There is no evidence that cadmium has any role in nutrition of plants and animals. It is toxic in relatively small amounts. Being highly mobile in soil and water it is taken up freely by plants and passed on to grazing food chain (Coughtrey and Martin, 1976). In animals and humans, cadmium tends to accumulate in kidneys, pancreas and bones. In Japan the disease itai itai was caused by people's consumption of heavy metals, primarily cadmium either by drinking water or by eating rice which had accumulated the metal from the irrigation water. The affliction is characterized by kidney malfunction, a drop in phosphate level of blood serum, loss of minerals from the bones, and a condition called osteomalacia, which is a rickets-like condition characterized by pathogenic bone fracture and intense pains.

10.3.8.5 Fluorine

Fluorine makes up about 0.1 per cent of the earth's crust. In its elemental state it is a gas. However, in nature it is always found in various combinations. The greater proportion is in the form of the mineral fluorspar (Calcium fluorate, CaF) and in large deposits of mineral cryolite (sodium aluminium fluoride, NaAIF). Sources of atmospheric fluorine are aluminium smelting using cryolite as a flux, coal burning and the firing of clays in brick manufacture.

Fluorine is freely mobile in the atmosphere and ultimately appears in rainfall as fluoride. Plants take it from soil and water. In gaseous form, it enters open stomata, causes collapse of mesophyll cells, loss of photosynthetic activity and necrosis. Animals derive it from food, water, and minerals. The effect on tooth decay from drinking the water deficient in fluorine was noted. On the other hand, teeth impairment, called dentineri or black teeth, was observed among people.

10.4 Food Chains

The transfer of food energy from the source in plants through a series of organisms with repeated stages of eating and being eaten is known as the food chain. The green plants, in the food chain, occupy the first trophic (nutritional or energy) - the producer level, the herbivores that eat the plants the second trophic - the primary consumer level, the carnivores that eat the herbivores the third trophic - the secondary consumer level and perhaps even a fourth- the tertiary consumer level. Some organisms are omnivores that eat the plant as well as animals at their lower level in the food chain and they may occupy more than one trophic level in the food chain. Thus, in any food chain, energy flows from producers -----> primary consumers (herbivores) -----> secondary consumers (carnivores) A tertiary consumers (carnivores), and so on. At each step of food transfer, a large proportion, 80 to 90% of the potential energy is lost through dissipation of heat resulting in continuous diminution of available energy. This is the reason that rarely more than five trophic levels occur in a food chain. The efficiency of energy transfer also varies from one trophic level to another.

In nature, three types of food chains have been distinguished:

10.4.1 Grazing food chain

The consumers which utilise the living plant parts as their food or energy source constitute the grazing food chain. The food chain, thus begins from a green plant base. It is common in the terrestrial and aquatic ecosystems where most of the primary production is edible by herbivores. Some of the common examples of grazing food chain are given in Table 10.2

10.4.2 Parasitic food chain

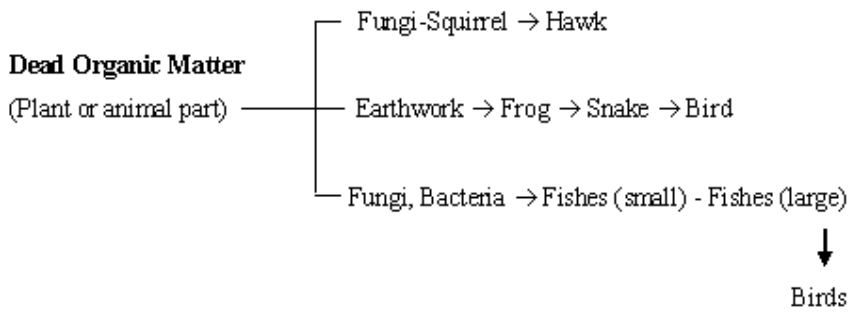
It also begins from a green plant base and goes to herbivores, which may be the host of a huge number of lice living as ectoparasites.

10.4.3 Detritus food chain

The food chain goes from dead organic matters of decaying animal and plant bodies to the microorganisms and then to detritus feeding organisms (detrivores or saprovores) and their predators is known as "detritus food chain". Soil organisms are thus less dependent on direct solar energy and depend chiefly on the influx of organic matter produced in another system. This is very clear from the following illustration:

Table 10.2 Some examples of grazing food chains

Type	Producer	Primary consumer	Secondary consumer	Tertiary consumer	Quaternary consumer
1	**Aquatic**	Phytoplankton (small fish)	Zooplankton (large fish)	Fish (perch)	Fish (bass) Man
2	**Aquatic terrestrial**	Phytoplankton	Fish (minnow)	Frog	Raccoon
3	**Terrestrial**				
	(a) Grass	Grass Hoper	Frog Snake Hawk or Peacock		
	(b) Grass	Grass Hoper	Birds Hawks or Falcon	-	
	(c) Grass	Rabbit or Dear	Lion -	-	
	(d) Grass	Pig Man	-	-	



A good example of detritus food chain based on mangrove leaves.
Some examples of food chains are shown in Fig. 10.6

In the brackish zone of Southern Florida, leaves of the red mangrove (Rhizophore mangle) fall into the warm, shallow waters. The fallen leaf fragments acted on by such saprotrophs as fungi, bacteria, and protozoa, and colonised by phytoplanktonic and benthic algae are eaten and reeaten by a group

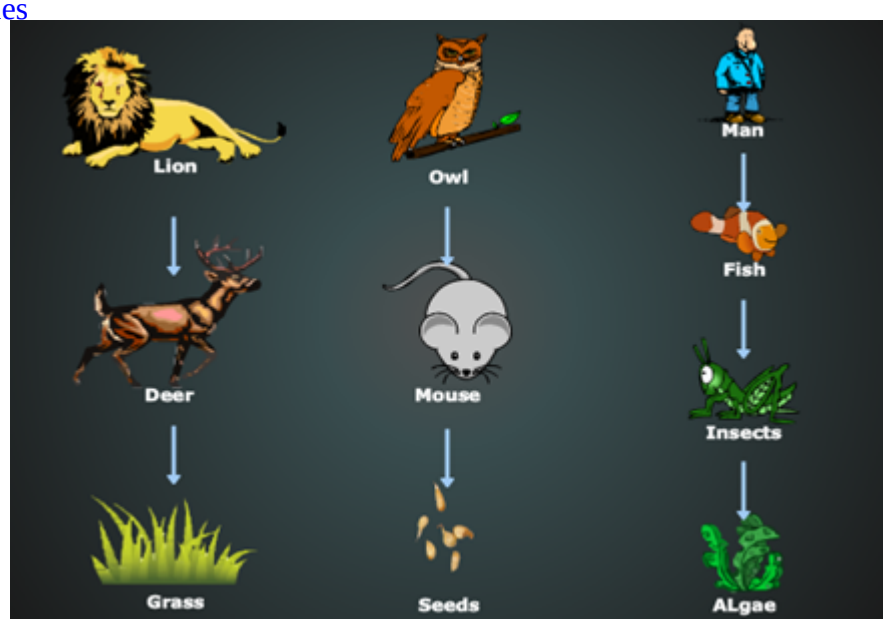


Fig. 10.6

of small animals. These animals include crabs, copepods, insect larvae, mysids, nematodes, grass shrimps, amphipods, etc. All these animals are called detritus consumers. These animals, in turn, are eaten by some minnows, small game fish, etc. The small carnivores, which in turn, serve as the food for large game fish, and so on. Mangrove leaves, through detritus food chain make substantial contribution to the food chain that is upto 90% of the stored energy in the dead organic material is consumed through detritus food chain. This chain is further important from the view point of mineral cycles within the ecosystem.

10.5 Food Web

Food chain, normally do not operate in isolated but are interlocked with each other forming some sort of pattern known as food web. An organism in the ecosystem may operate at more than one trophic level, i.e. it derives its food from more than one source and in turn, may serve as a source of food for several organisms of higher trophic level. This results into linking together, but intersecting each other, of several food chains. Another reason for the formation of food web seems to be successive loss of energy at higher trophic levels till no more energy is available to support yet another link in the food chain. A food web delineated for small organisms of a stream community in South Wales. This illustrates: (i) the interlinking of food chain, (ii) three trophic levels, (iii) intermediate position of the organisms e.g. Hydropsyche, and (iv) an “open” system in which part of the basic food is “imported” from outside the stream.

The food webs are very important in maintaining the stability of an ecosystem, in nature. For example, in grazing food chain of a grassland, (Fig 10.7) in the absence of rabbit, grass may be eaten by mouse. The mouse in turn may be eaten directly, either by hawk or snake. The snake then may be eaten by hawk.

Absence of rabbit thus would not disturb the ecosystem as the alternative (mouse) may serve for the maintenance of its stability. Moreover, a balanced ecosystem is essential for the survival of all the living organisms of the system. For example, if the primary consumers (herbivores) are not in nature than the producers would perish due to overcrowding and competition. In the same way, the survival of the primary consumers is linked with the secondary consumers (carnivores) and so on. Thus each species of an ecosystem is indeed kept under some sort of a natural check so that the system may remain stable.

Fig. 10.7

A food web, unlike a food chain has therefore, several alternative pathways for flow of energy. Sudden decrease in population of one category of consumers at any trophic level does not affect much the functioning of an ecosystem, as at that trophic level, the second category of consumers multiply and build up their numbers. An ecosystem is, therefore, more stable, if it has a greater number of alternative pathways. Some examples of food webs are given in fig. 10.8, 10.9, 10.10.

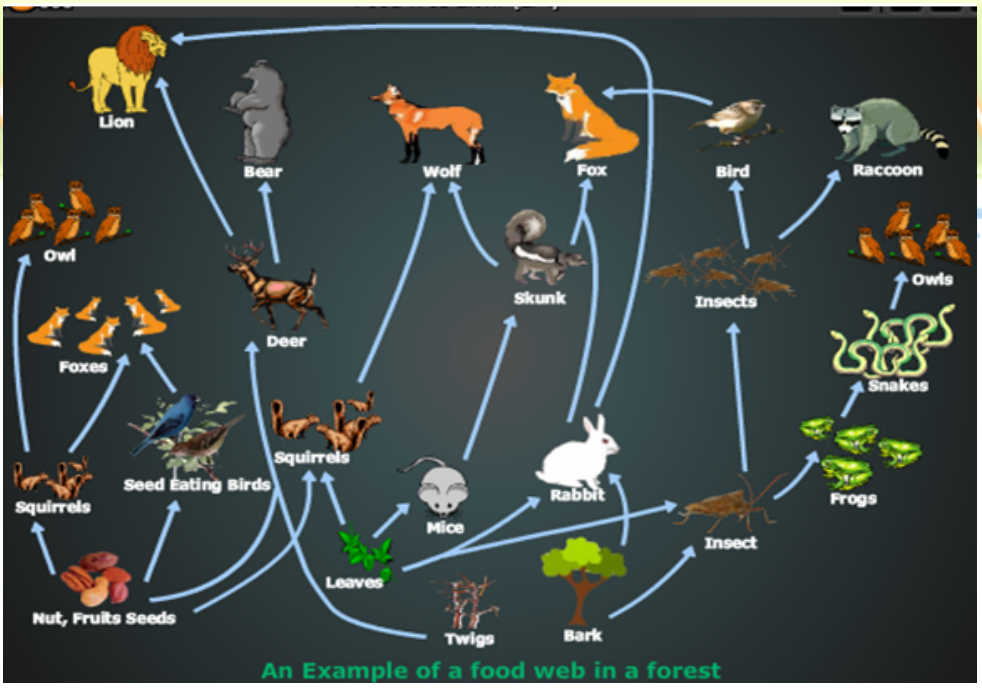


Fig. 10.8

10.6 Ecological Pyramids

The concept of ecological pyramids was developed by Charles Elton (1927), the pioneer British Ecologist. There is some sort of relationship between the number, biomass and energy content of the primary producers, consumers of the first and second orders and so on to top carnivores in the ecosystem. This relationship may be represented graphically by means of pyramids which is referred to as ecological pyramids, where the first or producer level forms the base of the pyramid

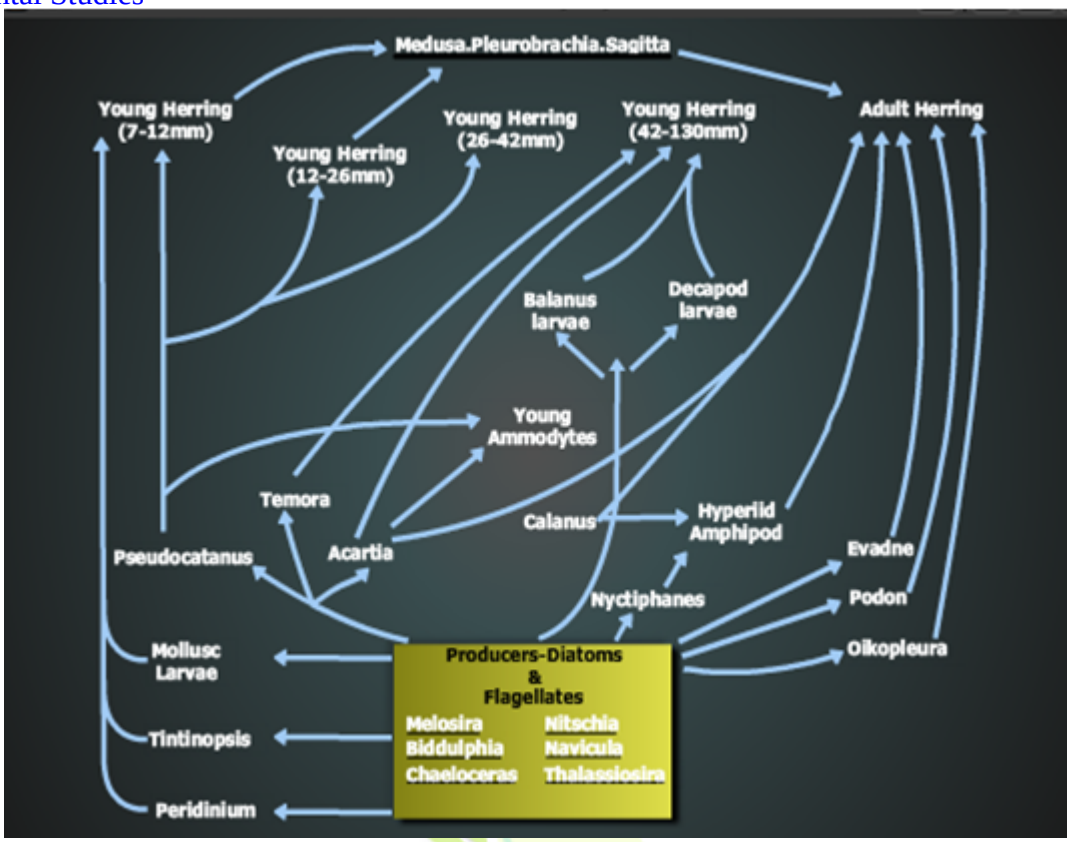


Fig. 10.9

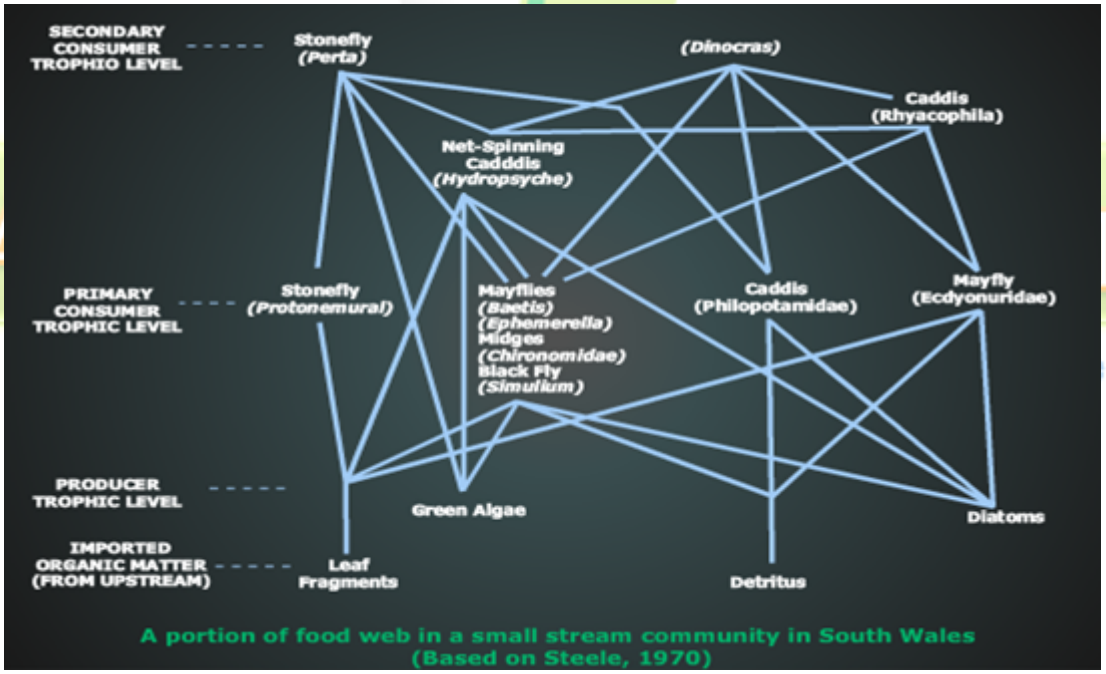


Fig. 10.10

and the successive levels (the tiers) making the apex. Ecological pyramids are of three general types: (i) Pyramid of numbers, showing the number of organisms at each trophic level (number m^{-2}), (ii) Pyramid of biomass, showing the total dry weight or any other suitable measure of the total amount of living matter (g m^{-2}), and (iii) Pyramid of energy, showing the amount of energy flow and/or productivity at successive trophic levels (calories m^{-2} $year^{-1}$).

10.6.1 Pyramid of numbers

The relationship between the number of producers, consumers of primary, secondary and tertiary orders constitutes the pyramid of numbers. The form of the pyramid of numbers will vary widely with different communities, depending on whether producers are small (phytoplankton, grass) or large (oak trees). Sometimes, number of individuals varies so widely that it is difficult to represent the entire ecosystem on the same numerical scale. Such data could best be presented in a tabular form. The pyramids of numbers in grassland, pond, and forest ecosystem are shown in Fig. 10.11, 10.12, 10.13. In a grassland, the producers which are mainly grasses, are always maximum in number. This number then shows a successive decrease towards apex, as the primary consumers (herbivores), which are rabbits, mice, etc., are lesser.

Fig. 10.11

in number than the grasses; the secondary consumers, the snakes and lizards are lesser in number than the rabbits and mice. Finally, the top (tertiary) consumers, the hawks and birds, are least in number. Thus, the pyramid becomes upright. Similarly, in pond ecosystem, the pyramid is upright. Here the producers, which are mainly phytoplanktons as algae, bacteria, etc. are maximum in number; the herbivores which are very small fish, rotifers, etc., are lesser in number than the producers; and the secondary consumers (carnivores), such as water beetles and small fish, etc., are lesser in number than the herbivores. Finally, the top (tertiary, consumers), the bigger fish and birds are least in number.

Fig. 10.12

In a forest ecosystem (Fig. 10.12), however, the pyramid of numbers is somewhat different in shape the producers which are mainly large-sized trees are lesser in number, and form

Fig. 10.13

base of the pyramid. The herbivores, which are the fruit eating birds, deers, etc., are more in number than the producers. Then, there is a gradual decrease in the number of successive carnivores, thus making the pyramid again upright one.

However, in a parasitic food chain (Fig. 10.14), the pyramids are always inverted. This is due to the fact that a single plant may support the growth of many herbivore birds and each one of these, in turn, may provide nutrition to several hyperparasites like bugs and lice. Thus from the producers towards consumers, the number of organisms successively shows an increase, making the pyramid inverted one. In crop ecosystem, the pyramid is upright one where primary consumers, viz., grasshoppers are lesser in number than the crops; frogs, snakes, and eagle- the primary, the secondary and the top consumers respectively are present in decreasing number.

Fig. 10.14

10.6.2 Pyramids of biomass

In this type of pyramid, the relationship between different trophic levels is presented in terms of weight of organisms (biomass). The pyramids of biomass in different ecosystems are shown in Fig. 10.15. In grassland and forest, there is generally a gradual decrease in mass of organisms at successive levels from the producers to the top consumers. Thus, pyramids are upright. In an aquatic ecosystem (like pond), however, the biomass of producers is least. This value gradually shows an increase towards the apex of the pyramid, thus making the pyramid inverted one. In this case the biomass of diatoms and phytoplanktons (primary consumers) that feed on them. The biomass of large carnivore fishes (secondary consumers) which feed on smaller fishes is the highest of all the trophic levels. In English Channel the biomass of primary producers is only 4 g m^{-2} whereas that of the consumers is 21 g m^{-2}. Infact, this is the case in most aquatic bodies . In lakes and sea, on the other hand, the phytoplanktons usually outweigh their grazers (zooplanktons) during periods of high primary productivity, as during the spring "bloom", but at other times, as in winter the reverse may be true. This difference in biomass trend can be explained if the time is also taken into account.

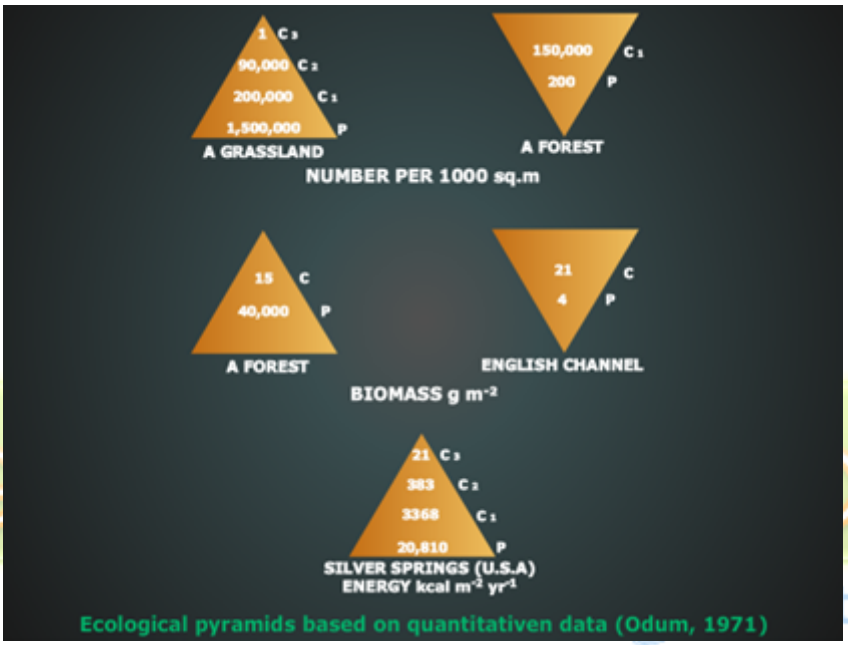


Fig. 10.15

10.6.3 Pyramid of energy

The pyramid of energy represents the total quantity of energy utilized by different trophic level organisms of an ecosystem per unit area over a set period of time (usually, per square metre per year). The primary producers of an ecosystem trap the radiant energy of the sun and covert it into potential chemical energy. This trapped energy flows in the food chain from the producers to the top carnivores, decreasing at successive trophic levels. If the relationship of total quantity of energy utilized in unit area over a particular period of time by different trophic levels is diagrammatically represented, an upright pyramid is invariably formed. As against the pyramid of numbers and biomass, the shape of the pyramid of energy is always upright because in this the time factor is taken into account. In a grassland the green plants (primary producers) trap the maximum light energy in a particular area over a fixed period of time. Similarly, in a pond ecosystem, the phytoplanktons, in a particular area, trap and accumulate much more energy than the herbivore fishes in the course of year because of their large numbers and quicker rate of multiplication. Comparatively, the amount of energy utilized in a year by the top carnivores is much less than that of herbivore fishes.

Of the three types of pyramids as discussed above, the energy pyramid gives by far the best overall picture of the functional role of communities in an ecosystem. This is because of the fact that energy pyramid is a picture of rate of passage of food mass through the food chain, whereas number and biomass pyramids are pictures of standing states, i.e. organisms present at any moment. Its shape is invariably an upright one, and not affected by variation in the size and metabolic state of individuals, if all the sources of energy in the ecosystem are considered. The number and biomass pyramids on the other hand, may be upright or inverted depending upon the size and biomass of the producer organisms as compared to consumers.

10.7 Ecological succession

Ecological succession is the phenomenon or process by which an ecological community undergoes more or less orderly and predictable changes following disturbance or initial colonization of new habitat. Succession was among the first theories advanced in ecology and the study of succession remains at the core of ecological science. Succession may be initiated either by formation of new, unoccupied habitat (e.g., a lava flow or a severe landslide) or by some form of disturbance (e.g. fire, severe wind throw, logging) of an existing community.

10.7.1 Primary Succession

Succession that begins in new habitats, uninfluenced by pre-existing communities is called primary succession. In primary succession pioneer species like lichen, algae and fungus as well as other abiotic factors like wind and water start to "normalize" the habitat. This creating conditions nearer optimum for vascular plant growth; pedogenesis or the formation of soil is the most important process.

These pioneer plants are then dominated and often replaced by plants better adapted to less odd conditions, these plants include vascular plants like grasses and some shrubs that are able to live in thin soils that are often mineral based.

For example, spores of lichen or fungus, being the pioneer species, are spread onto a land of rocks. Then, the rocks are broken down into smaller pieces and organic matter gradually accumulates, favouring the growth of larger plants like grasses, ferns and herbs. These plants further improve the habitat and help the adaptation of larger vascular plants like shrubs, or even medium- or large-sized trees. More animals are then attracted to the place and finally a climax community is reached.

10.7.2 Secondary succession

Succession that follows disruption of a pre-existing community is called secondary succession. (e.g. forest fire, harvesting, hurricane) that reduces an already established ecosystem (e.g. a forest or a wheat field) to a smaller population of species, and as such secondary succession occurs on preexisting soil whereas primary succession usually occurs in a place lacking soil.

Simply put, secondary succession is the succession that occurs after the initial succession has been disrupted and some plants and animals still exist. It is usually faster than primary succession as:

1. Soil is already present, so there is no need for pioneer species;
2. Seeds, roots and underground vegetative organs of plants may still survive in the soil.

ENVIRONMENTAL STUDIES

Module 3. Ecosystems

Lesson 11
CHARACTERISTIC FEATURES OF VARIOUS ECOSYSTEMS

11.1 Homeostatis, Management and Optimization of Ecosystem

Ecosystems are capable of self-maintenance and self-regulation as their component population and organisms. However, they have a delicate balance of inputs and outputs, and this balance is often insufficient to avoid instability. The term homeostatis (homeo = same; statis = standing) is generally applied to the tendency for biological system to resist change and to remain in a state of equilibrium. An essential feature of such regulatory mechanism is the process of feedback operating both at the level of individual and the entire system.

Many of the large-scale human activities- industrial, agricultural or transport - tend to alter the natural balance of biotic and abiotic components in a stable ecological system. These activities frequently lead to acceleration of hydro geochemical cycles, disturbance of input-output balances, accumulation of toxic substances such as hydrocarbons, metals and gases, overproduction or depletion of certain essential substances, and eutrophication. All these involve simplification of ecosystem resulting into shortening of food webs, decrease in species diversity and counteraction of forces of natural selection and organic evolution has developed a theory of ecosystem stability based on energy-matter constraints in living systems. Some important features of the theory are:

1. Ecosystems have a zero state trending tendency, pertinent to stability. The concept of stability incorporates two ideas, (a) resistance to change, and (b) restoration to the near original state after the change has occurred;
2. Curtailment of energy and material inputs tends to lead decay or extinction of ecosystems to zero state; such decay is guaranteed by the second law of thermodynamics;
3. Ecosystems have only one free (unforced) equilibrium, the zero state;
4. Ecosystems tend to revert to nominal, no equilibrium dynamics when perturbed by uniformly vanishing disturbances;
5. Ecosystems have only one forced steady state;
6. Ecosystems are structurally stable;
7. Ecosystems adapt and evolve in small degrees by parameter variation within fixed structure, and
8. Ecosystems adapt and evolve in large degrees by structure variation.

Proper management is essential for maintaining the stability of the ecosystem. This will require an adequate knowledge of the nature and kinds of system components, functional relationship between them, and the degree of tolerance and resistance to the environmental strain and stress has listed the following features contributing to stabilization of ecosystem: (a) tolerance to extreme and harsh conditions, (b) ability for rapid recovery upon the

recurrence of favourable growth conditions, (c) flexible and opportunistic feeding habitat, (d) nomadic migration of animals, etc. Similarly, some destabilizing features include: (i) sensitivity to damage to reserves, (ii) sensitivity to lagging components, (iii) low density, biomass and productivity, and (iv) sensitivity to soil erosion.

11.2 Evolution of Ecosystems

Life began on earth more than three billion years ago. The first ecosystems then were populated by tiny anaerobic heterotrophs that lived on organic matter synthesized by abiotic processes. Following the origin and population explosion of algal autotrophs, which converted a reducing atmosphere into an oxygenic one, organisms have evolved through the long geological ages into increasingly complex and diverse systems that (i) have achieved control of the atmosphere and (ii) are populated by larger and more highly organized multi cellular species. Within this community component, evolutionary change is believed to occur principally through natural selection at below the species level, but natural selection above this level may also be important, especially (i) co evolution, i.e., the reciprocal selection between interdependent autotrophs and heterotrophs, and (ii) group or community selection, which leads to the maintenance of traits favourable to the group. Similarities between major biomass or ecosystems in respect to ecosystem structure and function can be attributed to evolutionary convergence as a consequence of their evolution under similar environmental conditions.

11.3 Major Ecosystems

11.3.1 Introduction

Various ecosystems like a pond, a lake, a river, a stream, a spring, an estuary, the sea, a forest, grassland, a desert, a coral reef and a cropland are operating as self-sufficient interacting systems in the biosphere. These ecosystems have a more or less similar fundamental plan of their gross structure and function. However they differ in respect of their species composition and productivity rates. In brief, organization pattern of some of the major ecosystems is described here.

11.3.2 The forest ecosystem

Forests are natural plant communities with dominance of phanerophytes and occupy nearly 40% of the land. In India, the forests occupy roughly 10% of the total land area. According to Champion and Seth (1968), Indian forests are of 11 types, which are classified on the basis of physiography, physiognomy floristics, habitat etc. The different components of forest ecosystems are as follows:

11.3.2.1 Abiotic components

These include inorganic and organic substances present in the soil and atmosphere. The climate (temperature, light, rainfall, etc.) and soil (minerals) vary from forest to forest. In addition to minerals the occurrence of litter is characteristic feature of majority of forests.

