THE NOTES ON BASICS OF ENERGY AND ENVIRONMENT CONTAINS THE FOLLOWING TOPICS:

1. INTRODUCTION
2. ECOLOGY
3. ECOSYSTEM
4. ENVIRONMENTAL POLLUTION
5. EIA
6. SUSTAINABLE DEVELOPMENT AL TREATIES AND CONVENTIONS
7. BIODIVERSITY CONSERVATION + LAND AND SOIL DEGRADATION
8. FEW POINTS ON SUSTAINABLE DEVELOPMENT
9. ENERGY CONSERVATION
10. WATER CONSERVATION

Since long i was looking for a precise book on energy and environment that helps the students during entrance exams. In ese this topic has a huge weightage in paper 1 pre. So i start looking into different sources available and come up with a small book. This contains information on different subtopics mentioned above as per your need guys.

WISH U ALL THE VERY BEST

DISCLAIMER: THE MATERIAL IN THE NOTES IS NOT MY OWN AND I HAVE ONLY TRIED TO COMPILE THE SAID NOTES FROM DIFFERENT SOURCES AVAILABLE IN THE MARKET FOR THE READING PURPOSE ONLY. MOREOVER, THERE IS NO GUARANTEE THAT QUESTIONS IN THE UPSC WILL BE ASKED FROM THESE NOTES.
WHAT IS ENVIRONMENT

Every living organism is constantly interacting with its environment comprised of air, light, water, land or substratum and the various kinds of living organisms.

The environment may be defined as the **surroundings or conditions in which an organism lives or operates.** The environment broadly includes living (biotic) and non living (abiotic) components

A. Abiotic components

i. **Light** – Sunlight provides energy. Green plants utilize sun light for photosynthesis for synthesizing food for themselves as well as all other living organisms.

ii. **Rainfall** – Water is essential for all living beings. Majority of biochemical reactions take place in an aqueous medium. Water helps to regulate body temperature. Further, water bodies form the habitat for many aquatic plants and animals.

iii. **Temperature** – Temperature is a critical factor of the environment which greatly influences survival of organisms. Organisms can tolerate only a certain range of temperature and humidity.

iv. **Atmosphere** - The earth’s atmosphere is made of 21% oxygen, 78% nitrogen and 0.038% carbon dioxide. Rest are inert gases (0.93% Argon, Neon etc).

v. **Substratum** - Organisms may be terrestrial or aquatic. Land is covered by soil and a wide variety of microbes, protozoa, fungi and small animals (invertebrates) thrive in it. Roots of plants pierce through the soil to tap water and nutrients. Terrestrial animals live on land. Aquatic plants, animals and microbes live in fresh water as well as in the sea. Some microbes live even in hot water vents under the sea.

B. Biotic components

i. **Green Plants** – Prepare food through photosynthesis for all living organisms.

ii. **Animals** – Individuals of the same species occur in a particular type of habitat. They also live with other species. One species forms food for another. Micro-organisms and fungi decompose dead plants and animals releasing nutrients locked in bodies of dead organisms for reuse by the growing plants. Living organisms, therefore, need both abiotic and biotic components of the environment for survival. A delicately balanced relationship between living organisms and their environment is critically important for their survival.

In nature, there exists an ecological balance. The activities of various organisms are balanced. The interaction between abiotic and biotic components are so fine tuned that there exists an equilibrium in nature. As years passed by, human activities interfered with this equilibrium. Uncontrolled human activities caused damage to the environment. Some of the human activities that have led to environmental degradation are mentioned below-
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1. Forests are natural resources but they have been cut down for use by humans for converting them into the cultivable fields, for building houses and for taking away logs for making shelters and furniture or fuel. The rate at which trees are cut far exceeds the rate at which trees grow, so forests are getting denuded.
2. Trees lose lot of water through transpiration. This helps in forming rain clouds. Cutting of trees and clearing of forest reduced rainfall in the area. Also removal of plants and trees leads to soil erosion.
3. Forests are natural habitats of wild life. Extinction of wild life species is on the rise because their natural habitats are being destroyed due to deforestation.
4. Non-renewable energy resources such as coal, natural gas and petroleum are being used up speedily, leading to their depletion. These are examples show the loss of natural resources due to the overuse by humans.

On the other hand,

1. Excessive burning of coal, wood, kerosene, petrol etc. release toxic gases such as SO2 (sulphur dioxide), NOx (oxide of nitrogen), CO (carbon monoxide) and hydrocarbons in the air. These gases are also emitted by industries, power plants, automobiles and aircrafts. The toxic gases pollute air which adversely effects human health and plants.
2. Acid water from mines, toxic waste of industries, chemical fertilizers and pesticides from agricultural fields have polluted rivers and other water bodies.
3. The problem of soil pollution is increasing day by day in villages, cities and industrial areas due to faulty disposal of solid and liquid wastes generated from households and industries.

Thus humans have spoilt the environment by (i) depleting natural resources to a critical level and (ii) causing pollution to natural water bodies and land areas.

DEFORESTATION AND ITS CONSEQUENCES

Forests are found all over the world except the polar regions. Originally forests covered one third of the land area. Cutting of trees in forests is called deforestation. Deforestation has taken place for various purposes at an alarming rate in different parts of the world resulting in severe loss of wild plants and animals.

Consequences of deforestation

1. Soil erosion Trees intercepts rainfall and cutting of trees and removal of plants leads soil erosion. Plants roots hold the soil in place. With loss of protecting cover of plants, top soil, that is rich in organic matter, is washed away and the soil looses its fertility.
2. Landslides Removal of trees from forests leads to soil erosion. Ultimately cause landslides in hilly areas. This is because roots of trees hold the soil in position;
3. Silting The loss of trees from forests also causes silting of rivers and lakes as loose soil gets washed with rainwater and reaches water bodies;
4. **Loss of wild habitat** Wild animals live in forests. Cutting forests means loss of their habitat which in turn renders them endangered or even extinct.

5. **Change of climate** Deforestation results in change of climate since trees make the surroundings humid. Loss of trees leads to loss of humidity. Also transpiration from plants makes rain clouds and so rainfall is reduced due to deforestation.

6. **Loss of CO2 sink** Pollutants released by industries take CO2 are taken up by trees. When forests are denuded. This CO2 sink is lost and CO2 collects in the environment.

7. **Pollution** When trees are cut to use for making furniture or paper, the sawmills and paper mills pollute water in which they dump the waste.

8. **Loss of medicinal and other useful plants** Unique medicinal plants grow in certain forests. They are lost due to deforestation. Aromatic herbs, rubber trees and other useful plants are also lost due to deforestation.

Thus forest destruction leads to large scale environmental degradation

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**ENVIRONMENTAL DEGRADATION FROM MINING**

1. **Loss of vegetation**
   Vegetation and soil are removed to get access to mineral deposits. The flora and fauna present in the area is lost.

2. **Depletion of minerals**
   Earth is full of metals and mineral resources. They are very important non-renewable natural resource. India is very rich mineral resources. In last two hundred years advancement in mining technology has progressively intensified mining of mineral resources. Large amount of lead, aluminum, copper and iron ores have been used up. It is believed that in the next 20 years silver, tin, zinc and mercury will be depleted to an alarming level if their exploitation continues at the present rate.

3. **Dumping of debris**
   Extraction of minerals from the earth also produces significant amounts of over burden or debris. Often it is much more as compared to the quantity of mineral obtained. The dug out loose waste material is dumped on the adjacent land. Dumping of mining waste not only occupies large land area but the waste dumps also become a source of soil erosion.

4. **Land subsidence**
   Excessive mining specially underground mining may lead to land subsidence and may also cause landslides. The landscape too is spoilt. Unless care is taken, not only minerals will be alarmingly depleted but also a large land area, which could otherwise be used productively, is lost due to disposal of mining waste.

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**IMPACT OF INDUSTRIALIZATION ON THE ENVIRONMENT**

1. Natural resources used as raw materials by industry are depleting rapidly.
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2. Industries generate lot of toxic gases, and liquid effluents leading to environmental degradation.
3. Industries generate large amount of waste, which pile up in the environment. Disposal of waste not only needs land but also pollutes the environment and poses hazards to human health.
4. Industries use up a lot of fossil fuels as source of energy. Accelerated consumption of fossils fuels is depleting their stock as they are limited and non-renewable. But burning of fossil fuels releases CO2 in the atmosphere leading to global warming.

IMPACT OF MODERNIZED AGRICULTURE ON ENVIRONMENT

1. Forests have been cleared transformed into farmlands for growing food crops.
2. Excessive irrigation and poor drainage causes water logging and kill plants.
3. Pollution by agrochemicals Increased use of synthetic fertilizers causes to serious environmental problems. For example, unused fertilizers from agricultural fields are carried away by run off waters into lakes and rivers causing pollution. These agrochemicals may even seep through the soil and pollute ground water. Excessive nutrients enrichment of water bodies leads to ‘eutrophication’ (i.e. enrichment of water with nutrients particularly nitrates and phosphates triggers the explosive growth of green algae) may take place in water bodies and kill aquatic life. Use of pesticides not only kills pests that destroy crop but may also kill many non pest organisms which may include even useful species of insects such as pollinators, birds and helpers in dispersal of plant seeds. Pesticides tend to accumulate and their concentration increases through the food chain and reach toxic levels in eggs, milk and other food items. (biomagnification)
4. Agro- industrial wastes are generated. e.g. crop residues such as paddy, jawar, gram straws, cotton straws, sugarcane trash, and coconut shells etc. pile up causing environmental degradation.
5. High yielding varieties (HYV) of food crops replaced various traditional crop varieties. Traditional agriculture was based on multicropping system, i.e. growing of food crops, fodder and firewood crops together. This practice had been replaced by monoculture i.e growing of only one kind of crop (such as wheat etc) in a field of specific set of nutrients making soil unfit for growing other crops but is being considered again.

URBANIZATION AND ENVIRONMENT

1. Cultivated land was lost forever for building houses, industries, roads and other facilities.
2. A water supply system had to be developed to provide water for drinking and other domestic uses. Growing urban population created increasing demand for potable water. As a result, availability of water become more and more scarce.
3. Industries, that were set up to provide the necessary goods for urban folk, generated industrial waste, leading to the pollution of the environment. In cities,
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Black smoke emitted from industries, buses, truck etc. cause air pollution. Large amount of garbage is generated and not disposed properly. As a result garbage remains scattered and unattended. Domestic and industrial effluents are drained into rivers and lakes. High noise levels are a common feature of urban environment.

4. An incessant influx of people into cities and shortage of housing result in development of slums and squatter areas. Inadequate facilities and lack of basic amenities in slums leads to unhygienic condition and social distortion and crime.

ENVIRONMENTAL BACKLASH

Local environmental backlash

1. **Salination of irrigated soils** In several areas over irrigation resulted in salt accumulation in the soil as water is lost from evaporation but the salts dissolved in water remains in the soil and accumulate progressively making the soil saline and unfit for cultivation and infertile.

2. **Eutrophication** Eutrophication of a water body occurs when plant nutrients such as nitrates and phosphates are released by the action of aerobic bacteria on organic wastes entering a water body. These nutrients promote growth of algae (algae bloom). Algae consume all the oxygen and aquatic organism die due to lack of oxygen.

3. **The Minamata disease** Plastic, caustic soda, fungicide and pesticide manufacturing factories release mercury along with other effluents in the water body nearby. Mercury enters food chain through bacteria –algae-fish and finally the humans. **Fish died due to consumption of Hg.** Those who ate these fish were affected by mercury poisoning which proved fatal in certain cases. The high concentration of Hg in water and in tissues of fish resulted from formation of soluble mono methyl mercury \((\text{CH}_3\text{Hg}^+)\) and volatile dimethyl mercury \((\text{(CH}_3)_2\text{Hg})\) by the action of anaerobic bacteria.

4. **Extinction of wild life species** The numbers of tigers and lions have dwindled, the great Indian bustard is endangered and the list of the animals and plants threatened to extinction is long and growing. **The Kalu River near Mumbai is severely polluted by industrial waste and the Bombay duck, a favorite edible fish which was once common in this river has been lost forever.** Tigers and lions are being killed for sport and by poachers.

Regional Environmental backlash

1. **Floods** Floods are a natural disaster and India is a flood prone country. Floods occur almost every year during the period monsoon, continuous heavy rainfall brings huge quantities of water into rivers which overflow and cause flood. The habitations close to the river get flooded resulting in loss of human life and property. This means heavy economic losses. The flood affected areas suffer from quite shortage of potable water often outbreak of epidemic diseases.

2. **Drought** Failure of monsoon and absence of rain leads to drought. Rise in the average global temperature due to global warming will increase water use and may create water shortage. **It is estimated that a 30C. Global warming may reduce as much as 10% precipitation and creating water scarcity leading to drought conditions.** Shortage of water would adversely affect agriculture,
industries and plants communities. Animals that are unable to move to greener pastures will perish; humans will suffer from health problems.

3. **Acid rain** Moisture laden air rises to higher altitudes and condenses to fall as rain or snow. Pure rain has a pH of 5.6 but in areas where industries burn oil and coal emit SO2 (sulphur dioxide) into the atmosphere and motor vehicles release NOx (compound of nitrogen) into air, the rain becomes more acidic reaching pH of 2. This is because SO2 and Nox dissolve in water vapour present in the atmosphere and forms H2SO4 and HNO3. When acidic snow melts acid rain drops reaches water bodies and making them acidic. Acidic water kills aquatic fauna and flora. Acidic rain is toxic to trees and corrodes buildings, marble structures and archaeological monuments.

4. **Oil spills** Sometimes there is accidental spill of crude oil and petroleum products into the sea by oil tankers and ships. A thin layer of oil covers sea surface depriving marine organisms of oxygen. Floating oil slicks kill marine life and severely affect ocean ecosystem.

**Global backlash**

1. **Biodiversity loss** Dwindled forests the natural habitat of various plants and animals has vanished and so have vanished forever many valuable trees and animals. Some are on the verge of extinction while others are on the borderline.

2. **Global warming and green house effect** Green house is a glass chamber in which heat or solar radiations is trapped and plants grown in its closed warm environment. Industrialization and urbanization have led to emission of large quantities of carbon dioxide into atmosphere from burning of fossil fuels. Increased CO2 concentration in the atmosphere does not allow heat radiations given out by earth, to escape into the outer space. Increased atmospheric concentration of CO2 has raised the average global temperature causing global warming. Consequences of global warming include melting of snow caps and rising of sea level, rising temperature of the earth will cause polar ice caps to melt leading rise in sea level. Excessive heat expands water. Sea level rise cause flooding of coastal cities and damage coastal ecosystems like marshes and swamps. Global warming may change rainfall pattern; lead to early maturation of crops and reduce grain size and yield of crop.

3. **Collapse of marine fisheries** Global warming has driven marine fish towards cooler northern parts of the earth. Others are swimming to reach the cool deeper realms of ocean. The temperature of northern sea, it is estimated, to have increased by 10C in the last twenty-five years, several species of fish and other marine animals have permanently moved to cooler northern regions. Smaller fish are able to move faster to cooler areas away and the elevated temperature is taking its toll no larger fish, some of which are likely to become extinct. This change in behaviour of fish has led to collapse of marine fisheries and loss of livelihood for many - many fisher folk. Other reasons for collapse of marine fisheries is the dumping of massive amount waste into the sea. The waste dumped with the sea include sewage and garbage generated by people living in coastal areas and industrial waste from industries. Run off from agricultural fields carrying fertilizers and pesticides are brought by rivers to the sea. Fertilizers cause “eutrophication.” Oil spills and oil slicks also kill marine life.

4. **Ozone layer depletion** The ozone layer in earth's atmosphere prevents harmful UV radiations of sun from reaching earth's surface. CFCs (Chloroflorocarbons)
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used in refrigeration, air conditioning, cleaning solvents, fire extinguishers and aerosols have damaged the ozone layer or ozone shield particularly over Arctic and Antarctic. 30-40% reduction in the ozone layer may cause sunburn, fast ageing of skin, skin cancer, cataract, cancer of retina, genetic disorders, and reduced productivity in sea and forests.

Asthma, pulmonary fibrosis, pneumoconiosis are caused due to air pollution. Long exposure to pollutants in the working place such as mines, textile mills, poultry, crackers, sand blasting and chemical industries cause respiratory diseases. Carcinogenic chemicals and ionizing radiations in the environment have been responsible for cancer. The enormously large population means reduced job opportunities, unemployment and related stress. Stress may also due to job pressure, money problems, uncomfortable living and dislike for work or workplace. Asthma, ulcers, diabetes, hypertension, depression, schizophrenia are stress related diseases and increasing rapidly.
Ecology may be defined as the scientific study of the relationship of living organisms with each other and with their environment. The term ecology was first coined in 1869 by the German biologist Ernst Haeckel.

Ecology not only deals with the study of the relationship of individual organisms with their environment, but also with the study of populations, communities, ecosystems, biomes, and biosphere as a whole.

A large community unit, characterized by a major vegetation type and associated fauna, found in a specific climatic region is a **biome**. Biomes refer basically to terrestrial areas. The aquatic systems like the seas, rivers etc. are also divided into distinct life zones on basis of salinity.

**LEVELS OF ECOLOGICAL ORGANIZATION**

1. **Organisms** (individual) basic unit of study
2. **Population** A group of organisms consisting of a number of different populations that live in a defined area and interact with each other.
3. **Community** A group of organisms consisting of a number of different species that live in an area and interact with each other.
4. **Ecosystem** A communities of organisms and their physical environment, interacting as an ecological unit.

**HABITAT** is the physical environment in which an organism lives (it corresponds to the address of an organism). Each organism has particular requirements for its survival and lives where the environment provides for those needs. The environmental requirement of an elephant would be a forest. You would not expect an elephant in the ocean nor would you expect a whale in the forest? Forest, ocean, river etc. are examples of habitat. Earth has four major habitats-(1) **Terrestrial** (2) **Freshwater** (3) **Estuarine** (Where rivers meet the ocean) and (4) **Ocean**. The human gut is the habitat of a tapeworm and the rotating log a habitat of a fungus.

**NICHE:**

In nature, many species occupy the same habitat but they perform different functions. The functional characteristics of a species in its habitat is referred to as **niche** in that common habitat. Habitat of a species is like its ‘address’ (i.e. where it lives) whereas niche can be thought of as its “profession” (i.e. activities and responses specific to the species). **The term niche means the sum of all the activities and relationships of a species by which it uses the resources in its habitat for its survival and reproduction.** A niche is unique for a species while many species share the habitat. No two species in a habitat can have the same niche. This is because if two species occupy the same niche they will compete with one another until one is displaced. For example, a large number of different species of insects may be pests of the same plant but they can co-exist as they feed on different parts of the same plant. Another example is the vegetation of the forest. The forest can support a large number of plant species as they occupy different niches: the tall trees, the short trees, shrubs, bushes and grasses are all part of the forest but because of varying heights they differ in their requirements for sunlight and nutrients and so can survive together. The most important resources in the niches of animals are food and shelter while in case of plants, they are moisture and nutrients (phosphorous and nitrogen).
ADAPTATION:
Every organism is suited to live in its particular habitat. You know that the coconuts cannot grow in a desert while a camel cannot survive in an ocean. Each organism is adapted to its particular environment. **An adaptation is thus, “the appearance or behaviour or structure or mode of life of an organism that allows it to survive in a particular environment”**. Presence of gills and fins are examples of adaptation in fishes to aquatic habitat

A **SPECIES** is defined as; “a group of similar populations of organisms whose members are capable of interbreeding, and to produce fertile offspring (children)”. A tiger, a lion, a lotus and a rose are examples of different species. Every species has a scientific name, understood by people of all over the world. Humans belong to species of *Homo sapiens*. Only members of the same species can interbreed to produce fertile offspring. Every species has its own set of genetic characteristics that makes the species unique and different from other species.

**POPULATION** is defined as a group of freely interbreeding individuals of the same species present in a specific area at a given time. For example, when we say that the population of a city is 50,000, we mean that there are 50,000 humans in that city. However, all populations of humans living in any part of the world constitute the species *Homo sapiens*. A population has traits of its own which are different from those of the individuals forming the population. An individual is born and dies but a population continues. It may change in size depending on birth and death rates of the population. An individual is either female or male, young or old but a population has a sex ratio and age structure, which means, the ratio of male to female in the population and the various age groups into which the population may be divided.

The characteristics of any population depends on:
(i) density of the population, (ii) natality (birth rate), (iii) mortality (death rate), (iv) dispersal, (v) biotic potential (vi) age distribution (vii) dispersion and (viii) growth form.

**BIOTIC COMMUNITY** refers to the populations of different kinds of organisms living together and sharing the same habitat.

**STRATIFICATION**
Stratification of a community refers to the vertical layers of the vegetation. Tropical forests represent a good example of vertical stratification. In moist tropical rain forests up to five distinct strata or layers of vegetation can be formed. These include from the forest floor to the top:
(i) Ground layer of mosses and liverworts associated with dead leaves and other **The bottom layer** substances rich in organic matter.
(ii) Herb or grass layer **The middle layer**
(iii) Tall shrub layer
(iv) Layer of under storey of short trees,
(v) Layer of canopy of lower trees and **The upper layer**
(vi) Over storey or emergent tree layer formed by tall trees.
ECOLOGICAL SUCCESSION is the successive growth of primary succession occurs in an area where there is no previous community. Secondary succession forms on existing natural vegetation.

BIOTIC INTERACTION refers to the interaction taking place between individuals belonging to the same species (intra specific) or different species (interspecific).

NEGATIVE INTERACTIONS
i. Amensalism: one species is inhibited while the other species is unaffected
ii. Predation: Predator–prey relationship: one species (predator) benefits while the second species (prey) is harmed and inhibited.
iii. Parasitism: Beneficial to one species (parasite) and harmful to the other species (host).
iv. Competition: Adversely affects both species

II. POSITIVE ASSOCIATIONS
i. Commensalism: One species (the commensal) benefits, while the other species (the host) is neither harmed nor inhibited
ii. Mutualism: Interaction is favourable to both species

III. NEUTRAL INTERACTIONS
i. Neutralism: Neither species affects the other
The portion of the earth which sustains life is called biosphere. Biosphere is very huge and cannot be studied as a single entity. It is divided into many distinct functional units called ecosystem.

In nature several communities of organisms live together and interact with each other as well as with their physical environment as an ecological unit. We call it an ecosystem. The term ‘ecosystem’ was coined by A.G. Tansley in 1935. An ecosystem is a functional unit of nature encompassing complex interaction between its biotic (living) and abiotic (non-living) components. For example- a pond is a good example of ecosystem.

Components of Ecosystem

(a) Abiotic components (Nonliving): The abiotic component can be grouped into following three categories:-
(i) Physical factors: Sun light, temperature, rainfall, humidity and pressure. They sustain and limit the growth of organisms in an ecosystem.
(ii) Inorganic substances: Carbon dioxide, nitrogen, oxygen, phosphorus, sulphur, water, rock, soil and other minerals.
(iii) Organic compounds: Carbohydrates, proteins, lipids and humic substances. They are the building blocks of living systems and therefore, make a link between the biotic and abiotic components.

(b) Biotic components (Living)
(i) Producers: The green plants manufacture food for the entire ecosystem through the process of photosynthesis. Green plants are called autotrophs, as they absorb water and nutrients from the soil, carbon dioxide from the air, and capture solar energy for this process.
(ii) Consumers: They are called heterotrophs and they consume food synthesized by the autotrophs. Based on food preferences they can be grouped into three broad categories. Herbivores (e.g. cow, deer and rabbit etc.) feed directly on plants, carnivores are animals which eat other animals (eg. lion, cat, dog etc.) and omnivores organisms feeding upon both plants and animals e.g. human, pigs and sparrow.
(iii) Decomposers: Also called saprotrophs. These are mostly bacteria and fungi that feed on dead decomposed and the dead organic matter of plants and animals by secreting enzymes outside their body on the decaying matter. They play a very important role in recycling of nutrients. They are also called detritivores or detritus feeders.

Functions of ecosystem
Ecosystems are complex dynamic system. They perform certain functions. These are:-
(i) Energy flow through food chain
(ii) Nutrient cycling (biogeochemical cycles)
(iii) Ecological succession or ecosystem development
(iv) Homeostasis (or cybernetic) or feedback control mechanisms
Ponds, lakes, meadows, marshlands, grasslands, deserts and forests are examples of natural ecosystem. Many of you have seen an aquarium; a garden or a lawn etc. in your neighbourhood. These are man made ecosystem.

Types of ecosystems
Ecosystems are classified as follows:
   i. Natural ecosystems
   ii. Man made ecosystems

(i) Natural ecosystems
(a) Totally dependent on solar radiation e.g. forests, grasslands, oceans, lakes, rivers and deserts. They provide food, fuel, fodder and medicines.
(b) Ecosystems dependent on solar radiation and energy subsidies (alternative sources) such as wind, rain and tides. e.g tropical rain forests, tidal estuaries and coral reefs.

(ii) Man made ecosystems
(a) Dependent on solar energy-e.g. Agricultural fields and aquaculture ponds.
(b) Dependent on fossil fuel e.g. urban and industrial ecosystems.

Floating microorganisms (green) and plants are called phytoplankton ("phyto"- plants, "plankton" –floating). They are microscopic organisms. Sometimes they are so abundant in pond that they make it look green in colour e.g. Spirogyra, Ulothrix, Cladophora, Diatoms, Volvox.

Zooplanktons are floating animals. Cyclops, Cypris
Nektons are the animals that can swim and navigate at will. Eg. fishes
Benthic animals are the bottom dwellers: beetle, mites, mollusks and some crustaceans.

ECOSYSTEM FUNCTION–ENERGY FLOW THROUGH ECOSYSTEM

Food chains and energy flow are the functional properties of ecosystems which make them dynamic. The biotic and abiotic components of an ecosystem are linked through them.

FOOD CHAIN
Transfer of food energy from green plants (producers) through a series of organisms with repeated eating and being eaten is called a food chain. e.g.
Grasses → Grasshopper → Frog → Snake → Hawk/Eagle
Each step in the food chain is called trophic level. In the above example grasses are 1st, and eagle represents the 5th trophic level.
During this process of transfer of energy some energy is lost into the system as heat energy and is not available to the next trophic level. Therefore, the number of steps are limited in a chain to 4 or 5.
Following trophic levels can be identified in a food chain.
(1) Autotrophs: They are the producers of food for all other organisms of the ecosystem. They are largely green plants and convert inorganic material in the presence of solar energy by the process of photosynthesis into the chemical energy (food). The
total rate at which the radiant energy is stored by the process of photosynthesis in the green plants is called **Gross Primary Production** (GPP). This is also known as total photosynthesis or total assimilation. From the gross primary productivity a part is utilized by the plants for its own metabolism. The remaining amount is stored by the plant as **Net Primary Production** (NPP) which is available to consumers.

(2) **Herbivores**: The animals which eat the plants directly are called primary consumers or herbivores e.g. insects, birds, rodents and ruminants.

(3) **Carnivores**: They are secondary consumers if they feed on herbivores and tertiary consumers if they use carnivores as their food e.g. frog, dog, cat and tiger.

(4) **Omnivores**: Animals that eat both plant and animals e.g. pig, bear and man

(5) **Decomposers**: They take care of the dead remains of organisms at each trophic level and help in recycling of the nutrients e.g. bacteria and fungi.

There are two types of food chains:

(i) **Grazing food chains**: which starts from the green plants that make food for herbivores and herbivores in turn for the carnivores.

(ii) **Detritus food chains**: start from the dead organic matter to the detrivore organisms which in turn food for protozoan to carnivores etc.

In an ecosystem the two chains are interconnected and make y-shaped food chain. These two types of food chains are:-

(i) Producers → Herbivores → Carnivores

(ii) Producers → Detritus Feeders → Carnivores

### 5.3.2 Food web

Trophic levels in an ecosystem are not linear rather they are interconnected and make a food web. Thus **food web is a network interconnected food chains existing in an ecosystem.**

One animal may be a member of several different food chains. Food webs are more realistic models of energy flow through an ecosystem. The flow of energy in an ecosystem is always linear or one way. The quantity of energy flowing through the successive trophic levels decreases. At every step in a food chain or web the energy received by the organism is used to sustain itself and the left over is passed on to the next trophic level.

**Ecological pyramid**

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

**Pyramid of number**: This represents the number of organisms at each trophic level. For example in a grassland the number of grasses is more than the number of herbivores that feed on them and the number of herbivores is more than the number of carnivores. In some instances the pyramid of number may be inverted i.e. herbivores are more than primary producers as you may observe that many caterpillars and insects feed on a single tree.

**Pyramid of biomass**: This represents the total standing crop biomass at each trophic level. **Standing crop biomass** is the amount of the living matter at any given time. It is expressed as gm/unit area or kilo cal/unit area. In most of the
terrestrial ecosystems the pyramid of biomass is upright. However, in case of
aquatic ecosystems the pyramid of biomass may be inverted e.g. in a pond
phytoplankton are the main producers, they have very short life cycles and a rapid
turn over rate (i.e. they are rapidly replaced by new plants). Therefore, their total
biomass at any given time is less than the biomass of herbivores supported by them.

(3) Pyramid of energy: This pyramid represents the total amount of energy at each
trophic level. Energy is expressed in terms such as kcal/unit area/unit time
or cal/unit area/unit time. eg. in a lake autotroph energy = 20810 kcal/m/year
Energy pyramids are never inverted.

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

1. At each trophic a part of the available energy is lost in respiration or used up in
   metabolism.

2. A part of energy is lost at each transformation, i.e. when it moves from lower to higher
   trophic level as heat.

It is the ratio between the amount of energy acquired from the lower trophic level and the
amount of energy transferred from higher trophic level is called ecological efficiency.
Lindman in 1942 defined these ecological efficiencies for the 1st time and proposed 10%
rule e.g. if autotrophs produce 100 cal, herbivores will be able to store 10 cal. and
carnivores 1 cal. However, there may be slight variations in different ecosystems and
ecological efficiencies may range from 5 to 35%.

Significance of studying food chains
1. It helps in understanding the feeding relations and interactions among different
   organisms of an ecosystem.
2. It explain the flow of energy and circulation of materials in ecosystems.
3. It help in understanding the concept of biomagnification (Biomagnifications is
   the concentration of non-degradable pollutants in the successive tropic
   level in a food chain.) in ecosystems.