11.3.2.2 Biotic components

a) Producers

These are mainly trees that show much species diversity and greater degree of stratification especially in tropical moist deciduous forests. Besides trees, there are also present shrubs and ground vegetation. In these forests, the producers include the dominant tree species such as Tectona grandis, Butea frondosa, Shorea robusta and Lagerstroemia parviflora. In temperate coniferous forests, shrubs and ground flora are insignificant. In temperate deciduous forests the dominant trees are species of Quercus, Acer, Betula, Thuja, Picea, etc., whereas in temperate coniferous forests, the producer trees are species of Abies, Picea, Pinus, Cedrus, Juniperus, Rhododendron, etc.

b) Consumers

These are as follows:

i) Primary consumers

These are the herbivores that include smaller animals feeding on tree leaves as ants, flies, bettles, leaf hoppers, bugs, spiders, etc., and larger animals grazing on shoots and/ or fruits of producers as elephant, neelgai, deer, moles, squirrels, shrews, flying foxes, mongooses, etc.

ii) Secondary consumers

These are the carnivores like snakes, birds, lizards, fox, etc. feeding on the herbivores.

iii) Tertiary consumers

These are the top carnivores like lion, tiger, etc., that eat carnivores of secondary consumers level.

c) Decomposers

These are wide variety of microorganisms including fungi (species of Aspergillus, Polyporus, Alternaria, Fusarium, Trichoderma, etc.), bacteria (species of Bacillus, Pseudomonas, Clostridium, etc.), and actinomycetes (species of Streptomyces). Rate of decomposition in tropical and subtropical forests is more rapid than in the temperate ones.

11.3.3 The grassland ecosystem

Grasslands occupy roughly 24% of the earth's surface (Shantz, 1954). Whyte (1957) divided grassland into 8 types based on the floral characteristics. The different components of a grassland ecosystem are:

11.3.3.1 Abiotic components

These include nutrients present in soil and the atmosphere. Thus the elements like C, H, O, N, P, S, etc. are supplied by carbon dioxide, water, nitrates, phosphates and sulphates present in air and soil of the area.

11.3.3.2 Biotic components

These are as follows:

a) Producers

They are mainly grasses, as species of Dichanthium, Cynodon, Desmodium, Dactyloctenium, Digitaria, Setaria, Sporobolus, etc. Besides them a few forbs and shrubs also contribute to primary production.

b) Consumers

These are as follows:

i) Primary consumers

The herbivores feeding on grasses are mainly such grazing animals as cows, buffaloes, deers, sheep, rabbit, mouse, etc. Besides them, there are also present some insects as Leptocorisa, Dysdercus, Oxyrhachis, Cicindella, Coccinella, some termites and millipeds, etc. that feed on the leaves of grasses.

ii) Secondary consumers

Snake, lizard, birds, jackals, fox, etc. are common secondary consumers which feed on herbivores.

iii) Tertiary consumers

These include hawks which feed on secondary consumers.

c) Decomposers

Several fungi (Mucor, Aspergillus, Penicillium, Cladosporium, Rhizopus, Fusarium, etc.), actinomycetes and bacteria decay the dead organic matter of different forms of higher life. They bring about minerals back to the soil, thus making them available to the producers.

11.3.4 Cropland ecosystem

This is an artificial or man - engineered ecosystem aimed primarily to grow a single species of one's choice. To secure maximum production, man makes much planned manipulation in the physico-chemical environment. These include addition of fertilizers to the soil, use of chemicals for disease control, proper irrigation practices, etc. This may include the dominant species like maize, sugar-cane, jowar, paddy, vegetables, etc. The following are the main components of a maize cropland ecosystem:

11.3.4.1 Abiotic components

These include the climatic conditions of the region, where the crop may grow most successfully, and the various minerals and gaseous elements such as C, H, O, N, P, K in soil and atmosphere. Maize generally grows best in slightly alkaline soil with good aeration.

11.3.4.2 Biotic components

These occur in the following order:

a) Producers

In the field, in addition to dominant species of maize, a number of weeds like Cynodon dactylon, Launaea nudicaulis, Euphorbia hirta, Cyperus rotundus, Digitaria species., and Alysicarpus also contribute to primary production of the field.

b) Consumers

These are as follows:

i) Primary consumers

These are herbivores. The smaller animals include chiefly the insects as aphids, thrips, beetles, etc., which feed and lay their eggs on maize leaves. The larger animals include birds, rats, rabbits and man feeding on leaves, flowers and fruits on the crop.

ii) Secondary consumers

These are carnivores like frogs and some birds that eat insects.

iii) Tertiary consumers

Snakes and hawks belong to this category which can eat frogs and small birds, respectively.

c) Decomposers

Several microbes such as actionmycetes, fungi and bacteria found in soil and climate decompose dead organic matter of plants as well as animals and help in circulation of minerals making available them to producer again.

11.3.5 The desert ecosystem

The areas with an annual rainfall of less than 25 cm come in deserts. They occupy about 17% of land. Due to extremes of both, water and temperature factors the biota is much more varied and is poorly represented. The various components of the ecosystem are:

11.3.5.1 Abiotic components

In desert ecosystem temperature is found to be very high and rainfall is very low. A dry atmosphere, high temperature and intense illumination favour the rate of transpiration.

11.3.5.2 Biotic components

These are as follows:

a) Producers

These are shrubs, especially bushes, some grasses, and a few trees. The shrubs have widespread branched root system with their leaves, branches and stems variously modified. Sometimes a few succulents like cacti are also present. Some lower plants like lichens and xerophytic mosses may also be present.

b) Consumers

Insects, reptiles, nocturnal rodents, birds, camels, etc. are the main consumers.

c) Decomposes

These are very few, as due to poor vegetation the amount of dead organic matter is correspondingly less. They are some fungi and bacteria, most of which are thermophilic.

11.3.6 The mountain ecosystem

The chief components of the ecosystem are:

11.3.6.1 Abiotic components

It is the altitude which provides different climates.

11.3.6.2 Biotic components

These are as follows:

a) Producers

They differ to difference in climatic conditions even on the same mountain e.g., in the forests, trees are the main producers, while in desert the chief producers are shrubs, herbs and only a few trees.

b) Consumers

They vary with the type of producers in the area.

11.3.7 Cave ecosystem

A cave is a natural hollow opening under the surface of the earth, or a mountain or a hill. Many caves are found in North America and Europe, e.g., Mammoth cave in North America. The main components of the cave ecosystem are as follows:

11.3.7.1 Abiotic components

Absence of light is the most striking feature since it has telling effect on the cave dwelling organisms. Temperature is nearly uniform, except some fluctuations with the depth of the cave. Several fluctuations in moisture level occur. Atmospheric pressure varies as that of the terrestrial environment.

11.3.7.2 Biotic components

These are as follows:

a) Producers

They are almost absent.

b) Consumers

Both vertebrates and invertebrates of cave dwelling existence are found. They may be temporary, such as bats, owls, etc., or permanent, such as turbellarians, Leeches, insects, etc., (invertebrates). Mammals are rare; birds are absent.

c) Decomposers

Fungi and bacteria are present

11.3.8 Tundra ecosystem

Tundra means a barren land or a hostile territory. Tundra biomes occur in the polar regions in northern Canada, Greenland, other islands of Arctic oceans, and northern Europe (northern hemisphere). Since, Antarctic Ocean has not been exploited much; this biome has been designated as Arctic Tundra. Tundra biome also occurs on the peaks of High Mountain of world and has been called as the Alpine Tundra. The chief components of the Tundra ecosystem are as follows:

11.3.8.1 Abiotic components

These include temperature, light, moisture, pressure, soil, etc. Of these temperature exerts a very powerful influence so that only a few organisms have successfully got adapted to the Tundra conditions. In the Arctic Tundra, the winters are very long and cold, during which the ground remains frozen. The summer is short and sharp during which snow melts to some depth only, hence the deeper layer of soil remains permanently frozen and is known as permafrost. Due to this Tundra soil is very shallow. In the Alpine Tundra, Alpine climate prevails.

11.3.8.2 Biotic components

These are as follows:

a) Producers

Suitable conditions for plant growth exist only for about 60 days. The dominant producers are the hardiest of plants like bushes, lichens, mosses, grasses and grass like herbs.

b) Consumers

These include mammals like carbou, hares, reindeers, foxes, and polar bears, amphibians and reptiles are totally absent. However, some species of birds and insects are present. The insects are represented by black flies, bumble bees, etc. The birds are migratory and are represented

by arctic loon, goose, hawks, gulls, larks, etc. The South Pole has only marine birds, penguins. The fauna of Alpine Tundra varies with the type of vegetation.

11.3.9 The pond ecosystem

A pond is a good example of a small self-sufficient and self-regulating ecosystem. Location, size, depth and substratum of a pond influence the biology of pond ecosystem. The components of the systems are as follows:

11.3.9.1 Abiotic components

Temperature, light, water, and several inorganic and organic substances like CO_2, O, N, PO, Ca, S, and carbohydrates, proteins and lipids make abiotic components. Some proportions of nutrients are in solution state but most of them are present stored in particulate matter as well as in living organisms. The amount of minerals present at any time in the physical environment of the pond is called standing state.

11.3.9.2 Biotic components

These include:

a) Producers

They are green plants and photosynthetic bacteria categorized into two types:

i) Macrophytes

Ceratophyllum, Hydrilla, Utricularia, Vallisneria, Jussiaea, Nitella, Wolfia, Lemna, Spirodella, Pistia, Eichhornia, Azolla, Salvinia, Trapa, Typha, Marsilea, etc. are included in this category. This may be classified further into submerged, free floating and amphibious plants.

ii) Phytoplanktons

These are minute floating or suspended lower plants belong to some algae and flagellates. Ulothrix, Spirogyra, Oedogonium, Chlamydomonas, Zygnema, Volvox, Pandorina, Cosmarium, Scendesmus, Closterium, Anabaena, Pediastrum, Microcystis, diatoms, etc. are common algal phytoplanktons.

b) Consumers

These are as follows:

i) Primary consumers

(a) Zooplankton comprises ciliates, flagellates, other protozoans, small crustacean like Copepods and Daphnia, etc. These animals drift with the water current and are found along with phytoplankton upon which they feed. (b) Benthos or bottom forms comprise the bottom dwelling animals, e.g., annelids and mollusks which feed on plants directly or on plant remains at the bottom.

ii) Secondary consumers

These are the carnivores which feed on the herbivores, e.g. insects and fish.

iii) Tertiary consumers

These are some large fish as game fish that feed on the smaller fish.

c) Decomposers (or microconsumers)

Several bacteria, fungi (Aspergillus, Cephalosporium, Pythium, etc.) and actinomycetes represent the group.

11.3.10 The ocean (marine) ecosystem

The oceans of the world cover approximately 36,10,00,000 km2, i.e. about 71% of the earth's surface. Atlantic, Pacific, Indian, Arctic and Antarctic are the main oceans of the world. The ocean represents a very large and stable ecosystem. The main components of the ocean ecosystem are as follows:

11.3.10.1 Abiotic components

Marine environment, as compared with fresh water, appears to be more stable in chemical composition due to being saline (35 parts of salts by weight per 1000 parts of water, while salinity of fresh water is less than 0.5%), and moreover other physico-chemical factors such as dissolved oxygen content, light and temperature are also different. About 27% is NaCl; most of the rest consists of Ca, Mg, and K salts. Water is strongly buffered. The concentration of dissolved nutrients is low and constitutes an important limiting factor to determine the size of marine populations. Waves of various kinds and tides prevail there. Like ponds and lakes, ocean show distinct zonation.

11.3.10.2 Biotic components

This category includes phytoplanktons and larger marine plants. The former group includes diatoms and dinoflagillates. The latter group includes sea weeds (algae) belonging to chlorophyceae, phaeophyceae and rhodophyceae; and angiosperms. Ruppia, Zostera, Posidonia, Halophila, Enhalus, etc. are true marine angiosperms while various species of Rhizophora, Avicennia, Sonneratia, Carapa, Aegiceros, etc., represent the mangrove complex-tidal woodlands

a) Consumers

These are heterotrophic macroconsumers, being dependent for their nutrition on the primary producers. These are:

i) Primary consumers

The herbivores that feed directly on producers are chiefly crustaceans, mollusks, fish, etc.

ii) Secondary consumers

Carnivorous fishes, such as Herring, Shad, Mackerel, etc. are included in this group.

iii) Tertiary consumers

Fishes like Cod, Haddock, etc. are the tertiary or top consumers.

b) Decomposers

They are chiefly bacteria and some fungi which participate actively in decomposition of dead organic matter.

11.3.11 Estuarine ecosystem

An estuary is a semiclosed coastal body of water that has a free connection with sea. It is strongly affected by tidal action, and within it sea water is mixed with fresh water from land drainage. River mouths, coastal bays, tidal marshes and bodies of water behind barrier beaches are some of the examples. Estuaries are generally productive because of water flow subsidises an abundant of nutrients. The chief biotic components of estuarine ecosystem are as follows:

a) Producers

Macrophytes- marsh grasses, sea weeds, sea grasses, benthic algae and phytoplankton.

b) Consumers

Oysters, crabs, several kinds of shrimp and many commercial sport fish.

11.3.12 Coral reef ecosystem

A coral reef represents one of the most beautiful and well adapted ecosystems to be found in the world. Coral reefs are made up of calcareous skeletal remains and secretion of corals and certain algae. They are confined largely to the warm waters of the Pacific and Indian oceans. A few coral reefs also occur elsewhere. The reef-building corals grow best in waters having an average annual temperature of about 24°C at a depth of about 40-50 metres. They can survive neither sudden temperature changes nor prolonged exposure to temperature below 18°C. They also require for their growth rocky floor and sunlit water having normal salinity of 35g I-1. They cannot grow in fresh or turbid waters or on highly saline lagoons.

Reef structures are built around islands and volcanic peaks by coral and other lime-secreting minute animals. Corals build protective shells of calcium carbonate around their bodies, which after their death, sink and accumulate on the sea bottom. Coral families usually produce forms that resemble branching trees or shrubs. In due course, the inner-spaces between the branching coralline structures are filled up by the deposition of calcium carbonate either by lime-secreting organisms or by debris brought by sea waves. Apart from polyps (corals), a number of organisms and plants such as calcareous algae, bryozoans, molluscs and microscopic protozoans (foraminifera) take part in building coral reefs.

11.3.13 Microecosystem

These are little self-contained worlds, in bottles or other containers that simulate in miniature the nature of ecosystems. Completely closed microecosystems (or microcosms) that require only light energy are very difficult to have on a small scale. Experimental microcosms usually vary from partially closed systems having outlets and inlets only for gaseous exchange with the atmosphere to very open systems involving assemblages of organisms maintained in various kinds of chemostates and turbidostates with regulated flux of both nutrients and organisms. Well-designed microcosms may exhibit most of the basic functions and trophic structures of an ecosystem, except the reduction in variety and size of constituent components. Microcosms are suitable for the study of nature and functions of the ecosystems in laboratory.

11.3.14 Spacecraft as an ecosystem

During space travel for a short journey, such as a few orbits around the earth, man does not require to take along with him a self-sustaining ecosystem since sufficient oxygen and food can be stored in the capsule to last for a short time. However, for a long journey involving a number of astronauts, such as an expedition to one of the planets he must devise some self-contained system so as to get at least minimum requirements, necessary for his smooth working and survival, as in nature. Such a self-contained space-craft must include all four of the basic components producers, consumers, decomposers, and abiotic components in such proportion and diversity as to maintain a stable environment capable of adjusting to the incoming solar radiation as do the earth's ecosystems. A small capsule with a few components might function outside the biosphere for a short time, but a larger, more diverse system would be more stable and safer for a longer time. Engineers and environmentologists associated with such a planning, however, could not able to decide as yet on the size and composition of self-contained system that might function completely independent of other ecosystems during a long space journey.

ENVIRONMENTAL STUDIES

Module 4. Biodiversity and its conservation

Lesson 12
INTRODUCTION TO BIODIVERSITY

12.1 The Concept of Biodiversity

The term biodiversity is a relatively new term. It is a contraction of 'biological diversity'. Simply stated, biodiversity is the variety of life on earth and its myriad of processes. It includes all life forms – from the unicellular fungi, protozoa and bacteria to complex multicellular organisms such as plants, birds, fishes and mammals. According to the World Resources Institute – "Biodiversity is the variety of the world's organisms, including their genetic diversity and the assemblage they form. It is the blanket term for natural biological wealth that undergirds human life and well-being. The breadth of the concept reflects the inter-relatedness of genes, species and ecosystems. Because genes are the components of species, and species are the components of ecosystems. Therefore, altering the make-up of any level of this hierarchy can change the others – species are central to the concept of biodiversity'.

Since biodiversity covers a wide range of concepts and can be examined at different levels; therefore, it has now become customary to study the concept of biodiversity at three hierarchical levels.

12.1.2 Genetic diversity

Within any given species, there can be several varieties, strains or races which slightly differ from each other in one or more characteristics such as size, shape, resistance against diseases, pests, insects, etc., and resilience to survive under adverse environmental conditions. Such diversity in the genetic make-up of a species is termed as the 'genetic diversity'. In other words 'genetic diversity', is the variety of building blocks found within individuals of a species. The species having large number of varieties, strains or races are considered as rich and more diverse in its genetic organization. The differences between individual organisms arise from variation in the genetic material possessed by all organisms and passed on to successive generations (heritable variation), and from environmental influence on the growth and development of each individual organism. Heritable variation serves as the raw material for both, evolution by natural selection and by artificial selection, and is ultimately the basis for all biodiversity.

Opportunities for evolutionary change, the survival of species and the formation of new species are in part a function of the amount of genetic diversity in populations. The various applications of biotechnology, such as crop or animal breed improvement, depend on the identification of genetic material that give rise to desirable traits and the incorporation of this genetic material in appropriate organisms.

12.1.3 Species diversity

In practice, most attention is generally given to 'species diversity'. It refers to the number of different kinds of organisms found at a particular place, and how it varies from place to place and even seasonally at the same place. In terms of species diversity, it must be noted that merely counting the number of species is not enough to describe biological diversity. Diversity has to do with the relative chance of seeing species as much as it has to do with the actual number present. A community in which each species has the same number of individuals as all others would be the most diverse; whereas, a community with one species making up most of the individuals would be least diverse. Further, species that are very different from each other contribute more to overall diversity than species which are similar to each other.

12.1.4 Ecosystems diversity

Ecosystem diversity is generally assessed in terms of the global or continental distribution of broadly-defined ecosystem types, or in terms of the species diversity within ecosystems. It is the distinctive assemblage of species that live together in the same area and interact with their physical environment in unique ways. A system having the component species present in nearly equal abundance is considered as more diverse than one having extremes of high and low abundance.

12.1.5 Landscape diversity

Sometimes, the phrase 'landscape diversity' is used on a broad regional scale. It refers to size and distribution of several ecosystems and their interaction across a given land surface.

12.2 The Biogeographic Zones of India

India is recognized to be uniquely rich in biodiversity. Here, almost all the biogeographic zones of the world are represented. According to a recent classification done by the Wild-life Institute of India, the country's biological wealth can be seen as representing about ten broad biogeographical zones (Fig. 12.2). Each of these ten biogeographic zones has characteristic biota, and broadly represents similar climatic conditions and constitutes the habitat for diverse species of fauna and flora.

12.2.1 Trans-Himalayan zone

The Trans-Himalayan zone, spreads over an area of about 1,86,000 sq.km. With its sparse mountain vegetation type it has the richest wild sheep and goat community in the world. The snow leopard is found here, as is the migratory black-necked crane.

12.2.2 Himalayan zone

The Himalayan zone extends from north-west region of Kashmir to the east upto NEFA (North East Frontier Area). It encompasses an area of about 3,47,000 sq.km and comprises of four biotic provinces--north-west, west, central and east Himalayas. Altitudinally there are three zones of vegetation in the Himalayan zone corresponding to three climatic belts. First, the sub-montane or lower region (tropical and subtropical), that extends from plain foot of the hill upto 5,000 to 6,000 ft. altitude, has vegetation dominated by trees of Acacia catechu,

Cedrala toona, Eugenia jambolana, Albizzia procera, etc. Second, the temperate or montane zone (ranges between 5,500 to 12,000 ft. altitude) has vegetation dominated by Pinus excelsa, Cedrus deodara, Cedrela, Eugenia, etc. in the lower region, and confers such as Abies pindrow, Picea morinda, Juniperus, Taxus baccata, etc. in the upper regions. Third, the alpine zone (above 12,000 ft.) is the limit of tree growth (known as 'timber or tree line'), where the shrubby growth of Betula utilis, Juniperus and Rhododendron is found in grassy areas. At about 15,000 ft. and above snow-line, plant growth is almost nil.

12.2.3 Desert zone

The desert zone comprises of three biotic provinces, viz. Kutch, Thar and Ladakh. The north-west Desert region (Kutch and Thar) spreads over an area of about 2,25,000 sq.km. and consists of parts of Gujarat, Rajasthan, Haryana and Delhi. The climate of this region is characterized by very hot and dry summer, and cold winter. Rainfall here is less than 700 mm. The north-west desert region has extensive grasslands. The plants are mostly Xerophytic, such as Acacia nelotica, Prosopis spicifera, etc.; and the ground vegetation is dominated by the species Calotropis, Eleusine, Panicum antidotale, etc. The Great Indian Bustard, a highly endangered species, is found in this north-west desert region. The Ladakh region, on the other hand, has sparse vegetation – it is a cold desert region.

12.2.4 Semi-Arid zone

Adjoining the north-west desert are the Semi-Arid areas comprising of Madhya Pradesh, Chattisgarh, parts of Orissa and Gujarat. It spreads over an area of about 5 lac sq.km. Depending upon the amount of rainfall, the forests in this region have developed into thorny, mixed decidiuous and sat type. The forest vegetation is mostly constituted by Tectona grandis, Diospyros melanoxylon and Butea monosperma. The thorny vegetation is dominated by Acacia leucophloea, Accacia catechu, etc.

12.2.5 Western ghats zone

The Western Ghats zone comprises the Malabar coast and Western Ghat mountains of India extending from Gujarat in the north to the Cape Camorin in the south. This zone encompasses an area of about 1.6 lac sq.km. Rainfall in this region is heavy. The vegetation is of four types – tropical moist evergreen forests, sub-tropical or temperate evergreen forests, mixed deciduous forests and the mangrove forests.

12.1.6 Deccan peninsular zone

The Deccan Penninsula zone comprises of five biotic provinces, viz. Deccan Plateau (South), Central Plateau, Eastern Plateau, Chhota Nagpur Plateau and Central Highlands. The zone spreads over an area of about 14 lac sq. km. It is a semi-arid region lying in the rain-shadow of the Western Ghats. Rainfall is about 100 mm. The zone has a centrally hilly plateau with forests of Boswellia serrata, Hardwickia Pinnata and Tectona grandis.

12.2.7 The gangetic plain

In the North, is the Gangetic Plain extending up to Himalayan foothills. This region comprising of Uttar Pradesh, Bihar and West Bengal is the most fertile region and encompasses an area of about 3.5 lac sq.km. The major climatic factors, the temperature and

rainfall together are responsible for the distinctive type of vegetation in this zone. The rainfall varies from less than 700 mm in Western Uttar Pradesh to more than 1,500 mm in West Bengal. Vegetation is chiefly of tropical moist and dry deciduous forest type.

12.2.8 The north-east India

The North-East India is one of the richest flora regions in the country covering an area of about 1.6 lac sq.km. The region receives the heaviest rainfall, with Cherrapunji as much as more than 10,000 mm. The temperature and wetness are also very high, resulting in dense tropical evergreen forests. The important trees are Mesua ferrea, Michelia champaca, Dipterocarpus macrocarpus etc., and many Bamboo species. Many grass species and insectivorous plants like are also present. Beside this, the region has several wild relatives of cultivated plants such as banana, mango, citrus and pepper.

12.2.9 The Islands

The Islands of Lakshadweep in the Arabian Sea, and Andaman and Nicobar Islands in the Bay of Bengal have a wide range of coastal vegetation like mangroves, beech forests and in the interior some of the best preserved evergreen forests of tall trees. Rhizophora, Calophyllum and Dipterocarpus are some of the important species of Islands' vegetation.

12.2.10 Coast

India has a coastline of about 7,516.5 km. Mangroves vegetation is the characteristic of estuarine tracks along the coast, for instance, at Pichavaram near Chennai and Ratna Giri in Maharashtra.

ENVIRONMENTAL STUDIES

Module 4. Biodiversity and its conservation

Lesson 13
VALUES OF BIODIVERSITY

13.1 Values of biodiversity

Environmental economics (or ecological economics) provides methods of assigning economic values to species, communities and ecosystem. These values include the harvest (or market place) value of resources, the value provided by un-harvested resources in their natural habitat, and the future value of resources. For example, the Asian wild guar could be valued for the meat could be harvested from its current populations, its value for eco-tourism, or its future potential in cattle breeding.

The values can be divided as:

13.1.1 Direct values

Direct values, also known as use values and commodity values, are assigned to the products harvested by people. Direct values can be readily estimated by observing the activities of representative groups of people, by monitoring collection points for normal products and by examining the export/ import statistics. These values can be further sub-divided as:

a) Consumptive use value

It can be assigned to goods such as fuel wood and goods that are consumed locally and do not figure in national and international market

b) Productive use value

It is assigned to products that are derived from the wild and sold in commercial markets, both national as well as international markets.

13.1.2 Indirect values

Indirect values are assigned to benefits provided by biodiversity that do not involve harvesting or destroying the natural resource. Such benefits include ecological benefits such as soil formation, nutrient cycling, waste disposal, air and water purification, education, recreation, future options for human beings, etc. Indirect value can be further sub-divided as:

a) Non-consumptive use value

It is assigned to benefits such as soil formation/ protection, climate regulation, waste disposal, water and air purification, eco-tourism, medical research, etc.

b) Aesthetic, social and cultural value

The diversity of life on Earth brings us many aesthetic and cultural benefits. It adds to the quality of life, providing some of the most beautiful and appealing aspects of our existence.

Biodiversity is an important quality of landscape beauty. Many species of birds, large land mammals, sea animals and flowering plants are appreciated for their beauty. Millions of people enjoy hiking, camping, picnics, fishing, wildlife watching, and other recreational activities based on nature. These activities provide invigorating physical exercise and allow us to practice pioneer living skills. Contact with nature can also be psychologically and emotionally restorative. In many cultures, nature carries spiritual connotations, and a particular plant or animal species or landscape may be inextricably linked to a sense of identity and meaning.

Today we continue to imbue certain animals and plants with cultural significance; for instance, in India tiger and peacock, which are endangered, are especially valued because they have been adopted as national animal and bird respectively.

c) Option value

The option value of a species is its potential to provide our economic benefit to human society in the near future. For instance, there are several plant species which are edible and superior than those which are currently in use; e.g. Katemfe, a plant found in W. Africa, produces proteins that are 1,600 times sweeter than sucrose.

d) Existence value

It is assigned to protect wildlife. Since, for many people, the value of wildlife goes beyond the opportunity to photograph or even see a particular species. They argue that 'existence value', based on simply knowing that a species exist, is a sufficient reason to protect and preserve it. This right to exists was also stated in the U.N. General Assembly World Charter for Nature, 1982.

e) Ethical value

Moral justification for conservation of biodiversity is based on the belief that species have a moral right to exist, independent of our need for them. Consequently, the argument follows that in our role as the most intelligent species on Earth we have a responsibility to try as much as possible for the continuance of all forms of life.

Ethical values are deep rooted within human culture, a religion and society, but, those who look on cost benefit analysis, they overlook these ethical values. International boycotts of furs, teak and ivory are the good examples of moral justification.

13.2 Significance/ Importance/ Uses of Biodiversity

Various uses of biodiversity regarding direct and indirect values are as follows:

13.2.1 Timber

Wood is one of few commodities used and traded worldwide that is mainly harvested from wild sources. It is also one of the economically most important commodities in national and international trade. Wood export constitutes a significant part of the export earnings of many tropical developing countries. Malaysia, Papua New Guinea and Indonesia are among the

major exporters of hardwoods, including prized timbers such as teak and mahogany, produced mainly from natural forests.

13.2.2 Fishery

Fish and other fishery products make up another class of commodities of great economic importance in international trade that are harvested mainly from wild sources. These resources are also of crucial importance to global food security. Annual landings of aquatic resources have increased nearly five-times in the past four decades; and more than 80% was harvested from marine capture fisheries, the remainder was from inland fisheries and from aquaculture, both inland and marine. Though there are over 22,000 species of fish, but just ten individual marine fish species make up one-third of marine capture landings. The most important are the herrings, sardines and anchovies group.

13.2.3 Food

Food plants exemplify the most fundamental values of biodiversity. Presently, around 200 species have been domesticated as food plants. Out of these about 15 to 20 are of major international economic importance.

13.2.4 Medicinal value

Living organisms provide us with many useful drugs and medicines. Digitalis, an important drug in the treatment of certain heart ailments, comes from a small flowering plant – purple foxglove; Penicillin is a derivative of fungus; and so on. The UNDP estimates the value of pharmaceutical products derived from Third World plants, animals and microbes to be more than $30 billion per year.

There are numerous organisms that may produce useful medical compounds that are as yet unknown and untested. For instance coral reefs offer a particularly promising use in pharmaceutical drugs, because many coral reef species produce toxins to defend themselves. Many plant species native to India such as Neem, Tulsi, etc. too have potential medicinal applications.

13.2.5 Genetic value

Biological diversity is a valuable genetic resource. Most of the hybrid varieties of crops under cultivation have been developed by incorporating useful genes from different species of plants to produce better quality of the product with longer self-life or having better resistance to pests. Though such breeding techniques are unlimited in scope; but, for getting better strains in future, it is essential to build-up a gene-pool because the quality, yield, and resistance to pests, disease and adverse climatic conditions mostly depend on genetic factors and combination of genes which may be different in different strains/ varieties of species. There are hundreds of examples which illustrate how genetic modification helped in improved quality of the product. A few of them are mentioned as under:

- The genes from a wild variety of melon grown in U.P. helped in imparting resistance to powdery mildew in musk-melons grown in California (USA).
- The genes from the Kans grass (Saccharum Spontaneium) grown in Indonesia helped in imparting resistance to red rot disease of sugarcane.
- A wild variety of rice from U.P. saved millions of hectares of paddy crop from Grossy-Stunt virus.

13.2.6 Tourism

Tourism industry is mainly based on observation of wildlife within protected areas and is a major source of income for many developing countries. Tourism is the major source of foreign income for Kenya. Eco-tourism is now getting more attention and it includes interest in the all species of plants and animals, and forests.

13.2.7 Poor and indigenous people

Poor and indigenous people of under-developed countries are dependent on diversity in forests and wildlife for food, shelter, tools, and materials for clothing and medicines. Further reduction in the biodiversity can further increase the poverty of these poor people.

13.2.8 Pollution control

Plants and certain micro-organisms in particular can remove toxic substances from the air, water and soil. Since the different species have different characteristics and capabilities, therefore, a diversity of species can provide wide range of pollution control. For example, toxins like carbon-di-oxide and sulphur-di-oxide are removed by vegetation; carbon-monoxide is controlled by soil fungi and bacteria.

Module 4. Biodiversity and its conservation

Lesson 14
BIODIVERSITY AT GLOBAL, NATIONAL AND LOCAL LEVELS: INIDA AS A MEGA-DIVERSITY NATION

14.1 The global patterns in biodiversity

The present geological era is perhaps the richest in biological diversity. About 2.1 million species have been identified till date, while many more species are believed to exist. According to UNEP (1993-94) (UN convention on environment protection) estimate, the total number of species that might exist on Earth range between 9.0 – 52 million (Table 14.1).