BIOGEOCHEMICAL CYCLES
In ecosystems flow of energy is linear but that of nutrients is cyclical. This is because
energy flows down hill i.e. it is utilized or lost as heat as it flows forward. The nutrients
on the other hand cycle from dead remains of organisms released back into the soil by
detrivores which are absorbed again i.e. nutrient absorbed from soil by the root of green
plants are passed on to herbivores and then carnivores. The nutrients locked in the
dead remains of organisms and released back into the soil by detrivores and
decomposers. This recycling of the nutrients is called biogeochemical or nutrient
cycle (Bio = living, geo = rock chemical = element). There are more than 40 elements
required for the various life processes by plants and animals. The entire earth or
biosphere is a closed system i.e. nutrients are neither imported nor exported from the
biosphere.
There are two important components of a biogeochemical cycle:

1. **Reservoir pool** - atmosphere or rock, which stores large amounts of nutrients.
2. **Cycling pool or compartments of cycle** - They are relatively short storages of carbon in the form of plants and animals.

**CARBON CYCLE**

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

1. **Photosynthesis** Green plants in the presence of sunlight utilize CO2 in the process of photosynthesis and convert the inorganic carbon into organic matter (food) and release oxygen. A part of the food made through photosynthesis is used by plants for their own metabolism and the rest is stored as their biomass which is available to various herbivores, heterotrophs, including human beings and microorganisms as food. Annually 4-9 x10^13 kg of CO2 is fixed by green plants of the entire biosphere. Forests act as reservoirs of CO2 as carbon fixed by the trees remain stored in them for long due to their long life cycles. A very large amount of CO2 is released through forest fires.

2. **Respiration** Respiration is carried out by all living organisms. It is a metabolic process where food is oxidized to liberate energy, CO2 and water. The energy released from respiration is used for carrying out life processes by living organism (plants, animals, decomposers etc.). Thus CO2 is released into the atmosphere through this process.

3. **Decomposition** All the food assimilated by animals or synthesized by plant is not metabolized by them completely. A major part is retained by them as their own biomass which becomes available to decomposers on their death. The dead organic matter is decomposed by microorganisms and CO2 is released into the atmosphere by decomposers.

4. **Combustion** Burning of biomass releases carbon dioxide into the atmosphere.

5. **Impact of human activities** The global carbon cycle has been increasingly disturbed by human activities particularly since the beginning of industrial era. Large scale deforestation and ever growing consumption of fossil fuels by growing numbers of industries, power plants and automobiles are primarily responsible for increasing emission of carbon dioxide gas.

Carbon dioxide has been continuously increasing in the atmosphere due to human activities such as industrialization, urbanization and increasing use and number of automobiles. This is leading to increase concentration of CO2 in the atmosphere, which is a major cause of global warming.

**NITROGEN CYCLE**

Nitrogen is an essential component of protein and required by all living organisms including human beings. Our atmosphere contains nearly 79% of nitrogen but it can not be used directly by the majority of living organisms. Broadly like carbon dioxide, nitrogen also cycles from gaseous phase to solid phase then back to gaseous phase through the activity of a wide variety of organisms. Cycling of nitrogen is vitally important for all living organisms. There are five main processes which essential for nitrogen cycle are elaborated below.
1. **Nitrogen fixation**: This process involves conversion of gaseous nitrogen into Ammonia, a form in which it can be used by plants. Atmospheric nitrogen can be fixed by the following three methods:
   
i. **Atmospheric fixation**: Lightening, combustion and volcanic activity help in the fixation of nitrogen.
   
ii. **Industrial fixation**: At high temperature (400°C) and high pressure (200 atm.), molecular nitrogen is broken into atomic nitrogen which then combines with hydrogen to form ammonia.
   
iii. **Bacterial fixation**: There are two types of bacteria-
   
a. **Symbiotic bacteria** e.g. Rhizobium in the root nodules of leguminous plants.
   
b. **Freeliving or symbiotic** e.g. 1. Nostoc 2. Azobacter 3. Cyanobacteria can combine atmospheric or dissolved nitrogen with hydrogen to form ammonia.

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

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

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

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

**Water Cycle**

Water is essential for life. No organism can survive without water. Precipitation (rain, snow, slush dew etc.) is the only source of water on the earth. Water received from the atmosphere on the earth returns back to the atmosphere as water vapour resulting from direct evaporation and through evapotranspiration the continuous movement of water in the biosphere is called water cycle (hydrological cycle). You have already studied that earth is a watery planet of the solar system, about 2/3rd of earth surface is covered with water. However a very small fraction of this is available to animals and plants. Water is not evenly distributed throughout the surface of the earth. Almost 95% of the total water on the earth is chemically bound to rocks and does not cycle. Out of the remaining 5%, nearly 97.3% is in the oceans and 2.1% exists as polar ice caps. Thus only 0.6% is present as fresh water in the form of atmospheric water vapours, ground and soil water.

The driving forces for water cycle are 1) solar radiation 2) gravity.

Evaporation and precipitation are two main processes involved in water cycle. These two processes alternate with each other

Water from oceans, lakes, ponds, rivers and streams evaporates by sun’s heat energy. Plants also transpire huge amounts of water. Water remains in the vapour state in air and forms clouds which drift with wind. Clouds meet with the cold air in the
mountainous regions above the forests and condense to form rain precipitate which comes down due to gravity.

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

5.7 HOMEOSTASIS OF ECOSYSTEM

Ecosystems are capable of maintaining their state of equilibrium. They can regulate their own species structure and functional processes. This capacity of ecosystem of self regulation is known as **homeostasis**. In ecology the term applies to the tendency for a biological systems to resist changes. For example, in a pond ecosystem if the population of zooplankton increased, they would consume large number of the phytoplankton and as a result soon zooplankton would be short supply of food for them. As the number zooplankton is reduced because of starvation, phytoplankton population start increasing. After some time the population size of zooplankton also increases and this process continues at all the trophic levels of the food chain.

Note that in a homeostatic system, negative feed back mechanism is responsible for maintaining stability in a ecosystem. However, homeostatic capacity of ecosystems is not unlimited as well as not everything in an ecosystem is always well regulated. Humans are the greatest source of disturbance to ecosystems.

Few more points to remember:

- Tundra biome occurs in the region where the environmental conditions are very severe and there is very little vegetation below the poles and at high mountain peaks. Deserts like tundra form an extreme condition in the sequence of biomes. They occur in dry barren regions of the earth.
- Ecotone is a zone of junction between two adjoining communities e.g. estuaries, mangroves and grassland Wetlands are ecotones between terrestrial and aquatic ecosystems like marshes, swamps and mangroves.
- Recently plantations of *Jatropha curcure* have become very popular for obtaining biodiesel.
- Industrial accidents that have taken away several lives e.g. in Bhopal, accidental leakage of MIC (methyl isocyanate) gas from Union Carbide Company killed more than 2000 people within 12 to 72 hours.
- Agro ecosystems have created many environmental problems such as soil erosion, ground water depletion and environmental pollution by fertilizers and pesticides.
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POLLUTION AND POLLUTANTS
Pollution may be defined as addition of undesirable material into the environment as a result of human activities. The agents which cause environmental pollution are called pollutants. A pollutants may be defined as a physical, chemical or biological substance unintentionally released into the environment which is directly or indirectly harmful to humans and other living organisms.

TYPES OF POLLUTION
Pollution may be of the following types:
• Air pollution
• Noise pollution
• Water pollution
• Soil pollution
• Thermal pollution
• Radiation pollution

AIR POLLUTION
Air pollution is a result of industrial and certain domestic activity. An ever increasing use of fossil fuels in power plants, industries, transportation, mining, construction of buildings, stone quarries had led to air pollution. Air pollution may be defined as the presence of any solid, liquid or gaseous substance including noise and radioactive radiation in the atmosphere in such concentration that may be directly and indirectly injurious to humans or other living organisms, plants, property or interferes with the normal environmental processes.
Air pollutants are of two types (1) suspended particulate matter, and (2) gaseous pollutants like carbon dioxide (CO2), NOx etc.

TABLE 01
SUSPENDED PARTICULATE MATTER/DUST:
SOURCES:Smoke from domestic, industrial and vehicular soot
EFFECTS: Depends on specific composition Reduces sunlight and visibility, increases corrosion, Pneumoconiosis, asthma, cancer, and other lung diseases.

FLY ASH
SOURCES:Part of smoke released from chimneys of factories and power plants in the air.
EFFECTS: Settles down on vegetation, houses. Adds to the suspended participate matter (SPM) Leachates contain harmful material

PARTICULATE POLLUTANTS
Particulate matter suspended in air are dust and soot released from the industrial chimneys. Their size ranges from 0.001 to 500 μm in diameter. Particles less than 10μm float and move freely with the air current. Particles which are more than 10μm in diameter settle down. Particles less than 0.02 μm form persisent aerosols. Major source of SPM (suspended particulate matter) are vehicles, power plants, construction activities, oil refinery, railway yard, market place, industries, etc.
Fly ash
Fly ash is ejected mostly by thermal power plants as by products of coal burning operations. Fly ash pollutes air and water and may cause heavy metal pollution in water bodies. Fly ash affects vegetation as a result of its direct deposition on leaf surfaces or indirectly through its deposition on soil. **Fly ash is now being used for making bricks and as a land fill material.**

Lead and other metals particles
**Tetraethyl lead (TEL) is used as an anti-knock agent in petrol for smooth and easy running of vehicles.** The lead particles coming out from the exhaust pipes of vehicles is mixed with air. If inhaled it produces injurious effects on kidney and liver and interferes with development of red blood cells. Lead mixed with water and food can create cumulative poisoning. It has long term effects on children as it lowers intelligence. Oxides of iron, aluminum, manganese, magnesium, zinc and other metals have adverse effect due to deposition of dust on plants during mining operations and metallurgical processes. They create physiological, biochemical and developmental disorders in plants and also contribute towards reproductive failure in plants.

Gaseous pollutants
Power plants, industries, different types of vehicles – both private and commercial use petrol, diesel as fuel and release **gaseous pollutants** such as carbon dioxide, oxides of nitrogen and sulphur dioxide along with particulate matter in the form of smoke. All of these have harmful effects on plants and humans.

**Table 10.3:** Gaseous air pollutants: their sources and effects

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Source</th>
<th>Harmful effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon compound (CO and CO₂)</td>
<td>Automobile exhaust burning of wood and coal</td>
<td>Respiratory problems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Green house effect</td>
</tr>
<tr>
<td>Sulphur compounds (SO₂ and H₂S)</td>
<td>Power plants and refineries, volcanic eruptions</td>
<td>Respiratory problems in humans</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Loss of chlorophyll in plants (chlorosis)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acid rain</td>
</tr>
<tr>
<td>Nitrogen Compound (NO and N₂O)</td>
<td>Motor vehicle exhaust, atmospheric reaction</td>
<td>Irritation in eyes and lungs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low productivity in plants</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acid rain damages material (metals and stone)</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>Automobiles and petroleum industries</td>
<td>Respiratory problem</td>
</tr>
<tr>
<td>(benzene, ethylene)</td>
<td></td>
<td>Cancer causing properties</td>
</tr>
<tr>
<td>SPM (Suspended Particulate Matter)</td>
<td>Thermal power plants, construction activities, metalurgical processes particles suspended in the air, (flush, dust, lead)</td>
<td>Poor visibility, breathing problems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lead interferes with the development of red blood diseases and cancer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Smoge (smoke &amp; fog) formation leads to poor visibility and aggravates asthma in patients</td>
</tr>
</tbody>
</table>
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Fibres (Cotton, wool) Textiles and carpet weaving industries • Lung disorder

Prevention and control of air pollution
Indoor air pollution
Poor ventilation due to faulty design of buildings leads to pollution of the confined space. Paints, carpets, furniture, etc. in rooms may give out volatile organic compounds (VOCs). Use of disinfectants, fumigants, etc. may release hazardous gases. In hospitals, pathogens present in waste remain in the air in the form of spores. This can result in hospital acquired infections and is an occupational health hazard. In congested areas, slums and rural areas burning of firewood and biomass results in lot of smoke. Children and ladies exposed to smoke may suffer from acute respiratory problems which include running nose, cough, sore throat, lung infection, asthma, difficulty in breathing, noisy respiration and wheezing.

Prevention and control of indoor air pollution

- **Use of biogas and CNG (Compressed Natural Gas) need to be encouraged.**
- **Those species of trees such as baval (Acacia nilotica) which are least smoky should be planted and used.**
- **Charcoal is a comparatively cleaner fuel.**

Prevention and control of industrial pollution

**Filters** – Filters remove particulate matter from the gas stream. The medium of a filter may be made of fibrous materials like cloth, granular material like sand, a rigid material like screen, or any mat like felt pad. **Baghouse filtration system is the most common one and is made of cotton or synthetic fibres (for low temperatures) or glass cloth fabrics (for higher temperature up to 290oC).**

**Electrostatic precipitators (ESP)** - The emanating dust is charged with ions and the ionized particulate matter is collected on an oppositely charged surface. The particles are removed from the collection surface by occasional shaking or by rapping the surface. **ESPs are used in boilers, furnaces, and many other units of thermal power plants, cement factories, steel plants, etc.**

**Inertial collectors** – It works on the principle that inertia of SPM in a gas is higher than its solvent and as inertia is a function of the mass of the particulate matter this device collects heavier particles more efficiently. ‘**Cyclone**’ is a common inertial collector used in gas cleaning plants.

**Scrubbers** – Scrubbers are wet collectors. They remove aerosols from a stream of gas either by collecting wet particles on a surface followed by their removal, or else the particles are wetted by a scrubbing liquid. The particles get trapped as they travel from supporting gaseous medium across the interface to the liquid scrubbing medium. Gaseous pollutants can be removed by absorption in a liquid using a wet scrubber and depends on the type of the gas to be removed e.g. for removal of sulphur dioxide alkaline solution is needed as it dissolves sulphur dioxide. Gaseous pollutants may be absorbed on an activated solid surface like silica gel, alumina, carbon, etc. Silica gel can
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remove water vapour. Condensation allows the recovery of many by products in coal and petroleum processing industries from their liquid effluents.

Control of vehicular pollution

- The emission standards for automobiles have been set which if followed will reduce the pollution. Standards have been set for the durability of catalytic converters which reduce vehicular emission.
- In cities like Delhi, motor vehicles need to obtain Pollution Under Control (PUC) certificate at regular intervals. This ensures that levels of pollutants emitted from vehicle exhaust are not beyond the prescribed legal limits.
- The price of diesel is much cheaper than petrol which promotes use of diesel. To reduce emission of sulphurdioxide, sulphur content in diesel has been reduced to 0.05%.
- Earlier lead in the form of tetraethyl lead was added in the petrol to raise octane level for smooth running of engines. Addition of lead in petrol has been banned to prevent emission of lead particles with the vehicular emission.

OZONE HOLE-CAUSES AND HARM DUE TO OZONE DEPLETION

The stratosphere has an ozone layer which protects the earth's surface from excessive ultraviolet (UV) radiation from the Sun. Chlorine from chemicals such as chlorofluorocarbons (CFCs) used for refrigeration, air conditioning, fire extinguishers, cleaning solvents, aerosols (spray cans of perfumes, medicine, insecticide) cause damage to ozone layer. Chlorine contained in the CFCs on reaching the ozone (O3) layer split the ozone molecules to form oxygen (O2). Amount of ozone, thus gets reduced and cannot prevent the entry of UV radiation. There has been a reduction of ozone umbrella or shield over the Arctic and Antarctic regions. This is known as ozone hole. This permits passage of UV radiation on earth's atmosphere which causes sunburn, cataract in eyes leading to blindness, skin cancer, reduced productivity of forests, etc. Under the “Montreal Protocol” amended in 1990 it was decided to completely phase out CFCs to prevent damage of ozone layer.

GLOBAL WARMING AND GREENHOUSE EFFECT

Atmospheric gases like carbondioxide, methane, nitrous oxide, water vapour, and chlorofluorocarbons are capable of trapping the out-going infrared radiation from the earth. Infra-red radiations trapped by the earth's surface cannot pass through these gases and to increase thermal energy or heat in the atmosphere. Thus, the temperature of the global atmosphere is increased. As this phenomenon of increase in temperature is observed in green houses, in the botanical gardens these gases are known as green house gases and the heating effect is known as green house effect. If greenhouse gases are not checked, by the turn of the century the temperature may rise by 50C. This will melt the polar ice caps and increase the sea level leading to coastal flooding, loss of coastal areas and ecosystems like swamps and marshes, etc.

NOISE POLLUTION

Noise by definition is "sound without value" or “any noise that is unwanted by the recipient”. Noise in industries such as stone cutting and crushing, steel forgings, loudspeakers, shouting by hawkers selling their wares, movement of heavy transport vehicles, railways and airports leads to irritation and an increased blood pressure, loss of temper, decrease in work efficiency, loss of hearing which may be first temporary but
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can become permanent as the noise stress continues. It is therefore of utmost importance that excessive noise is controlled. Noise level is measured in terms of decibels (dB). W.H.O. (World Health Organization) has prescribed optimum noise level as 45 dB by day and 35 dB by night. Anything above 80 dB is hazardous.

NOTE: A green belt of trees is an efficient noise absorber.

WATER POLLUTION
Sources of water pollution
Water pollution is the major source of water born diseases and other health problems. Sediments brought by runoff water from agricultural fields and discharge of untreated or partially treated sewage and industrial effluents, disposal of fly ash or solid waste into or close to a water body cause severe problems of water pollution. Increased turbidity of water because of sediments reduces penetration of light in water that reduces photosynthesis by aquatic plants.

Pollution due to pesticides and inorganic chemicals

- Pesticides like DDT and others used in agriculture may contaminate water bodies. Aquatic organisms take up pesticides from water get into the food chain (aquatic in this case) and move up the food chain. At higher trophic level they get concentrated and may reach the upper end of the food chain.
- Arsenic pollution of ground water has been reported from West Bengal, Orissa, Bihar, Western U.P. Consumption of such arsenic polluted water leads to accumulation of arsenic in the body parts like blood, nails and hairs causing skin lesions, rough skin, dry and thickening of skin and ultimately skin cancer.
- Pollution of water bodies by mercury causes Minamata disease in humans and dropsy in fishes. Lead causes displexia, cadmium poisoning causes Itai – Itai disease etc.

(ii) Thermal pollution
Power plants- thermal and nuclear, chemical and other industries use lot of water (about 30 % of all abstracted water) for cooling purposes and the used hot water is discharged into rivers, streams or oceans. The waste heat from the boilers and heating processes increases the temperature of the cooling water. Discharge of hot water may increase the temperature of the receiving water by 10 to 15 °C above the ambient water temperature. This is thermal pollution. Increase in water temperature decreases dissolved oxygen in water which adversely affects aquatic life. Unlike terrestrial ecosystems, the temperature of water bodies remains steady and does not change very much. Accordingly, aquatic organisms are adopted to a uniform steady temperature of environment and any fluctuation in water temperature severely affects aquatic plants and animals. Hence discharge of hot water from power plants adversely affects aquatic organisms. Aquatic plants and animals in the warm tropical water live dangerously close to their upper limit of temperature, particularly during the warm summer months. It requires only a slight deviation from this limit to cause a thermal stress to these organisms. Discharge of hot water in water body affects feeding in fishes, increases their metabolism and affects their growth. Their swimming efficiency declines. Running away from predators or chasing prey becomes difficult. Their resistance to diseases and parasites decreases.
Due to thermal pollution biological diversity is reduced. One of the best methods of reducing thermal pollution is to store the hot water in cooling ponds, allow the water to cool before releasing into any receiving water body.

**Ground water pollution**
Lot of people around the world depend on ground water for drinking, domestic, industrial and agricultural uses. Generally groundwater is a clean source of water. However, human activities such as improper sewage disposal, dumping of farm yard manures and agricultural chemicals, industrial effluents are causing pollution of ground water.

**Eutrophication**

‘Eu’ means well or healthy and ‘trophy’ means nutrition. The enrichment of water bodies with nutrients causes entrophication of the water body. Discharge of domestic waste, agricultural surface runoff, land drainage and industrial effluents in a water body leads to rapid nutrients enrichment in a water body. The excessive nutrient enrichment in a water body encourages the growth of algae duckweed, water hyacinth, phytoplankton and other aquatic plants. The biological demand for oxygen (BOD) increases with the increase in aquatic organisms. As more plants grow and die, the dead and decaying plants and organic matter acted upon by heterotrophic protozoans and bacteria, deplete the water of dissolved oxygen (DO). Decrease in DO result in sudden death of large population of fish and other aquatic organisms including plants, releasing offensive smell and make the water unfit for human use. The sudden and explosive growth of phytoplankton and algae impart green colour to the water is known as water bloom, or “algal blooms”. These phytoplankton release toxic substances in water that causes sudden death of large population of fishes. This phenomenon of nutrient enrichment of a water body is called Eutrophication. Human activities are mainly responsible for the Eutrophication of a growing number of lakes and water bodies in the country.

**Methods for control of water pollution and water recycling**

**Control water pollution**

Waste water from domestic or industrial sources or from garbage dumps is generally known as sewage. It may also contain rain water and surface runoff. The sewage water can be treated to make it safe for disposal into water bodies like rivers, lakes etc. The treatment involves three stages: primary, secondary and tertiary. This includes 1. Sedimentation, 2. Coagulation/Flocculation, 3. Filtration, 4. Disinfection, 5. Softening and 6. Aeration.

The first four steps are of primary treatment. The first three steps are involved in primary treatment remove suspended particulate matter. Secondary treatment removes organic solids, left out after primary treatment, through their microbial decomposition. Effluents after secondary treatment may be clean but contain large amounts of nitrogen, in form of ammonia, nitrates and phosphorous which can cause problem of Eutrophication upon their discharge into a receiving water body such as river, lake or pond. The tertiary treatment is meant to remove nutrients, disinfect for removing pathogenic bacteria, and aeration removes hydrogen.
sulphide and reduce the amount of carbon dioxide and make water healthy and fit for aquatic organisms. This treatment of waste water or sewage is carried out in effluent treatment plants especially built for this purpose. The residue obtained from primary treatment one known as sludge.

Water recycling
With increasing population the requirement for water is increasing rapidly. However, the availability of water is limited but an ever increasing water withdrawal from different sources such as rivers, lakes and ground water is depleting these sources and deteriorating their water quality. Therefore, it is essential to utilize the available water with maximum economy. This involves recycling of waste water for certain uses with or without treatment. Recycling refers to the use of waste-water by the original user prior to the discharge either to a treatment system or to a receiving water body. Thus the waste water is recovered and repetitively recycled with or without treatment by the same user.

Control of water pollution
The following measures can be adopted to control water pollution:

- The water requirement should be minimized by altering the techniques involved.
- Water should be reused with or without treatment.
- Recycling of water after treatment should be practiced to the maximum extent possible.
- The quantity of waste water discharge should be minimized.

SOIL POLLUTION
Addition of substances which adversely affect the quality of soil or its fertility is known as soil pollution.

Sources of soil pollution

**Plastic bags** – Plastic bags made from low density polyethylene (LDPE), is virtually indestructible, create colossal environmental hazard. The discarded bags block drains and sewage systems. Leftover food, vegetable waste etc. on which cows and dogs feed may die due to the choking by plastic bags. Plastic is non biodegradable and burning of plastic in garbage dumps release highly toxic and poisonous gases like carbon monoxide, carbon dioxide, phosgene, dioxine and other poisonous chlorinated compounds.

**Industrial sources** – It includes fly ash, chemical residues, metallic and nuclear wastes. Large number of industrial chemicals, dyes, acids, etc. find their way into the soil and are known to create many health hazards including cancer.

**Agricultural sources** – Agricultural chemicals especially fertilizers and pesticides pollute the soil. Fertilizers in the runoff water from these fields can cause Eutrophication in water bodies. Pesticides are highly toxic chemicals which affect humans and other animals adversely causing respiratory problems, cancer and death.
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Control of soil pollution
Indiscriminate disposal of solid waste should be avoided. To control soil pollution, it is essential to stop the use of plastic bags and instead use bags of degradable materials like paper and cloth. Sewage should be treated properly before using as fertilizer and as landfills. The organic matter from domestic, agricultural and other waste should be segregated and subjected to **vermicomposting** which generates useful manure as a byproduct. The industrial wastes prior to disposal should be properly treated for removing hazardous materials. Biomedical waste should be separately collected and incinerated in proper incinerators.

RADIATION POLLUTION: SOURCES AND HAZARDS

Radiation pollution is the increase in over the natural background radiation. There are many sources of radiation pollution such as nuclear wastes from nuclear power plants, mining and processing of nuclear material etc. The worse case of nuclear pollution was the cherndoyl disaster in Russia occured in 1986 but the effects still longer today.

**Radiation**
Radiation is a form of energy travelling through space. The radiations emanating from the decay of radioactive nuclides are major sources of radiation pollution. Radiations can be categorized into two groups namely the non-ionizing radiations and the ionizing radiations.

**Non-ionizing radiations** are constituted by the electromagnetic waves at the longer wavelength of the spectrum ranging from near infra-red rays to radio waves. These waves have energies enough to excite the atoms and molecules of the medium through which they pass, causing them to vibrate faster but not strong enough to ionize them. In a microwave oven the radiation causes water molecules in the cooking medium to vibrate faster and thus raising its temperature.

**Ionizing radiations** cause ionization of atoms and molecules of the medium through which they pass. Electromagnetic radiations such as short wavelength ultra violet radiations (UV), X-rays and gamma rays and energetic particles produced in nuclear processes, electrically charged particles like alpha and beta particles produced in radioactive decay and neutrons produced in nuclear fission, are highly damaging to living organisms. Electrically charged particles produced in the nuclear processes can have sufficient energy to knock electrons out of the atoms or molecules of the medium, thereby producing ions. The ions produced in water molecules, for example, can induce reactions that can break bonds in proteins and other important molecules. An example of this would be when a gamma ray passes through a cell, the water molecules near the DNA might be ionized and the ions might react with the DNA causing it to break. They can also cause chemical changes by breaking the chemical bonds, which can damage living tissues. The ionizing radiations cause damage to biological systems and are, therefore, pollutants.
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Radiation damage
The biological damage resulting from ionizing radiations is generally termed as **radiation damage**. Large amounts of radiation can kill cells that can dramatically affect the exposed organism as well as possibly its offspring. Affected cells can mutate and result in cancer. A large enough dose of radiation can kill the organism. Radiation damage can be divided into two types: (a) **somatic damage** (also called radiation sickness) and (b) **genetic damage**. Somatic damage refers to damage to cells that are not associated with reproduction. Effects of somatic radiation damage include reddening of the skin, loss of hair, ulceration, fibrosis of the lungs, the formation of holes in tissue, a reduction of white blood cells, and the induction of cataract in the eyes. This damage can also result in cancer and death. Genetic damage refers to damage to cells associated with reproduction. This damage can subsequently cause genetic damage from gene mutation resulting in abnormalities. Genetic damages are passed on to next generation.

Radiation dose
The biological damage caused by the radiation is determined by the intensity of radiation and duration of the exposure. It depends on the amount of energy deposited by the radiation in the biological system. In studying the effects of radiation exposure in humans, it is important to realize that the biological damage caused by a particle depends not only on the total energy deposited but also on the rate of energy loss per unit distance traversed by the particle (or "linear energy transfer"). For example, alpha particles do much more damage per unit energy deposited than do electrons.

Radiation effects and radiation doses
A traditional unit of human-equivalent dose is the **rem**, which stands for radiation equivalent in man. At low doses, such as what we receive every day from background radiation (< 1 m rem), the cells repair the damage rapidly. **At higher doses (up to 100 rem), the cells might not be able to repair the damage, and the cells may either be changed permanently or die**. Cells changed permanently may go on to produce abnormal cells when they divide and may become cancerous. At even higher doses, the cells cannot be replaced fast enough and tissues fail to function. An example of this would be "radiation sickness." This is a condition that results after high doses is given to the whole body (>100 rem).

Nuclear explosions and accidents in nuclear reactors are a serious source of radiation hazard. The effects of atomic explosions in Nagasaki and Hiroshima are still not forgotten. The nuclear reactor accident at Chernobyl in 1986 led to deaths of many reactor personnel and a very large release of radionuclide to the environment causing a long term radiation damage to the people living in the neighboring regions.

Accidents at nuclear power plants
Nuclear fission in the reactor core produces lot of heat which if not controlled can lead to a meltdown of fuel rods in the reactor core. If a meltdown happens by accident, it will release large quantities of highly dangerous radioactive materials in the environment with disastrous consequences to the humans, animals and plants. To prevent this type of accidents and reactor blow up, the reactors are designed to have a number of safety features. Inspite of these safety measures two disasters in the nuclear power plants are noteworthy- namely **at 'Three Mile Island' in Middletown (U.S.A.) in 1979**, at
ENVIRONMENTAL POLLUTION

Chernobyl (U.S.S.R.) in 1986. In both these cases a series of mishaps and errors resulted in over heating of the reactor core and lot of radiation was released into the environment. The leakage from Three Mile Island reactor was apparently low and no one was injured immediately. However, in case of Chernobyl the leakage was very heavy causing death of some workers and radiation spread over large areas scattered all over Europe. People of the city had to be evacuated to safer places and the plant had to be closed down. These two disasters are a reminder that nuclear power reactors require a constant up gradation of safety measures. Accidents with nuclear submarines also points to the same.