Invertebrate animals and plants make-up most of the species. About 70% of all known species are invertebrates (animals without backbones such as insects, sponges, worms, etc.); while, about 15% are plants. Mammals, the animal group to which man belong, comprise a comparatively small number of species. Of all the world's species, only 10 to 15% live in North America and Europe. By contrast, the centers of greatest biodiversity tend to be in the tropics. The twenty countries most rich in biodiversity are listed in Table 14.1

Table 14.1 The world biota

Group	*No. of identified species*	*Estimated Total*
WORLD TOTAL (all groups)	21,25,300	9 to 52 million
Vertibrates	45,300	49,500
Mammals	4,200	4,300
Birds	9,100	9,200
Amphibians and Reptiles	12,000	13,000
Fishes	20,000	23,000
Invertibrates	15,00,000	7 to 50 million
Plants	4,00,000	5,00,000
Vascular	2,50,000	3,00,000
Nonvascular	1,50,000	2,00,000
Fungi	80,000	15,00,000
Protists	1,00,000	2,50,000
Prokaryotes	5,800	10,000

Table 14.2 The twenty countries most rich in biodiversity

Australia	Costa Rica	Malaysia	Philippines
Brazil	Ecuador	Mexico	South Africa
Cameroon	India	Panama	Venezuela
China	Indonesia	Papua New Guinea	Vietnam
Colombia	Madagascar	Peru	Zaire

14.2 Patterns in Biodiversity

Species are not uniformly distributed over the Earth; diversity varies greatly from place to place. In terms of the number of basic kinds of organism and number of species of each kind, biodiversity has varied markedly through geological time; and, in terms of present day species richness, biodiversity varies greatly between one part of the earth and another. The present global patterns in biodiversity indicate that the species richness tends to vary geographically according to a series of fairly well defined rules. For example, in case of terrestrial environments:

- Warmer areas hold more species than the colder areas;
- Wetter areas hold more species than the drier ones;
- Larger areas hold more species than the smaller areas;
- Areas of varied climate and topography hold more species than the areas of uniform climate and topography;
- Areas at lower altitude (elevation) hold more species than the high altitude areas; and
- Less seasonal areas hold more species than the highly seasonal areas.

Similarly, in case of pelagic marine species, there tends to be more species in warmer and less seasonal waters, i.e. at lower latitudes.

In a much more simplified way, it can be said that there are much more species, both per unit area and overall, in the tropics than in temperate regions and for more in the latter (temperate regions) than in Polar Regions. The moist tropical forests, in general, are the most species rich areas or environments on earth. Though they cover just about 7% of the world's surface; but it is estimated that they may hold more than 90% of the world's species, if the yet unknown tropical forest micro fauna (mainly insects) are accepted. If small tropical forest insects are discounted, then the areas that may be similarly rich in species are:

- Coral reefs; and
- Areas of Mediterranean climate in South Africa and Western Australia. These areas are rich in species, especially for flowering plants (angiosperms).

14.3 The reasons for Greater Biodiversity in the Tropics

The centers of greatest biodiversity tend to be in the tropics. The reasons for greater biodiversity in the tropics are as under:

1. Tropical areas receive more solar energy over the year. Therefore, tropical communities are more productive resulting in a greater resource base that can support a wider range of species.
2. Warm temperatures and high humidity of tropical areas provide favourable environmental conditions for many species that are unable to survive in the temperate areas.

3. Over geological times, the tropics have had a more stable climate than the temperate areas. In tropics, therefore, local species continued to thrive and live there itself; whereas, in temperate zones, they tend to disperse to other areas.
4. There has been more time for tropical communities to evolve as they are older than temperate ones. This could have allowed tropical communities greater degree of specialization and local adaptation to occur.
5. In tropics, the greater pressure from pests, parasites and diseases does not allow any single species to dominate. Thus, there is opportunity for many species to coexist. In temperate areas, on the other hand, there is reduced pressure from pests, parasites and diseases due to cold, and there is one or a few dominating species that exclude many other species.
6. In tropics, higher rates of out crossing among plants may lead to higher levels of genetic variability.

14.4 India as Mega-diverse Biodiversity

Biodiversity has three aspects, viz. genetics, species and ecosystem. India is recognized to be uniquely rich in all these three aspects. The country has a rich heritage of biodiversity, encompassing a wide spectrum of habitats from tropical rainforests to alpine vegetation, and from temperate forests to coastal wetlands. Almost all the biogeographical regions of the world are represented here in India. With a mere 2.4% of the total land area of the world, the known biodiversity of India contributes 8.22% of the known global biodiversity. India is one of the twelve mega-diversity nations of the world accounting for 7.31% of the global faunal and 10.88% of the global floral total species. Currently available data place India in the tenth position in the world and fourth in the Asia in plant diversity. In terms of number of mammalian species, the country ranks tenth in the world; and in terms of endemic species of higher vertebrates, it ranks eleventh. In terms of number of species contributed to agriculture and animal husbandry, it ranks seventh in the world.
Some of the salient features of India's biodiversity are as under:

- India has two major realms called the Palaearctic and the Indo Malayan; and three biomes, namely the tropical humid forests, the tropical dry deciduous forests and the warm desert/ semi-deserts.
- India has ten biogeographic regions, namely the Trans-Himalayan, the Himalayan, the Indian desert, the semi-arid zone, the Western Ghats, the Deccan Peninsula, the Genetic plain, North-East India, the Islands, and the coasts.
- India is one of the 12 mega-diversity nations of the world.
- India is one of the 12 centres of origin of cultivated plants.
- There are two hotspots that extend into India. There are the Western Ghats/ Sri Lanka and the Indo-Burma region (covering the Eastern Himalayas). Further these hotspots are included amongst the top eight most important or hottest hotspots.
- India has 26 recognised endemic centres that are home to nearly a third of all the flowering plants (angiosperms) identified and described to date.
- India has six Ramsar Wetlands. They are –
- Chilika Lake, Harike Lake, Loktak Lake, Keoladeo National Park, Wular Lake and Sambhar Lake.
- India has 5 world heritage sites namely, Kaziranga National Park, Keolades Ghana National Park, Manas Wildlife Sanctuary, Nanda Devi National Park and Sundarban National Park.
- India has twelve biosphere reserves, namely Nilgiri, Nanda Devi, Nokrerk, Manas, Sunderbans, Gulf or Mannar, Great Nicobar, Similpal, Dibru-Saikhowa, Dehang

Debang, Pachmarchi and Kanchanjanga.

- Further, amongst the protected areas, there are 88 national parks and 490 sanctuaries in India covering an area of 1.53 lakh sq.km.

Based on a survey of about two-third of the geographical area of the country, the Ministry of Forests and Environment (MOEF) reports that India has at present 89,317 species of fauna and 45,364 species of flora representing about 7.31% of the world fauna and 10.88% the world flora described so far.

In plants, the species richness is high in angiosperms, bryophyta and petridophyta, and in the family orchidaceae. In animals, arthropoda (insects) are predominant.

India is also rich in agro-biodiversity. There are 167 crop species and wild relatives. Further, India is considered to be the centre of origin of 30,000 to 50,000 varieties of rice, pigeon-pea, mango, turmeric, ginger, sugarcane, gooseberries, etc. and ranks seventh in terms of contribution to world agriculture.

India also boasts of rich marine biodiversity, along the coastline of 7516.5 km with exclusive economic zone of 202 million sq.km, supporting the most productive ecosystems such as mangrooves, estivaries, lagoons and coral reefs. The number of zooplankton recorded is about 16,000 species. The benthic fauna largely consists of polychaeta (62%), crustacean (20%) and molluscs (18%) with the biomass of about 12 gm per sq.metre. Over 30 species of marine algae and 14 species of seagrass have been reported. There are over 45 species of mangrove plants. Over 342 species of corals belonging to 76 genera have been reported and about 50% of the world's reef building corals are found in India.

Module 4. Biodiversity and its conservation

Lesson 15
HOT-SPOTS OF BIODIVERSITY AND THREATS TO BIODIVERSITY

15.1 Hotspots of Biodiversity

The most remarkable places/ areas on earth are also the most threatened ones, and many of them have been reduced to less than 10 percent of their original vegetation. These places/ areas are called hotspots of biodiversity for preservation. Hotspots are the main areas of focus for biodiversity conservation. These are the areas that are extremely rich in biodiversity, have high level of endemism, and are under constant threat of species extinctions and habit destruction.

Recently, Norman Myers and a team of scientists have brought out updated lists of 25 hotspots (Myers et. al. 2000). These identified hotspots of biodiversity are

Caribbean, California Floristic Province and Mesoamereca in North and Central America; Tropical Andes, Choco-Darien-Western Ecuador, Atlantic Forest, Brazilian Cerrado and Central Chile in South America; Caucasus and Mediterranean Basin in Europe and Central Asia; Madgascar and Indian Ocean Islands, Eastern Arc Mountains and Coastal Forests, Guinean Forests of West Africa, Cape Floristic Region and Succulent Karoo in Africa; Mountains of Southwest China, Indo-Burma and Western Ghats of India in Mainland Asia; and Philippines, Sundaland, Wallacea, Southwest Australia, Newzeland, New Calenonia and Pollynesia and Micronesia in Asia Pacific region..

The two hotspots of biodiversity that extend into India.

The two hotspots that extend into India are the:

1. Indo-Burma and Western Ghat
2. Sri Lanka.

15.1.1 Indo-Burma

The Indo-Burma hotspot covers about 2 million square kilometres of tropical Asia east of the Indian subcontinent. The hotspot includes all of Cambodia, Vietnam and Laos, and nearly the entire areas of Thailand, Myanmar and Bhutan, as well as part of Nepal, far eastern India and extreme southern China. In addition, it covers several offshore Islands including Mainan Islands in the South China Sea, and the Andaman and Nicobar Islands in the Indian Ocean. Today, it is estimated that about 1,00,000 square kilometres or 5% of the original extent of the habitat is in pristine condition.

The entire hotspot was originally covered with broad-leaf forests; but, today, only fragments remain. In these fragments, a wide variety of ecosystems is represented including deciduous,

wet evergreen dry evergreen and montane forests. Also, there are patches of shrublands, woodlands and scattered heath forests. The hotspot has the world's highest diversity of freshwater turtle species. Moreover, the hotspot is still revealing its biological treasures, for example, three large mammal species have been discovered in recent years.

15.1.2 Western ghats and Sri Lanka

The hotspot encompasses the montane forests in the south-western parts of India and on the neighbouring Island of Sri Lanka. Although the two forest blocks are separated from each other by about 400 kilometres of land and water, yet they are similar enough that they can be grouped into a single hotspot. Though the entire extent of the hotspot was originally about 1,82,500 square kilometres; but, due to tremendous population pressure, now only 12,445 square kilometres or 6.8% is in pristine condition.

The Western Ghat Mountains stretch from India's southern tip of Gujarat in the North, and run parallel to the country's western coast. They cover an area of about 1,60,000 square kilometres. The western slopes of the mountains receive heavy annual rainfall, whereas the eastern slopes are drier. The wet tropical south-western zone of Sri Lanka is remarkably similar to the Western Ghats because of the repeated appearance and disappearance of a land bridge between them over many thousands of years.

The predominant vegetation of the entire hotspot includes deciduous and tropical rain forests, montane forests and grasslands, as well as scrup forests in lower, drier areas. The hotspot is home to a diverse and endemic assemblage of plants, reptiles and amphibians. The important populations include Asian elephants, Indian tigers and the endangered lion-tailed macaque.

15.2 Threats to Biodiversity

Human actions have caused extinctions (elimination of species) over a long time, not just in recent decades. The earliest humans probably caused extinctions through hunting; with the invention of fire, humans began to change habitats over large areas; with the development of agriculture and the rise of civilization, rapid deforestation and other habitat changes took place; as new areas were explored, the introduction of exotic species became an important cause of extinction; later, in the twentieth century, with the introduction of industrial chemicals and emissions, pesticides, etc. into the environment, pollution has become an increasingly significant cause of extinction.

Human actions poses threats to biodiversity through:

15.2.1 Habitat loss and degradation

Habitat loss and degradation are the major proximate causes of species extinction, affecting 89% of all threatened birds, 83% of mammals and 91% of all threatened plants assessed globally. The main causes of habitat loss are agricultural activities, harvesting or extraction (including mining, fishing, logging, etc.) and development of human settlements, industry and associated infrastructure.

Habitat destruction inevitably results from the expansion of human populations and human activities. The ever-expanding human settlements have been causing destruction of natural ecosystems to meet their requirements of food, space, shelter, etc. The greatest destruction of biological communities has occurred during the last 150 years during which the human population went from just one billion in 1850 to 6.2 billion in 2002, and will reach an

estimated 7.8 billion in 2025. In many countries, particularly Islands and where human population density is high, most of the original habitat has already been destroyed.

15.2.2 Habitat fragmentation

It is a process where a large, continuous area of habitat is both reduced in area and divided into two or more fragments. Habitat fragmentation may take place due to the development of roads, towers, canals, fields, industries, etc. in an original large habitat. The fragments thus divide populations into isolated groups that not only limit the potential of species for dispersal and colonization but also reduce the foraging ability of animals. These isolated, small, scattered populations are increasingly vulnerable to inbreeding depression, high infant mortality and susceptible to environmental hardships, and consequently, in the end, possible extinction.

15.2.3 Genetic assimilation

Some rare and endangered species are threatened by genetic assimilation because they crossbreed with closely related species that are more numerous or more vigorous. Opportunistic plants or animals that are introduced into a new habitat by human actions may genetically overwhelm local populations. For example, hatchery-raised trout introduced into lakes or streams may genetically dilute indigenous stocks.

15.2.4 Pollution

Environmental pollution is the most subtle form of habitat degradation. The most common causes of which are pesticides, industrial effluents and emissions, and emission from automobiles. Toxic pollutants can have disastrous effects on local populations of organisms. Pesticides linked declines of fish-eating birds and falcons was well documented in the 1970s. Mysterious, widespread deaths of thousands of seals on both sides of Atlantic in recent years are linked to an accumulation of chemicals such as DDT, PCB's and dioxins. Lead poisoning is another major cause of mortality for many species of wildlife.

15.2.5 Poaching

Poaching is another insidious threat that has emerged in recent decades as one of the primary reasons for the decline in number of species. Poaching pressures, however, are unevenly distributed since certain selected species are more heavily targeted that others are. Despite legal protection in many countries, products from endangered species are widely traded within and between nations.

Wildlife is sold for live specimens, folk medicines, furs, hides, skin (or leather) and other products such as ivory, antlers and horns amounting to millions of dollars each year. Developing countries in Asia, Africa and Latin America with the richest biodiversity in the world are the main source of wild animal and animal products, while Europe, North America and some Wealthy Asian countries are the principal importers.

15.2.6 Introduction of exotic species

Organisms introduced into habitats where they are not native are termed as exotics. They can be thought of us biological pollutants and are considered to be among the most damaging agents of habitat alteration and degradation in the world. Inducing species intentionally or unintentionally (accidentally) from one habitat into another where they have never been

before is a very risky business. Freed from the parasites, pathogens, predators and competitors that normally keep their numbers in check, exotics often exhibit explosive population growth that crowds out native species. Their aggressive invasion might be considered a kind of ecological cancer. Introductions of exotic species have caused especially severe problems on Islands.

The above mentioned causes of biodiversity loss due to human actions, however, are poverty, macroeconomic policies, international trade factors, policy failures, poor environmental laws/ weak enforcement, unsustainable development projects and lack of local control over resources. Population pressures and accompanying increases in the collection of fuel wood and fodder, and grazing in forests by local communities too take their toll on the forests, and consequently its biodiversity.

15.3 Important Terms in Biodiversity

(i) Endangered species
(ii) Vulnerable species
(iii) Rare species
(iv) Threatened species

15.3.1 Endangered species

The species that are considered in imminent danger of extinction and whose survival is unlikely if factors causing their decline continue to operate. These are species whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are in immediate danger of extinction.

15.3.2 Vulnerable species

The species that are under threat such that they may have to be classified as endangered in the near future if causal factors continue to operate. These include species whose populations have been seriously depleted and whose ultimate security is not assured, as well as those species whose populations are still abundant but are under threat throughout their range.

15.3.3 Rare species

These are species with small total population size in the world. In their distribution, they are usually localized within restricted habitats or geographical area or are thinly scattered over an extensive range. It is necessary to mention here that a species that is rare is not necessarily in danger of becoming extinct; some species, like the whooping crane, are naturally rare. However, rarity does raise concerns about the possibility of extinction. Rare species, thus, are not at present endangered and vulnerable but are at risks.

15.3.4 Threatened species

The term ‘threatened’ is used in the context of conservation of the species which are in any one of the above three categories. These are species that have declined significantly in total numbers and may be on the verge of extinction in certain localities.

At present, 1672 species of animals are listed in these four categories worldwide (Table 4.10). Information is sketchier about plants, because numerous plant species grow only in poorly explored areas. Of 34,266 plants in the IUCN Red Database, 15780 are listed as threatened.

As per IUCN estimates, there are 20,000 to 25,000 species of vascular plants (plants having a system for moving fluid, such as sap) that either have recently become extinct or are endangered, vulnerable or rare. Infact, the total number of species that are threatened is not yet known, because many areas, particularly in tropics, have not yet been explored for species diversity.

Table 15.1 Worldwide threatened species of animals

Group	*E*	*V*	*R*	*The*	*Total*
Mammals	167	143	39	1	350
Birds	111	69	122	0	302
Reptiles	36	39	41	4	120
Amphibians	8	9	20	0	37
Fish	79	135	83	3	300
Mollusks	67	22	20	0	109
Annelids	2	8	1	0	11
Spiders	1	1	1	0	3
Crustacea	4	3	9	0	16
Insects	117	150	155	2	424
Total	529	579	491	10	1672

15.4 'Endangered and Endemic Species of India'

India ranks second in terms of the number of threatened mammals, while sixth in terms of countries with the most threatened birds. The numbers of threatened species of India by taxonomic group are shown in Table 4.11. Such a biological impoverishment of the country is a serious threat to sustainable advances in biological productivity as gene erosion also erodes the prospects for deriving full economic and ecological benefits from recent advances in molecular biology and genetic engineering.

Table 15.2 Threatened species of India by taxonomic group

Taxonomic Group	Number of threatened species
Mammals	86
Birds	70
Reptiles	25
Amphibians	3
Fish	3
Mollusks	2
Other Invertebrates	21
Plants	244
Total	459

According to the Red List of Threatened Animals, 18 animal species are critically endangered, 54 endangered and 143 are vulnerable, while 10 species are lower risk conservation dependent and 99 are lower risk near threatened. Amongst plants, 44 are

critically endangered, 113 endangered and 87 vulnerable.

Some of the animal species that have been identified as endangered or threatened ones are Lion tailed macaque, Golden monkey, Himalayan brown beer, Tiger, Indian Lion, Great Indian one-horned rhinoceros, Indian antelope (or Blackbuck), Kashmir stag (or Hangul), Swamp deer (or Barasingha), Baleen whale, Mute swan, Great Indian bustard, Indian pied hornbill, Gharial.

Endemics are species that are found in a single locality/ area and nowhere else in the world. They, thus, have a value in their uniqueness. Areas of endemism containing several endemic species, genera or even families have generally been isolated for a long time, thus enabling the original species to evolve into new genetic entities better adopted to local area. Isolated mountain tops, valleys and large oceanic Islands are usually areas of endemism. Conservation of resources of these areas is very difficult as each area will pose its own peculiar problems.

The endemism of Indian biodiversity is quite high. About 33% of the country's flora are endemic to the country and are concentrated mainly in the North-East, Western Ghats, North-West Himalaya and the Andaman and Nicobar Islands. Of the 49,219 plant species, 5,150 are endemic (not found elsewhere) and distributed into 141 genera under 47 families corresponding to about 30% of the world's recorded flora, which means 30% of the world's recorded flora are endemic to India. About 15,000 species of flowering plants (angiosperms) are known to occur in India, out of which 4,950 species of flowering plants had a birth in India. Of all these endemic plant species, 3,500 are found in the Himalayas and adjoining regions and 1,600 in the Western Ghats alone. Many deep and semi-isolated valleys are exceptionally rich in endemic plant species. Such as, in Sikkim, in an area of 7,298 square kilometer, of the 4,250 plant species, 2,550 (60%) are endemic.

India is particularly rich in floral wealth and endemism, not only in flowering plants but also in reptiles, amphibians, swallow-tailed butterflies, and some mammals. About 62% of the known amphibian species and nearly 50% of the lizards of the country are endemic with the majority occurring in the Western Ghats.
Endangered species of mammals, amphibians, reptiles and birds

Mammals
Andaman wild pig (*Sus scrofa & S. amanensis*)
Bharal (*Ovis nahura*)
Binturong (*Arctictis binturong*)
Bison or gaur or mithun (*Bos gaurus*)
Black buck (*Antelope cevicapra*)
Blue whale (*Balaenoptera musculus*)
Brown-antlered deer or Thamin (*Cervus eldi*)
Capped langur (*Presbytis pileatus*)
Caracal (*Felis caracal*)
Cetecean species
Cheetah (*Acinonyx jubatus*)
Chinese pangolin (*Manis pentadactyla*)
Chinkara or Indian gazelle (*Gazella gazella bennetti*)
Chital (*Axis axis*)
Clouded leopard (*Neofelis nebulosa*)
Crab-eating macaque (Macaca irus umbrosa)
Desert cat (*Felis libyca*)
Dugong (*Dugong dugong*)
Fishing cat (*Felis viverrina*)
Flying squirrels (all species of genera *Petaurista, Eupetaurus, Belomys, Hylopetes*)
Four-horned antelope (*Tetraceros quadricornis*)
Gangetic dolphin (*Platanista gangetica*)
Giant squirrels (*Ratufa macroura, R.indica, R.bicolor*)

Giant squirrels (*Ratufa macroura, R. indica, R. bicolor*)
Golden cat (*Felis temmincki*)
Golden langur (*Presbytis geei*)
Gorals (*Nemorhaedus goral, N. hodgsoni*)
Himalayan black bear (*Selenarctos thibetanus*)
Himalayan brown bear (*Ursus arctos*)
Himalayan crestless porcupine (*Hystrix hodgsoni*)
Himalayan ibex (*Capra ibex*)
Himalayan tahr (*Hemitragus jemlachicus*)
Hispid hare (*Caprolagus hispidus*)
Hog badger (*Arctonyx collaris*)
Hoolock or gibbon (*Hylobates hoolock*)
Hump-backed whale (*Megaptera nevaeangliae*)
Hyaena (*Hyaena hyaena*)
Indian elephant (*Elephas maximus*)
Indian lion (*Panthera leo persica*)
Indian wild ass (*Equus hemionus khur*)
Indian wolf (*Canis lupus pallipes*)
Kashmir stag or hangul (*Cervus elephus hangul*)
Leaf monkey (*Presbytis melalophos*)
Leopard cat (*Felis bengalensis*)
Leopard or panther (*Panthera pardus*)
Lesser or red panda (*Wilurus fulgens*)
Lion-tailed macaque (*Macaca silenus*)
Loris (*Loris tardigradus*)
Lynx (*Felix lynx isabellinus*)
Malabar civet (*Viverra megaspila*)
Malay or sun bear (*Helarctos malayanus*)
Marbled cat (*Felis mormorate*)
Markhor (*Capra falconeri*)
Mouse deer (*Tragulus meminna*)
Musk deer (*Moschus moschiferus*)
Nilgai (*Boselaphus tragocamelus*)
Nilgiri langur (*Presbytis johni*)
Nilgiri thar (*Hemitragus hylocrius*)
Otters (*Lutra lutra, L. perspicilata, Aonyx cinerea*)
Ovis ammon or nyan (*Ovis ammon hodgsoni*)
Pallasts cat (*Felis manul*)
Pangolin (*Manis crassicaudata*)
Pig-tailed macaque (*Macaca memestrina*)
Pygmy hog (*Sus sulvanius*)
Ratel (*Mellivora capensis*)
Red fox (*Vulpes vulpes*)
Rhinoceros (*Rhinoceros unicornis*)
Rusty-spotted cat (*Fellis rubuginosa*)
Sambar (*Cervus unicolor*)
Serow (*Capricornis sumatraensis*)
Sloth bear (*Melursus ursinus*)
Slow loris (*Nycticebus caucang*)
Small travancora flying squirrel (*Pteromys fuscocapillus*)
Snow leopard (*Panthera uncia*)
Spotted linsang (*Prinodon pardicolor*)
Swamp deer or gond (*Cervus duvauceli*, all species)
Takin or mishmitakin (*Budorcas taxiclor*)
Tibetan antelope or Chiru (*Panthelopes hodgesoni*)
Tibetan fox (*Vulpes ferrilatus*)
Tibetan gazelle (*Procapra picticaudata*)
Tibetan wild ass (*Equus hemionus kiang*)
Tiger (*Ponthera tigris*)
Urial or shapu (*Ovis vignei*)
Wild buffalo (*Bubalus bubalis*)
Wild dog or dhole (*Cuon alpinus*)
Wild yak (*Bos grunniens*)
Amphibians and Reptiles
Agra monitor lizard (*Varanus griseus*)
Atlantic ridley turtle or Kemp's ridley turtle (*Lepidochelys kempii*)
Barred, gral or yellow monitor lizard (*Varanus flavescens*)

Barred, oval or yellow monitor lizard (*Varanus flavescens*)
Estuarine crocodile (*Crocodylus porosus*) Salt water
Crocodile (*Crocodylus palustris*)
Gharial (*Gavialis gangeticus*)
Ganges soft-shelled turtle (*Trionyx gangeticus*)
Green sea turtle (*Chelonia mydas*)
Hawksbill turtle (*Eretmochelys imbricata inlscata*)
Himalayan newt or salamander (*Tryletotriton verrucosus*)
Indian egg-eating snake (*Elachistodon westermanni*)
Indian soft-shelled turtle (*Lissemys punctata punctata*)
Indian tent turtle (*Kachuga tecta tecta*)
Large Bengal minitor lizard (*Varanus bengalensis*)
Leathery turtle (*Dermochelys coriacea*)
Loggerhead turtle (*Caretta caretta*)
Olive-Back loggerhead turtle (*Lepidochelys olivacea*)
Pythons (all species of genus *Python*)
Three keeled turtle (*Geoemyda tricarinata*)
Tortoise (genera of families of Testudinidae, Trionychidae)
Viviparous toads (*Nectophyrynoides spp.*)
Water lizard (*Varanus salvator*)
Birds
Andaman teal (*Anas gibberifrons albogularis*)
Assam bamboo partridge (*Bambuscicola fytechii*)
Bazas (*Aviceda jeordoni* and *A. leuphotes*)
Bengal florican (*Eupodotis bengalensis*)
Black necked crane (*Grus nigricollis*)
Blood pheasants (*Ithaginis cruentus tibetanus, Ithaginis cruentus kuseri*)
Brown headed gull (*Larus brunnicephalus*)
Cheer pheasant (*Catreus wallichii*)
Comb duck (*Sarkidiornis melanotos*)
Forest spotted owlet (*Athene blewitti*)
Great Indian bustard (*Choriotis nigriceps*)
Great Indian hornbill (*Buceros bicornis*)
Hooded crane (*Grus monacha*)
Hornbills (*Ptilolaemus tickelli austeni, Aceros nipalensis, Rhyticeros undulatus ticehursti*
Houbara bustard (*Chlamydotis undulata*)
Humes bar-backed pheasant (*Syrmaticus humiae*)
Indian pied hornbill (*Anthracoceros malabaricus*)
Jerdon courser (*Cursorius bitorquatus*)
Lammergeter (*Gypaetus barbatus*)
Large falcons (*Falco peregrinus. F. biarmicus and F.chicquera*)
Large whistling teal (*Dendrocygna bicolor*)
Monal pheasants (*Lophophorus impejanus*)
Mountain quail (*Ophrysia superciliosa*)
Narcondom hornbill (*Rhyticeros undulatus narcondami*)
Nicobar megapode (*Megapodius freycinet*)
Nicobar pigeon (*Caloenas nicobarica pelewensis*)
Peacock pheasant (*Polyplectron bicalcaratum*)
Peafowl (*Pavo crsitatus*)
Pinkheaded duck (*Rhodonessa caryophyllacea*)
Sclater's monal (*Lophophorus sclateri*)
Siberian white crane (*Grus leucogeranus*)
Spurfowl (*Gallaperdix spp.*)
Tibetan sno-cock (*Tetraogallus tibetanus*)
Tragopan pheasants (*Tragopan melanocephalus, T.blythii, T. satyra, T. temminckii*)
Whitebellied sea eagle (*Haliaeetus leucogaster*)
White-eared pheasant (*Crossoptilon crossoptilon*)
White spoonbill (*Platalea leucorodia*)
White-winged wood duck (*Cairina scutulata*)

Module 4. Biodiversity and its conservation

Lesson 16
CONSERVATION OF BIODIVERSITY

16.1 Conservation of Biodiversity

Conservation is defined as 'the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generation while maintaining its potential to meet the needs and aspirations of future generations'. Conservation of our natural resources has the following three specific objectives:

1. To maintain essential ecological processes and life-supporting systems;
2. To preserve the diversity of species or the range of genetic material found in the organisms on the planet; and
3. To ensure sustainable utilization of species and ecosystems which support millions of rural communities as well as the major industries all over the world?

The wildlife conservation efforts are mostly centred on protecting plant and animal life in protected habitats, such as – botanical gardens, zoos, sanctuaries, national parks, biosphere reserves, etc. The two basic approaches to the wildlife conservation in protected habitats are:

16.1.1 In-situ conservation

In-situ or on-situ conservation means conservation of species in its natural ecosystem or even in man-made ecosystems (i.e. artificial ecosystems). This type of conservation applies only to wild fauna and flora, and not to the domesticated animals and plants because conservation is possible by protection of population in nature. In-situ conservation is a comprehensive system of "protected area", which involves setting aside large portions of earth's surface for wildlife with emphasis either to save the entire area or an endangered species. According to World Conservation Union, 'protected area' is defined as -" an area of land and/ or sea specially dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources and managed through legal or other effective means". There are different categories of protected areas which are managed with different objective. These include – national parks, sanctuaries, biosphere reserves, etc.

The advantages of In-situ conservation are:

- In-situ conservation is the best strategy for the long term protection of biodiversity.
- Large pockets/ areas of protected zones are essential for not only conserving vast number of species of living organisms but also provide opportunities to evolve. Otherwise, man-made habitats (e.g. zoo, aquarium, etc.) may end-up with static gene-pool.
- Further in-situ conservation are always preferred because, in most cases, it is cheaper to protect populations in their natural habitat than to reintroduce captive-bred ones.

Some of the limitations or factors that reduce the laudable advantages of in-situ conservation to some extent are:

- Many protected habitats are not large enough, not maintained properly, and are not properly protected from environmental pollution; and
- Many protected habitats are used for logging, tourism or other profitable activities; thus, diluting the objective of conservation biodiversity.

16.1.2 Ex-situ conservation

Ex-situ conservation means conservation of species (sample of genetic diversity), particularly of endangered species, away from their natural habitat under human supervision. Though in-situ conservation is the best

strategy for the long-term protection of biodiversity; however, for many rare species or species having small remaining population, it is not a viable option in the light of increasing human disturbances. Further, species may decline and go extinct in the wild due to genetic drift and inbreeding, environmental and demographic variation, deteriorating habitat quality, competition from exotic species, disease or over-exploitation. Under such circumstances, the only possible way a species can be prevented from going extinct is to maintain individuals in artificial conditions under human care. This strategy of conservation of biodiversity is termed as 'ex-situ or off-site preservation'. In ex-situ conservation, the endangered species of animals are collected and bred under controlled conditions in zoos, game farms, aquaria, etc., while plant species are maintained in botanical gardens, arboreta and seed banks.