ENVIRONMENT AND HEALTH

<table>
<thead>
<tr>
<th>Disease</th>
<th>Causative organism</th>
<th>Mode of spread</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacterial diseases:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typhoid</td>
<td>Salmonella typhi</td>
<td>Contaminated food, water, milk, unwashed raw vegetables and flies</td>
<td>Continuous fever which increases day by day Temperature higher in evening than morning, body ache, headache and constipation. Haemorrhage from an ulceration in small intestine</td>
</tr>
<tr>
<td>Cholera 30-40</td>
<td>Vibrio cholerae</td>
<td>Water or food contaminated by bacteria from stools of cholera patient</td>
<td>Painless diarrhoea, vomiting, stools per day which soon becomes typically watery and colourless with flakes of mucous floating in them</td>
</tr>
<tr>
<td>Bacterial Diaorhoea</td>
<td>Shigella spp.</td>
<td>Contaminated food, water and by direct personal contact</td>
<td>Diarrhoea, with blood and dysentry mucous in the stools along with severe gripping pain in the abdomen. Stools not too frequent (4-10 per day), faecal matter scanty. Patient looks ill</td>
</tr>
<tr>
<td>Leptospirosis</td>
<td>Leptospira</td>
<td>Rodents primary hosts-carry organisms in kidneys. Infection by wading or swimming in water contaminated with rodent urine</td>
<td>Fever, pain in legs, nausea, vomiting are common, congestion of the conjunctival blood vessels around corneas of the eyes</td>
</tr>
</tbody>
</table>

**B. Viral diseases:**

| Infective Hepatitis | Hepatitis virus | Food and water contaminated with virus in stools | Loss of appetite, nausea, vomiting and diarrhoea, accompanied with fever. Urine dark coloured. Eye and skin appear yellow |
ENVIRONMENTAL POLLUTION

C. Protozoan diseases:

<table>
<thead>
<tr>
<th>Disease</th>
<th>Causative Organisms</th>
<th>Vector</th>
<th>Hosts</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amoebic dysentery</td>
<td>Entamoeba histolytica</td>
<td>Ingestion of cysts in food and water</td>
<td>Abdominal discomfort and diarrhoea, with or without blood or mucous in stools, fever, chills and gripping pain in abdomen</td>
<td></td>
</tr>
<tr>
<td>Diarrhoea</td>
<td>Giardia (=Lamblia) intestinalis</td>
<td>Food or water contaminated with faeces having cysts</td>
<td>Intestinal disorders leading to epigastric pain, abdominal discomfort, loss of appetite, headache and loose bowels</td>
<td></td>
</tr>
</tbody>
</table>

D. Helminth diseases:

<table>
<thead>
<tr>
<th>Disease</th>
<th>Causative Organisms</th>
<th>Vector</th>
<th>Hosts</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilharzia</td>
<td>Schistosoma spp</td>
<td>Cercaria larvae of flukes in water penetrate skin of persons wading in water</td>
<td>Allergy-like itch, rash, aches, fever, eosinophilia etc. When infection heavy, eggs may block arterioles of lungs cardio-pulmonary water causing schistosomiasis and may lead to congestive heart failure</td>
<td></td>
</tr>
<tr>
<td>Guinea worm</td>
<td>Dracunculus</td>
<td>Unfiltered water</td>
<td>Blister near the ankle, causing medinensis allergy and aches</td>
<td></td>
</tr>
</tbody>
</table>

E. Vector borne diseases related with water:

Diseases transmitted by mosquitoes-

<table>
<thead>
<tr>
<th>Disease</th>
<th>Causative Organisms</th>
<th>Vector</th>
<th>Hosts</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria</td>
<td>Plasmodium sp</td>
<td>Female Anopheles (primary or final hosts)</td>
<td>Man (intermediate hosts)</td>
<td>Shivering, chills and sweating. As chills subside body temperature rises as high as 106º F. When temperature comes down patient sweats profusely and becomes comfortable until next attack which takes place at regular intervals</td>
</tr>
<tr>
<td>Filaria (Elephantiasis)</td>
<td>Wuchereria (=filaria)</td>
<td>Culex fatigans (reservoir)</td>
<td>Man (final hosts)</td>
<td>Enlargement of limbs and scrotum</td>
</tr>
<tr>
<td>Dengue</td>
<td>Barbo - virus</td>
<td>Aedes aegypti (reservoir)</td>
<td>Sudden onset of moderately high fever, excruciating joint pain, intense pain behind eyes, a second rise in temp following brief remission, reduction in neutrophilic white blood cells</td>
<td></td>
</tr>
</tbody>
</table>

- Sulphur dioxide is a major pollutant released from oil refineries, etc.

11.5 ENVIRONMENTAL CARCINOGENS AND METHODS OF THEIR CONTROL

Cancer is a group of related diseases that begin in cells of the body. Normally cells divide to produce more cells when body needs them for development, growth and repair of cell damage. Process of continuous division and growth of cells keeps the body healthy and normal. However, at times cells keep on dividing even when new cells are not required.

By ARUN SHARMA
These cells form a mass of tissue known as a tumor. The tumors can be either benign or malignant. The benign tumors are not harmful. Generally they can be removed surgically and do not reappear. Further, cells from these tumors do not move to other parts of the body and rarely endanger life. On the other hand, malignant tumors are cancerous. Cells of these tumors are abnormal and they divide and re-divide without any control. They can invade and damage nearby tissues and organs. Cells from these tumors can break away and enter the blood stream or lymphatic system and spread from the original site to form new tumors in other organs.

Leukemia and lymphoma are cancers which are initiated in blood-forming cells. Most cancers are named after the organ concerned e.g. Cancer that begins in lungs is lung cancer and the one in skin is known as melanoma. The cancer-causing agents are known as carcinogens. Agents present in the environment are the environmental carcinogens.

**Tobacco**

Smoking tobacco or being regularly exposed to tobacco smoke are responsible for about 85% of all cancer deaths. Smoking may increase the chances of getting cancers of stomach, liver, prostate, colon and rectum. Use of smokeless tobacco, chewing tobacco and snuff cause cancer of mouth and throat. Exposure to environmental tobacco smoke, termed passive smoking also increases the risk of lung cancer for non-smokers. The risk of cancer begins to decrease soon after quitting smoking and chewing tobacco. This risk continues to decline gradually after quitting.

**Ultraviolet (UV) radiation**

UV radiation coming from sun can cause premature aging of and skin damage. Prolonged exposure to UV radiation may lead to skin cancer. The formation of ozone hole by compounds like chlorofluorocarbons and others, increase the incidence of UV radiation reaching the earth. This is because ozone layer acts as a shield to prevent passage of UV radiations preventing melanoma. Avoiding exposure to direct midday sun light (from 10 a.m. to 3 p.m.) is perhaps the best way of reducing the risk of skin cancer. Wearing of a broad-brimmed hat, use of UV absorbing sunglasses and clothing to cover the body adequately also offers protection against UV.

**Ionizing radiation**

High levels of radiation like those from radiation therapies and X-rays, and from radioactive substances can damage normal (somatic) cells and increase the risk of developing leukemia and cancers of the breast, thyroid, lung, stomach and other organs. Studies with survivors of the atomic bomb in Japan showed that ionizing radiation increases the risk of leukemia and other cancers. It is always desirable to minimize diagnostic and therapeutic exposure to ionizing radiation and protect other parts of the body during such procedures.

**Chemicals and other substances**

**Pesticides:** Excessive use of pesticides particularly herbicides like 2,4 dichlorophenoxyacetic acid (2,4-D) has been associated with a 200-800% increase of NHL (Non-Hodgkin's Lymphoma) – one type of cancer in Sweden. Pesticides such
as toxaphene, hexachlorocyclohexane (BHC), trichlorophenol, dieldrin, DDT are known to cause lymphatic cancer in rats and mice. The danger is increased due to the persistent nature of the residues of these pesticides in the environment resulting in chronic exposure to low levels of pesticides. The use of all these pesticides has now either been banned or restricted. Organic farming and emphasis on Integrated Pest Management (IPM) as an alternate and environment friendly method of pest control. Asbestos, nickel, cadmium, radon, vinyl chloride, benzidine and benzene are well known carcinogens. Reduction in exposure to these will reduce the incidence of various types of cancer.

**Allergens and allergy**

Substances in the environment that cause allergic reactions, are known as allergens. Allergens stimulate within the body an immune response which may be in the form of a reaction. An allergic person’s immune system believes allergens to be damaging and so produces a special type of antibody immunoglobulin E (IgE) to attack the invading material. This leads other blood cells to release further chemicals (including histamine) which together cause the symptoms of an allergic reaction. 

The most common symptoms are sneezing, runny nose, itchy eyes and ears, severe wheezing, coughing, breathlessness, sinus problems, a sore palate and nettle- like rash. Other commonly known problems could include asthma, eczema and headaches.

The most common allergens are pollen from specific trees and grasses, house dust mites, moulds, cats, dogs, insects like wasps and bees, industrial and household chemicals, medicines and foods such as milk and eggs. Allergens contain protein which is often regarded as a constituent of the food we eat. There are some non-protein allergens including drugs like penicillin- but they need to be bound to a protein once they are in the body. The best method to combat allergy is to identify the allergen (often difficult) and avoid coming into contact with it.

**Blue Baby disease**

Modern agriculture uses a lot of nitrogenous fertilizers and manures. This leads to increased levels of nitrates in the ground water as nitrates being soluble in water easily leach into the soil. Once the level exceeds 10 ppm it may become harmful. In areas where ground water is the only source of drinking water, this causes methaemoglobinemia particularly in bottle fed infants who are very sensitive to this pollutant. Babies drink large quantities of water; water is used to mix powdered or concentrated recipes or juices. When water containing nitrates is consumed and it reaches intestines, the intestinal bacteria convert nitrates into nitrites. The nitrite ions combine with haemoglobin to form methaemoglobin which inhibits the oxygen carrying capacity of the blood causing a kind of anaemia known as methaemoglobinaemia. Methaemoglobin is formed when iron in the haemoglobin molecule is oxidized from Fe2+ (ferrous) to Fe 3+ (ferric) form. Due to reduced carrying capacity for oxygen the babies gradually acquire a blue tinge and hence the name – “Blue Baby disease”. Symptoms are sleeping, poor feeding, decreased energy, etc. Nitrates can be removed from the water by processes like electrodialysis and reverse osmosis. Nitrites in the water can be oxidized to nitrates by introducing a strong oxidant like ozone in the water.
ENVIRONMENTAL POLLUTION

Asthma
It is a chronic (long term) disease of the respiratory passages. It is characterized by reversible airflow obstruction (tightening of the smooth muscles around airways), inflammation (swelling) and mucous production when airways are exposed to various stimuli (triggers). Asthma has no cure but there are effective medications to control the symptoms and prevent asthma attacks. Asthma can be life threatening, requiring emergency room care or hospital admission. Asthma can develop at any age. What exactly causes bronchial tubes to become swollen is still not known. However, possible risk factors for developing asthma in childhood includes-

- family history of allergy and allergic disorders.
- high exposure of airborne allergy causing substances (pet dander, house dust mites, cockroaches, moulds, etc) among susceptible children in the first year of life.
- exposure to tobacco smoke.
- frequent respiratory infections early in life.

Symptoms of asthma are breathelessness, wheezing, chest tightness or pain around the chest, persistent cough that can last several weeks.

HEAVY METAL TOXICITY AND METHODS OF THEIR PREVENTION

Lead
Lead enters the atmosphere from automobile exhaust. Tetraethyl lead (TEL) was added to petrol as an anti-knock agent for smooth running of automobile engines. TEL has now been replaced by other anti-knock compounds to prevent emission of lead by automobiles. Lead in petrol is being phased out by introduction of lead free petrol. Many industrial processes use lead and it is often released as a pollutant. Battery scrap also contain lead. It can get mixed up with water and food and create cumulative poisoning. It can cause irreversible behavioural disturbances, neurological damage and other developmental problems in young children and babies. It is a carcinogen of the lungs and kidneys.

Mercury
In Japan, mass mercury poisoning (Minamata disease) was observed in 1960s, caused by eating fish from Minamata Bay which were contaminated with methyl mercury. Largest source of mercury pollution is through aquatic animals such as fish which accumulate mercury as methyl mercury. Mercury kills cells in the body and damages organs which come in contact with mercury and thus impairs their functioning. Inhalation of mercury vapours is more dangerous than its ingestion. Chronic exposure causes lesions in the mouth and skin and neurological problems. Typical symptoms of mercury poisoning are irritability, excitability, loss of memory, insomnia, tremor and gingivitis. Exposure to mercury can be prevented by taking care that mercury is not released in the environment as well as by replacing mercury by other materials. Mercury thermometers used earlier are getting replaced by mercury free thermometer.
Arsenic

Arsenic is associated with copper, iron and silver ores. Arsenic is emitted from fossil fuel burning. Liquid effluents from fertilizer plants also contain arsenic. Ground water contamination with arsenic is very common in areas where it is present. People depending on ground water containing arsenic get exposed to this pollutant. Chronic arsenic poisoning leads to loss of appetite, weight, diarrhoea, gastrointestinal disturbances and skin cancer. The water from underground sources contaminated with arsenic should not be used for drinking and cooking purposes. Surface waters are generally free from arsenic pollution and should be preferred for drinking and cooking. Alternatively the tube well/ hand pump water should be purified to remove arsenic before consumption. Techniques for removing arsenic from water are available.

Arsenic Pollution—A Case Study

A patient from Balia, Utter Pradesh came to All India Institute of Medical Sciences (AIIMS), New Delhi for consultation in summer, 2004. An injury in his leg in 1996 did not heal. His two fingers got ulcers which could not be treated and had to be ultimately amputated. Subsequently he was diagnosed to be suffering from skin cancer. His blood had 34.40 ppb (ppb = arsenic which is many times higher than normal).

Out of a population of 1800 about 100 persons who were examined (age more than 35 years) were suffering from melanosis. Many of them were suffering from keratosis and some had breathing problems. Arsenic levels in hairs of two persons were 4790 and 6310 ppb (normal 80 to 250 ppb), nails 2480 ppb (normal 430-1080 ppb). Large number of people had died due to cancer. Examination of water from hand pumps, which was the main source of drinking water, showed that more than half had arsenic higher than 10 ppb in their blood ( permissible limit). In 8 % cases arsenic was higher than 500 ppb.

If a person drinks water contaminated with arsenic for about 10 years, dark spot develop on the upper chest, back and arms known as melanosis. The next stage is keratosis in which palms become hard and patient may suffer from diarrhoea, stomach pain, breathing problems, etc. Later along with dark spots, develop white spots, legs become swollen and walking become difficult and painful, some wounds start bleeding, the liver and kidney suffer damage.

Cadmium

Mining especially of zinc and metallurgical operations, electroplating industries, etc. release cadmium in the environment. It may enter the human body by inhalation or from aquatic sources including fish, etc. It may cause hypertension, liver cirrhosis, brittle bones, kidney damage and lung cancer. Itai-itai disease first reported from Japan in 1965 was attributed to cadmium contamination in water and rice caused by discharge of effluents from a zinc smelter into a river.

Other Heavy Metals

Metals such as zinc, chromium, antimony and tin enter food from cheap cooking utensils. Preserved foods stored in tin cans also cause contamination by tin. Zinc is a skin irritant and affects pulmonary system.
OCCUPATIONAL HEALTH HAZARDS

Black lung disease
In coal mining areas coal dust is the main air pollutant to which miners are exposed everyday. The deposits of coal dust makes miners lungs look black instead of a healthy pink and hence the name black lung disease. Black lung disease is the common name for pneumoconiosis (CWP) or anthracosis, a lung disease of older workers in the coal industry, caused by inhalation over many years, of small amounts of coal dust. Although people who live in cities often have some black deposits in their lungs from polluted air, coal miners have much more extensive deposits. The particles of fine coal dust accumulate in lungs as they cannot be destroyed within the lungs or removed from them. Eventually this build-up causes thickening and scarring making the lungs less efficient in supplying oxygen to the blood.

The primary symptom of the disease is shortness of breathe which gradually gets worse as the disease progresses. In severe cases it may eventually cause heart failure. In some cases a progressive massive fibrosis develops, in which damage continues in the upper parts of the lungs even after exposure to dust has ended.

Often some patients develop emphysema (Shortness of breathe), as a complication of black lung disease. X-rays can detect black lung disease before it causes any symptoms. Patients who develop this disease at an early age, or who have progressive massive fibrosis, have a higher risk of premature death.

Prevention- The only way to prevent black lung disease is to avoid long-term exposure to coal dust. Coal mines may help prevent this condition by lowering coal dust level and providing protective clothes to coal miners.

Noise
Sound levels higher than 80 to 90 dB (dBdecibles- unit of sound) for more than eight hours are harmful to human ear

Chemicals and Biological Agents
Occupational asthma is caused due to exposure to organic dusts, microorganisms, bacteria, fungi and moulds and several chemicals. Silicosis first reported from Kolar gold mines in 1947 is a common disease among miners, pottery and ceramic industry workers. Pneumoconiosis and byssinosis are common among mica and textile industry workers respectively.
GLOBAL ENVIRONMENTAL ISSUES

GREEN HOUSE EFFECT AND GLOBAL WARMING

What is the green house effect?
The temperature surrounding the earth has been rising during the recent past. This is
due to the ‘green house effect’. A green house is a glass chamber in which plants are
grown to provide them warmth by trapping sun light. Sunlight (a form of energy) passes
through the glass and it gets absorbed inside releasing heat radiations unlike sunlight,
heat radiation can not escape through glass the heat generated there from, cannot
escape out of the glass chamber. Thus, even on a cold winter day, the inside of a green
house can become quite warm to support plant growth. The phenomenon of heat build
up inside a glass chamber from the absorption of solar radiation is called green house
effect.

Global warming and green-house effect

The green-house effect is a natural phenomenon and has been occurring for millions of
years on the earth. Life on the earth has been possible because of this natural green
house effect which is due to water vapour and small particles of water present in the
atmosphere. Together, these produce more than 95 percent of total green-house
warming. Average global temperatures is maintained at about 150°C due to natural
green house effect. Without this phenomenon, average global temperatures might have
been around –170°C and at such low temperature life would not be able to exist.

Solar radiations strike the earth. Some of these radiations are reflected
back by the atmosphere into the space, but some pass through the atmosphere
towards earth. About half of these are absorbed by the atmosphere and heat the
air. The rest reaches the earth’s surface. The earth’s surface now heats up and
gives off longer wavelength, lower energy (infra red or heat) radiations. These
infra-red radiations pass back up into the atmosphere. Instead of being radiated
100 percent back into the space, much of it is absorbed by the atmosphere and
are reradiated back to the earth’s surface. The temperature near the earth’s
surface as well as that of the atmosphere then rises.

Before industrialization, simple human activity did not cause any significant increase in
the atmospheric temperature. What is particularly worrisome is the increase in the
emission of green house gases due to urbanization and industrialization. These green
house gases have increased significantly in the atmosphere in recent years

<table>
<thead>
<tr>
<th>Gas</th>
<th>Sources and Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide (CO2)</td>
<td>Burning of fossil fuels, deforestation</td>
</tr>
<tr>
<td>Chlorofluorocarbons(CFCs)</td>
<td>Refrigeration, solvents, insulation foams, aero propellants, industrial and commercial uses</td>
</tr>
<tr>
<td>Methane (CH4)</td>
<td>Growing paddy, excreta of cattle and other livestock, termites, burning of fossil fuel, wood, land fills</td>
</tr>
</tbody>
</table>
ENVIRONMENTAL POLLUTION

Nitrogen oxides (N\textsubscript{2}O)  Burning of fossil fuels, fertilizers; burning of wood and crop residue.

Global warming affects both living and non-living components of our planet.

**Effect on climate**
**Effect on living beings**

Increased CO\textsubscript{2} concentration in the atmosphere may increase photosynthetic productivity of plants. This in turn produces more organic matter. It may seem a positive effect. But,

- Weeds may proliferate rapidly, and that too at the expense of useful plants.
- Insects and other pests that feed on plants may also increase in number.
- Survival of other organisms gets affected.

**Strategies to cope with greenhouse effect**

- Increased fuel efficiency of power plants and vehicles;
- Development/implementation of solar energy/non-fossil fuel alternatives;
- Halting deforestation;
- Supporting and undertaking tree-planting (afforestation);
- Reduce air-pollution

BIODIVERSITY

Plants and animals of a region constitute biodiversity. Biodiversity is a natural wealth essential for human survival.

**Classification**

Biodiversity could be classified as -

- **Species biodiversity:** It includes total number of different taxonomical or biological species. There are more than 200000 species in India of which several are confined to India (endemic).

- **Genetic biodiversity:** It includes land traces; horticultural varieties; cultivars, ecotypes (related types differing due to difference in the ecological condition); all within a biological species.

- **Ecosystem biodiversity:** It includes various biological zones, like lake, desert, coast, estuaries, wetlands, mangroves, coral reefs etc. Both flora and fauna, all over the world are under an assault from a variety of indiscriminate human activities. These activities are often related to rapid growth of human population, deforestation, urbanization and industrialization.

**Reasons for biodiversity loss**

Rapid decline of biodiversity is a result of various causes.

1. **Loss of habitat:** Due to the growing human population, wetlands are being made dry through landfills, as the demand for land increases. Natural forests are cleared for industry, agriculture, dams, habitation, recreational sports, etc. As a consequence every plant and animal species occupying that ecosystem is temporarily or permanently affected. So are the migrating birds or other animals visiting that habitat. Thus, the population of different species occupying that habitat become unsettled. An altered ecosystem causes changes in the neighbouring ecosystems.
ENVIRONMENTAL POLLUTION

(2) **Pollution**: Pollution also alters the habitat to such an extent that it becomes critical for survival of some of the species. For example, pollution that leads to green house effect results in global warming. All those species that are slow to adjust to the changed environment are eventually lost.

(3) **Overuse**: Whales for oil, fish for food, trees for wood, plants for medicines etc. are being removed by humans at higher rates than they can be replaced. Excessive cutting of trees, overgrazing, collection of fire-wood, hunting of wild animals for skin (for example tigers from reserve forests of India), ivory etc. all result in gradual loss of species.

(4) **Introduction of foreign species**: With growing volume of international travel accidental introduction of species into a new or foreign area has become easier. There are many species which have invaded new areas to which they were introduced unintentionally. Many of the new species introduced into new regions thrive at the expense of native species. For example: Parthenium, Argemone and Lantana are the common weeds of foreign origin in our country.

(5) **Environmental degradation**: A vast array of factors causing environmental degradation may result in the loss of biodiversity. Some of these factors are: global warming, increased CO2 concentration in atmosphere, nuclear radiation; UV-exposure; oil spills, etc.

DESERTIFICATION

Desertification is diminution or destruction of the biological potential of the land which ultimately leads to the formation of desert. The land that has lost its productivity (ability to grow plants) is called a desert. A desert landscape supports a very limited growth of sparse vegetation and stunted growth of plants. Substantial part of earth’s 132.4 million sq km of terrestrial area is facing desertification due to overexploitation and mismanage of land resources for human activities.

Some of the principal causes, which promote desertification, are:
- over cultivation,
- overgrazing,
- deforestation, and
- salt accumulation due to irrigation.

(a) **Over Cultivation**

Every cycle of cultivation is preceded by ploughing to remove weeds. The ploughed land turns soil upside down thus exposing rich sub-soil to wind and water erosion. Such land may remain barren for most part of the year and in turn lose more soil due to erosion. Such erosion is most pronounced on slopes. Moreover, in regions where rainfall is low, the soil is often dry and is more susceptible to erosion. Ploughed soil loses more water by evaporation.

(b) **Overgrazing**

Deserts receive less rainfall. Deserts have sparse vegetation mostly consisting of grasses and herbs less and best used for grazing. Overgrazing by goats, domestic cattle remove the protective vegetation and expose the soil. Further the movement of grazing animals loosen the soil surface by their hoofs. Unprotected loose soil becomes highly susceptible
Fig 14.4: Factors causing desertification

(d) Salting due to Irrigation

With demand for more land for agriculture, crops are grown in areas that have little access to natural water bodies. The water is supplied to these growing areas by artificial means and improved irrigation methods. Such water brings salts dissolved in it. Even the best
to erosion by wind and water.

(c) **Deforestation**
Forests and vegetation prevent soil erosion and to hold water in soil. Plant roots absorb and recycle nutrients released from the decaying organic matter. Forests are often cleared to agriculture, timber, construction wood, firewood, raw material for paper etc. All this leads to barrenness of the land leading to desertification.

(d) **Salting due to Irrigation**
With demand for more land for agriculture, crops are grown in areas that have little access to natural water bodies. The water is supplied to these growing areas by artificial means and improved irrigation methods. Such water brings salts dissolved in it. Even the best quality of irrigation water contain 200-500 ppm of salts. Water used for irrigation is lost from agriculture field through evaporation and transpiration by crop plant. The water gets evaporated but the dissolved salt keeps on accumulating which makes the soils more salty. Saline accumulation of excessive soils prevents plant growth. Land devoid of plant cover easily becomes desertified. Accumulation of excessive salt in soil or salinization makes the soil unfit for agriculture.

**OZONE LAYER DEPLETION**

**Formation of ozone layer**
Ozone (O3) is a highly reactive molecule containing three oxygen atoms. The upper part of the earth’s atmosphere, between 10 and 50 km above the earth surface called stratosphere contains a thin layer of ozone. This ozone layer serves as a natural filter for blocking deadly incoming uv radiation from the sun.

**Ultra violet (UV) radiation, with wavelengths shorter than visible spectrum has high energy. UV radiations can be divided into three forms:** UV-A (wavelength between 320-400nm), UV-B (wave length lesser than 280 nm), and UV-C (wavelength lesser than 280 nm). UV-C is most damaging to biological systems.

Since, the early 1970's levels of the stratospheric ozone have thined markedly over certain regions of the earth, particularly over the Antarctic region. The Antarctic region contains one of the worlds’ most productive marine ecosystems. The thinning of stratospheric ozone layer is termed “ozone hole”.

**Causes of ozone layer depletion**
Ozone (O3) layer can be destroyed both by natural and man-made causes-

(i) **Natural causes**: A number of naturally occurring substances destroy stratospheric ozone. Most important of these compounds are: Hydrogen oxide (HOx), Methane (CH4), Hydrogen gas (H2), Nitrogen oxides (NOx). Chlorine monoxide (ClO); during volcanic eruptions, significant amount of chlorine may be released in the stratosphere. Tiny particulate matter in the stratosphere, known as stratospheric aerosols, may also lead to ozone destruction.

(ii) **Human activity related causes**: Any event, which release chlorine atoms into the atmospheric, can cause severe ozone destruction, because chlorine atoms in the
stratosphere can destroy ozone very efficiently. Most damaging among such agents are human made chlorofluorocarbons (CFCs), which is widely used as refrigerants and to pressurize sprays cans. In stratosphere, chlorine atoms from CFCs react with ozone to form chlorine monoxide and oxygen molecule.

\[
\text{Cl + O}_3 \rightarrow \text{ClO} + \text{O}_2
\]

Chlorine monoxide, may then react with oxygen atoms to release more chlorine atoms:

\[
2\text{ClO} + \text{O}_2 \rightarrow 2\text{Cl} + 2\text{O}_2
\]

One chlorine atom can break down 1,00,000 ozone molecules.

**IMPORTANT OZONE DEPLETING CHEMICALS AND THEIR USES.**

<table>
<thead>
<tr>
<th>Name of the compound</th>
<th>Used in</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFCs</td>
<td>Refrigeration, aerosol, foam, food freezing, warming devices, cosmetics, heat detectors solvents, cosmetics, refrigerants, firefighting</td>
</tr>
<tr>
<td>Halon</td>
<td>Fire fighting</td>
</tr>
<tr>
<td>HCFC-22</td>
<td>Refrigeration, aerosol, foam, fire fighting</td>
</tr>
<tr>
<td>Methyl chloroform</td>
<td>Solvent</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>Solvent</td>
</tr>
</tbody>
</table>

**Effect of O₃-layer depletion**

Why are we so concerned about ozone hole? It is because without the ozone-shield the deadly uv radiation shall pass through the atmosphere and reach the earth surface. A small amount of uv-radiation is necessary for well-being of human beings and other organisms, such as uv-B promote synthesis of vitamin-D. UV-radiation also act as a germicide to control microorganisms. However, increased uv dose is highly dangerous to living organisms.

**Measures to prevent ozone (O₃) layer depletion**

Global awareness and action on the part of world community in the form of Helsinki (1989), Montreal (1990’s) conventions and protocol have had some important success on this front. A complete ban on the use of CFCs and other ozone destroying chemicals is recommended. Further, use of HCFCs (Hydrochloric fluorocarbons) as a substitute for CFCs is being recommended on temporary basis because HCFCs are relatively less damaging to ozone layer as compared to CFCs, but they are not completely ozone safe.

**Harmful effects on human beings**

- Increase susceptibility of skin-cancer
- Increase cataract
- Damage DNA
- Damage cornea
- Cause retinal diseases
- Suppers human immune systems
ENIRONMENTAL POLLUTION

**Harmful effects on plants**
- Inhibit photosynthesis
- Inhibit metabolism
- Repress growth
- Destroy cells
- Cause mutation
- Decline forest productivity

**Harmful effects on other organisms**
- Marine/freshwater organisms are very sensitive to UV-rays
- Fish larvae are very sensitive
- Plankton population severely damaged.
- Affect fish/shrimp/crab larvae

**Harmful effects on non-living materials**
- Accelerate breakdown of paints
- Accelerate breakdown of plastics
- Affect temperature gradient levels in the atmosphere
- Affect atmospheric circulation pattern, climatic changes.

**ACID RAIN**
Acid rain refers to any precipitation (rain, fog, mist, snow) that is more acidic than normal. Acid rain is caused by atmospheric pollution from acidic gases such as sulphur dioxide and oxides of nitrogen emitted from burning of fossil fuels. Acid rain is formed when the air that contains acidic gases emitted mostly from power plants industries and automobiles, combines with the rain drops. Therefore, emission of sulphur dioxide oxide and of oxides nitrogen into the atmosphere can lead to the formation of acid rain. It is also recognized that acidic smog, fog, mist, move out of the atmosphere and settle on dust particles which in turn accumulate on vegetation as acid depositions. When rain falls, the acid from these depositions leak and form acid dews.

**ACIDIC GASES AND THEIR EMISSION SOURCES.**

<table>
<thead>
<tr>
<th>Acidic gases</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2 (Carbon dioxide)</td>
<td>Fossil fuel burning, industrial process, respiration.</td>
</tr>
<tr>
<td>CH4 (Methane)</td>
<td>Paddy fields, wetlands, gas drilling, landfills, animals, termites</td>
</tr>
<tr>
<td>CO (Carbon monoxide)</td>
<td>Biomass burning, Industrial sources, Biogenesis, Plant isoprene’s.</td>
</tr>
<tr>
<td>SOx (Sulphur oxides)</td>
<td>Fossil fuel burning, industrial sources, volcanoes, oceans.</td>
</tr>
<tr>
<td>NOx (nitrogen oxides)</td>
<td>Fossil fuel burning, lightening, biomass burning, oceans, power plants</td>
</tr>
</tbody>
</table>
Harmful effects of acid rain
Acid precipitation affects both aquatic and terrestrial organisms. It also damages buildings and monuments.

(i) Effects on aquatic life
The pH of the surrounding or medium is very important for metabolic processes of aquatic organisms. The eggs or sperms of fish, frogs and other aquatic organisms are very sensitive to pH change. Acid rain kills their gametes affecting the life cycles and productivity. Death or their inability to increase in numbers affects aquatic food chains in acidic water bodies, causing severe ecosystem imbalances. Acidic lake waters may kill bacteria/microbes/planktons and the acidic lakes become unproductive and life less. Such acidic and lifeless ponds/lakes adversely affect fisheries and livelihood.