The advantages of ex-situ conservation are:

- The organism is assured of food, shelter and security, and hence can have longer life-span and breeding activity. Thus, increasing the possibility of having more number of off springs.
- Under human care and secure conditions, the chances of survival increase.
- Ex-situ conservation also provides the possibility of using genetic techniques to improve the concerned species.
- Captive breeding can provide animals for possible reintroduction to the wild at a later stage or for supplementing current populations with new stock.
- However, there are certain limitations and disadvantages of ex-situ conservation:
- Ex-situ conservation can be adopted only for a few selected species because of limitations of space, finances and facilities in the institutions that undertake captive breeding. This limitation, however, can be solved to a certain extent by having more mini zoos and deer parks which can act as a sink for the surplus, hybrid, aged and infirm animals while the larger zoos can focus on serious captive breeding of endangered species.
- Ex-situ conservation, under a set of favourable environmental conditions, deprives the organism the opportunity to adopt to the ever changing natural environment. As a result, new life-forms cannot evolve and the gene-pool gets stagnant.

16.3 National Parks and Sanctuaries

A National Park (Table 16.2) is an area dedicated to conserve the scenery (or environment) and natural objects and the wildlife therein. In national parks, all private rights are non-existent and all forestry operations and other usages such as grazing of domestic animals are prohibited. However, the general public may enter it for the purpose of observation and study.

A national park is a relatively large area

1. where one or several ecosystems are not maternally altered by human exploitation and occupation, where plant and animal species, geomorphological sites and habitats are of special scientific, educative and recreative interest or which contain a natural landscape of great beauty and
2. where the highest competent authority of the country has taken steps to prevent or eliminate as soon as possible exploitation or occupation in the whole area and to enforce effectively the respect of ecological, geomorphological or aesthetic features which have led to its establishment and
3. where visitors are allowed to enter, under special conditions, for inspirational, cultural and recreative purposes.

A **Wildlife Sanctuary**, similar to national park, is dedicated to protect the wildlife, but it considers the conservations of species only and also the boundary of it is not limited by a state legislation. Further, in the sanctuary, killing hunting or capturing of any species of birds and mammals' is prohibited except by or under the control of highest authority in the department responsible for management of that sanctuary. Private ownership may be allowed to continue in a sanctuary, and forestry and other usages permitted to the extent that they do not adversely affect wildlife.

Table 16.1 A comparison of national parks, wildlife sanctuaries and biosphere reserves

	National Park	Sanctuary	Biosphere Reserve
1	Attention is not givenon biotic community as a whole, i.e. conservation being hitched to habitat for particular wild animal species like tiger, lion, rhino etc.	Attention on biotic community not given; conservation, being species oriented, e.g. citrus, pitcher plant, Great Indian Bustard.	Attention is focused on biotic community as a whole, i.e. conservation being ecosystem oriented.
2	The approach is not based on scientific principles.	Not based on scientific principles.	Based on sound scientific principles.
3	The size ranges from 0.04 to 3162 sq. km.; the usual size being between 100 and 500 sq.km. (in about 39%) and between 500 and 1000 sq.km. (in about 165)	Size ranges from 0.61 to 7818 sq.km; usual size being between 100 and 500sq.km (in about 39%), between 500 and 1000 sq.km. (in about 24%)	Size well over 5670 sq.km.
4	Boundaries circumscribed by state legislation.	Limits are not sacrosanct.	Boundaries circumscribed by state legislation.
5	No biotic interference except in buffer zone.	Limited biotic interference.	No biotic interference, except in buffer zone.
6	Tourism is not only permissible, but often encouraged.	Permissible	Normally not permissible.
7	Research and scientific management lacking.	Lacking	Carried on
8	Due attention to gene pool conservation of economic species, particularly of plants, has not been given.		Due attention being given to conservation of plants as well as animal species.

Table 16.2 Important national park/ wildlife sanctuary in India

State	Name of National Park/Wildlife sanctuary
Andhra Pradesh	Pakhal Wildlife sanctuary, Pocharam Wildlife sanctuary, Kawal Wildlife sanctuary Kolleru Pelicanary.
Arunachal Pradesh	Namidapha Wildlife Sanctuary
Assam	Kaziranga national park, Manas Wildlife

	Sanctuary
Bihar	Hazaribagh National Park, Betla National Park
Goa	Mollen Wildlife Sanctuary
Gujarat	Gir National Park, Velavadar national park, Wild Ass Sanctuary, Nal Sarovar Bird Sanctuary
Haryana	Sultanpur Lake Bird Sanctuary
Himachal Pradesh	Sechu-tun –Nallah Sanctuary
Jammu & Kashmir	Dechigam Wildlife Sanctuary
Jharkhand	Hazaribagh National Park
Karnataka	Bandhipur National Park, Nagarhole national Park, Ranganthitto Bird Sanctuary, Silent Valley National Park
Kerala	Periyar Wildlife Sanctuary, Wynad Wildlife Sanctuary.
Madhya Pradesh	Kanha National Park, Shivpuri National Park, Bandhavgarh National Park, Panna national park
Maharashtra	Tadoda National Park, Yawal Wildlife Sanctuary
Manipur	Keibul Lamjao National Park
Meghalaya	Balpakram sanctuary
Mizoram	Dampa Wildlife sanctuary
Nagaland	Intangki Wildlife Sanctuary
Orissa	Simlipal national Park, Chilka Lake Bird Sanctuary
Punjab	Aoohar Wildlife Sanctuary
Rajasthan	Ranthambore National park, Sariska wildlife Sanctuary, Ghana Bird Sanctuary
Sikkim	Kanchenjunga National Park
Tamil Nadu	Mudumalai Wildlife Sanctuary, Vedanthangal Water Bird Sanctuary
Uttar Pradesh	Corbett National Park, Rajaji national park, Dudhwa National Park
West Bengal	Jaldapara Wildlife Sanctuary

16.3 Biosphere Reserves

Biosphere reserves (Table 16.3) have been described as undisturbed natural areas for scientific study as well as areas in which conditions of disturbance are under control. They have been set aside for ecological research and habitant preservation. These are used as the means to protect ecosystems, whether natural or modified by human activity, in order to preserve ecological 'evidence' for the purpose of scientific research.

Table 16.3 Biosphere reserves in India

Biosphere reserves	State(s)
Nilgiris	Tamil Nadu, Kerala and Karnataka
Namdapha	Arunachal Pradesh
Nanda Devi	Uttrakhand
Uttrakhand (Valley of Flowers)	Uttrakhand
North Islands of Andamans	Andmans & Nicobar
Gulf of Mannar	Tamil Nadu
Kaziranga	Assam
Sunderbans	West Bengal
Thar Desert	Rajasthan
Mannas	Assam
Kanha	Madhya Pradesh
Nokrek (Tura range)	Meghalaya
Little Rann of Kutch	Gujarat
Great Nicobar Island	Andaman & Nicobar

ENVIRONMENTAL STUDIES

Module 5. Environmental pollution

Lesson 17
INTRODUCTION AND CLASSIFICATION OF POLLUTION

17.1 Introduction

Pollution is defined as 'an undesirable change in physical, chemical and biological characteristics of air, water and land that may be harmful to living organisms. The Pollution Control Board, defined pollution as unfavorable alteration of our surrounding, largely as a by-product of human activities.

17.1.1 Pollutant

Pollutant is a substance which causes pollution. Unlimited exploitation of nature has disturbed the ecological balance between living and non living components in the biosphere. The major environment pollutants are deposited matter, gases, metals, fluorides, acid droplets, agro chemicals, photo chemical accidents, radioactive waste and solid waste.

17.1.2 Classification of Pollutants

Environment pollution is of many types like air pollution, water pollution, noise pollution, soil pollution, marine pollution, etc. In developing countries major source of environment pollutions are air pollution, water pollution and soil pollution.

1. On the Basis of Nature

Depending upon the nature of the pollutants and their interaction with environment process, the pollution caused by different agents can be classified into the following categories:

1. Solid pollutants.
2. Liquid pollutants
3. Gaseous pollutants
4. Pollution from Waste without Weight: This type of pollution is also known as pollution by energy waste; Wastes without weight may be of the following types:
    - Radio-active Substance: Despite of all possible precautions in the functioning and maintenance of nuclear reactors, it is seen that minute quantity of radio-active waste escapes out into the environment.
    - Heat
    - Noise

2. On the Basis of Decomposition

1. Non-Degradable Pollutants: These are not broken down by the natural processes like action of microbes.
2. Degradable Pollutants or Bio-degradable Pollutants: These are natural organic substances which can be decomposed, removed or consumed and thus, reduced to acceptable levels

either by natural processes like biological or microbial action or by some engineered systems, like sewage treatment plants.

17.2 Air Pollution

Air pollution is the resultant of direct or indirect change in physical, chemical and biological characteristics of atmosphere, which mainly results from gases emission from industry, thermal power station, auto mobile and domestic combustions, etc.

17.2.1 Air pollutants

- "Air Pollutant" can be defined as any solid, liquid or gaseous substance present in the atmosphere in high concentration more than prescribed limits that may be harmful to the living creatures.
- Pollutants can be classified as primary and secondary pollutants.
- Primary pollutants are carbon dioxide, nitrogen oxides, sulphur dioxide, carbon monoxide and CFC.
- Secondary pollutants are acid rain and ozone.

17.2.2 Sources of air pollution

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

17.2.2.1 Natural sources

The natural sources of air pollution are volcanic eruptions, forest fires, thunder storms, cyclones, typhoons, fog, biological decay, photochemical oxidation, deposition of dead matters, vegetation and animals etc. Radioactive minerals present in the earth crust are the sources of radioactivity in the atmosphere.

17.2.2.2 Man-made sources

Man made sources include industry, thermal power stations, industrial units, vehicular emissions, automobiles, farming practises, domestic equipments, nuclear weapons and test, etc.

17.2.3 Indoor air pollution

The most important indoor air pollution 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, tiles etc. Many houses in the underdeveloped countries including India use fuels like coal, dung-cakes, wood and kerosene in their kitchens.

17.2.4 Air pollutants criteria

Major pollutants responsible for air pollution are: Sulfur dioxide (SO_2), nitrogen oxides (NO_2 and NO) , carbon dioxide (CO_2) and carbon monoxide (CO), solid or liquid particulates (smaller than 10 µm).

17.2.5 Gaseous pollutants

Major gaseous pollutants are

1. Sulfur dioxide (SO_2)
2. Nitrogen oxides
3. Carbon monoxide and carbon dioxide

17.2.6 Ozone, photochemical smog hydrocarbon and fluorocarbons

- Ozone (O_3) is outcome of chemical reaction between nitrogen dioxide and volatile organic components. Ozone layer in stratosphere protects from harmful UV rays via absorbs ultra violet radiation. Ozone is the key component of photochemical smog.

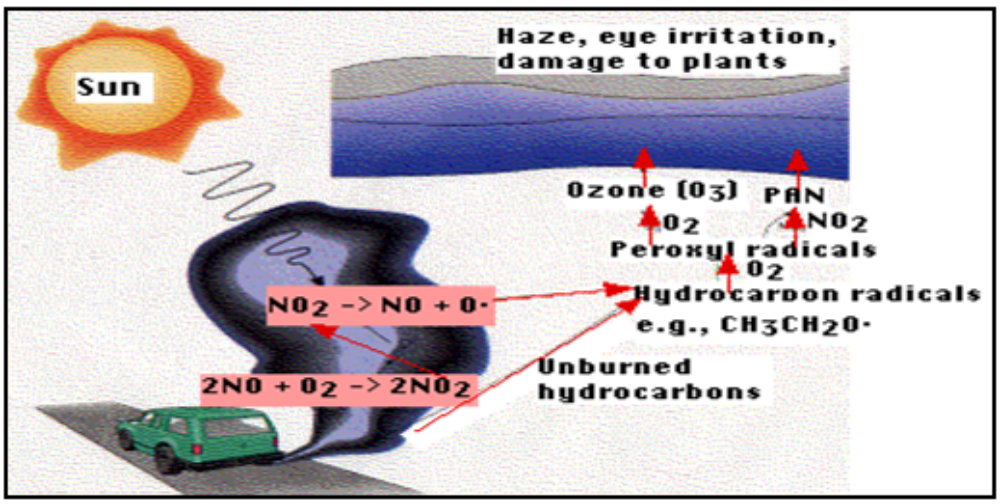


Fig. 17.1 Photochemical smog (courtesy: users.rcn.com)

- Nitric oxide in the atmosphere with ozone causes elimination of ozone layer. Thinning or hole of ozone layer can cause skin cancer .It is estimated that 1% reduction in ozone increases UV radiation by 2%.
- The main hydrocarbon are benzene, venzbyrene and methane and it emerges from motor vehicles. Hydrocarbons combine with nitrites under UV radiation and form other pollutants known as photochemical products such as Aldehydes, Ozone Pans, Olifins, etc.
- On the other hand fluorocarbons at higher level are toxic and creates problem of fluorosis, the source of fluoride in the environment are industrial process of phosphate fertilizers, aluminum, fluorinated plastics, uranium and other metals

17.2.7 Ozone layer depletion

Earth's stratospheric ozone layer, which contains about 90 percent of the ozone in the atmosphere, makes the planet habitable by absorbing harmful solar ultraviolet (UV) radiation before it reaches the planet's surface. UV radiation at higher levels it can cause skin cancer and immune system suppression.depletion of ozone layer was identified during 1970's.this is mainly happened due to more release of manmade industrial chemicals called chlorofluorocarbons (CFCs), which at the time were widely used as refrigerants, in aerosol sprays, and in manufacturing plastic foams. CFC molecules are inert in the troposphere, so they are transported to the stratosphere, where they photolyze and release chlorine (Cl) atoms. Chlorine atoms cause catalytic ozone loss by cycling with ClO (Fig. 17.2).

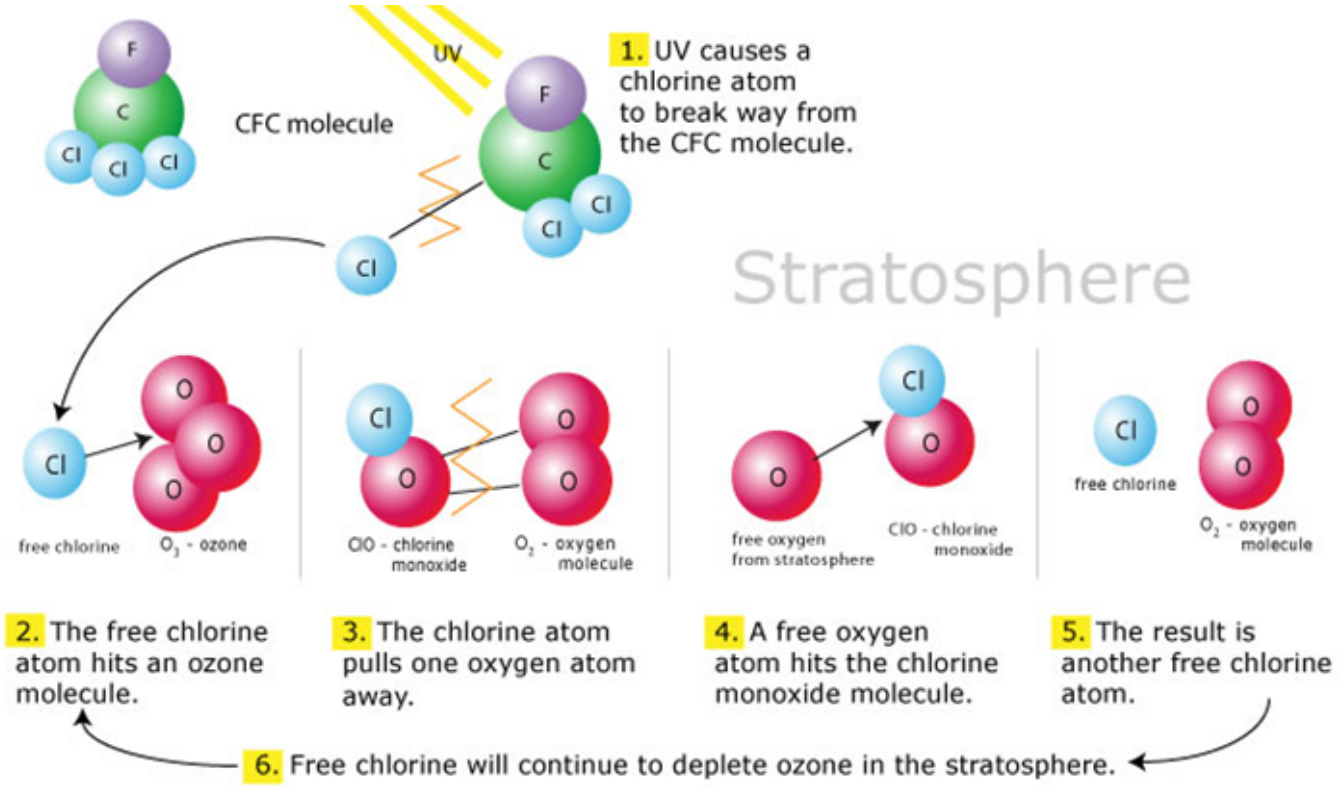


FIg. 17.2 Chlorine-catalyzed ozone depletion mechanism (courtesy : learner.org)

17.2.8 Particulate matters

- Discrete mass of any material which exist as a solid or liquid droplets and microscopic, sub microscopic dimension is known as particulate matter(PM).The main source of particulate matter are fuel combustions and industrial operations like mining, smelting ,polishing ,pesticides, fertilizer and chemical fertilizers,
- Particulate matters can have adverse effect on human health and are generally less than 10 µm size.

17.2.9 Effects of air pollution

- Nitrogen dioxide has more harmful effect as compare to nitric oxide. Exposure to NO_2 causes resistance in air movement in lungs.
- Nitric oxide and carbon monoxide can combine haemoglobin to reduce oxygen caring capacity of blood.
- These pollutants affect plants by entering through stomata. Particulate pollutants affect the photo synthetic activity which may damage the plants and can affect productivity. Air pollutants can enhance the acidity of water resources therefore can adversely affect aquatic life. Material can be damaged due to effect of pollutants when exposed to the environment

17.2.10 Prevention and control of air pollution

Steps to control and prevention of air pollution

- Engineers should consider the possibility by changing the manufacturing process. For example to minimise the high level of lead in air simple solution is to eliminate lead in gasoline (supply of unleaded petrol)
- Use CNG (compressed natural gas) as an alternative fuel .
- Use gas additives to improve combustions.
- Control devices: The following items are commonly used as pollution control devices by industry or transportation devices. They can either destroy contaminants or remove them

from an exhaust stream before they are emitted into the atmosphere.

1. Mechanical collectors (dust cyclones, multicyclones)
2. Electrostatic precipitators An electrostatic precipitator (ESP), or electrostatic air cleaner is a particulate collection device that removes particles from a flowing gas (such as air) using the force of an induced electrostatic charge.
3. Baghouses Designed to handle heavy dust loads, a dust collector consists of a blower, dust filter, a filter-cleaning system, and a dust receptacle or dust removal system.
4. Wet scrubber is a form of pollution control technology. The term describes a variety of devices that use pollutants from a furnace flue gas or from other gas streams.

17.3 Noise Pollution

Noise can be defined as wrong sound in wrong place at wrong time. Sound at undesirable level creates pollution because it cause discomfort to the people. There are two basic properties of sound i.e. loudness and frequency. Loudness is strength of sensation of sound perceived by individual and is measured in terms of decibel, where as frequency of sound defined as number of vibrations per second and measured as hertz (Hz).

Human ear is sensitive to frequency between 20-20000 Hz. whereas best range of hearing is 2000-10000 Hz

17.3.1 Sources of noise pollution

Major sources of noise pollution are industries, transportation, and community, religious and cultural activities. Loudspeaker and amplifiers used in different occasions is another source of noise pollution

17.3.2 Effects of noise pollution

- Noise pollution is harmful to body and mind. It causes irritation and headache. It may cause number of physiological disorder like neurosis anxiety, insomnia, hipper tension, behaviour and emotional stress.

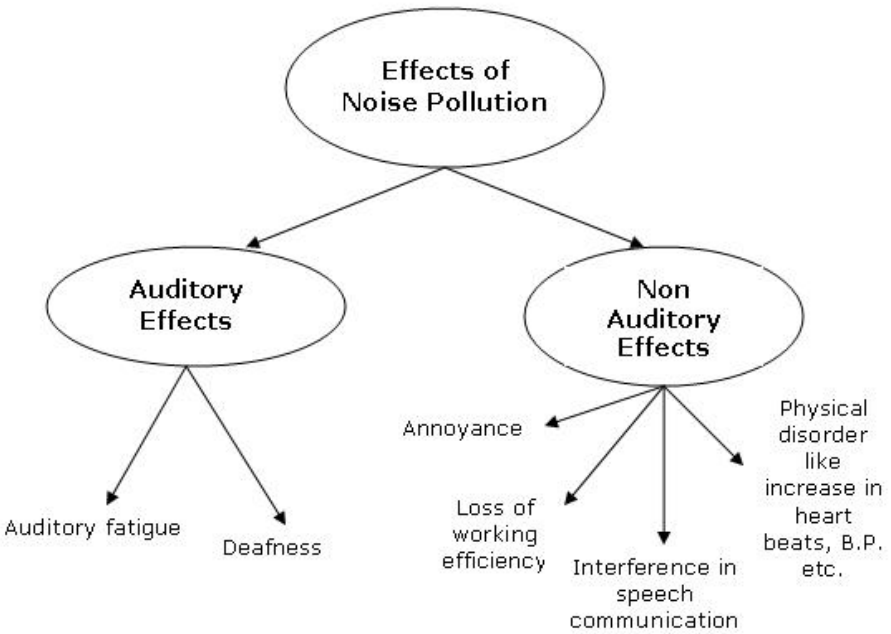


Fig. 17.2 Effects of Noise pollution

17.3.4 Control of noise pollution

- Eliminate the noise at source by use of silencing devises.
- Control the noise transmission level using sound absorbers and acoustic tiles.
- Using self precaution measures such as ear plugs and earmuffs.
- Creating buffer zone between high noise level zone and residential areas by afforestation.
- Taking strict statuary measure to govern the noise level in sensitive areas like schools, hospitals, etc

17.4 Water Pollution

Water pollution is referred as a presence of foreign substances or impurities which can contribute to health hazards by lowering water qualities and making it unfit for use.

17.4.1 Sources of water pollution

Main sources of water pollution are

- Pollution due to decaying of plants ,animals and organic matter in water bodies
- Addition of soil-silt washings, insecticides, herbicide and fungicides are agricultural sources can be water pollution.
- Ore washing, inert suspended solid and soluble toxic materials.
- Sewage obtained from domestic promises, institutions and industrial buildings are main sources of pollution of water in cities.
- Industrial Effluents are one of the important agents of water pollution.
- Accidental spillage of chemical or petroleum products also contributes towards water pollution.
- Ground water pollution with arsenic, fluorides and nitrites which are poisonous in nature are posing serious health problems.
- Major point sources of water pollution are industries, power plants, underground coalmines, offshore oil wells etc.

17.4.2 Water pollutants

Major water pollutants are

1. Organic pollutants: Water carrying organic pollutants have decreased level of oxygen and such organic pollutants promote disease causing agent.
2. Inorganic pollutants: Inorganic pollutants include inorganic salts, metallic compounds, trace elements and organ metallic compounds.
3. Thermal pollutants: Main source of thermal pollutants are coal water plants, nuclear water plants and other industrial process.
4. Sediments
5. Radioactive materials

17.4.3 Effects of water pollution

- Sewage is an excellent medium for growth of pathogens which are responsible for spread of many diseases.
- Water pollution makes the drinking water unfit for domestic use. Industrial effluents have harmful effect on living organism and can lead to death.
- Radioactive substances present in the water may cause cancer, eye, cataract and DNA breakage; it may also destroy biological immune system.
- Residual toxic compounds of pesticides may cause many health problems.
- Sediments reduce the light penetration in water which lowers the photosynthetic activity of aquatic plants.

- Toxic substances observed into tissues from polluted water can cause injuries leading death of the plant.
- Eutrophication: It is the ecosystem response to the addition of artificial or natural substances, such as nitrates and phosphates, through fertilizers or sewage, to an aquatic system. One example is the "bloom" or great increase of phytoplankton in a water body as a response to increased levels of nutrients. Negative environmental effects include hypoxia, the depletion of oxygen in the water, which induces reductions in specific fish and other animal populations. Eutrophication can be human-caused or natural. Untreated sewage effluent and agricultural run-off carrying fertilizers are examples of human-caused eutrophication. However, it also occurs naturally in situations where nutrients accumulate (e.g. depositional environments), or where they flow into systems on an ephemeral basis.

17.4.4 Prevention and control of water pollution

It is said that prevention is better than cure. Strict legislation can help to reduce water pollution and policy maker should formulate strategies to prevent water pollution sources.
Following measures can help to control water pollution

- Prevent generation of pollutants at first place. Control the pollutants to minimise its effects on water pollution.
- Domestic and industrial waste water should be disposed off only after treatment.
- Enforce pollution control laws strictly.
- Use treatment plants to clean discharged industrial waste water and utilise it for irrigation purpose.
- Discourage excess use of pesticide and insecticide.
- Water bodies should be regularly cleaned of aquatic weed and wild plants
- Create public awareness regarding water pollution
- Afforestation will help to reduce the pollution and water erosion
- Use methods of biological nitrogen fixation to improve soil health and adopt integrated pest management to minimise chemical contamination in water.

17.5 Thermal Pollution

Thermal pollution, also known as heat pollution, is releasing of heat in air or water causing undesired changes to environment .It can be both natural as in case of forest fires and heat emanating from volcanoes, or it can be from manmade sources.

17.5.1 Sources of thermal pollution

There are several discrete sources of Thermal Pollution

1. Thermal Power Plants
2. Industries
3. Release of domestic sewerage
4. Nuclear Sources

17.5.2 Effects of thermal pollution

- Solubility of oxygen has inverse proportionality relationship with temperature. That is, with increase in temperature of water bodies, oxygen content of water decreases. Dissolved oxygen is essential component for survival for aquatic life.
- High surface water temperature also has detrimental effect on penetration of oxygen in deep cold water. Thus, it also affects on deep sea species.

- Increase in water temperature has harmful effect on population of aquatic species who are sensitive to temperature changes .On the other hand it propagates temperature change tolerant species. Thus, adversely affecting balance of the aquatic ecosystem.

17.5.3 Control of thermal pollution

17.5.3.1 Cooling towers

Water from water body affected is directed pumped towards the cooling tower having condensers, usually with temperature control. After bringing water temperature to desire level, it is returned to the source. Use of condenser makes this method expensive.

17.5.3.2 Cooling ponds

These are the most cost effective way to tackle thermal pollution. In this method, heat of heating effluents on surface of the water is dissipated in atmosphere.

17.5.3.3 Artificial lake

These are the man made bodies of water .Effluents are discharged into the lake and heat is gradually lost to the atmosphere through evaporation.

17.6 Marine Pollution

Marine Pollution refers to degradation of marine ecosystem by discharge of pollutants in large water bodies, in particular the sea and the oceans.

17.6.1 Sources of marine pollution

- Major concern for Marine ecosystem is Oil Spills. Origin of oil spills can be attributed to natural phenomenon and also due to human activities. Natural sources are oil seeps at geographical fault lines in the ocean floors .Human activities leading to oil spills include leaking of oil tankers, well blowouts, drilling oil rigs, etc.
- Addition of pollutants to sea by rivers flowing into seas.
- Addition of pollutants due to human activities such as industrial activities, agriculture practices and tourism along coastline.
- Over exploitation of aquatic resources such as excessive fishing in particular region can adversely affect marine ecology.
- Mining of minerals at coast and sea-bed near coast results in defiling the marine ecological system.

17.6.2 Control of marine pollution

- Reducing the cases of oil spills due to leaking of tankers and well blowouts.
- Use of effective measures to control oil spills such as use of sinking material such as chalk and dispersants.
- Developing no fishing zones in areas where aquatic life has been adversely affected due to excessive fishing.
- Checking addition of toxic waste to rivers flowing into seas.
- Banning mining activities in and around coastal regions and on sea bed.
- Minimizing human activities in coastal regions adjoining areas sensitive marine ecosystem such as coral reefs.

17.7 Soil Pollution

Soil pollution is contamination of upper layer of earth's crust by chemicals or other toxic substances that lead to either reduction in fertility of soil in terms of crop production or whose addition results in detrimental effects to soil microorganism, insects, plant life and organism who consume those plants.

17.7.1 Sources of soil pollution

- Industrial Wastes.
- Improper Use of fertilizers, insecticides, pesticides, etc.
- Urban waste consisting of solid waste and sludge also contribute heavily towards soil pollution.
- Radioactive Pollutants

17.7.2 Effects of soil pollution

- Industrial effluents containing toxic chemicals dumped on land cause soil pollution and enter in food chain, which has adverse effect on human health .
- Solid waste dumped on land cause disruption in everyday life and destroys natural beauty of the landscape.
- Dumped waste and organic waste give rise to foul odour.
- Pathogenic bacteria cause diseases like cholera.
- Biomagnification: Biological magnification also known as bioamplification, is the increase in concentration of a substance that occurs in a food chain. Biological magnification refers to the process whereby certain substances such as pesticides or heavy metals move up the food chain, work their way into rivers or lakes, and are eaten by aquatic organisms such as fish, which in turn are eaten by large birds, animals or humans. Bioaccumulants are substances that increase in concentration in living organisms as they take in contaminated air, water, or food because the substances are very slowly metabolized or excreted. There is good evidence that DDT, DDE, PCBs, toxaphene, and the organic forms of mercury and arsenic do biomagnify in nature. e.g endosulphon banned in some states due to overuse on cashewnut plantations.

17.7.3 Control measures of soil pollution

- Industries should be banned from dumping toxic chemicals on agricultural land and proper disposal methods should be used.
- Government should provide subsidies, concessions and tax exemption to companies that use recycled raw materials.
- Application of organic manures and pesticides should be encouraged in agriculture.
- Plastic carry bags should be replaced by jute bags.
- Public awareness campaigns should be organized.
- Solid waste from urban and industrial areas should be disposed of using proper techniques.
- Trees and grass should be grown to check soil erosion.

17.8 Nuclear Hazards

Radioactive (nuclear) pollution is a special form of physical pollution related to all major life-supporting systems – air, water and soil. It is always convenient to discuss radioactive pollution separately because its nature of contamination is different from other types of pollution. Its effects are also of special kinds.

17.8.1 Sources of nuclear pollution

1. Source of energy of Sun and other stars is nuclear energy (nuclear fusion reaction taking place in the core), therefore the cosmic rays emanating from sun and other stars are primary source of nuclear hazards.
2. Use and testing of nuclear weapons leads unprecedented loss to life and property as was the case in Second World War.
3. Natural emission of radiation from radioactive isotopes, such as Uranium present in earth's crust.
4. Mining, processing and extraction of radioactive ores.
5. Use of radioactive isotopes in nuclear reactors.
6. Problem associated disposal of nuclear waste from nuclear reactors.
7. Accidental leakages in nuclear power plants and other nuclear facilities.