(ii) Effect on terrestrial life
Acid rain damage cuticle of plant leaves resulting etiolation of foliage. This in turn reduces photosynthesis. Reduced photosynthesis accompanied by leaf fall reduces plant and crop productivity. Acidic medium promotes leaching of heavy metals such as aluminum, lead and mercury. Such metals when percolate into ground water affect soil microflora/ micro fauna. The soil becomes lifeless. Absorption of these toxic metal ions by plants and microorganisms affect their metabolism.

(iii) Effects on forests
Acid rains damage forests and kill vegetation and causes severe damage to the landscape.

(iv) Effect on buildings and monuments
Many old, historic, ancient buildings and works of art/textile etc. are adversely affected by acid rain. Limestone and marble are destroyed by acid rain. Smoke and soot cover such objects. They slowly dissolve/flake away the surfaces because of acid fumes in the air. Many buildings/monuments such as Taj Mahal in Agra have suffered from acid rain.

Strategies to cope with acid rain
Any procedure that shall reduce, minimize, or halt emission of sulphur and nitrogen oxides into the atmosphere shall control acid rain. Use of low sulphur fuel or natural gas or washed coal (chemical washing of pulverized coal) in thermal plants can reduce incidences of acid rain.
INTRODUCTION:

Environment assessment involves a study to determine any unique environmental attributes from endangered species to existing hazardous waste to historical significance. Environment Assessment procedure ensures consideration of environmental implications before making a final decision of assessing the environmental attribute. Process of assessment analyses the effects on environment and is useful for reporting those effects undertaking a public consultation exercise and lastly it reveals decision to public after reviewing the comment of the report.

One of the main strengths of environmental assessment (EA) is its flexibility.

- Project planning processes can integrate EA as essential step giving sensitivity to the social and economic as well as environmental impacts of projects. In this way project managers can compensate shortcomings in the project planning process. For example, a project which failed to adequately consult the community at the outset can take advantage of the Environment Assessment to involve the community in a necessary exchange of ideas and views.

- The EA can help establish and strengthen decision-making and communication mechanisms within a project.

- It can also pave the way for introducing innovations.

- An EA may reveal sound environmental, social or economic reasons for shifting a project’s direction.

In view of the primacy accorded the opinions and aspirations of local people, the EA process may also function as a project control mechanism. While the EA should not be expected to correct all the weaknesses of a flawed planning process, when properly designed and executed, it can be a valuable tool for project implementation. When the role of the EA is more restricted, the situation can work in reverse. Other project planning activities can be used to gather necessary information for the EA and to create support for the EA process. Each project manager must decide how much importance to accord each planning.

Duration for EA will hinge on:

- The size and complexity of the proposed project.

- The extent of co-operation received from the project sponsor and third parties such as local government.

- The level of interest and support demonstrated by the community.

- The ability of the project team to sustain interest in the EA.

- The skills of the EA team.

- The EA techniques employed.
In principle, environmental assessment can be undertaken for

- Individual projects such as a dam, motorway, airport or factory and call it as 'Environmental Impact Assessment' (EIA).

- Plans, programs and policies and call it as 'Strategic Environmental Assessment' (SEA).

These two sections are discussed in detail in the further sections.

In recent years, there has been a remarkable growth of interest in environmental issues, sustainability and the better management of development in harmony with the environment. Associated with this growth of interest has been the introduction of new legislation, emanating from national and international agencies (e.g., the European Commission) that seek to influence the relationship between development and environment. *Environmental impact assessment (EIA) is an important example. It is defined as an activity designed to identify and predict the impact of legislative proposals, policies, programmes, projects and operational procedures on the bio-geophysical environment and on the health and well being of human beings and to interpret and communicate information about the impact.*

That is to say, EIA focuses on problems, conflicts or natural resource constraints that could affect the viability of a project. It also examines implications of a project that might harm people, their homeland or their livelihoods, or other nearby developments. After predicting the problems, a EIA identifies measures to minimise the problems and outlines ways to improve the project's suitability for its proposed environment. In the last three decades, EIA has been recognised as the most valuable, inter-disciplinary and objective decision-making tool with respect to alternate routes for development, process technologies and project sites. It is considered an ideal anticipatory mechanism allowing measures that ensure environmental compatibility in our quest for socio-economic development.

EIA is generally wider in scope and less quantitative than other techniques, such as cost-benefit analysis. EIA has the potential to be a basis for negotiation among the developers, public interest groups and planning regulators.

### 2. THE BENEFITS OF ENVIRONMENTAL ASSESSMENT

Most governments and donor agencies acknowledge the contribution of EA to improved project design. The weakness of EA in the past has been largely due to poor techniques and the failure to pay attention to findings at the implementation stage (ESSA Technologies 1994). A review of current environmental practices found the major benefits of the EA process for project sponsors to be (ESSA Technologies 1994: 16):

- Reduced cost and time of project implementation.
- Cost-saving modifications in project design.
- Increased project acceptance.
Avoided impacts and violations of laws and regulations.
- Improved project performance.
- Avoided treatment/clean up costs.

The benefits to local communities from taking part in environmental assessments include:

- A healthier local environment (forests, water sources, agricultural potential, recreational potential, aesthetic values, and clean living in urban areas).
- Improved human health.
- Maintenance of biodiversity.
- Decreased resource use.
- Fewer conflicts over natural resource use.
- Increased community skills, knowledge and pride.

3. PRINCIPLE OF EIA

It is important to recognise that there is a general principle of assessment that applies to EIA, and to other assessment processes. There are several other processes that relate closely to the review of environmental impacts that may result from a proposed project. The following are well recognised processes:

- Social Impact Assessment
- Risk Assessment
- Life Cycle Analysis
- Energy Analysis
- Health Impact Assessment
- Regulatory Impact Assessment
- Species Impact Assessment
- Technology Assessment
- Economic Assessment
- Cumulative Impact Assessment
- Strategic Environmental Assessment
- Integrated Impact Assessment

Some, like Energy Analysis, focus on a particular part of the environment. Others, like Life Cycle Analysis, enable the consideration of all those parts of the environment that are relevant to the assessment. Also, depending on how the terms, like health, are defined for the study you may find that it is covering most of the issues that would be found in an EIA. For example a Technology Assessment does include review of the impacts on ecosystems, air quality and the like. Similarly, if the definition of environmental is taken broadly for an EIA, then the EIA may cover the issues of the other assessment processes; for example:
ENVIRONMENT IMPACT ASSESSMENT

- Social aspects (such as impacts on employment, community interaction);
- Risks (such as threats to native animals, water supplies);
- Life cycle (such as the impacts at each stage of the project design through to operation and closure); and
- Energy (such as use of non-renewable energy sources, Greenhouse gas emissions), etc

So there is the potential for a lot of connections between the different forms of assessment. The essential difference between them is how the terms, or scope of assessment, are defined narrowly, or broadly. Otherwise they all follow the same general principle.

With all the assessment approaches noted above, they are designed to identify potential impacts of a development, action or project. To do this the assessor needs to use personal experience and the experiences of others (including available knowledge) to think broadly about the changes that are possible, and whether those impacts will be positive or negative. Particular approaches emphasis specific types of impacts (i.e. on health, on social groups). All have basically the same approach, although each may have its own individual language and detailed techniques.

Most of the assessment processes also include a second step. After identifying the impacts, they also consider what may be needed to avoid or reduce adverse impacts.

4. PURPOSES OF EIA

EIA is a process with several important purposes, which can be categorised as follows:

1. To facilitate decision-making: For the decision-maker, for example the local authority, it provides a systematic examination of the environmental implications of a proposed action, and sometimes alternatives, before a decision is taken. The decision-maker along with other documentation relating to the planned activity can consider the environment impact statement (EIS).

2. To aid in the formation of development: Many developers see EIA as another set of hurdles for them to cross in order to proceed with their various activities. They may also see the process involved in obtaining the permission from various authorities as costly and time-consuming. In reality, however, EIA can be of great benefit to them, since it can provide a framework for considering location and design issues and environmental issues in parallel. It can be an aid to the formulation of developmental actions, indicating areas where the project can be modified to minimise or eliminate altogether the adverse impacts on the environment. The consideration of environmental impacts early in the planning life of a development can lead to environmentally sensitive development; to improved relations between the developer, the planning authority and the local communities; to a smoother planning permission process and sometimes to a worthwhile financial return on the expenditure incurred.

3. To be an instrument for sustainable development: The key characteristics of sustainable development include maintaining the overall quality of life, maintaining continuing access to natural resources and avoiding lasting environmental damage. Institutional responses to sustainable development are, therefore, required at several levels. For example, issues of global concern, such as ozone-layer depletion, climate change, deforestation and biodiversity loss, require a global political commitment to
action. The United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992 was an example of international concern and also of the problems of securing concerted action to deal with such issues. Governments have recognised the interaction of economic and social development and the ecosystems, and the reciprocal impact between human actions and the bio-geophysical world. While there are attempts to manage this interaction better, investigation reveal disquieting trends that could have devastating consequences for the quality of the environment. These trends are likely to be more pronounced in developing countries where, because of greater rates of population growth and lower current living standards, there is more pressure on environmental resources.

In short, an interaction among the resources, sectors and policies is necessary for sustainable development as illustrated in Figure 1 below, and EIA contributes to this process:

![Figure 1 Sustainable Development: An Illustration](image)

5. **STEPS IN EIA PROCESS**

EIA represents a systematic process that examines the environmental consequences of the development actions, in advance. The emphasis of a EIA is on prevention and, therefore, is more...
ENVIROMENT IMPACT ASSESSMENT

proactive than reactive in nature. The EIA process involves a number of steps, some of which are listed below:

- **Project screening**: This entails the application of EIA to those projects that may have significant environmental impacts. It is quite likely, however, that screening is done partly by the EIA regulations, operating in a country at the time of assessment.

- **Scoping**: This step seeks to identify, at an early stage, the key, significant environmental issues from among a host of possible impacts of a project and all the available alternatives.

- **Consideration of alternatives**: This seeks to ensure that the proponent has considered other feasible approaches, including alternative project locations, scales, processes, layouts, operating condition and the no-action option.

- **Description of the project/development action**: This step seeks to clarify the purpose and rationale of the project and understand its various characteristics, including the stages of development, location and processes.

- **Description of the environmental baseline**: This includes the establishment of both the present and future state of the environment, in the absence of the project, taking into account the changes resulting from natural events and from other human activities.

- **Identification of key impacts**: This brings together the previous steps with a view to ensuring that all potentially significant environmental impacts (adverse and beneficial) are identified and taken into account in the process.

- **The prediction of impacts**: This step aims to identify the likely magnitude of the change (i.e., impact) in the environment when the project is implemented in comparison with the situation when the project is not carried out.

- **Evaluation and assessment of significance**: This seeks to assess the relative significance of the predicted impacts to allow a focus on key adverse impacts. Formal definition of significance is the product of consequence and likelihood as

  \[ \text{Significance} = \text{consequence} \times \text{Likelihood} \]

- **Mitigation**: This involves the introduction of measures to avoid, reduce, remedy or compensate for any significant adverse impacts.

- **Public consultation and participation**: This aims to assure the quality, comprehensiveness and effectiveness of the EIA, as well as to ensure that the public’s views are adequately taken into consideration in the decision-making process.

- **EIS presentation**: This is a vital step in the process. If done badly, much good work in the EIA may be negated.

- **Review**: This involves a systematic appraisal of the quality of the EIS, as a contribution to the decision-making process.
Decision-making: At this stage, decisions are made by the relevant authority of the EIS (including consultation responses) together with other material considerations as to whether to accept, defer or reject the project.

Post-decision monitoring: This involves the recording of outcomes associated with development impacts, after the decision to proceed with the project. It can contribute to effective project management.

Auditing: This follows monitoring and involves comparing actual outcomes with predicted outcomes, and can be used to assess the quality of predictions and the effectiveness of mitigation. It provides a vital step in the EIA learning process.

Figure below illustrates the steps involved in the EIA process:

Note that the actual EIA process is not so linear and sequential as Figure 2 seems to suggest. In other words, it is a cyclical process involving feedback and interaction among the various steps and the sequence of the steps may also vary.

6. HIERARCHY IN EIA

The EIA studies are broadly categorised as:

A. Site selection studies: These studies involve an evaluation of the alternative sites with respect to environmental and project attributes such as proximity to raw materials, infrastructure facilities, markets, etc. These studies aim at ranking site alternatives for objective decision-making.
B. **Rapid or comprehensive studies**: Rapid studies refer to the assessment based on a one-season monitoring (i.e., 3-month period), whereas comprehensive studies relate to the assessment based on a three-seasons monitoring (i.e., 9-month period) of baseline data. Rapid EIA facilitates decision-making in situations where a fair amount of knowledge exists about the proposed site or the impacts of the proposed development. It also helps in identifying significant issues for comprehensive EIA. Essentially, rapid and comprehensive studies differ with respect to timeframes required for baseline data collection.

C. **Regional studies**: These relate to the development in/of a region based on seasonal data collection and address themselves to the analysis of assimilative capacity of air, water and land components of the environment.

D. **Carrying capacity studies**: The scope of a carrying capacity study is extended to the analysis of supportive capacity in the region with respect to resource availability/utilisation, supply/demand, infrastructure/congestion and assimilative capacity/residuals.

In the last two decades, national governments and also financial institutions have realised that EIA has to be an integral part of the project life cycle: from project conceptualisation to post implementation corrective action.

Figure illustrates this cycle:
A EIA exercise culminates in an environmental impact statement (EIS), which we will study, next.

7. **ENVIRONMENTAL IMPACT STATEMENT (EIS)**

The environmental impact statement (EIS) provides documentation of the information and estimates derived from the various steps in the EIA process. The information contained in a EIS provides the decision-makers/regulators with valuable information that could ultimately contribute to either the abandonment or substantial modification of a proposed development action. A typical EIS contains the following three parts:

1. **Methods and key issues**: This part deals with the statement of methods used and a summary of key issues.

2. **Background to the proposed development**: This part deals with preliminary studies (i.e., need, planning, alternatives, site selection, etc.), site description/baseline conditions, description of proposed development and construction activities and programmes.

3. **Environmental impact assessments on topic areas**: This part deals with land use, landscape and visual quality, geology, topography and soils, hydrology and water quality, air quality and climate, terrestrial and aquatic ecology, noise, transport, socio-economic and interrelationships between effects.

8. **IMPACT INDICATORS**

An impact indicator is an element or a parameter that provides a measure (in at least some qualitative sense) of the significance of the effect, i.e., the magnitude of an environmental impact. Some indicators such as morbidity and mortality statistics and crop yields have associated numerical scales. Other impact indicators, however, can only be ranked as ‘good’, ‘better’, ‘best’ or ‘acceptable’, ‘unacceptable’, etc. The selection of a set of indicators is often a crucial step in the impact assessment process, requiring input from the decision-maker. In the absence of relevant goals or policies, the assessor himself or herself may suggest some indicators and scales, but he or she should not proceed with the assessment until his or her proposals are accepted.

The most widely used impact indicators are those within statutory laws, acts, i.e., indicators such as air and water quality standards that have statutory authority. For example, the problem of designing an environmentally acceptable oil-fired generating station is simplified for the engineers, if they are given one or both of the following:

1. Emission standards for various pollutants.

2. Air and water quality standards.

These standards integrate the worth that a jurisdiction places on clean air and clear water. The numerical values that have been derived from examination of the available toxicological matter are data relating polluting dosages to health and vegetation effects, combined with a consideration of the best practical technology. Factors such as the displacement of arable land by industry are also equally important. A EIA that ignores these other components is incomplete and sometimes misleading (Munn, 1979).
9. EVOLUTION OF EIA

To understand the use of EIA as a tool for environmental management, let us discuss how EIA has evolved over the years.