17.8.2 Effects of nuclear hazards

- Effects of nuclear hazards are prolonged and can haunt civilizations for year and can have adverse effect on generations to come.
- Exposure to nuclear radiations can affect genetic make-up by breaking the chemical bonds that hold the DNA together. Thus the effect can be transferred to future generations.
- Nuclear explosion and nuclear weapons can cause mass destruction to life and property of a scale unprecedented in history of mankind.
- Nuclear hazards are transferred in food chains from bottom to top with transfer of nuclear elements from prey to the predator.
- Continuous exposure to radiation can lead to cancer.

17.8.3 Nuclear disaster

Hiroshima and Nagasaki atomic bombing in World War-II(1945) & Chernobyl Nuclear Power Plant Disaster (1986) and meltdown of nuclear reactors in Fukushima Nuclear Power Plant in March 2011 are examples of nuclear disaster that can be cited from history that have caused mass destruction to life and property.

17.8.4 Nuclear hazard control

- Nuclear Power plants and research facilities should be set up after careful evaluation in less inhabited areas.
- Nuclear Power Plants must be carefully designed to minimize risks of leakage.
- Strict vigilance bodies should be constituted and laws should be enforced to ensure nuclear safety.
- Summits and conferences must be organized to facilitate the evolution and exchange of new research and ideas in field of nuclear safety.
- Efficient nuclear waste disposal mechanism should be evolved.
- Preventive measures must be taken to minimize risks associated with occupation connected to processing of nuclear material.
- Disarmament of nuclear weapons must be strongly advocated in International Diplomacy

ENVIRONMENTAL STUDIES

Module 5. Environmental pollution

Lesson 18
SOLID WASTE MANAGEMENT

18.1 Introduction

Solid waste includes all discarded solid and semi-solid materials arising from various human activities. Municipal solid waste (MSW), consist mainly of refuse and trash. It predominantly includes food wastes, yard wastes, containers and product packaging, other miscellaneous inorganic wastes from residential, commercial, institutional, and industrial sources.

Trash refers to the bulky waste such as TV, refrigeration goods, broken furniture, etc. Refuse comprises of two components mainly garbage and rubbish. Garbage includes putrescible waste such as vegetables, meats, food wastes and other readily degradable organic wastes. Rubbish consists of the non-degradable material such as glass, rubber, metals, plastics, etc and slowly degradable material such as paper products, textiles etc.

18.2 Sources of Solid Waste

- Residential sources: Waste arising from day to day household activities is a important constituent to the solid waste. Proportion from this source is increasing day by day with rapid increase in population. Household waste includes variety of things such as food wastes, paper, cardboard, plastics, textiles, leather, etc
- Industrial Waste: Solid waste resulting from industries typically includes construction and demolition waste, rubbish, ashes and special waste.
- Community Services: community services such as street cleaning, landscaping, recreational activities, water and waste water treatment plants give rise to solid waste such as wood, dirt, plastic and other general wastes.
- Agricultural activities: Agricultural activities generate spoiled food wastes, agricultural wastes such as straw and sugarcane trash, hazardous wastes such as pesticides and insecticides.
- Construction and demolition activities such as construction sites, road repair, renovation sites, and demolition of buildings generate solid waste like wood, steel, concrete, dirt, etc.
- nstitutions such as schools, hospitals, prisons, government centers generate solid waste like paper, cardboard, plastics, wood, food wastes, glass, metals, etc.

18.3 Effects of Solid Waste Pollution

- Diseases such as diarrhea and dysentery are spread by carriers especially fly which breed on garbage.
- Rubbish and trash can block the drains thus making breeding grounds for mosquitoes, that spread diseases like malaria and dengue.
- Rotting garbage gives out foul smell that can render a locality inhospitable.

- Dumping places are usually also home to stray animals such as abandoned cows that frequently block traffic on roads and occasionally lead to road accidents.
- Seeping of toxic chemicals from factories and garbage waste underground, can render underground water unfit for human consumption.
- Accumulation of construction and demolition waste at places lessens the aesthetic beauty of surroundings.
- Intake of solid non-biodegradable waste such as plastic by scavengers and stray animals like pigs and abandoned cows can choke their windpipes and lead to death.

18.4 Need for Reducing, Reusing and Recycling of Waste

Waste management is necessary because if it is not done the waste may lead to environmental and health problems harmful for mankind. Our planet is going to be filled with waste soon if we don't manage our garbage and trash properly.

- It cuts back on global warming.
- It makes us more energy-efficient. It often takes a great deal more energy to create something from scratch than to recycle it.
- It keeps our landfills from overflowing. We’re fast running out of space for landfills—especially near cities. Seaside cities have been dumping trash into their oceans for decades to circumvent the problem
- It improves the quality of our groundwater.
- It reduces air pollution. Many factories that produce plastics, metals, and paper products release toxins into the air. Recycle these materials, and there will be less need for companies to manufacture new materials—saving on the amount of pollution dumped into our atmosphere.
- It creates jobs. From manufacturing to processing, from collection to invention—it’s no secret that recycling is a growth industry, earning billions of dollars annually.
- It adds to property value. It’s obvious that a landfill near your home can decrease your property values significantly. Recycling reduces the amount of land needed for landfills. This reduces the number of houses near landfills, keeping property values up and homeowners happy.

18.5 Management of Solid Waste

- Best way to manage the problems associated with solid waste is by to reduce wastage itself. With higher standards of living especially in urban areas there is tendency to declare goods outdated and obsolete. This leads to solid waste. Thus, the problem can be checked by promoting efficient utilization and reuse.
- Recycling the trash and refuse greatly reduces the non-biodegradable component of solid waste. Items made up of plastic, glass, paper, metal, etc. can be recycled to form other products, thus saving raw materials and also reducing solid waste.
- Disposing off the solid waste with techniques such as land filling, incineration, pulverization, etc.

18.6 Methods of Solid Waste Disposal

- Land Filling: This is simple and economical method that requires no skilled labour. Method involves dumping the solid waste collected into a low lying area usually at the outskirts of the settlement in layers. The layers are usually 1.5 to 2 meters thick are covered with a thin layer of good earth, before filling another layer of solid waste over it. The layer of solid waste is thus sandwiched between thin layers of good earth. Over

time, solid waste breaks and is stabilized. After the site reaches certain height, it can be developed as parks by landscaping and planting trees.

- Incineration: In this method, solid waste is burned in specially designed furnaces. Combustible waste is separated from non-combustible and fed into the furnace. Temperature conditions in furnace are carefully adjusted to burn all organic matter and oxidize all foul smell. If moisture content of solid content is high, some auxiliary fuel such as coal or wood can be added to support burning. Since, this method involves high temperature; all pathogens and pest are destroyed, though, smoke coming from furnace causes air pollution.
- Pulverization: In this method, collected solid waste is powdered by grinding machines, thereby changing its volume and physical characteristics. This pulverized solid waste is further disposed-off by land filling. This is costly technique.
- Composting: This method involves digesting organic matter by anaerobic process, converting it into organic manure and other stable compounds. It solves twin purpose of solid waste disposal and providing manure for farms .Composting by trenching, open window composting and mechanical composting are three widely used composting techniques.
- Disposal into the sea: This method involves dumping the solid waste at sea floor. It can only be applied in coastal areas with strong currents .It is cheap method but tides can bring back some portion of solid waste dumped back to beaches.

ENVIRONMENTAL STUDIES

Module 5. Environmental pollution

Lesson 19
ROLE OF AN INDIVIDUAL IN PREVENTION OF POLLUTION

19.1 Introduction

Environment protection has been burning issue in last half century. In order to tackle the menace of pollution, urgent steps have to be taken at not only global or country level, but also at local level. In fact, the role of individuals in prevention of pollution is of critical importance, because it is the individuals that make a community or country. Effort by each individual at his or her level can have a significant effect on global level. It has been aptly said "charity begins at home".

Aware and inspired individuals are strongest tool to tackle pollution. This is because an aware individual not only lessens the burden on state but also he/she can tackle problem of pollution more effectively as he/she is more familiar with problems persisting at local level and he himself/herself deals with them in his/her day to day life. It is better and more viable to prevent pollution by educating individuals than controlling pollution. Individuals should encourage to modify their lifestyle and living habits if that are not healthy for environment.

19.2 Ways in Which a Individual can Help in Prevention of Pollution

- Individuals should minimize wastage of resources such as electricity. Every unit of electricity saved is equivalent unit of electricity produced as it not only saves the fuel that would be used to produce that electricity, but also help to prevent pollution that is accompanied by burning of that fuel. Therefore, person should always switch off appliances when not in use.
- Individuals should prefer walking or use cycles instead of using motor vehicles, especially when distances to be travelled are small.
- Individuals can make considerable contribution by using mass transport (buses, trains, etc) instead of using personal vehicles.
- When going to workplace, colleagues from nearby localities should pool vehicles instead of going in individual personal vehicles.
- Taking personal vehicles for periodic pollution checks at centres approved by authorities.
- Individuals should reuse items whenever possible.
- Products that are made of recycled material should be given preference.
- Use gunny bags made of jute instead of plastic bags.
- Take part in environment conservation drives such as tree planting drives.
- Use water resources efficiently.
- Use renewable resources by installing equipment such as solar heaters and using solar cookers.

- Dispose potentially harmful products such as cells, batteries, pesticide containers, etc properly.
- Use of refrigerators should be minimised wherever possible as they are main source of CFC, which is responsible for Ozone layer depletion.
- Follow and promote family planning, as more population means more resources utilized and more resources utilized imply more pollution.
- Avoid making noise producing activities such as listening to loud music.
- Use handkerchiefs instead of paper tissues.
- Organize drives to clean streets and clean drains with help of other people of locality.
- Spread awareness and inspire other people to prevent pollution. Individuals should be encouraged to acquire information and innovations from world over and implement them locally.

ENVIRONMENTAL STUDIES

Module 5. Environmental pollution

Lesson 20
POLLUTION CASE STUDIES

20.1 London Smog Disaster

Smog has been part of London life. But the effect of the Great Smog of '52 was unprecedented. A period of cold weather, combined with an anticyclone and windless conditions, collected airborne pollutants (mostly from the use of coal), to form a thick layer of smog over the city. It lasted from Friday 5 to Tuesday 9 December 1952. It is considered the worst air pollution event in the history of the United Kingdom. Medical reports estimated that 4,000 people had died prematurely and 100,000 more were made ill because of the smog's effects on the human respiratory tract. More recent research suggests that the number of fatalities was considerably greater at about 12,000.

The weather in November and early December 1952 had been very cold, with heavy snowfalls across the region. To warm homes, people burned coal in their homes. Also, it was primary fuel in industries. In normal conditions, smoke would rise into the atmosphere and disperse, but due to anticyclone, inversion was created, which pushed air downwards. As a result, smoke from the chimneys was trapped.

The fog finally cleared on December 9, but it had already taken a heavy toll.

A series of laws were brought in to avoid a repeat of the situation. This included the Clean Air Acts of 1956 and 1968. These acts banned emissions of black smoke.

Fig. 20.1 Nelson column during Great Smog of 1952

20.2 Bhopal Gas Tragedy

Bhopal gas tragedy accounts for most infamous incidents of industrial pollutions. On December 3 1984, more than 40 tons of methyl isocyanate gas leaked from a pesticide plant

in Bhopal, India, immediately killing at least 3,800 people and causing significant morbidity and premature death for many thousands more. At around 1.00 AM, December 3, loud rumbling reverberated around the plant as a safety valve gave away, sending a plume of MIC gas into the early morning air. Within hours, air was full of toxic contents. Gas circulated through the blood streams of victims, carrying toxins and causing damage to the eyes, lungs, kidneys, liver, intestines, muscles, brain, reproductive and immune systems.

Soon Bhopal was full of corpse of humans and animals. Immediate loss was around 3800 human lives, with death toll increasing to 10000 in that week. As a result of aftermath, region has reported 15000 to 20000 premature deaths. These numbers can be assumed to be understated. In l985 the Indian Government sued Union Carbide for 3.3 billion dollars and in l989, case settled for a mere $470 million. This money, later deposited with RBI, has now swelled up to Rs 1,503 crore. UCC got away by paying a compensation of mere $470 million, although actual compensation was accounted to less than $10 billion as calculated by some agencies.

UCC ceased its operations at Bhopal plant, but did not take responsibility to clean the mess either. The plant continues to leak several toxic chemicals and heavy metals that have percolated into underground water. Reports suggest that underground water of the region still contain heavy metals even after around three decades. When it rains, especially in the monsoon season, rainwater washes these chemicals into puddles, streams and eventually into the ground water.

Despite the horror of "that night" and the chemical terror that its survivors have endured, the people of Bhopal continue their struggle for justice, for corporate accountability, and for their basic human right to an environment free of chemical poisons.

Fig. 20.2 Union Carbide MIC plant

20.3 Fukushima Disaster

On March 11, 2011, a powerful, 9.0 magnitude quake hit north-eastern Japan, triggering a tsunami with 10-meter-high waves that reached the U.S. west coast. It was triggered by an earthquake near Honshu off eastern coast of Japan. It was followed by horrors of tsunami, followed by after-shock of 6.7 magnitudes. Duel punch of earthquake and tsunami caused damage that led to explosions and partial meltdowns at the Fukushima Nuclear Power Plant in Japan.

Three out of six reactors failed. Radiation levels from Fukushima Nuclear Power Plant were

reported as high as 1,000 mSv/h (milli sievert per hour). These were 20 times acceptable levels of nuclear radiations allowed in the US. The high levels of radiation in and around the plants hampered efforts to cool the reactors. The evacuation area around the plant was 20 kilometres (12.4 miles), while people living up to 30 kilometres (18.6 miles) from the plant have been advised to stay indoors. Other countries were even more cautious. On 3 April 2011, two bodies were discovered in the basement turbine room most likely because the workers ran there during the tsunami.

It will take decades for complete clean-up of pollutants from this disaster. A permanent exclusion zone could end up stretching beyond the plant's perimeter. Seriously exposed workers may be at increased risk of cancers for the rest of their lives. More importantly it hindered much needed rescue work for the victims of earthquake and tsunami required. Some of the areas in the temporary 19 km (12 miles) radius evacuation zone around Fukushima were found to be heavily contaminated with radio-nuclides According to a new reports released by the Japanese Ministry of Science and Education, the town of Okuma was reported as being over 25 times above the safe limit of 20 millesievers per year. Marine life around Japanese eastern coast will be adversely affected for years. Radionuclides in seawater were reported from the Fukushima plant's discharge canals, from coastal waters five to 10 kilometres south of the plant, and from 30 kilometres offshore, even months after the disaster. It can be expected that the marine dispersion of seawater tagged with radionuclides released from Fukushima will take years to reach other riparian Pacific countries. Although the immediate direct losses to life in this incident were less than other disasters the history has witnessed, long term hazards of this incident are immense.

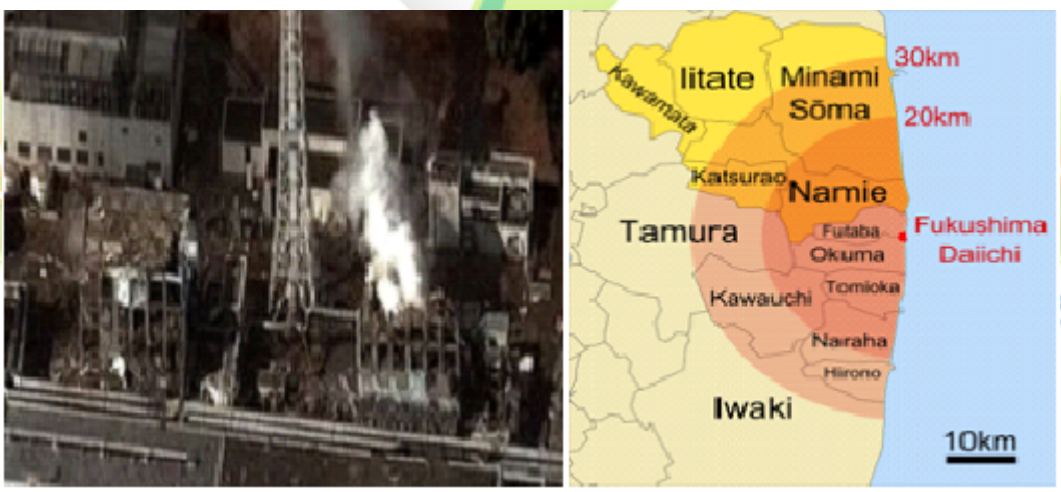


Fig. 20.3 LEFT: Fumes coming out from three damaged nuclear reactors in Fukushima Nuclear Power Plant. RIGHT: Evacuation Zone

ENVIRONMENTAL STUDIES

Module 5. Environmental pollution

Lesson 21
DISASTER MANAGEMENT

21.1 Disaster Management

Disaster management refers to effective management of counter measures that are taken in order to mitigate the effect natural calamities that lead to desperate situations after calamities such as earthquakes, floods, landslides, tsunamis, etc. Although these sudden calamities are natural geographical processes that have been taking place from beginning and have played important role in shaping of earth, these geographical activities are wreck havoc and bring misfortune to people in region affected. Among the 36 states and Union territories in the country, 22 are prone to disasters. Among all the disasters that occur in the country, floods are the most frequently occurring natural disasters, due to the irregularities of the Indian monsoon. About 75 percent of the annual rainfall in India is concentrated in three to four months of the monsoon season. As a result there is a very heavy discharge from the rivers during this period causing widespread floods. Approximately 40 million hectares of land in the country has been identified as being prone to floods. Major floods are mainly caused in the Ganga-Brahmaputra-Meghna basin which carries 60 percent of the total river flow of our country.These processes inflict huge losses to life and property and it can take years for life to take normal shape.

Every region of the world will confront disaster in some way or other. As these disasters are sudden and rarely predictable, best way to mitigate their effect is to be prepared to them. This requires preplanning and professional approach.

Disaster management pivots around preplanning, which includes

- Organizing general disaster management teams to respond to any general disaster and in any terrain.
- Organizing special quick response teams that are highly specific to nature and region of disaster.
- Most important part is indentifying threats that a particular region is most venerable to. This involves setting up of research stations that study the terrain, climate and underground seismic activities of the region.

Following diagram is self explanatory regarding steps involved in Disaster management at authority level.

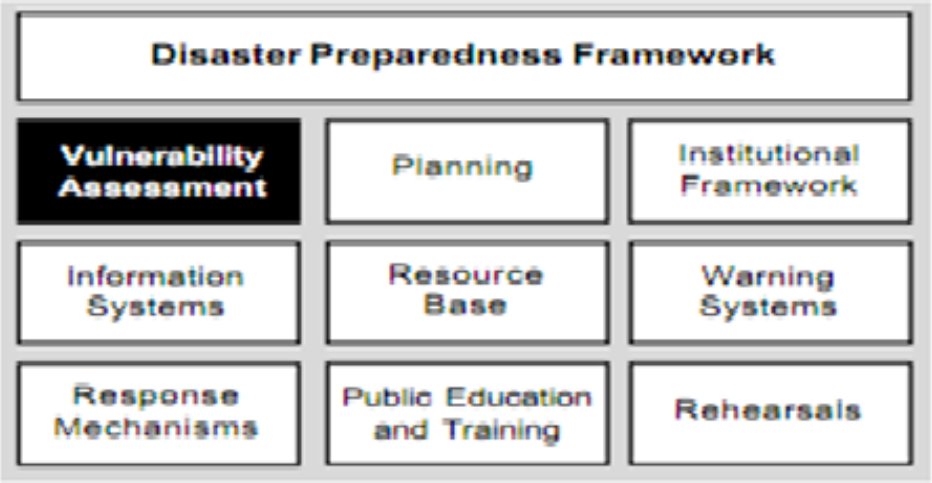


Fig 21.1 self explanatory regarding steps involved in Disaster management at authority level

21.2 Major Causes for Disasters

1. Anthropogenic activities such as Impoundment of huge quantities of water in the lake behind a big dam e.g. Koyna Dam in Maharashtra have created few incidence of minor and major earthquakes., under ground nuclear testing e.g.Pokharan II testing at desert of Rajasthan, Deep well disposal of liquid waste.
2. Due to heavy rainfalls or sudden snow melt can swell the rivers disproportionately- causes a great economic loss and health related problems.
3. Landslides occur when coherent rock of soil masses move down 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.

Here are some control measures that are disaster-type specific.

21.3 Earthquake

In order to abate the effect of earthquakes, these precautionary measures must be taken.

- People should evacuate buildings and stay in open until the time, tremors have ceased.
- In case people are unable to get out of the buildings, they should try and stay in corners of the rooms.
- People using transport should stop vehicles and wait for tremors to subside.
- Buildings should be made by using construction material that is recommended by authorities.
- Design of the houses and buildings must be approved by authorities. Rectangular building design is most effective design that can withstand earthquake.
- People should help each other and provide first aid to the victims and not just wait for disaster management teams to arrive.
- Temporary relief camps and rehabilitation centres should be provided to people who have been affected.
- Compensation should be given to people who lost their house and livelihood.
- People should be made aware and trained through campaigns to tackle adversities as it is not possible for disaster management teams to reach everywhere.

21.4 Cyclones

In order to abate the effect of cyclones, following measures are advised.

- With help of technology, advent and paths cyclones can be predicted to some extent. First and foremost measure is to vacate the region that is predicted to be affected.
- People should be warned about cyclones through weather news, internet, newspapers, radio broadcast, etc.
- People should take to shelter in safe buildings during cyclones. Storm shelter should be constructed by authorities.
- Fisherman should be warned not to go to sea.
- Electricity supply should be cut off to the region that is affected.
- Temporary relief camps and rehabilitation centres should be provided to people who have been affected.
- Compensation should be given to people who lost their house and livelihood.

21.5 Floods

In order to pacify the effects of flood disaster, following steps must be taken.

- Floods in general are caused by heavy and concentrated rains. Therefore best defence is to study and predict weather developments and issue early warnings through broadcast and print media.
- People should be evacuated to safer places and relief camps should be provided.
- People who could not be evacuated should move to relatively higher places.
- Dams and embankments must be constructed by the government to check the flow in regions frequently affected by flood disasters.
- Floods often result in breaching of canal embankments and river embankments. Strength of these embankments must be periodically evaluated by authorities so that they can withstand deluge.
- Sand bangs must be used to repair temporary breaches in canals during floods.

21.6 Landslides

In general the chief mitigatory measures to be adopted for landslide areas are

- Drainage correction,
- Proper land use measures,
- Reforestation for the areas occupied by degraded vegetation
- Creation of awareness among local population.

The most important triggering mechanism for mass movements is the water infiltrating into the overburden during heavy rains and consequent increase in pore pressure within that overburden. When this happens in steep slopes, the safety factor of the slope material gets considerably reduced causing it to move down. Hence, the natural way of preventing this situation is by reducing infiltration and allowing excess water to move down without hindrance. As such, the first and foremost mitigation measure is drainage correction. This involves maintenance of natural drainage channels both micro and macro in vulnerable slopes.

The universal use of contour bunding for all types of terrain without consideration of the slope, overburden thickness and texture or drainage set-up needs to be controlled especially in

the plateau edge regions. It is time to think about alternative and innovations, which are suitable for the terrain, to be set up. It need not be emphasized the governmental agencies have a lot to contribute in this field.

21.7 Agencies Working on Disaster Management

21.7.1 National disaster management authority (NDMA)

NMDA is headed by the Prime Minister of India, is the Apex Body for Disaster Management in India. The setting up of the NDMA and the creation of an enabling environment for institutional mechanisms at the State and District levels is mandated by the Disaster Management Act, 2005. NDMA as the apex body is mandated to lay down the policies, plans and guidelines for Disaster Management to ensure timely and effective response to disasters.

21.7.2 International association of emergency managers (IAEM)

IAEM is a non-profit educational organization dedicated to promoting the goals of saving lives and protecting property during emergencies and disasters. The mission of IAEM is to serve its members by providing information, networking and professional opportunities, and to advance the emergency management profession. It currently has seven Councils around the World: Asia, Canada, Europa,International, Oceania, Student and USA.

21.7.3 Red cross/Red crescent

National Red Cross/Red Crescent societies often have pivotal roles in responding to emergencies. Additionally, the International Federation of Red Cross and Red Crescent Societies (IFRC, or "The Federation") may deploy assessment teams, e.g.Field Assessment and Coordination Team – (FACT) to the affected country if requested by the national Red Cross or Red Crescent Society. After having assessed the needs Emergency Response Units (ERUs) may be deployed to the affected country or region. They are specialized in the response component of the emergency management framework.

21.7.4 United nations

Within the United Nations system responsibility for emergency response rests with the Resident Coordinator within the affected country. However, in practice international response will be coordinated, if requested by the affected country's government, by the UN Office for the Coordination of Humanitarian Affairs (UN-OCHA), by deploying a UN Disaster Assessment and Coordination (UNDAC) team.

ENVIRONMENTAL STUDIES

Module 6. Social issues and the environment

Lesson 22
SUSTAINABLE DEVELOPMENT

Strategies for Sustainable Development

The Rio Summit established sustainable development as the guiding vision for the development efforts of all countries. At Rio, and in later commitments, all governments undertook to establish and implement national sustainable development strategies. The strategies for sustainable development called for at Rio are foreseen as highly participatory instruments intended "to ensure socially responsible economic development while protecting the resource base and the environment for the benefit of future generations". The Rio Agenda 21 was reaffirmed most recently in the Millennium Summit Declaration. The International Development Goals call specifically for the "establishment of sustainable development strategies by 2005". In the run up to the World Summit on Sustainable Development (WSSD), in Johannesburg in 2002, it is appropriate that we review progress towards achieving this commitment and to agree how the international community can best assist developing countries in meeting this goal. Thus, it is particularly timely that the High Level Meeting of the Development Assistance Committee (of the OECD) DAC on 25-26 April 2001 endorses the DAC Guidelines: "Strategies for Sustainable Development: Guidance for Development Co-operation". We are committed to provide support for sound nationally-owned sustainable development strategies where conditions for effective partnership are in place. In simple terms, sustainable development means integrating the economic, social and environmental objectives of society, in order to maximise human well-being in the present without compromising the ability of future generations to meet their needs. This requires seeking mutually supportive approaches whenever possible, and making trade-offs where necessary. For developing countries, and for development co-operation, reducing poverty and meeting the International Development Goals are imperatives — within the broad context of sustainable development — for this generation.

As the nineties unfold, the world is entering a new era, one in which it is far more difficult to expand food output. Many knew that this time would eventually come, that at some point the limits of the earth's natural systems, the cumulative effects of environmental degradation on cropland productivity, and the shrinking backlog of yield-raising technologies would slow the record growth in food production of recent decades. But because no one knew exactly when or how this would happen, the food prospect was widely debated. Now we can see that several constraints are emerging simultaneously to slow the growth in food production.

After nearly four decades of unprecedented expansion in both land-based and oceanic food supplies, the world is experiencing a massive loss of momentum. Between 1950 and 1984, world grain production expanded 2.6-fold, outstripping population growth by a wide margin and raising the grain harvested per person by 40%. Growth in the world fish catch was even more spectacular- a 4.6-fold increase between 1950 and 1989, which doubled seafood consumption per person. Together, these developments reduced hunger and mal-nutrition

throughout the world, offering hope that these biblical scourges would one day be eliminated.

The world's rangelands, a major source of animal protein, are also under excessive pressure. The language used to describe them is similar to that used for fisheries: they are being grazed at or beyond capacity on every continent. This means that rangeland production of beef and mutton may not increase much, if at all, in the future. Here, too, availability per person will decline indefinitely as population grows.

With both fisheries and rangelands being pressed to the limits of their carrying capacity, future growth in food demand can be satisfied only by expanding output from croplands. The growth in demand for food that until recently was satisfied by three food systems must now all be satisfied by one.

From mid-century until recently, grain output projections were for the most part simple extrapolations of trends. The past was a reliable guide to the future. But in a world of limits, this is changing. In projecting food supply trends now, at least six new constraints need to be taken into account:

1. Constraints, the backlog of unused agricultural technology is shrinking, leaving the more progressive farmers fewer agronomic options for expanding food output.
2. Growing human demands are pressing against the limits of fisheries to supply seafood and of range-lands to supply beef, mutton, and milk.
3. Demands for water are pressing against the limits of the hydrological cycle to supply irrigation water in key food-growing regions.
4. In many countries, the use of additional fertilizer on currently available crop varieties has little or no effect on yields.
5. Countries that are already densely populated when they begin to industrialize risk losing cropland at a rate that exceeds the rise in land productivity, initiating a long-term decline in food production.
6. Social disintegration, often fed by rapid population growth and environment degradation, is undermining many national governments and their efforts to expand food production.

The six limits or constraints briefly discussed here have emerged rather recently. In many cases, they were not anticipated. All available projections of world fertilizer use made during the eighties, for example, showed growth continuing smoothly through the remainder of the century and in to the next. Few analysts anticipated the scale of water scarcity that is unfolding in large parts of the world. Many assumed that the agricultural research establishment could continue to churn out new technologies that would rapidly raise crop yields for the indefinite future. And few have even asked the question of what happens if China starts losing cropland as fast as Japan has during the last few decades.

At the international level, the population-driven environmental deterioration/political disintegration scenario described by Robert Kaplan is not only possible; indeed, it is likely in a business-as usual world. But it is not inevitable. This future can be averted if security is redefined, recognizing that food scarcity, not military aggression, is the principal threat to our future. This would lead to a massive reordering of priorities- giving top place to filling the family planning gap; to attacking the underlying causes of high fertility, such as illiteracy and poverty; to protecting soil and water resources; and to raising investment in agriculture.

Any form of alternative development strategy for the agricultural sector must explicitly

consider its environmental and social impacts. While much lip-service is given to the environmental implications of the agricultural sector, not much is done about them in most countries. The emphasis has too often been on short-term gains that may not be sustainable over a longer period of time.

The Food and Agriculture organization of the United Nations, FAO, has already stressed that 'the major environmental problems facing agriculture, forestry, and fisheries, were not only avoidance of environmental pollution, but also the ensuring, in the development process, of the maintenance of the productive capacity of basic natural resources for food and agriculture through rational management and conservation measures' (FAO, 1974). It also 'recognized that agricultural development and world food security depended on careful husbandry of living resources, on their biological laws and ecological balances, as well as on the adjustments of production, supply, and reserves, to demands.'

There are many environmental implications of any new developmental policies for the agricultural sector, but only one will be discussed here-pesticides. It is now evident that continued heavy reliance on pesticides to protect vast areas of monocultures is ultimately bound to be self-defeating. For such a practice kills many useful insects that could help naturally to keep the pest population down, and commonly requires repeated increase in the doses of application that are needed to counter the continual development of new strains of pesticide-resistant forms. Thus, the number of applications of pesticide to cotton in recent years has risen from 8 to 40 yearly in some Central American countries (FAO, 1974), and evolution of new strains of cotton pests necessitates the use of new forms of pesticides every three or so years in Egypt.

There are several similar examples of eventual reduction in crop production owing to heavy reliance on chemical pesticides. Thus, an alternative approach to development will have to depend on new concepts of integrated pest-management, which can be broadly defined as an ecological approach to pest control by optimal combinations of biological and chemical control-technologies. This would be based upon information about individual pests, their environment, and their natural enemies, whereupon farming practices could be modified to control the pest and aid its natural enemies.

Realistic economies injury-levels of crops would be used to determine the need for suppressive measures. For example, during the first 30 days, and for stages after 100 days, following planting, cotton can withstand up to 50% defoliation. During the period of fruit formation (taking 30-100 days), the economic level for defoliation drops to about 20%. Integrated pest management takes advantage of these types of sensitivities, and the measures undertaken might include releasing biological control agents or pest-specific diseases or, when necessary, applying pesticides in limited amounts. The use of biological control against Fungi and weeds has so far been little exploited. Release of sterile males or artificially-reared natural enemies of the pest have, however, proven successful to control a number of insect pests.

ENVIRONMENTAL STUDIES

Module 6. Social issues and the environment

Lesson 23
URBAN PROBLEMS

23.1 Introduction

Developments in the four target sectors of transport, tourism, energy and industry, and action in the priority themes of air, noise, water and waste have a significant impact on the quality of the urban environment. Activities are importance to develop co-operation between cities in the promotion of local Agenda plans. The local Agenda process by assisting local authorities in developing policy tools and instruments and through awareness rising.

The Sustainable Cities project in 1993, as a follow-up to the discussion that flowed from the 1990 Green Paper on the urban environment. The main aims of the project are to:

- Promote new ideas on sustainability in European urban settings,
- Foster a wide exchange of experience,
- Disseminate good practices on sustainability at the urban level, and
- Formulate recommendations aimed at influencing policy at the EU, Member State, and regional and local level.

Essentially it consists of

- Policy reports and recommendations for institutions,
- Networking activities that are run by the Sustainable Cities campaign launched. The charter calls for increased inter-local authority co-operation and commits its signatories to drawing up long-term action plans for sustainable development with those involved at the local level.

A wide range of human activities affect water availability and quality especially in areas with a high population density, concentrated industrial activity and intensive agriculture.
Only a small fraction of the world's population has access to tap water that is suitable for drinking. In the European Union, this service is taken for granted, and it is forgotten that this is not the case everywhere. The indicators selected by the panels of water experts will give a comprehensive description of the pressures imposed on quality and availability of water resources and of the success of environmental policy to reduce them.

- The prevention of over-exploitation of ground water and surface water for drinking water or industrial or other purposes;
- The prevention of pollution of ground water from diffuse sources; and
- A better ecological quality of surface and marine water.

The indicators formulated by the Scientific Advisory Groups for the policy field Water Pollution & Water Resources go into more detail: nutrients, overuse of ground water resources, pesticides, heavy metals and organic matter are listed as the most important

pressures on water. A more general indicator "wastewater treated" is also included as a measure of the efforts invested in the protection of water quality.

23.2 Related to Air Pollution

The term "air pollution" is used to describe substances that are artificially introduced into the air. Air pollution stems from gases and airborne particles which, in excess, are harmful to human health, buildings and ecosystems.

Four major impacts determine the classification of pollutants under the traditional policy field

23.2.1 Air pollution

- The acidification of soil and water by pollutants such as sulphur oxides, nitrogen oxides and ammonia;
- The damage to buildings sensitive to the same acidifying substances;
- The formation of troposphere ozone from so-called ozone precursors, e.g. Volatile organic compounds, nitrogen oxides and carbon monoxide which indirectly affect human and animal health and vegetation;
- Direct effects on human health and ecosystems e.g. through high atmospheric concentrations of particles, and vocs.

Excluded from this chapter are emissions of CO_2, N_2O, CH_4 and CFCs, which are covered in the policy fields Climate Change and Ozone Layer Depletion. Emissions of highly toxic substances are given special consideration under the heading Dispersion of Toxic Substances

Although some of these pollutants are also produced by nature, the main environmental problems result from human activities. Air pollutants are often transported over considerable distances, affecting air quality, ecosystems, lakes and other surface water, groundwater, soils and buildings in adjacent and distant countries.
The following list of indicators selected by the Scientific Advisory Group (SAG) "Air Pollution" comprises four indicators of pressure. The two "background" or "driving force" indicators Consumption of petrol & diesel oil by road vehicles and Primary energy consumption represent the major causes of these pressures.

23.2.2 Water conservation

Water conservation can be defined as:

1. Any beneficial reduction in water loss, use or waste as well as the preservation of water quality.
2. A reduction in water use accomplished by implementation of water conservation or water efficiency measures; or,
3. Improved water management practices that reduce or enhance the beneficial use of water. A water conservation measure is an action, behavioral change, device, technology, or improved design or process implemented to reduce water loss, waste, or use. Water efficiency is a tool of water conservation. That results in more efficient water use and thus reduces water demand. The value and cost-effectiveness of a water efficiency measure must be evaluated in relation to its effects on the use and cost of other natural resources (e.g. energy or chemicals).

The goals of water conservation efforts include as follows:

- Sustainability. To ensure availability for future generations, the withdrawal of fresh water from an ecosystem should not exceed its natural replacement rate.
- Energy conservation. Water pumping, delivery, and waste water treatment facilities consume a significant amount of energy. In some regions of the world over 15% of total electricity consumption is devoted to water management.
- Habitat conservation. Minimizing human water use helps to preserve fresh water habitats for local wildlife and migrating water flow, as well as reducing the need to build new dams and other water diversion infrastructure.

23.2.3 Rain water harvesting

Rain water harvesting is the accumulating and storing of rainwater for reuse before it reaches the aquifer. It has been used to provide drinking water, water for livestock, water for irrigation, as well as other typical uses. Rainwater collected from the roofs of houses and local institutions can make an important contribution to the availability of drinking water. It can supplement the subsoil water level and increase urban greenery. Water collected from the ground, sometimes from areas which are especially prepared for this purpose, is called Storm water harvesting. In some cases, rainwater may be the only available, or economical, water source. Rainwater harvesting systems can be simple to construct from inexpensive local materials, and are potentially successful in most habitable locations. Roof rainwater may not be potable and may require treatment before consumption. As rainwater rushes from your roof it may carry pollutants, such as mercury from coal burning buildings, or bird faeces. Although some rooftop materials may produce rainwater that would be harmful to human health as drinking water, it can be useful in flushing toilets, washing clothes, watering the garden and washing cars; these uses alone halve the amount of water used by a typical home. Household rainfall catchment systems are appropriate in areas with an average rainfall greater than 200 mm (7.9 in) per year, and no other accessible water sources (Skinner and Cotton, 1992). Overflow from rainwater harvesting tank systems can be used to refill aquifers in a process called groundwater recharge; though this is a related process, it must not be confused with rainwater harvesting.

There are several types of systems to harvest rainwater, ranging from very simple home systems to complex industrial systems. The rate at which water can be collected from either system is dependent on the plan area of the system, its efficiency, and the intensity of rainfall (i.e., annual precipitation (mm per annum) x square meter of catchment area = liters per annum yield ex, ... a 200 square meter roof catchment catching 1,000mm PA yields 200 KLPA.)

23.2.4 Watershed management

Watershed management is the study of the relevant characteristics of a watershed aimed at the sustainable distribution of its resources and the process of creating and implementing plans, programs, and projects to sustain and enhance watershed functions that affect the plant, animal, and human communities within a watershed boundary. Features of a watershed that agencies seek to manage include water supply, water quality, drainage, storm water runoff, water rights, and the overall planning and utilization of watersheds. Landowners, land use agencies, storm water management experts, environmental specialists, water use purveyors and communities all play an integral part in the management of a watershed.

ENVIRONMENTAL STUDIES

Module 6. Social issues and the environment

Lesson 24
RESETTLEMENT AND REHABILITATION

Development projects that displace people involuntarily generally give rise to severe economic, social, and environmental problems: production systems are dismantled; productive assets and income sources are lost; people are relocated to environments where their productive skills may be less applicable and the competition for resources greater; community structures and social networks are weakened; kin groups are dispersed; and cultural identity, traditional authority, and the potential for mutual help are diminished. Involuntary resettlement may cause severe long-term hardship, impoverishment, and environmental damage unless appropriate measures are carefully planned and carried out.

The World Bank was the first multilateral lending agency to adopt a policy for Resettlement and Rehabilitation (R&R).

The treatment of resettlement issues beyond hydropower and irrigation projects to all types of investment operations. It emphasizes the need for:

- Minimizing involuntary resettlement;
- Providing people displaced by a project with the means to improve, or at least restore, their former living standards, earning capacity, and production levels;
- Involving both resettles and hosts in resettlement activities;
- A time-bound resettlement plan; and
- Valuation and compensation principles for land and other assets affected by the project.

A full EA is required if a project is likely to have significant adverse impacts that may be sensitive, irreversible, and diverse. The impacts are likely to be comprehensive, broad, sector-wide, or precedent-setting. Impacts generally result from a major component of the project and affect the area as a whole or an entire sector.

- Dams and reservoirs; Forestry production projects;
- Industrial plants (large-scale) and industrial estates;
- Irrigation, drainage, and flood control (large-scale);
- Land clearance and leveling;
- Mineral development (including oil and gas);
- Port and harbor development;
- Reclamation and new land development;
- Resettlement and all projects with potentially major impacts on people;
- River basin development;
- Thermal and hydropower development; and
- Manufacture, transportation, and use of pesticides or other hazardous and/or toxic materials.

The impacts are not as sensitive, numerous, major, or diverse as category A impacts; remedial measures can be more easily designed. Preparation of a mitigation plan suffices for many category B projects. Few category B projects would have a separate environmental report. Examples of Category B projects are:

- Agro-industries (small-scale);
- Electrical transmission;
- Aquaculture and mariculture;
- Irrigation and drainage (small-scale);
- Renewable energy;
- Rural electrification;
- Tourism;
- Rural water supply and sanitation;
- Watershed projects (management or rehabilitation); and
- Rehabilitation, maintenance, and upgrading projects (small-scale).

An EA or environmental analysis is normally not required for Category C projects because the project is unlikely to have adverse impacts. Professional judgment finds the project to have negligible, insignificant, or minimal environmental impacts. Category C projects might be:

- Education,
- Family planning,
- Health,
- Nutrition,
- Institutional development,
- Technical assistance, and
- Most human resource projects.

Social analysis is a part of the EA process, and resettlement is one of five topics that are required, where they are relevant, be explicitly addressed in an EA. The five topics are:

- involuntary resettlement,
- new land settlement,
- induced development,
- indigenous peoples,
- and cultural property

The objective of the resettlement policy is to ensure that the population displaced by a project receives benefits from it. Involuntary resettlement is an integral part of project design and should be dealt with from the earliest stages of project preparation, taking into account the following policy considerations:

- Involuntary resettlement should be avoided or minimized where feasible, exploring all viable alternative project designs. For example, realignment of roads or reductions in dam height may significantly reduce resettlement needs.
- Where displacement is unavoidable, resettlement plans should be developed. All involuntary resettlement should be conceived and executed as development programs, with resettles provided sufficient investment resources and opportunities to share in project benefits. Displaced persons should be (i) compensated for their losses at full replacement cost prior to the actual move; (ii) assisted with the move and supported during the transition period in the resettlement site; and (iii) assisted in their efforts to

improve their former living standards, income earning capacity, and production levels, or at least to restore them. Particular attention should be paid to the needs of the poorest groups to be resettled.

- Community participation in planning and implementing resettlement should be encouraged. Appropriate patterns of social organization should be established, and existing social and cultural institutions of resettles and their hosts should be supported and used to the greatest extent possible.
- Resettles should be integrated socially and economically into host communities so that adverse impacts on host communities are minimized. The best way of achieving this integration is for resettlement to be planned in areas benefiting from the project and through consultation with the future hosts.
- Land, housing, infrastructure, and other compensation should be provided to the adversely affected population, indigenous groups, ethnic minorities, and pastoralists who may have usufruct or customary rights to the land or other resources taken for the project. The absence of legal title to land by such groups should not be a bar to compensation.

Resettlement and outlines of the main point's planners should consider when preparing a resettlement plan. Depending on the magnitude of displacement and other factors, the resettlement plan will normally contain a statement of objectives and policies, an executive summary, a budget, a timetable coordinated with the physical works of the main investment project, and provision for:

- Organizational responsibilities;
- Community participation and integration with host populations;
- Socioeconomic survey;
- Legal framework;
- Alternative sites and selection;
- Valuation of and compensation for lost assets;
- Land tenure, acquisition, and transfer ;
- Access to training, employment, and credit;
- Shelter, infrastructure, and social services;
- Environmental protection and management ; and
- Implementation schedule, monitoring, and evaluation.

The foregoing is meant to be an indicative, not authoritative, discussion of the World Bank's involuntary resettlement policy. For more information, visit the World Bank's Public Information Center or the Environmental Management for Power Development page supported by the World Bank and other sponsors.

Case studies:

The Case study of a village to be affected by the indira sagar pariyojana

Indira Sagar Pariyojana (ISP) has been under planning and construction since decades. Work on the project has gained momentum in the last decade. Since then, the construction has been on and off depending on the availability of funds. On 24 April, 2002, an announcement was published both in Nai Duniya and Dainik Bhaskar1 stating that the village Jabgaon would be inundated with water in the coming monsoons owing to the increase in the height of the dam. The village was being asked to evacuate the area by 20 May, 2002. In March 2002, with the release of funds from the Center to the Narmada Hydro Development Corporation, a decision

was taken to increase the height of the dam to 212 m by June 2002. In fact since October 2001, there was a sudden spurt in announcements of the Section 4 notices of land acquisition in the regional Hindi newspapers making it evident that the project would soon be underway again. Meanwhile there had also been reports in the press that the rehabilitation had been lagging behind.

Manthan Adhyayan Kendra, which had been following the events in the history of the construction of this dam, decided to attempt to bring to fore the ground realities regarding the status of resettlement and rehabilitation of villages affected by this project. It was thought that the situation would be analysed at 3 points in time: pre-monsoon, monsoon and post-monsoon. Accordingly, 2 visits to this village had been undertaken: the first in the first week of May and the second in the third week of August. There have been less than normal monsoons this year and therefore while the village has not been submerged, some farms had been flooded.
The Kendra is a centre set up to monitor, analyse and research water and energy related issues, with a special focus on the latest developments resulting from the liberalisation, globalisation and privatisation of the economy. The Centre is located at Badwani, a district town in Madhya Pradesh five kilometers from the banks of Narmada. While the focus of the work is on water and energy issues, this will be in the larger context of equitable, just and sustainable development.

Uttaranchal's disaster management

Uttaranchal's location and geographical features render it vulnerable to minor changes. Hence any activity disapproved by mountain ecosystem triggers a disaster. One cannot stop disaster happening but can certainly take some steps to reduce its effects. If disasters cannot be averted, then reduction of losses of any type caused by disaster becomes a focal point of the policy for disaster management. To devise Uttaranchal's disaster management mechanism for reduction of effects of disaster, i.e. damage to property and loss of life and the rapid and effective rescue, relief and rehabilitation of the victims.

The study reveals that 83 villages in Uttaranchal need rehabilitation but, to date, Uttaranchal has no resettlement and rehabilitation policy. In India only three States, Maharashtra, Madhya Pradesh and Punjab, have state-wide resettlement and rehabilitation (R&R) policies. Other States have issued Government Orders or Resolutions, sometimes sector-wide but more often for specific projects. The study is based on secondary data; however, sufficient care has been taken to consider all important factors while suggesting Rehabilitation Policy for Uttaranchal State. A disaster of rare severity requires a high level of resettlement and rehabilitation assistance from the State. Sound Resettlement and Rehabilitation Policy helps the Government to tackle the problem immediately and efficiently.

ENVIRONMENTAL STUDIES

Module 6. Social issues and the environment

Lesson 25
ENVIRONMENTAL ETHICS

25.1 Introduction

In recent times, the environment has emerged as a major area of concern worldwide. Pollution in particular is perceived as a serious threat in the industrialized countries, where the quality of life had hitherto been measured mainly in terms of growth in material output. Meanwhile, natural resource degradation is becoming a serious impediment to economic development and the alleviation of poverty in the developing world.

Mankind's relationship with the environment has gone through several stages, starting with primitive times in which human beings lived in a stage of symbiosis with nature, followed by a period of increasing mastery over nature up to the industrial age, culminating in the rapid material-intensive growth pattern of the twentieth century which resulted in many adverse impacts on natural resources. The initial reaction to such environmental damage was a reactive approach characterized by increased clean-up activities. In recent decades, mankind's attitude towards the environment has evolved to encompass the more proactive design of projects and policies that help anticipate and avoid environmental degradation. The world is currently exploring the concept of sustainable development an approach that will permit continuing improvements in the present quality of life with a lower enhanced stock of natural resources and other assets.

It is useful to recall here that the environmental assets that we seek to protect, provide three main types of services to human society – and the consequences of the degradation of all these functions must be incorporated in to the decision-making process. First, the environment is a source of essential raw materials and inputs that support human activities. Second, the environment serves as a sink which absorbs and recycles (normally at little or no cost to society) the waste products of economic activity. Finally, the environment provides irreplaceable life support functions (like the stratospheric ozone layer that filters out harmful ultraviolet rays), without which living organisms would cease to exist, at least in their present condition.

25.2 Role of Environmental Economics

Environmental economics facilitates the efficient use of natural resources (both mineral and biological), as well as manmade capital and human resources – an objective which is a vital prerequisite for sustainable development. Special attention is paid to the key role of environmental economics in helping value environmental and natural resources in to the conventional calculus of economic decision-making. More generally, the identification of sustainable development options requires:

- Good understanding of the physical, biological and social impacts of human activities;

- Improved estimates of the economic value of damage of the environment, to improve the design of policies and projects, and to arrive at environmentally sound investment decisions; and
- Development of policies tools and strengthening of human resources and institutions to implement viable strategies and manage natural resources on a sustainable basis.

25.3 Linking Economics and Environment

Environmental economics plays a key role in identifying efficient natural resource management options that facilitate sustainable development. It is an essential bridge between the traditional techniques of decision-making and the emerging more environmentally sensitive approach. Environmental economics helps us incorporate ecological concerns in to the conventional framework of human society.

Various economic sectors (such as energy, industry, agriculture, transport, etc.) exist within each country. Finally, each sector consists of different subsectors, projects and local schemes.

Unfortunately, the analysis of the environment cannot be carried out readily using the above socioeconomic structuring

A holistic environmental analysis would seek to study a physical or ecological system in its entirety. Complications arise because such natural systems tend to cut across the decision-making structure of human society. For example, a forest ecosystem (like the Amazon) could span several countries, and also interact with many different economic sectors within each country.

The causes of environmental degradation arise from human activity (ignoring natural disasters and other events of non-human origin). The physical (including biological and social) effects of socioeconomic decisions on the environment must then be traced through to the left side. The techniques of environmental assessment (EA) have been developed to facilitate this difficult analysis. For example, deforestation of a primary moist tropical forest may be caused by hydroelectric dams (energy sector policy), roads (transport sector policy), land clearing encouraged by land-tax incentives (fiscal policy), and so on. Disentangling and prioritizing these multiple causes (right side) and their impacts (left side) will involve a complex EA exercise.

Meanwhile, the usual decision-making process relies on techno-engineering, financial and economic analyses of projects and policies. In particular, we note that conventional economic analysis has been well developed over the past several decades, and uses techniques including project evaluation/cost-benefit analysis (CBA), sectoral/regional studies, multi sectoral macroeconomic analysis, and international economic analysis (finance, trade, etc.) at the various hierarchic levels.

Environmental economics plays its bridging role, by mapping the EA results onto the framework of conventional economic analysis. Once again, a variety of environmental economic techniques including economic valuation of environmental impacts (at the local/project level), integrated resource management (at the sector/regional level), environmental macroeconomic analysis and environmental accounting (at the economy wide, multi sector level), and global/transnational environmental economic analysis (at the international level), facilitate this process of incorporating environmental issues in to traditional decision making. We note that there is considerable overlap among the analytical

techniques described above, and therefore this conceptual categorization should not be interpreted too rigidly.

Once the foregoing steps are completed, projects and policies must be redesigned to reduce their environmental impacts and shift the development process towards a more sustainable path. Clearly, the formulation and implementation of such policies is itself a difficult task. In the deforestation example described earlier, the decision makers who wish to protect this single ecosystem are likely to face problems in coordinating policies in a large number of disparate and (usually) non-cooperating ministries and line institutions (i.e., energy, transport, agriculture, industry, finance, forestry, etc.).

25.4 Climate Change

The term, climate, is generally used to connote a complex natural phenomenon comprising such variables as air temperature and humidity, wind, and precipitation. Although the climate remains fairly stable on the human time scale of decades or centuries, it fluctuates continuously over thousands or millions of years and is affected by a large number of variables (Cunningham et al., 1999: 195). There have been perceptible changes in the climate all over the world, particularly in the last two decades or so. The climate change and its adverse impacts on the environment, human health and the economy have recently risen to the top of economic and political agenda in various national and international forums and meetings on environment.

As some of the climatic changes are attributable to human activities and therefore change in human behavior can be an important instrument of minimizing the extent of those changes in the climate which have harmful effects. The most important climatic changes that have come to the fore recently and that are harmful include acid rain, global warming, and depletion of stratospheric ozone shield or layer. Besides, such climatic aberrations as floods, droughts, cyclones, and tsunamis also cause serious damage to humans and have adverse effects on local, regional and global climate.

The Earth's atmosphere keeps the planet warm. Without the warming cover of natural greenhouse gases, mainly carbon dioxide (CO_2) and water vapour, life could not exist on Earth. Through the release of greenhouse gases such as CO_2, methane, CFCs and N_2O caused by human activities, our climate will change. How fast and where exactly, is still controversial, but there is consensus in the scientific community that the consequences may be serious:

- the expected rise in sea levels may threaten islands and nations with low coast lines;
- changes in rainfall levels and patterns may affect natural vegetation, agriculture and forestry;
- the loss of biodiversity may be accelerated if climate zones move so fast that species (e.g. in rain forests) cannot follow them;
- weather anomalies such as hurricanes may occur more frequently, causing immense damage to humans and their property, and to nature.
- Not all possible consequences are fully understood. For example, it is very uncertain:
- to what extent greenhouse gas-induced disturbances of the ocean-atmosphere equilibrium contribute to altered global circulation patterns such as the El Niño phenomenon;
- whether the gulf stream, Europe's central heating, could change its direction and/or intensity, thus leading to a drastic cooling of Europe's climate;

25.5 Global Warming

According to the National Academy of Sciences, the Earth's surface temperature has risen by about 1 degree Fahrenheit in the past century, with accelerated warming during the past two decades. In 1980, the mean global temperature was 15.18^{o}C; is increased to 15.38^{o}C in 1990, 15.39^{o}C in 1995 and 16.04^{o}C in 2005. In fact in the northern hemisphere, 2005 is likely to go down as the warmest year ever recorded with an increase in the mean global temperature of the order of + 0.6.5^{o}C. Increasing concentrations of greenhouse gases are likely to accelerate the rate of climate change. Scientists expect that the average global surface temperature could rise 0.6-2.5°C in the next fifty years, and 1.4 - 5.8°C in the next century, with significant regional variations. Evaporation will increase as the climate warms, which will increase average global precipitation. Soil moisture is likely to decline in many regions, and intense rainstorms are likely to become more frequent (http://www.epa.gov/ozone/intpol/index.html).

Global warming refers to the rising average temperature of Earth's atmosphere and oceans and its projected continuation. In the last 100 years, Earth's average surface temperature increased by about 0.8 °C (1.4 °F) with about two thirds of the increase occurring over just the last three decades. Warming of the climate system is unequivocal, and scientists are more than 90% certain most of it is caused by increasing concentrations of greenhouse gases produced by human activities such as deforestation and burning fossil fuels. These findings are recognized by the national science academies of all the major industrialized countries.

Climate model projections are summarized in the 2007 Fourth Assessment Report (AR4) by the Intergovernmental Panel on Climate Change (IPCC). They indicated that during the 21st century the global surface temperature is likely to rise a further 1.1 to 2.9 °C (2 to 5.2 °F) for their lowest emissions scenario and 2.4 to 6.4 °C (4.3 to 11.5 °F) for their highest. The ranges of these estimates arise from the use of models with differing sensitivity to greenhouse gas concentrations.

An increase in global temperature will cause sea levels to rise and will change the amount and pattern of precipitation, and a probable expansion of subtropical deserts. Warming is expected to be strongest in the Arctic and would be associated with continuing retreat of glaciers, permafrost and sea ice. Other likely effects of the warming include more frequent occurrence of extreme weather events including heat waves, droughts and heavy rainfall events, species extinctions due to shifting temperature regimes, and changes in agricultural yields. Warming and related changes will vary from region to region around the globe, with projections being more robust in some areas than others. The limits for human adaptation are likely to be exceeded in many parts of the world, while the limits for adaptation for natural systems would largely be exceeded throughout the world. Hence, the ecosystem services upon which human livelihoods depend would not be preserved.

Proposed responses to global warming include mitigation to reduce emissions, adaptation to the effects of global warming, and geo engineering to remove greenhouse gases from the atmosphere or reflect incoming solar radiation back to space. The primary international effort to prevent dangerous anthropogenic climate change ("mitigation") is coordinated by the 194-nation UNFCCC. The Kyoto Protocol is their only legally binding emissions agreement and only limits emissions through the year 2012. Afghanistan and the USA are the only nations in the UNFCCC that have not ratified the original protocol and several others have refused to extend the emissions limits beyond 2012. Nonetheless, in the 2010 Cancun Agreements, member nations agreed that urgent action is needed to limit global warming to no more than

2.0 °C (3.6 °F) above pre-industrial levels. Current scientific evidence, however, suggests that 2°C is the "threshold between ‘dangerous’ and ‘extremely dangerous’ climate change”, that this much warming is possible during the lifetimes of people living today.

25.6 Acid Rain

The acid rain adversely affects plants, fishes and birds and corrodes metals and building materials. The effects of aid rain have been recorded in parts of the United States, the erstwhile Federal Republic of Germany, Czechoslovakia, the Netherlands, Switzerland, Australia, Yugoslavia and elsewhere. It is also becoming a significant problem in Japan and China and in Southeast Asia. Rain with a pH of 4.5 and below has been reported in many Chinese cities. Sulphur dioxide emissions were reported in 1979 to have nearly tripled in India since the early 1960s, making them only slightly less than the then-current emissions from the Federal Republic of Germany (http://www.geocities.com/narilily/acidrain.html).

Acid rain is a rain or any other form of precipitation that is unusually acidic, meaning that it possesses elevated levels of hydrogen ions (low pH). It can have harmful effects on plants, aquatic animals, and infrastructure. Acid rain is caused by emissions of carbon dioxide, sulfur dioxide and nitrogen oxides which react with the water molecules in the atmosphere to produce acids. Governments have made efforts since the 1970s to reduce the release of sulfur dioxide into the atmosphere with positive results. Nitrogen oxides can also be produced naturally by lightning strikes and sulfur dioxide is produced by volcanic eruptions. The chemicals in acid rain can cause paint to peel, corrosion of steel structures such as bridges, and erosion of stone statues.

25.7 Ozone Layer Depletion

Global warming has several adverse effects on human health, and agricultural production. It leads to increase in heat-related diseases and deaths. Besides, it also indirectly affects human health due to higher incidence of malaria, dengue, yellow fever and viral encephalitis caused by expansion of mosquitoes and other disease carriers to warm areas. Adverse effect on agricultural production is due to droughts and increased incidence of pests, causing shortage of food.

Within the stratosphere, a concentration of ozone molecules makes up the ozone layer. Around 90% of the ozone is within the ozone layer. The ozone layer could be thought of as Earth's sunglasses, protecting life on the surface from the harmful glare of the sun's strongest ultraviolet rays, which can cause skin cancer and other maladies. The stratospheric ozone layer filters ultraviolet (UV) radiation from the sun. As the ozone layer is depleted, more ultraviolet radiation reaches the earth's surface (Raven et al.,1998: 471-75). There are reports of large ozone holes opening over Antarctica, allowing dangerous UV rays through to Earth's surface. Indeed, the 2005 ozone hole was one of the biggest ever, spanning 25 million sq km in area, nearly the size of North America. While the ozone hole over Antarctica continues to open wide, the ozone layer around the rest of the planet seems to be on the mend (Source: http://www.sciencedaily.com/releases/2006/05/060527093645.htm). Over-exposure to UV rays may cause several health hazards for humans. Skin cancer is the most widely known. In addition, over-exposure to UV rays can also cause cataracts.

Ozone depletion describes two distinct but related phenomena observed since the late 1970s: a steady decline of about 4% per decade in the total volume of ozone in Earth's stratosphere (the ozone layer), and a much larger springtime decrease in stratospheric ozone over Earth's

polar regions. The latter phenomenon is referred to as the ozone hole. In addition to these well-known stratospheric phenomena, there are also springtime polar tropospheric ozone depletion events.

The details of polar ozone hole formation differ from that of mid-latitude thinning, but the most important process in both is catalytic destruction of ozone by atomic halogens. The main source of these halogen atoms in the stratosphere is photodissociation of man-made halocarbon refrigerants (CFCs, freons, halons). These compounds are transported into the stratosphere after being emitted at the surface. Both types of ozone depletion were observed to increase as emissions of halo-carbons increased.

CFCs and other contributory substances are referred to as ozone-depleting substances (ODS). Since the ozone layer prevents most harmful UVB wavelengths (280–315 nm) of ultraviolet light (UV light) from passing through the Earth's atmosphere, observed and projected decreases in ozone have generated worldwide concern leading to adoption of the Montreal Protocol that bans the production of CFCs, halons, and other ozone-depleting chemicals such as carbon tetrachloride and trichloroethane. It is suspected that a variety of biological consequences such as increases in skin cancer, cataracts, damage to plants, and reduction of plankton populations in the ocean's photic zone may result from the increased UV exposure due to ozone depletion.

25.8 Nuclear Accidents & Holocaust

A nuclear and radiation accident is defined by the International Atomic Energy Agency as "an event that has led to significant consequences to people, the environment or the facility. Examples include lethal effects to individuals, large radioactivity release to the environment, or reactor core melt." The prime example of a "major nuclear accident" is one in which a reactor core is damaged and large amounts of radiation are released, such as in the Chernobyl Disaster in 1986.

The impact of nuclear accidents has been a topic of debate practically since the first nuclear reactors were constructed. It has also been a key factor in public concern about nuclear facilities. Some technical measures to reduce the risk of accidents or to minimize the amount of radioactivity released to the environment have been adopted. Despite the use of such measures, "there have been many accidents with varying impacts as well near misses and incidents.

The greenhouse effect is a process by which thermal radiation from a planetary surface is absorbed by atmospheric greenhouse gases, and is re-radiated in all directions. Since part of this re-radiation is back towards the surface, energy is transferred to the surface and the lower atmosphere. As a result, the average surface temperature is higher than it would be if direct heating by solar radiation were the only warming mechanism.

Solar radiation at the high frequencies of visible light passes through the atmosphere to warm the planetary surface, which then emits this energy at the lower frequencies of infrared thermal radiation. Infrared radiation is absorbed by greenhouse gases, which in turn re-radiate much of the energy to the surface and lower atmosphere. The mechanism is named after the effect of solar radiation passing through glass and warming a greenhouse, but the way it retains heat is fundamentally different as a greenhouse works by reducing airflow, isolating the warm air inside the structure so that heat is not lost by convection.

The existence of the greenhouse effect was argued for by Joseph Fourier in 1824. The argument and the evidence was further strengthened by Claude Pouillet in 1827 and 1838, and definitively proved experimentally by John Tyndall in 1859, and more fully quantified by Svante Arrhenius in 1896.

If an ideal thermally conductive blackbody was the same distance from the Sun as the Earth is, it would have a temperature of about 5.3°C. However, since the Earth reflects about 30% (or 28%) of the incoming sunlight, the planet's effective temperature (the temperature of a blackbody that would emit the same amount of radiation) is about −18 or −19°C, about 33°C below the actual surface temperature of about 14°C or 15°C. The mechanism that produces this difference between the actual surface temperature and the effective temperature is due to the atmosphere and is known as the greenhouse effect. Earth's natural greenhouse effect makes life as we know it possible. However, human activities, primarily the burning of fossil fuels and clearing of forests, have greatly intensified the natural greenhouse effect, causing global warming.

ENVIRONMENTAL STUDIES

Module 6. Social issues and the environment

Lesson 26
WASTELAND RECLAMATION

26.1 Introduction

Reclaiming lands that have been laid waste in an extraction or industrial process is "wasteland reclamation." Strip-mining coal produces wastelands. Using chemicals in an industrial process, then dumping the used chemicals either on the land or into a stream creates wastelands or releasing chemicals into the air in an industrial process can create waste lands. When there is no regulation of wastes disposal by the industry can create wastelands. And finally, nuclear accidents can create wastelands.

Environment keeps changing over time naturally and it is also amenable to changes by human beings. Thanks to scientific and technological developments, our ability to alter the environment has increased tremendously, whereas the capacity of environment to cope with those alterations is limited. Nature's bounty and abundance are disappearing at a rapid rate now in many regions of the world including India due to the human alterations of the environment. All this has brought to the fore the need for protection and preservation of environment and the urgency of developing sound environmental policies and programmes. Without them, development would not only be unsustainable but would be tantamount to retrogression. The challenge of creating and maintaining a sustainable environment is probably the single most pressing issue confronting us today and will remain so in the foreseeable future.

The Department of Land Resources, Ministry of Rural Development and Government of India has identified different types of degraded wastelands and has prepared a Wasteland Atlas of India for the year 2000, with the help of Indian Remote Sensing Satellites. According to their estimates, the degraded wastelands accounted for about 20.16 % of India's total geographical area. The degraded lands include several types of land such as gullied and /or ravinous land, water-logged and marshy land, land affected by salinity and / or alkalinity, degraded pastures / grazing land, degraded notified forest land, mining industrial wastelands, eroded steep slopping land, sandy and desertic lands, and barren rocky /stony wastelands. Whatever the type of degradation, a common characteristic of degraded lands is that their productivity is almost negligible but it could be restored through proper reclamation measures and management.

It is estimated that in India in 1994, about 188 million ha of land, which is 57 per cent of the country's total geographical area of about 329 million ha, was degraded. Of the 188 million ha of degraded land, about 149 million ha was affected by water erosion, 13.5 million ha by wind erosion, about 14 million ha by chemical deterioration and 11.6 million ha by water-logging (Sehgal and Abrol, 1994). A recent survey by the National Bureau of Soil Survey and Land Use Planning revealed that 66 per cent of India's total geographical area (around 192 m ha) was at varying stages of degradation (quoted in Haque, 1997).

Land degradation has significant adverse impacts on crop productivity and the environment. Joshi and Jha (1991) in a study of four villages in Uttar Pradesh found that a 50 per cent decline in crop yields over a period of eight years was due to salinity and water -logging caused by the irrigation system.

ENVIRONMENTAL STUDIES

Module 6. Social issues and the environment

Lesson 27
ENVIRONMENT PROTECTION ACT

27.1 Introduction

The essential purpose of National Environment Protection Act (NEPA) is to ensure that environmental factors are weighted equally when compared to other factors in the decision making process undertaken by the Government. The act establishes the national environmental policy, including a multidisciplinary approach to considering environmental effects in democratic government agency decision making. The effectiveness of NEPA originates in its requirement of state agencies to prepare an environmental statement to accompany reports and recommendations for funding from Government. This document is called an Environmental Impact Statement (EIS). NEPA is an action-forcing piece of legislation, meaning that the act itself does not carry any criminal or civil sanctions. All enforcement of NEPA was to be obtained through the process of the court system. In practice, a project is required to meet NEPA guidelines when a Government agency provides any portion of the financing for the project. Sometimes, however, review of a project by a state employee can be viewed as a federal action and would then, therefore, require NEPA-compliant analysis be performed.

NEPA covers a vast array of federal agency actions, but not all actions are necessarily covered under NEPA. The act does not apply to purely private or purely public state action. This means that there is a complete absence of government influence or funding concerning that specific action. Exemptions and exclusions are also present within NEPA's guidelines. Exemptions from NEPA include specific federal projects detailed in legislation, EPA exemptions and functional equivalent exemptions. Functional Equivalent exemptions apply where compliance with other environmental laws requires environmental analysis similar to NEPA. These other environmental laws can include but are not limited to the Clean Air Act, Resource Conservation and Recovery Act, Safe Drinking Water Act, and the Federal Insecticide.

27.2 Conclusion

The use of the term Environmental Science may imply a single subject, but the essence of environmental science is its multi-disciplinary nature. Environmental Science is the systematic study of our environment and our proper place in it. However, to the present and to all the generations still to come, how we affect our environment is important. Environmental problems are in part the result of the large number of human beings on the planet. Therefore, individual actions, summed over large number of people, can influence the environment greatly. So we must do more than simply identify and discuss environmental problems and solutions. We must think critically about them. It has to be recognized that the basis of human power and superiority lies in his knowledge of the environment. Individuals can involve themselves in many ways in the process of improving the environment. Similar to any social

and political movement, environmentalism (a range of moral codes directed at achieving better environmental management) too encompasses a wide range of approaches. At the one end, there is the conservative style of the nature conservancy whose major function has been to help purchase lands that are important for conservation and to ensure that these lands are maintained as nature preserves; while at the other opposite extreme end is the radical activism of organizations such as Greenpeace whose activities have included maneuvering small boats between whaling ships and whales in an attempt to prevent and draw attention to the practice of whaling. We should not forget that we have a special environmental responsibility to ourselves and to other follow living beings. We have to conserve the environment not merely for the preservation of the rich biological diversity, natural resources or aesthetic value, but for sheer survival.

ENVIRONMENTAL STUDIES

Module 6. Social issues and the environment

Lesson 28
ISSUES INVOLVED IN ENFORCEMENT OF ENVIRONMENTAL LEGISLATION

28.1 Introduction

In India, more than three-quarters its population depends directly for their livelihoods on activities based on natural resources and the remainder of the population relies on these resources indirectly for food, fuel, industrial output and recreation. Their economic well-being is inextricably tied to the productivity of natural resources and quality of environment. Sadly, most of the natural resources including environment in India are in a serious state of degradation. For example, agricultural lands suffer from soil erosion, water-logging, salinity and general loss of fertility, making them less productive, and water for drinking and irrigation is increasingly getting scarce and polluted. Fishery yields are falling, and air quality is deteriorating. Increasing levels of air, water and land pollution pose a serious threat to human health and longevity. Good management of natural resources and environment is essential to attain and sustain economic growth and development. It is not, as is sometimes mistakenly asserted, just a luxury for wealthy countries concerned with aesthetics.

A characteristic feature of environment is the preponderance of common pool resources (CPRs), i.e., the resources which are used in common by identifiable groups of people irrespective of whether they are owned by them or not, and open access resources (OARs), i.e. the resources that are accessible to everyone without any restrictions; they are nobody's property. Examples of CPRs include village grazing lands, public lands along highways and railways, ponds, rivers, groundwater basins, community inland fisheries and marine fisheries within the Exclusive Economic Zones (EEZs) of nations. The OARs include air sheds, solar radiation and high sea marine fisheries beyond the EEZs, space, ozone layer, and biodiversity. All CPRs and OARs suffer from what Hardin (1968) called, "the tragedy of the commons".

The logic of the 'tragedy' is purely economic and can be stated as: unregulated access to a CPR or OAR creates a decision-making environment in which incremental private benefits to an in¬dividual from the increased use of the resource markedly exceed the incremental private costs associated with the increased use. Under these circumstances, each rational consumer or user of the resource is motivated to consume or use more and more of the resource till the resource is completely destroyed or degraded as a result of collective and uncoordinated use by all the individuals in the community. Thus, individual rationality leads to collective ir¬rationality. The calculus of incremental or marginal private benefits markedly exceeding the incremental private costs follows from the fact that, in the case of a CPR or OAR, whereas an individual can appropriate all the benefits resulting from his increased use of the resource, he bears only a small fraction of the incremental costs associated with his increased use; the incremental costs are shared by all the members of the community (Singh, 1994 a: 12-14). This means that there exists an externality in the use of the CPR in question as evident from the difference between the incremental private cost and the incremental social

cost; the former being less than the latter. Thus, the common pool problem is basically one of the existences of exter¬nality - a divergence between private cost and social cost of exploitation which eventually leads to either depletion or over¬crowding or congestion (Friedman, 1971: 855). The problem is a manifestation of either the absence of exclusive private property rights or the breakdown of the structure of property rights (Randall, 1975: 734).

Hardin's thesis of the 'tragedy of the commons' has since become the dominant paradigm of the exploitation of CPRs and OARs. It has formed the basis of numerous policies seeking to privatize or nationalize natural CPRs in many developed and developing countries of the world. It is now widely agreed that co-users of CPRs and OARs usually fail to cooperate in using the resource optimally under the following three conditions:

1. When the perceived private costs to individuals of co-operat¬ing may exceed the perceived private benefits of cooperating;
2. When individuals feel that their own contribution to the collective goal is minuscule and would not be missed if withheld because others will continue contributing, enabling them easily to free ride on the contributions of others; and
3. When individuals have no assurance or certainty that the other members of the group will make their contributions (or cooperate) and that their lone contribution to the effort would be sufficient to produce the desired outcome.

When an externality is present, the competitive equilibrium use of the resource (CPR and OAR) is socially inefficient .This is illustrated in Figure 28.1 As shown in the figure, the competitive equilibrium level of grazing (X) in a community pasture is attained when the level of grazing is X2 where the private marginal cost is equal to the marginal revenue whereas the socially optimum level of grazing is X1, where the social marginal cost is equal to the marginal revenue. Thus, the open access equilibrium is attained at a higher level of grazing and hence a higher level of exploitation than the socially optimum level of exploitation, i.e., .X2 > X1.

The problem of non-cooperation of users of CPRs and OARs could also be illustrated through the Prisoners' dilemma (PD) game.

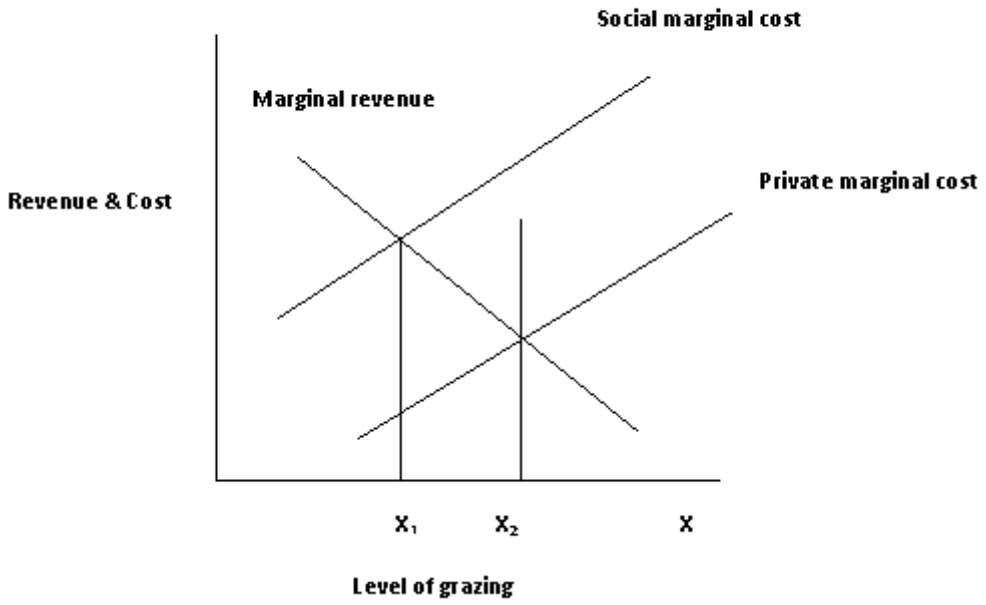


Fig. 28.1 Competitive (open access) equilibrium level and socially optimal level of grazing in a village pasture

Besides the pure economic logic, there are several other socio-economic factors such as population pressure, poverty, unemployment, ignorance, and lack of incentives for using the environment in a socially optimum manner on sustainable basis. So long as the human and animal population was within the carrying capacity of locally available natural resources and local environment, there was no environmental degradation due to human actions. But as the population increased and local economies got integrated with external economies through trade, the process of degradation of natural resources and environment started. Further, the fact that many communities who depend directly on natural resources for their livelihood are very poor, ignorant, and have no alternative employment opportunities means that they are compelled by their circumstances to over-exploit and degrade the natural resources accessible to them. Illicit felling of trees from forests, hunting, encroachment of forest land, and poaching are some of the activities resorted to by the communities, partly driven by their basic needs and partly by greed. This might happen even if it is to the long-term detriment of the communities' own well being.

Another important economic reason for environmental degradation is the fact that protection and conservation of environment has a high opportunity cost, especially in developing countries like India. For instance, in the case of forests, the opportunity cost is the value that could be derived by clear-cutting the timber and using the forest land for agricultural purpose, or as a site for a hydropower project. Likewise, the opportunity cost of conservation of a marine ecosystem is the value that could be derived from depleting the entire fish stock to extinction. In view of this, local resource users do not have any incentive to protect and conserve the environment.

Another major reason of environmental degradation in India is the fact that began in the mid 1960s, there have been many technological breakthroughs in the agricultural sector, which ushered in Green Revolution. For example, there has been widespread adoption of high yielding varieties of crops of a few of the major food grains crops such as rice and wheat in conjunction with increased use of water, chemical fertilizers and plant protection chemicals.

This has led to the increasing uniformity within those species and varieties of crops and hence the loss of biodiversity and increased levels of degradation of land due to excessive irrigation and pollution of water bodies due to leaching of harmful chemicals. Besides, development and wide-spread use of water extracting devices such as drilling machines and power-operated pump sets has led to over-exploitation of groundwater basins and development of mechanized trawlers to over-fishing of marine fisheries and pollution of sea water.

The measures that could be used for mitigating the problems of environmental degradation could broadly be classified into four categories, namely, institutional changes, direct controls, and economic / market-based instruments and technological measures. When identifying alternatives for mitigating the problems of environmental degradation, we should aim at minimizing it, or at least restricting it to a level consistent with society's objectives, rather than trying to prevent or eliminate it altogether. A simple rule of thumb for choosing a particular measure is that its estimated social benefits must markedly exceed its estimated social costs.
Creation of new institu¬tions, modification of existing institutions, changes in existing systems of property rights, enacting new laws, imposing new taxes, and provision of newly introduced subsidies belong in the category of institutional changes.

28.2 Institutional Instruments

Article 48-A of the Constitution of India provides that the state shall endeavor to protect and improve the environment and to safeguard the forest and wildlife of the country. Article 51-A imposes as one of the fundamental duties on every citizen the duty to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures.

The present legislative framework for environment management in India is broadly contained in the umbrella Environment Protection Act 1986, the Water (Prevention and Control of Pollution) Act, 1974, the Water Cess Act 1977 and the Air (Prevention and Control of Pollution) Act, 1981. The laws in respect of management of forests and biodiversity are contained iin the Indian Forest Act 1928, the Forest (Conservation) Act 1980, the Wild Life (Protection) Act 1972 and the Bio-diversity Act 2003. There are several other enactments, which complement the provisions of these basic enactments.

Now, India has a large number of environmental acts and regulations. Pollution limits for various industries have been prescribed in the Environmental Protection Rules 1986. Environmental clearance from the Union Ministry of Environment and Forests is mandatory for setting up new industries in many sectors. A list of major environmental acts and rules now in force in India can be found in the website: http:// www.envfor.nic.in).

As we know, most of the problems of environmental degradation arise because of the open access or common pool nature of the environment. In view of this, where technically feasible and economically viable, transforming the open access and common pool environmental resources into some sort of state or private property through the creation of property rights could resolve the problems of environmental degradation. An example of use of this measure is the privatization of degraded revenue lands (state property) and village common lands (CPRs) in West Bengal through granting of land pattas (leases) to individuals. This helped resolve the problem of their degradation and transformed those lands into productive private property (Singh, 1994 a: 149-163 and Singh and Shishodia, 2007: 221).

28.3 Direct Controls and Regulation

Conventionally, direct controls, or regulations are given effect through governmental orders, or pronouncements by judiciary. In certain cases, laws also are enacted which stipulate that, for instance, you are not allowed to pollute the air above a certain level and if you do, you will be fined, or imprisoned, or both. This form of intervention has high costs of administration and compliance, is often inflexible and provides little incentive for innovation to reduce environmental degradation. For all these reasons, the use of regulatory instruments in isolation from other measures is unlikely to be the least-cost method of achieving environmental objectives in many cases. Control and regulation compares unfavorably with the use of market-based approaches such as taxes and emission charges. Despite its weaknesses, control and regulation is still the predominant instrument for addressing environmental problems in most countries, including India.

28.4 Environmental Standards

Environmental standards refer both to the acceptable levels of specified environmental quality parameters at different categories of locations (ambient standards), as well as permissible levels of discharges of specified wastes into streams by different classes of activities (emission standards).
The NEP 2006 advocates the following three specific measures to improve the effectiveness of environmental standards:

1. Set up a permanent machinery comprising experts in all relevant disciplines to review notified ambient and emissions standards in the light of new scientific and technological information as they become available, and changing national circumstances, ensuring adequate participation by potentially impacted communities, and industry association;
2. Strengthen the network for monitoring ambient environmental quality, including monitoring through participation by local communities, and public -private partnerships; and
3. Progressively ensure real -time, and on-line availability of the monitoring data.

28.5 Economic Instruments

This set of instruments affect costs and benefits of alternative actions open to economic agents, and thereby influence the behaviour of decision makers in such a way that alternatives are chosen that lead to an environmentally more desirable situation than in the absence of the instrument. Economic instruments aim to bridge the gap between the private and social costs by internalizing all external costs to their sources, namely, the producers and consumers of resource depleting and polluting commodities. Such instruments are often referred to as market-based instruments, as they work by using market signals such as prices, emission charges / taxes, and subsidies to encourage socially better decisions.

Pollution of water bodies and degradation of land due to excessive use of chemicals in agriculture could be mitigated through the use of organic manures, and organic pesticides and the problem of soil salinity and water-logging created by excessive irrigation could be resolved by the use of micro irrigation technologies such as sprinklers and drips. Similarly the problem of air pollution engendered by the increased use of fossil fuels could be solved through the use of renewable sources of energy such as animal power, solar energy, hydropower, and biogas. But to motivate the farmer to adopt the new eco-friendly technologies, it is necessary for policy makers to ensure that the new eco-friendly

technologies are financially superior to the old environment -depleting ones and that the farmer has access to the requisite credit facilities and technical information and guidance.

Viable and sustainable conservation of the environment requires the participation of multiple stakeholders', particularly local people's participation in planning, implementation, and monitoring of environmental projects. In seeking to realize partnerships among the diverse stakeholders, it is essential on the part of the government agencies involved to eschew the confrontational posturing adopted in many cases in the past. While it is not possible that the interests and perceptions of all stakeholders will converge on each case, nevertheless, it is necessary to realize that progress will be seriously impeded if the motives of other partners are called into question during public discourse. It is also essential that all partnerships are realized through, and are carried out in terms of the principles of good governance, in particular, transparency, accountability, cost effectiveness, and efficiency.

The NEP- 2006 identifies a number of specific themes for partnerships, a few of which are stated below:

1. Public -Community Partnership: This is intended to seek the cooperation of public agencies and local communities in the management of a given environmental resource, each partner bringing agreed resources, assuming specified responsibilities, and with defined entitlements. The Joint Forest Management programme is an example of this kind of partnership.
2. Public-Private Partnerships: In this arrangement, specified public functions with respect to environment management are contracted out competitively to private providers, e.g., monitoring of environment quality.
3. Public -Community-Private Partnerships: In this system, the partners assume joint responsibility for a particular environmental function, with defined obligations and entitlements for each, with competitive selection of the private sector partner, e.g., afforestation of degraded forests.
4. Public -Voluntary Organization Partnerships: This is similar to public -private partnerships, in respect of functions in which voluntary organizations may have a comparative advantage over others, the voluntary organizations, in turn, being selected competitively, e.g. environmental awareness raising.
5. Public-Private-Voluntary Organization Partnerships: In this arrangement, the provision of specified public responsibilities is accomplished on competitive basis by the private sector, and the provision is monitored by competitively selected voluntary organizations, e.g. "Build, Own, Operate" sewage and effluent treatment plants.

To sum up, we could say that we now have the requisite knowledge of tools, techniques and instruments of environment management available in India and we also have a National Environment Policy in vogue. What we need is a strong political will at the national and state levels and a congenial political and economic environment to use appropriate measures to mitigate the problems of environmental degradation in the large interest of society as a whole.

ENVIRONMENTAL STUDIES

Module 6. Social issues and the environment

Lesson 29
POPULATION GROWTH AND VARIATIONS AMONG NATIONS

There are 5 main concepts that our students struggle with when learning about population growth and the relationship of population to geological resource use:

1. overpopulation is a leading environmental problem,
2. exponential population growth and development leads to faster depletion of resources,
3. population grows exponentially,
4. why population prediction is difficult,
5. population is not evenly distributed throughout the world.

A leading environmental problem: Overpopulation

Students do not understand that overpopulation is the cause of many other environmental problems. To help students understand this, one of my colleagues asks her students to list three important local and global environmental issues as part of a survey on the first day of class. During this lecture, we will present overpopulation as the top environmental problem:

1. Pollution (unspecified):14.7%
2. Global warming:14.5%
3. Air pollution:13.5%
4. Habitat destruction:13.1%
5. Resource depletion/degradation:11.8%
6. Population growth/Overpopulation:7.9%
7. Natural disasters:6.2%
8. Water pollution:6.6%
9. fossil fuels (oil spills/ANWR):6.0%
10. Waste management:3.5%
11. Miscellaneous (famine, poverty, ignorance, etc):2.3%

How many of these problems are the direct or indirect result of overpopulation? Would we have such a problem with the top three – pollution, global warming and habitat- if world population was not so large? Other than some of the natural disasters, most of these other environmental problems are due to overpopulation.

More people = More babies

Students may have a hard time understanding that population growth is controlled not only by birth and death rates but also by the present population. The mathematics of exponential growth govern the prediction of population growth. In some cases, you may want to point out that students may have heard of exponential growth in other contexts, such as compound interest or the spread of viral disease. The rate of population growth at any given time can be

written:

$$\frac{dN}{dt} = rN$$

where
N0 is the starting population;N is the population after a certain time, t , has elapsed,

r is the rate of natural increase expressed as a percentage (birth rate - death rate) and e is the constant 2.71828... (the base of natural logarithms).

$$\frac{dN}{N} = r \cdot dt$$

$$\int \frac{dN}{N} = \int r \cdot dt$$

$$\ln N = rt + c;$$

$$\textbf{when } t = 0,\ N = N_0,\ \textbf{therefore, } c = \ln N_0$$

$$\ln N = rt + \ln N_0$$

$$\ln N - \ln N_0 = rt$$

$$\ln N - \ln N_0 = \frac{\ln N}{\ln N_0}$$

$$\frac{\ln N}{\ln N_0} = rt$$

$$\frac{N}{N_0} = e^{rt}$$

$$N = N_0 e^{rt}$$

A plot of this equation looks something like the plot on the right. Population grows exponentially - if the rate of natural increase (r) doesn't change. The variable r is controlled by human behavior as described below.

Essential to understanding the mathematics of population growth is the concept of doubling time. Doubling time is the time it takes for population to double and it is related to the rate of growth. When the population doubles, N = 2N0. Thus the equation becomes

$$N = N_0 e^{rt}$$

$$N = 2N_0; \text{ so}$$

$$2N_0 = N_0 e^{rt}$$

$$\frac{2N_0}{N_0} = e^{rt}$$

$$2 = e^{rt}$$

$$\ln 2 = rt$$

$$\frac{\ln 2}{r} = t; \text{ t = doubling time}$$

ln 2/r = t

or 0.69/r = t; where r is the rate and t is the doubling time.

In many ways, it is similar to half-life. But instead of the time it takes for half the isotopes to decay, it is the time it takes for a known quantity to double.

"Birth control" was advanced as alternative to the then-fashionable terms "family limitation" and "voluntary motherhood." Family limitation referred to deliberate attempts by couples to end childbearing after the desired number of children had been born. Voluntary motherhood had been coined by feminists in the 1870s as a political critique of "involuntary motherhood" and expressing a desire for women's emancipation. Advocates for voluntary motherhood disapproved of contraception, arguing that women should only engage in sex for the purpose of procreation and advocated for periodic or permanent abstinence. In contrast the birth control movement advocated for contraception so as to permit sexual intercourse as desired without the risk of pregnancy. By emphasising "control" the birth control movement argued that women should have control over their reproduction and the movement had close ties to the feminist movement. Slogans such as "control over our own bodies" criticised male domination and demanded women's liberation, a connotation that is absent from family planning, population control and eugenics. Though in the 1980s birth control and population control organisations co-operated in demanding rights to contraception and abortion, with an increasing emphasis on "choice."

The societal acceptance of birth control required the separation of sex from procreation, making birth control a highly controversial subject in the 20th Century. Birth control has become a major theme in feminist politics who cited reproduction issues as examples of women's powerlessness to exercise their rights. In the 1960s and 1970s the birth control movement advocated for the legalisation of abortion and large scale education campaigns about contraception by governments. In a broader context birth control has become an arena for conflict between liberal and conservative values, raising questions about family, personal freedom, state intervention, religion in politics, sexual morality and social welfare.

The effectiveness of a birth control method is generally expressed by how many women become pregnant using the method in the first year of use. Thus, if 100 women use a method that has a 0 percent first-year failure rate, then 0 of the women should become pregnant

during the first year of use. This equals 0 pregnancies per 100 woman-years, an alternative unit. Sometimes the effectiveness is expressed in lifetime failure rate, more commonly among methods with high effectiveness, such as vasectomy after the appropriate negative semen analysis.

The most effective methods in typical use are those that do not depend upon regular user action. Surgical sterilization, Depo-Provera, implants, and intrauterine devices (IUDs) all have first-year failure rates of less than one percent for perfect use. In reality, however, perfect use may not be the case, but still, sterilization, implants, and IUDs also have typical failure rates under one percent. The typical failure rate of Depo-Provera is disagreed upon, with figures ranging from less than one percent up to three percent.

Other methods may be highly effective if used consistently and correctly, but can have typical use first-year failure rates that are considerably higher due to incorrect or ineffective usage by the user. Hormonal contraceptive pills, patches or rings, fertility awareness methods, and the lactational amenorrhea method (LAM), if used strictly, have first-year (or for LAM, first-6-month) failure rates of less than 1%. In one survey, typical use first-year failure rates of hormonal contraceptive pills (and by extrapolation, patches or rings) were as high as five percent per year. Fertility awareness methods as a whole have typical use first-year failure rates as high as 25 percent per year; however, as stated above, perfect use of these methods reduces the first-year failure rate to less than 1%. Intrauterine devices (IUDs) were once associated with health risks, but most recent models of the IUD, including the ParaGard and Mirena, are both extremely safe and effective, and require very little maintenance. Condoms and cervical barriers such as the diaphragm have similar typical use first-year failure rates (14 and 20 percent, respectively), but perfect usage of the condom is more effective (three percent first-year failure vs six percent) and condoms have the additional feature of helping to prevent the spread of sexually transmitted diseases such as the HIV virus. The withdrawal method, if used consistently and correctly, has a first-year failure rate of four percent. Due to the difficulty of consistently using withdrawal correctly, it has a typical use first-year failure rate of 19 percent, and is not recommended by some medical professionals. Combining two birth control methods, can increase their effectiveness to 95% or more for less effective methods. Using condoms with another birth control method is also one of the recommended methods of reducing risk of getting sexually transmitted infections, including HIV. This approach is one of the dual protection strategies

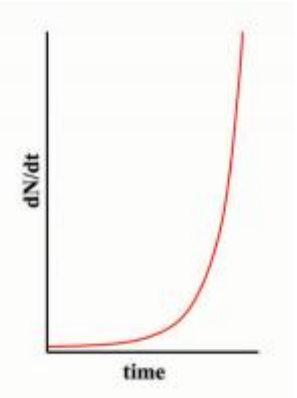


Fig 29.1 The Growth of Human Population can be Viewed in the Following Four Major Periods or Stages

Stage 1. An early period of hunters and gatherers

This period ranges between the first evolutions of humans on this planet to the beginning of agriculture. During this period, it is estimated that the total population was probably less than a million, population density was about 1person per 130-260 sq km in the most habitable areas, and the average rate of growth was perhaps less than 0.00011% per year.

Stage 2. Early, per-industrial agriculture

This period began sometime between 9,000 BC and 6,000 BC and lasted approximately until the 16th century AD. The first major increase in population came during this period. The total human population of the world was approximately 100 million by 1AD that further increased to about 500 million by 1600 AD. The population density increased greatly to about 1 or 2 people per sq km or even more. The average rate of growth was probably about 0.03%.

Stage 3. The age of industrial revolution

The second and much more rapid increase in population started about 400 years ago with the industrial revolution associated with the advances in medicines and health care. Experts are of the opinion that Renaissance in Europe, (beginning about 1600 AD) marks the transition from agricultural to liberate societies, when medical care and sanitation were factors responsible in reducing the death rate. The total human population of about 900 million in 1800 AD almost doubled in the next century and again doubled to approximately 3 billion by 1960. The average rate of growth by 1600 AD was about 0.1% per year, which increased about one-tenth of a percent every 50 years until 1950. The main reasons of this rapid increase in population were discovery of the causes of diseases, invention of vaccines, improvement in sanitation, and advances in agriculture that led to a great increase in the production of food, shelter and clothing.

Stage 4. The modern era

Though the rate of population growth has slowed down in developed countries, but population still continues to increase rapidly in many parts of the world, particularly developing countries. At mid 2002, the world population stood at 6.215 billion. The average rate of growth reached 2% in the middle of the 20th century and has declined to 1.3% in 2002 AD. According to projections, the global population will be Approximately 8 billion by 2025 and 10 billion by 2050 AD.

According to World Bank projections, the world population may stabilize between 10.1 to 12.5 billions. Developed countries would only increase from 1.2 billion today to 1.9 billion, but developing countries would increase from 5 billion to 9.6 billion. In these projections, the developing countries using by 95%

29.2 Variation of Population Among Nations

The distribution of world population densities show that while the great majority of the land surface is sparsely or moderately populated, but some limited areas are densely populated. The densely populated areas include Western Europe, the Indian subcontinent, the plains and river valleys of China, and north-eastern USA. High concentrations of people are also found in some relatively smaller areas, for example—the Nile valley of Egypt, the Islands of Java in Indonesia and the Southern part of Japan.

In terms of continents and countries, the world's population is very ill-balanced. More than

half of the world's people live in Asia (approximately 3.7 billion), which accounts for only one-fifth of the world's land area; while North, Central and South America together occupying more than a quarter of the land surface, have only one-fifth of the population (1.3 billion). The African continent also accounts for a quarter of the land surface but has just over one-eighth (840 million) of the world population. On the other hand, Europe whose area is only one twenty-fifth of the total has about one-ninth (729 million) of the world's people.

The distribution within the continents is also uneven. In Asia, China alone, with about 1.29 billion people, accounts for one-third Asian and one-fifth of the world population. The Indian subcontinent has a further 1.3 billion people—India, 1.05 billion; Pakistan, 143.5 million; Bangladesh, 133.6 million; Nepal , 23.9 million; Sri Lanka , 18.9 million; Bhutan, 0.9 million; and Maldives, 0.3 million. In Europe too, the population is an evenly distributed. Far less people live in Northern European countries than in other European countries .The most populous European countries are Russia (143.5 million), Germany (82.4 million), United Kingdom (60.2 million), France (59.5 million); Italy (58.1 million), Ukraine (48.2 million), Spain (41.3 million) and Poland (38.6 million). In Africa and Americas people are for the most part spread very thinly across the land, leaving large sections such as Northern Canada, Southwest USA, the Sahara desert and the Amazon forest practically uninhabited.

29.2.1 Factors discouraging settlement

They are usually climatic or relief factors. The main factors are—cold, altitude, heat, drought, poor soils, inaccessibility, etc.

29.2.2 Factors encouraging settlements

They are –good land, flat or undulating terrain, the existence of mineral resources, a good climate suitable for a wide range of crops or a less equable climate suitable to the cultivation of specialized crops which have a good market, etc. Other factors include extension of roads, railways and other modes of transportation.

29.3 Population Explosion

The rapid growth of population is perhaps the most obvious factor affecting the present and future national and regional development, but it is by no means the only population problem in the world today. The main problem is that of 'Population Explosion'.

Population explosion doesn't mean overpopulation or population density. Infact, overpopulation or population density is not the major problem. The problem arises when the economic developments fails to maintain pace with population growth. So the most important factors regarding population are how fast population is growing; and most important is where it is growing. For example, Japan has a high population density but it ranked first on the human development index formulated by U.N.D.P. On the other hand low population density areas of Africa or S. America are unable to support the existing population. Thus, the size, distribution and structure of the population within a country must be viewed in relation to its natural resources and the techniques of production used by its population. The extent to which they are used and the way in which they are utilized determine whether an area/country is under-or over-populated and hence witnessing population explosion or not. A country is said to have an "optimum population" so long as the number of people is in balance with the available resources of the country. If in a country the process of industrialization accompanied by urbanization is not fast and education is not widespread, then this is really a grave situation

called as Population Explosion.

29.3.1 Effects of population explosion

The effect of population explosion is numerous with far reaching consequences. Some of them are enumerated as under:

- Unemployment,
- Low living standard of people,
- Hindrance in the process of development of economy
- Pressure on agriculture land,
- Low per capital income,
- Lack of basic amenities like water supply and sanitation, education, health, etc.,
- High crime rate
- Environmental damage,
- Migration to urban area in search of job,
- Energy crisis,
- Overcrowding of cities leading to development of slums.

29.3.2 Population explosion in Indian context

The population explosion, though a worldwide phenomenon, poses a serious threat to India as it has to maintain 16.9% of world's population on only 2.4%of the world's area. The present growth rate of 1.7% is much higher than the world population growth rate of 1.3%, which is of great concern.
In order to overcome this problem of population explosion, a sound Population Policy is required with the following objectives:

1. Quick economic development and raising the per capital income.
2. Significant reduction in birth rate, which is more fundamental and important than the first, by providing legal and fiscal motivations like raising age of marriage, legalization abortion etc.
3. The planning of population must not aim merely at controlling the rate of multiplication but it should also include the improvement of the quality of the population as well by providing better facilities in education, health, etc.
4. (iv) The death rate should be brought down further, as high death rate results in waste of human energy and resources.
5. Integrating population planning with economic planning.

We are thus facing a population explosion of crisis dimensions which has largely diluted the fruits of the remarkable economic progress that we have made over the last few decades. It is clear that simply to wait for education and economic development to bring about a desirable drop in fertility is not a practical solution. The time factor is so pressing and the population growth so formidable that we have to get out of this vicious circle through a direct assault upon the population problem as a national commitment.

29.3.3 Methods of birth control

The effectiveness of a birth control method is generally expressed by how many women become pregnant using the method in the first year of use. Thus, if 100 women use a method that has a 0 percent first-year failure rate, then 0 of the women should become pregnant during the first year of use. This equals 0 pregnancies per 100 woman-years, an alternative

unit.

The most effective methods in typical use are those that do not depend upon regular user action.

a) Surgical sterilization, Depo-Provera, implants, and intrauterine devices (IUDs) all have first-year failure rates of less than one percent for perfect use. In reality, however, perfect use may not be the case, but still, sterilization, implants, and IUDs also have typical failure rates under one percent. The typical failure rate of Depo-Provera is disagreed upon, with figures ranging from less than one percent up to three percent.

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29.4 Aim of 'Family Welfare Programme'

In the year 1952, India launched a nation-wide family planning programme making it the first country in the world to do so. Unfortunately, family planning in India is associated with numerous misconceptions—one of them is its strong association in the minds of people with sterilization, while others equate it with birth control. The recognisation of its 'welfare concept' came only when the family planning programme was named as 'Family Welfare Programme' in the year 1977. The concept of welfare is very comprehensive and is basically related to quality of life. The Family Welfare Programme aims at achieving a higher end- that is, to improve the quality of life of the people.

Although the performance of the programme was low during 1977-78, but it was a good year in the sense that it moved into new healthier directions. The 42nd Amendment of the Constitution has made "Population Control and Family Planning" a concurrent subject. The

acceptance of the programme is now purely on voluntary basis. The launching of the Rural Health Scheme in 1977 and the involvement of the local people (e.g., trained Dais and Opinion leaders) in the family welfare programmes at the gross-root level were aimed at accelerating the pace of progress of the programme. India was a signatory to the Alma Ata Declaration, 1978. The acceptance of the primary health care approach to the achievement of 'Health For All by 2000 AD' led to the formulation of a 'National Health Policy' in 1982. The policy laid down the long-term demographic goal of Net Reproduction Rate (NRR)=1 by the year 2000-which implies a 2-child family norm-through the attainment of a birth rate of 21 and a death rate of 9 per thousand population, and a couple protection rate of 60% by the year 2000. The successive Five Year Plans were accordingly set to achieve these goals. The Government of India envolved a more detailed and comprehensive National Population Policy in 1986, to promote it on a voluntary basis as a 'movement of the people, by the people, for the people'. It has given family planning the broadest possible dimensions which include not only health and family welfare but also child survival, women's status and employment, literacy and education, socio-economic development and anti-poverty programmes.

The current approach in favour today is one of involvement and integration. The idea is to value those who stand to benefit from the programme and integrate the various attempts to propagate the same. Family Welfare Programme with such an approach can reduce the population growth to more manageable levels. Presently, the Family Welfare Programme seeks to promote on a voluntary basis, responsible and Planned Parenthood with one child norm, male or female, through independent choice of family welfare methods best suited to acceptors.

29.4.1 Problems of family welfare programme

The two major problem of Family Welfare Programme are:

1. Generally women are the major targets of family planning programmes .according to National Family Health Survey, the most widely used method of family planning in India is female sterilization. This shows that family planning has largely remained a women-centered programme. Due to reluctance of men to use permanent methods, women are forced to accept family planning methods. Gender specificity or gender subordination has to be eliminated in the approach in the family planning programmes as far as possible.

2. The imbalance in the sex ratio (female/1000 male) across the nation, which is 933, is another worrisome factor. In states like Haryana (SR=861), Punjab (SR=874), U.P. (S.R=898), Delhi (SR=821), Sikkim (SR=875) and others, the girl-child is being discriminated against even before birth. The instance of female infanticide in these and other states has brought down the sex ratio to an all time low. Though there is a law banning the determination of the sex of the child in the womb, unscrupulous medical practitioners and short-sighted parents connive to prevent the birth of female children. There is, thus, an urgent need to prevent the misuse of technology through education and awareness.

ENVIRONMENTAL STUDIES

Module 6. Social issues and the environment

Lesson 30
ENVIRONMENT AND HUMAN HEALTH

30.1 Introduction

It is an established fact that environment has a direct impact on the physical, mental and social well-being of those living in it. The environmental factors range from housing, water supply and sanitation, psychosocial stress and family structure through social and economic support systems, to the organization of health and social welfare services in the community.

In fact the occurrence, prevention and control of disease lies in the environment. If the environment is favourable to the individual, he or she can make full use of his or her physical and mental capabilities. On the contrary, if the environment is polluted it can affect the human health and his susceptibility to illness.

Thus, protection and promotion of 'environment health' is one of the major global issues today. It includes the issues of urban environmental health, water quality and health, air quality and health, industry and health, and energy and health.

30.2 Urban Environment Health

Environmental degradation is especially serious around crowded urban centers. In cities around the world, the living conditions of hundreds of millions of people (especially poor people in developing nations) threaten their health, impose misery, have potentially catastrophic social consequences and contribute to illness, accidents and crime. The crises in the urban environment are causing more immediate effects on human health than the current changes in the natural environment.

In the developing nations, the current rural exodus has led to a rapid increase in the pre-urban populations living in overcrowded conditions with inadequate provisions of infrastructure and services. Though average rate of disease and death for many cities are lower than those of surrounding rural areas because of the presence of a high proportion of the nation's middle- and upper-income classes who enjoy a relatively good standard of health; but, in contrast, the poor in urban areas usually suffer the same or even high rates of disease and death as their rural counterparts.

Good housing and suitable physical and social environments promote good mental and physical health. The most serious psychosocial health problems are depression, alcohol and drug abuse, suicide, child and spouse abuse, delinquency and target violence (e.g. rape, teacher assault, etc.). However, strong social networks and a sense of community organization can have a mitigating effect on the level of psychosocial health problems. Studies have shown a higher prevalence of mental illness in low-income, rundown areas. Deteriorating inner city areas or urban area with declining economies are characterized by social disorganization and

disintegration. They are inhabited by high- risk populations such as migrants, the homeless and street children. It has now been recognized that the environment plays an important role in violent behavior and that the public health sector has a legitimate role within the justice, social and education sectors in reducing the problem or urban environmental health.

30.2.1 Effect of water quality on human health

Water quality can have a significant effect on public health as a result of waterborne diseases. Inadequate supplies of water increase the problem of maintaining water quality, especially when there are multiple sources of water pollution such as sewage, industrial effluents, urban and agricultural runoff. According to an estimate about 170 million urban inhabitants and 770 million rural inhabitants lack access to safe and adequate water supplies. Most urban centers in Africa and Asia have no sewerage system at all; even where there is sewage disposal system, the system rarely serves more than a small proportion of the population. This means that human excrement and household wastes end up untreated in water sources. The problem of maintaining water quality is particularly acute in the more urbanized areas in developing countries due to two main reasons-failures to enforce pollution control and inadequacy of sanitation system and garbage collection and disposal system.

Waterborne diseases are the largest single category of communicable diseases contributing to infant mortality in developing countries (about 1500 million cases of diarrhea and some 4 million deaths per year). It is estimated that safe and sufficient water supplies can reduce infant and child mortality by more than 50 per cent.

30.2.2 Effect of air pollution on human health

Air pollution is a growing menace to health throughout the world. The problem of air pollution was first brought to sharp focus when air pollution epidemics took place in Los Angeles (1948), Donora (1948) and London (1952).In the London epidemic of 1952, thousands of people became ill and some 4000 people died within 12 hours. According to an estimate more than 1000 million urban residents worldwide are exposed to outdoor air pollution levels higher than those recommended by WHO. In many cities, the concentrations of air pollutants are already high enough to cause morbidity in susceptible individuals and premature mortality in the aged, particularly in those with respiratory problems.

Fossil fuels are the largest source of air pollution. The major sources of urban air pollution are overwhelmingly coal-fired (or oil-fired) power stations, motor vehicles, domestic cooking and heating (particularly when coal or biomass fuel is used) and industries. The symptoms are usually referable to the respiratory system. Health may be affected if acidified water (due to Acid Rains) is used untreated in water supplies. Depletion of ozone layer, due to the release of specific air pollutants, increases the incidence of skin cancer and cataracts. The indirect health effects, however, are likely to be more significant, such as changes in rainfall that may decrease agricultural production and the spread of diseases such as malaria to currently unaffected areas.

30.2.3 Effect of industrialization on human health

Industrialization has made many positive contributions to health. By and large, as countries move towards industrialization and generate wealth and employment, improved health should follow for their people. However, there are two exceptions to the general correlation between industrialization and human health. One exception is in some developing countries where

there has been remarkable success in reducing mortality and improving the health of the poor. The second exception is where industrialization has itself led to significant adverse health effects through failure to properly plan for, and prevent the release of chemical, physical or biological pollutants into the environment. A number of major accidents in developing countries due to release of chemicals or to explosions have caused adverse health effects.

Industrial effluents have polluted many rivers, lakes and coastal environments, especially in developing countries where pollution control is seldom enforced. Furthermore, hazardous wastes are sometimes exported from developed countries to developing countries because the cost of export is lower than the cost of disposal in the country of origin. Usually, there is little concern for the health of the local populations.

Some of the common occupation diseases are silicosis, pneumoconiosis, lead and mercury poisoning, and skin diseases. Continued and frequent exposure to noise, especially in industry, give rise to serious health problems.

30.2.4 Impact of energy on human health

Energy is a pre-requisite for socio-economic development and has direct and indirect benefits for health. The WHO Commission on Health and Environment's Panel of Energy has identified four major environmental health issues related to energy:

- Urban air pollution resulting from fossil fuel combustion and vehicular exhausts;
- Indoor air pollution resulting from domestic use of coal and biomass fuels for cooking and heating;
- Accident prevention and control; and
- Possible consequences of climate change.

People in developed countries use about ten times more commercial energy than those in developing countries and burn approximately 70% of all the fossil fuel used globally. The combustion of fossil fuels, accounting for about 90% of global commercial energy production, is the largest source of greenhouse gases and atmospheric pollution. Vehicle emissions also contribute to the formation of tropospheric ozone, photochemical smog and acid rain. Though it is possible to mitigate the environmental health effects of fossil fuel combustion, but the technologies are expensive.

Indoor air pollution from the combustion of coal or unprocessed biomass fuels represents the biggest energy-related cause respiratory disease with long-term cardiovascular effects, particularly among women and children especially in developing countries.

In case of nuclear power plants, there are risks to health for present and future generations from accidents and unsafe disposal of nuclear wastes.

Indirect health effects from climatic changes result from increased levels of greenhouse gases produced by the combustion of fossil fuels.

30.3 Value Education

The field of value education is as broad as life itself. It touches every aspect of human life, personality and education. Value education, in its full range of meaning, includes developing the appropriate sensibilities-moral, cultural, spiritual and the ability to make proper value

judgments and internalize them in one's life. Simply stated, value education is an education which teaches:

- How to live life well?
- How to find happiness?
- How to make others happy?
- How to behave and communicate with others?
- How to manage all kinds of people as well as happenings?
- How to grow and succeed in the right manner?

Value education, thus, is essentially 'Man Making' and 'Character Building'

The question then arises:"Which is more important-academic or value education?" The answer is simple, both are equally important. Without formal education, a person will not be able to read or write; and thus, without these skills to read or write, he/she cannot get a good job or manage even the simple things of daily living. Value education is equally important because if a highly qualified, well-employed person does not know how to behave properly, then all that he/she does has little meaning and will not serve him/her well. Therefore, fruitful education is the kind used for our welfare as well as that of others. And this can only happen when a person has both academic and value education.

Take the examples of two brilliant and very highly qualified scientists-one invents a life-saving drug, while the other invents a bomb. Though, both have a great deal of academic education but the scientist with character, a love for mankind and certain values, creates something that can save hundreds and thousands of lives; whereas, on the contrary, the other scientist creates something that can take hundreds and thousands of lives and cause pain and deformities even in future generations.

Emperor Asoka "The Great" had his early successes based on much violence. He became the King of Magadha only after killing nearly 90 of his kinsmen. One day, in the middle of the battle of Kalinga, he realised that there were no true victors in war because so many people died on both sides. He immediately renounced war and violence, and became a follower of Buddha and thus changed his entire life. He, then, served his people in wonderful ways. Even today, he is honoured and remembered. On the contrary, many leaders who gave up good values just to gain power met with failure and death in the end. Adolf Hitler, at one time the most powerful man on Earth, misused his power to confiscate land and money of others, tortured and killed millions of people, and caused the Second World War. But when defeat neared, he didn't face it bravely-he killed himself. His power deserted him when he needed it most because he had gained that power by throwing away all the good values from his life. His power is just an external show, it was not inner strength.

30.3.1 Methods and strategies of imparting value education

The methods and strategies of imparting value education are many and varied. The selection depends much upon the value chosen, sources of development of these values and other limiting factors. The following approaches can be used for teaching values in character building activities:

1. Telling: It is a process for developing values to enable a pupil to have a clear picture of a value- laden situation by means of his own narration of the situation.
2. Inculcating: It is an approach geared towards instilling and internalizing norms into person's own value systems.

3. Persuading: it is the process of convincing the learner to accept certain values and behave in accordance with what is acceptable.
4. Modeling: Modeling is a strategy in which a certain individual perceived as epitomizing desirable/ ideal values is presented to the learners as a model.
5. Role playing: acting out the true feelings of the actor/ actors by taking the role of another person but without the risk of reprisals.
6. Simulating: It is a strategy in which the learners are asked to pretend to be in a certain situation called for by the lesson and then to portray the events and also by imitating the character's personality.
7. Problem solving: It is an approach wherein a dilemma is presented to the learners asking them what decision they are going to take.
8. Discussing situations, stories, pictures, etc: This technique asks the learners to deliberate on and explain the details in the lesson.
9. Studying biographies of great men: This is an approach that makes use of the lives of the great men as the subject-matter for trying to elicit their good deeds and thoughts worthy for emulation.
10. Moralizing: It is the process of working out a sense of morality through active structuring and restructuring of one's social experiences (e.g. moral reasoning and analysis).
11. Value clarification: It may be considered as learner-centered. It relies mainly on the pupil's ability to process his beliefs and behave according to his beliefs, and also, to make a decision whenever confronted with the value dilemma.

30.4 What is AIDS? What are the Sources and Mode of Transmission of HIV Infection?

AIDS, the Acquired immune-Deficiency Syndrome is a fatal illness caused by a retrovirus known as the Human Immuno-Deficiency Virus (HIV) which breaks down the body's immune system, leaving the victim vulnerable to a host of life-threatening opportunistic infections, neurological disorders or unusual malignancies. Once a person is infected with HIV, it is probable that the person will be infected for life. Strictly speaking, AIDS refers only to the last stage of the HIV infection. There are two types of HIV- the most common HIV 1 and HIV 2 (commonly found in West Africa). The high risk groups include male homosexuals and bisexuals, hetero-sexual partners (including prostitutes), clients of STD, intravenous drug abusers, transfusion recipients of blood and blood products, haemophiliacs, and medical and paramedical staff. Since the first clinical evidence of AIDS in USA in 1981, the disease has become a more devastating disease than any other disease humankind has ever faced. It has acquired epidemic like proportion as more than 60 million people all over the world have been infected with the HIV (Africa-13.2%, Americans-13.6%, Asia-60.7%, Europe-12.0% and Oceania-0.5%).

Estimates of HIV infection cases in India are about 3.5 million. HIV sentinel surveillance data shows Maharashtra as the most affected state followed by Tamil Nadu, Andhra Pradesh, Karnataka and Manipur.

30.5 Sources of HIV Infection

The greatest concentration of HIV has been found in blood, semen and CSF (cerebo-spinal-fluid). Further, lower concentrations have been detected in tears, saliva, breast-milk, urine, and cervical and vaginal secretions. But, till date, only blood and semen have been conclusively shown to transmit the virus.

30.5.1 Mode of transmission

30.5.1.1 Sexual transmission

AIDS is first and foremost a sexually transmitted disease. Recent researchers have found that deep kissing where saliva is exchanged can also infect the partner.

30.5.1.2 Blood contact

AIDS is also transmitted by transfusion of contaminated blood. Intravenous drug users are at a high risk because they often share needles and syringes. Any skin piercing (including injections, ear-piercing, tattooing or acupuncture) can also transmit the virus via infected instruments.

30.5.1.3 Maternal-foetal transmission

An AIDS-infected mother can transmit virus to her child during pregnancy (through the placenta) or during birth or via breast-feeding.

30.5.2 HIV/AIDS is not spread by

- Drinking water or eating food from the same utensils (glasses, cups, plates, etc.) used by infected person.
- Shaking hands.
- Hugging or facial kissing.
- Working with people who are HIV infected.
- Swimming in pools used by infected people.
- Sharing toilets.
- Mosquitoes or any other insects.
- Casual social contact with infected persons even within households. That is, HIV is not spread by sitting next to someone who is infected, coughing or sneezing; but if person has any cuts or sores on his/her hands then make sure they are covered with plasters (band-aids or bandages).

30.5.3 Major precautions to avoid AIDS

The three major precautions to avoid AIDS are:

- Use condoms
- Use disposable syringes.
- Avoid multiple partners.

30.5.4 Control of AIDS

There are four basic approaches to control AIDS

30.5.4.1 Health education

Until a vaccine or cure for AIDS is found, the only means available at present is health education so as to enable people to make life-saving choices (for example, avoiding indiscriminate sex, using condoms). However, there is no guarantee that the use of condoms will give full protection. People should also avoid the use of shared razors and tooth brushes. Women suffering from AIDS or who are at high risk of infection should avoid becoming pregnant since infection can be transmitted to the unborn or new born. Intravenous drug users

should avoid sharing of needles and syringes. Educational material and guidelines for prevention should be made widely available. All mass media channels should participate in educating the people on AIDS, its nature, transmission and prevention.

30.5.4.2 Prevention of blood borne HIV transmission

People in high-risk group should be asked to refrain themselves from donating blood, body organs, sperm and other tissues. All donated blood should be screened for AIDS before transfusion. Strict sterilization practices should be ensured in hospitals and clinics. Pre-sterilized disposable syringes and needles should be used as far as possible.

30.5.4.3 Treatment

There is no vaccine or cure for AIDS. However, there are certain medicines like 'Zidovudine (Azt), Lamivudine (3TC) and Saquinavir (SQR) which can delay the onset of AIDS after HIV infection. Strictly speaking-these medicines cannot cure; they can only control/delay the onset of AIDS.

30.5.4.4 Integration of AIDS control programmes

Due to its wide-ranging health implications, AIDS touches all aspects of primary health care, including mother and child health, family planning and education. Therefore, it is essential to integrate AIDS control programmes into country's primary health care system. AIDS control programmes will be of no use if they are developed in isolation.

30.6 'Human Rights'?

The term 'Human Rights' refers to those basic rights which are essential for the development of human personality such as the right to life, liberty, property and security of an individual. The 'Universal Declaration of Human Rights' adopted by the United Nations on December10, 1948, states that-"the inherent dignity of all members of the human family is the foundation of freedom , justice and peace in the world". This is possible only when each and every human being enjoys fundamental rights, which include:

- The right to life, liberty and security of persons;
- The right to own property;
- The right to freedom of opinion and expression;
- The right to an adequate standard of living;
- The right to seek and to enjoy in other countries asylum from persecution.
- The right to education, freedom of thought, conscience and religion; and
- The right to freedom from torture and degrading treatment, etc.

Some of the important Articles of the Declaration are:

Article 1: deals with reason and conscience in the common spirit of brotherhood.
Article 2: deals with rights and freedoms irrespective of caste, sex, religion, etc.
Article3: deals with right to life, liberty and security of human beings.
Article4: deals with prohibition with slavery.
Article5: deals with prohibition of inhuman tortures and punishment.
Article6: deals with human recognition before law.
Article7: deals with equal protection against any discrimination in violation of human rights.
Article8: deals with the right to a remedy for acts violating the fundamental rights given by

constitution.
Article9: deals with the protection against arbitrary arrest, detention and exile.
Article 12: says that none should be subjected to arbitrary interference with his privacy, family, home or correspondence, etc.
Article 13: deals with right to freedom of movement.
Article 12: says that men and women of full age without any limitation due to race, nationality or religion, have the right to marry.
Article 18: deals with the right to freedom of thought, conscience and religion.
Article 19: deals with the right to freedom of opinion and expression.
Article 20: deals with the right to freedom of peaceful assembly and association.
Article 23: deals with the right to work without any discrimination.
Article 26: deals with the right to education.

30.6.1 Problem of human rights

Alarmed by the horrors of the holocausts, the United Nations had adopted 'Universal Declaration on Human Rights' in 1948, motivated by the desire to recognize that the same rights belong to all people and every individual. And since then, the UN has been actively monitoring human rights violations in various parts of the world.

But many countries have protested against the UN declaration saying that it is discriminatory in nature as it is used to condemn underdeveloped countries. Many of the developing countries have even accused the West of practicing double-standards. For instance, the US is quite willing to forget China's human rights violations (e.g., political dissidents are detained, and freedom of speech and expression are kept under considerable restraint in China) in return for a lucrative market. The US has even given China the status of 'Most Favoured Nation'.

The Malaysian former Prime minister, Dr. Mahathir Mohammad, has even launched a campaign for a review of the 'Universal Declaration on Human Rights'. He is of the opinion that the Declaration should take into account the Asian cultures in which the interests of the nation and society take precedence over those of the individuals.

Module 6. Social issues and the environment

Lesson 31
WOMEN AND CHILD WELFARE

31.1 Various Problems Affecting the Women and Welfare

31.1.1 Malnutrition

Pregnant women, nursing mothers and children are particularly vulnerable to the effects of malnutrition. The adverse effects of malnutrition on women are-maternal depletion, low birth weight, anaemia, toxemias of pregnancy, post-partum haemorrhage, all leading to high mortality and morbidity. Measures to improve the nutritional status of women and children may be broadly divided into two-direct and indirect nutrition interventions. Direct interventions cover a wide range of activities, such as, supplementary feeding programmes, distribution of iron and folic acid tablets, fortification and enrichment of foods, nutrition education, etc. indirect interventions include control of communicable diseases through immunization, improvement of environmental sanitation, provision of clean drinking water, family planning, food hygiene, education and primary health care.

31.1.2 Infections

Women or maternal infections can cause a variety of adverse effects such as threatened abortions, foetal growth retardation, low birth weight, embryopathy and puerperal sepsis. Women of under-developed nations are at high risk. Infections in the child may begin with labour and delivery and increase as the child grows older. Children may be ill with debilitating diarrhoeal, respiratory and skin infections, or the situation is further aggravated by the chronic infections, such as, malaria and tuberculosis. The children also suffer from the severe protein-energy malnutrition and anemia. Prevention and treatment of infections in women and children is being done by adopting the WHO Expanded Programme on Immunization. The children in the developing countries are being immunized against tuberculosis, diphtheria, pertusis (whooping cough), tetanus, measles and polio.

31.1.3 Uncontrolled reproduction

The severe health hazards for the women and children resulting from the unregulated/uncontrolled reproduction have been well recognized, viz., increased prevalence of low birth weight babies, severe infections and a high maternal and perinatal mortality. Statistics have shown that in most countries, a birth rate is associated with a high infant mortality rate and child death rate.

31.1.4 Education and socio-economic status

The dropout rate (from schools) of girls is much higher than the boys. In under-developed nations the educational preference, both at the primary level and at secondary level, is given to the male child as compared to the female child. This also indirectly affects the socio-

economic status of the women. This problem is very much under control by making the female education free at the primary level by the several under-developed nations. In India too, the female literacy rate has gone upto 50% from 39.3%.

ENVIRONMENTAL STUDIES

Module 6. Social issues and the environment

Lesson 32
ROLE OF INFORMATION TECHNOLOGY (IT) IN ENVIRONMENT

32.1 Introduction

Some of the areas in which information technology is playing a vital role in environmental management are briefly discussed as under:

32.1.1 Biodiversity conservation

Use of GIS (Geographic Information System) and Remote Sensing can help in determining the rates, causes and scale of biodiversity loss. Information on deforestation and land use change can be integrated with data on the distribution of biodiversity and existing information on climate, topography, soil, etc. to obtain a comprehensive picture.

32.1.2 Species monitoring

Not only the existence of flora and fauna can be detected, even counting of animals like elephants, tigers, etc. can be done with the help of GIS. The IUCN (International Union for Conservation of Nature) Red Database acts as an aid in appreciating the degree of danger that a species is in.

32.1.3 Site selection

GIS can help in the selection of optimum highway or railway routes, dam or reservoir sites, waste disposal sites, major industrial sites, etc. that can cause minimal disturbance to ecosystems.

32.1.4 Disaster management

Remote sensing data can be effectively used for obtaining near real time information on areas affected by earthquakes, cyclones, floods, landslides, volcanic eruptions, forest fires and other such disasters. Disaster prone areas can be identified where appropriate action can be taken up to reduce the losses and also disasters like cyclones, floods, etc. can be predicted well in advance.

32.1.5 Soil resources

Satellite data depict the nature of problem, degree of salinity, sodicity and spatial extent of the problem in each mapping unit. The information is extensively used to plan for the reclamation of salt affected soils and for adopting post-reclamation production technology.

32.1.6 Water resources

Remote sensing data proved effective in inventorying, monitoring and managing both surface and ground water resources to augment the water use efficiency. Satellite data serves as a unique tool for extracting information on geology, geomorphology, drainage, land use and soils, which are essential in identifying not only the potential segments of agricultural resources, but also the sites suitable for site selection of recharge structures.

32.2 Role of Information Technology in Human Health

Its various applications include:

- Bioinformatics and osteoporosis

  The application of bioinformatics is in the emerging possibility for the cure of osteoporosis-a crippling disease caused by the breakdown of bone, caused by a class of molecules called Cathepsin K. Now the pharmaceutical companies have to find a drug that blocks the Cathepsin K gene only.

- Role in genome sequencing

  Bioinformatics played a key role in the final stages of the Human Genome Project. In just four weeks, James kent (a Ph.D student of California University) produced a computer programmers that helped the public consortium to complete the sequencing in time and to present the draft sequence along with Celera Genomics on June26, 2000.

- DNA databases or data banks having genetic information about populations together with their personal physical characteristics (eye colour, height, weight, etc.), finger prints, dental records, medical records, financial records, etc. are used by the Government Departments to identify missing persons, by the investigating agencies (e.g., FBI, CBI, RAW, etc.) to identify criminals, and also by the insurance companies to prevent insurance fraud.
- Many organizations, such as WHO, maintain their web sites with information about endemic, epidemic and communicable diseases to inform people about dangers involving populations.
- Information about new drug release, their mode of action, indications and risk are also available on web sites.
- Any new development in the field of surgery is also available on net to be referred by the doctors of any country at any time.
- Telemedicine and distance medicine is now far-reaching along with documentation and display of human anatomy with the help of internet.

ENVIRONMENTAL STUDIES

ENVIRONMENTAL STUDIES

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