A. EVOLUTION OF EIA WORLWIDE

United States of America was the first country to assign mandatory status to EIA through its National Environmental Protection Act (NEPA) of 1969. A host of industrialised countries have since implemented EIA procedures. Canada, Australia, the Netherlands and Japan adopted EIA legislation in 1973, 1974, 1981 and 1984, respectively. In July 1985, the European Community (EC) issued a directive making environmental assessments mandatory for certain categories of projects (Wood, 1994).

Among the developing countries, Columbia was the first Latin American country to institute a system of EIA in 1974. In Asia and the Pacific region, Thailand and the Philippines have long established procedures for EIA. EIA was made mandatory in Sri Lanka in 1984. The EIA process in Africa is sketchy, although a number of nations including Rwanda, Botswana and Sudan have some experience of EIA (Wathern, 1988).

Bilateral and multilateral agencies have also recognised the value of EIA as a decision-making tool. The Organisation for Economic Co-Operation and Development (OECD) issued recommendations on EIA to its constituent States in 1974 and 1979 and for development aid projects in 1986. OECD issued guidelines for good practices in EIA in 1992 (OECD, 1992). United Nations Environment Programme (UNEP) in 1980 provided guidance on EIA of the development proposals (UNEP, 1980) and supported research on EIA in developing countries (Ahmad and Swamy, 1985). UNEP, in 1987, set out goals and principles of EIA for the member countries and provided guidance on basic procedures for EIA in 1988.


As foreseen by Garner and O'Riodan (1982) development of EIA, as a tool for decision-making world-over, has emerged through the following stages:

- No formal accounting, decisions made on interest group lobbying and engineering feasibility; primary emphasis on economic development.
- Conventional cost-benefit analysis; emphasis on efficiency criterion and engineering feasibility; major concern still on economic development.
- Innovative cost-benefit analysis, use of multiple objectives and discount rates, imaginative proxy pricing mechanisms; economic development as one of the objectives.
ENVIRONMENT IMPACT ASSESSMENT

- EIA mainly concerned with describing the repercussions of the proposals on bio-physical processes; economic development still primary objective.

- EIA with more attention paid to socio-cultural as well as bio-physical systems, economic development but not the sole objective.

B. EVOLUTION OF EIA IN INDIA

EIA in India was started in 1976-77, when the Planning Commission asked the then Department of Science and Technology to examine the river-valley projects from the environmental angle. This was subsequently extended to cover those projects, which required approval of the Public Investment Board. These were administrative decisions, and lacked the legislative support. The Government of India enacted the Environment (Protection) Act on 23rd May 1986. To achieve the objectives of the Act, one of the decisions taken was to make EIA statutory. After following the legal procedure, a notification was issued on 27th January 1994 and subsequently amended on 4th May 1994, 10th April 1997 and 27th January 2000 making environmental impact assessment statutory for 30 activities. This is the principal piece of legislation governing EIA in India. Besides this, the Government of India under Environment (Protection) Act 1986 issued a number of notifications, which are related to environmental impact assessment. These are limited to specific geographical areas, and are summarised below:

- Prohibiting location of industries except those related to Tourism in a belt of 1 km from high tide mark from the Revdanda Creek up to Devgarh Point (near Shrivardhan) as well as in 1 km belt along the banks of Rajpuri Creek in Murud Janjira area in the Raigarh district of Maharashtra (6th January 1989).

- Restricting location of industries, mining operations and regulating other activities in Doon Valley (1st February 1989).

- Regulating activities in the coastal stretches of the country by classifying them as coastal regulation zone and prohibiting certain activities (19th February 1991).

- Restricting location of industries and regulating other activities in Dahanu Taluka in Maharashtra (6th June 91).

- Restricting certain activities in specified areas of Aravalli Range in the Gurgaon district of Haryana and Alwar district of Rajasthan (7th May 1992).

- Restricting industrial and other activities, which could lead to pollution and congestion in the north west of Numaligarh in Assam (July 1996).

10. FORECASTING ENVIRONMENTAL CHANGES

- A EIA should be able to, among others, predict the nature and extent of the impact of human activities on the environment. Table below gives a list of human-induced environmental changes, which can be either benign or malignant to the environment:

<table>
<thead>
<tr>
<th>Environmental Changes</th>
<th>Environmental Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Edited by: Arun Sharma  
Source: NPTEL
Medium | Changes and Rates of Change in
---|---
Soil | Quality (e.g., depth, structure, fertility, degree of Stalinisation or Acidification, etc.)
| Stability
| Area of arable land
Air | Quality
| The climatic elements
Water | Quantity
| Quality
| Season ability
| Area of human-made lakes
| Extent of irrigation canals
Biota | Abundance/scarcity of species or genetic resources
| Extent of crops, ecosystems, vegetation and forests
| Diversity of species
| Extent of provision of nesting grounds, etc., for migratory species
| Abundance/scarcity of pests and disease organisms.

Of importance here are not only estimates of changes in environmental quality but also estimates of rate of change. A slow change may be acceptable, especially if it leads to a new stability, whereas rapid change or large fluctuations may place intolerable burdens on ecosystems. Of equal or perhaps greater importance is the degree of irreversibility of an environmental change, which will be either absolute, as in the extinction of a species, or partly absolute in that the situation can only be reversed over long periods of time or with unacceptable expenditures of money and energy, as in the case of catastrophic erosion.

A typical EIA contains information on the following three areas, as they relate to environmental effects:

1) A determination of the initial reference state.
2) An estimate of the future state without action.
3) An estimate of the future state with action.

Establishment of the initial reference state
An assessment of environmental change pre-supposes knowledge about the present state. It will be necessary, therefore, to select attributes that may be used to estimate this state. Some of these will be directly measurable; others will only be capable of being recorded within a series of defined categories, or ranked in ascending or descending order of approximate magnitude. Difficult decisions need to be made about the population (i.e., in a statistical sense), which is to be represented by the measured variables, and the extent to which the sub-division of this population into geographical regions, ecosystems, etc., is either feasible or necessary. In fact, it must be emphasised that the establishment of an initial reference state is difficult because not only are environmental systems dynamic but also they contain cyclical and random components.

**Predicting the future state in the absence of action**

In order to provide a fair basis for examining the impact of human activities on the environment, a EIA must estimate the future environmental states in the absence of action. As an example, the population of a species of animal or fish may already be declining, due to over-grazing or over-fishing, even before a smelter is built. This part of analysis is largely a scientific problem, requiring skills drawn from many disciplines. The prediction will often be uncertain but the degree of uncertainty should be indicated at least in qualitative terms. For example, forecasting of droughts 2 or 3 years in advance is not yet possible, although the statistical probability that a drought (of a given severity) will occur sometime in the next hundred years can be estimated with some confidence. The decision-maker should be aware of the degree of uncertainty, which surrounds the predicted state of the environment, and have some understanding of the methods by which this uncertainty is calculated.

**Predicting the future state in the presence of action**

For each of the proposed actions, and for admissible combinations of these actions, there will be an expected state of the environment, which is to be compared with the expected state in the absence of action. Consequently, predictions similar to those outlined above must be derived for each of the proposed alternatives.

Table below presents the main areas of concern that may affect human beings with regard to forecasting the environmental state in the presence of actions:

<table>
<thead>
<tr>
<th>Economic and Occupational status</th>
<th>Displacement of population; relocation of population in response to employment opportunities; services and distribution patterns; property values.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social pattern or life style</td>
<td>Resettlement; rural depopulation; change in population density; food; housing; material; agricultural; rural; urban.</td>
</tr>
<tr>
<td>Environment Impact Assessment</td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Social amenities and relationships</strong></td>
<td>Family life styles; schools; transportation; community feelings; participation vs. alienation; recreation; language.</td>
</tr>
<tr>
<td><strong>Psychological features</strong></td>
<td>Involvement; expectations; stress; frustration; Commitment.</td>
</tr>
<tr>
<td><strong>Physical amenities (intellectual, cultural, aesthetic and sensual)</strong></td>
<td>National parks; wildlife; art galleries; archaeological monuments; wilderness; clean air and water.</td>
</tr>
<tr>
<td><strong>Health</strong></td>
<td>Changes in health; medical services; medical standards.</td>
</tr>
<tr>
<td><strong>Personal security</strong></td>
<td>Freedom from molestation; freedom from natural disasters.</td>
</tr>
<tr>
<td><strong>Regional and traditional Beliefs</strong></td>
<td>Symbols; taboos; values.</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>Security; hazards; safety measures; benefits; emission of wastes; congestion; density.</td>
</tr>
<tr>
<td><strong>Cultural</strong></td>
<td>Leisure; new values; heritage; traditional and religious rites.</td>
</tr>
<tr>
<td><strong>Political</strong></td>
<td>Authority; level and degree of involvement; priorities; structure of decision-making; responsibility and responsiveness; resource allocation; local and minority interests; defence needs.</td>
</tr>
<tr>
<td><strong>Legal</strong></td>
<td>Restructuring of administrative management; changes in taxes; public policy.</td>
</tr>
<tr>
<td><strong>Aesthetic</strong></td>
<td>Visual physical changes; moral conduct; sentimental values.</td>
</tr>
<tr>
<td><strong>Statutory laws and acts</strong></td>
<td>Air and water quality standards; safety standards; national building acts; noise-abatement by-laws.</td>
</tr>
</tbody>
</table>
Note that the nature of impact listed in Table is likely to vary from place to place and from time to time, and there will be overlaps between classes (e.g., health depends in part on economic and occupational status).

In this Section, we explained the anthropogenic effect and their impacts in terms of environmental preservation. However, a specific parameter is necessary to provide a measure of the significance of an effect.

So far, we dealt with EIA, which is an indispensable tool for environmental engineers and managers alike. Now, let us introduce you to a new concept called strategic environmental assessment, which covers policies, plans and programmes at critical stages of development.

11. **STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA)**

One of the most recent trends in EIA is its application at earlier, more strategic stages of development at the level of policies, plans and programmes, and is known as strategic environmental assessment (SEA). *SEA is defined as the formalised, systematic and comprehensive process of evaluating the environmental impacts of a policy, plan or programme (PPP) and its alternatives, including the preparation of a written report on the findings of that evaluation, and using the findings in publicly accountable decision-making (Therivel, et al., 1992). In other words, the EIA of policies, plans and programmes, keeping in mind that the process of evaluating environmental impacts at a strategic level is not necessarily the same as that at a project level. In theory, PPPs are tiered – a policy provides a framework for the establishment of plans, plans provide frameworks for programmes and programmes lead to projects. The EIAs for these different PPP tiers can themselves be tiered as shown in Figure 3.4.1, and so the issues at higher tiers need not be reconsidered as the lower tiers:*

---

A hierarchy exists between policies, plans and programs with policies are at the top level of conceptualization and generality, plans are one level down from policies, and...
programs. Programs make plans more specific by including a time schedule for specific activities. Implementation of a program involves carrying out specific projects, which can be subjected to traditional EIA.

**12. RATIONALE AND SCOPE**

In broad terms, the rationale for SEA of policies, plans and programmes falls into three main categories: strengthening project EIA; advancing the sustainability agenda; and addressing cumulative and large-scale effects.

The EIA practice is constrained by certain limitations and weaknesses. These include structural weaknesses centred on the relatively late stage at which EIA is usually applied in decision-making. Put differently, high-order questions of whether, where and what type of development should take place are decided, often with little or no environmental analysis.

Project-by-project EIA is also an ineffective means of examining these issues. **SEA, or an equivalent approach, can be used as a complement to project-level EIA to incorporate environmental considerations and alternatives directly into policy, plan and programme design.** Thus, when applied systematically in the upstream part of the decision cycle and to the economic, fiscal and trade policies that guide the overall course of development, SEA can be a vector for a sustainability approach to planning and decision-making (Brundtland Commission of WCED, 1987 and Agenda 21 of UNCED, 1992). This upstream approach can also help in making EIA projects more consequential and reducing the time and effort involved in their preparation. SEA may yield significant other benefits, as well. For example, by ruling out certain kinds of development at the policy level, reducing the need for many project-level EIA and thus relieving pressure where institutional and/or skills capacity is limited.

Arguably, **SEA offers a better opportunity than project-level impact assessment to address cumulative effects.** Recently, considerable efforts have been made to extend EIA-based frameworks to encompass certain types of cumulative effects. These deal reasonably well with the ancillary impacts of large-scale projects (e.g., dams, transport infrastructure) and the incremental effects of numerous, small-scale actions of a similar type (e.g., road realignment and improvement). However, more pervasive cumulative effects and large-scale environmental change (which are the end result of multiple actions and stresses that cut across policy and ecological boundaries) are difficult to address. In principle, these can be addressed best by SEA of policies, plans and programmes. In practice, however, this has not proven to be the case.
What then is the scope of SEA?

Most practitioners view SEA as a decision aiding rather than a decision-making process. In other words, it is seen as a tool for forward planning to be flexibly applied at various stages of the policy-making cycle. Under this broad perspective, SEA encompasses assessments of both broad policy initiatives and more concrete programmes and plans that have physical and spatial references (e.g., town and regional plans, regional development programmes, etc). With this scope of coverage, one problem becomes evident, and that is, the methodologies to be applied at the opposite ends of the decision-making spectrum differ markedly. However, the principles of EIA apply at all levels.

### 13. COMPARISON OF EIA AND SEA

<table>
<thead>
<tr>
<th>EIA</th>
<th>SEA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is usually reactive to a development proposal.</td>
<td>Is pro-active and informs development proposals.</td>
</tr>
<tr>
<td>Assesses the effect of a proposed development on the environment.</td>
<td>Assesses the effect of a policy, plan or programme on the environment, or the effect of the environment on development needs and opportunities.</td>
</tr>
<tr>
<td>Addresses a specific project.</td>
<td>Addresses areas, regions or sectors of development.</td>
</tr>
<tr>
<td>Assesses direct impacts and benefits.</td>
<td>Assesses cumulative impacts and identifies implications and issues for sustainable development.</td>
</tr>
<tr>
<td>Focuses on the mitigation of impacts.</td>
<td>Focuses on maintaining a chosen level of environmental quality.</td>
</tr>
<tr>
<td>Narrow perspective and a high level of detail.</td>
<td>Wide perspective and a low level of detail to provide a vision and overall framework.</td>
</tr>
<tr>
<td>Focuses on project-specific impacts.</td>
<td>Creates a framework against which impacts and benefits can be measured.</td>
</tr>
</tbody>
</table>

Tiered planning system for EIA and SEA is shown in Table given below:

Table: Tiered planning system for EIA and SEA
SEA process is as comprehensive as EIA, if not as exhaustive. We will discuss this, next.

14. **SEA PROCESS**

In project EIA, impact mitigation, i.e., avoiding or reducing the project’s impacts, restoring the affected environment or compensating for adverse effects, is often considered a separate stage in the process. In SEA, instead, the focus of the project is on reconsidering the PPP from a cross-cutting perspective, leading to an improved understanding of the PPP and possibly changes to the PPP: each stage considers whether and how the PPP can be changed and improved. These changes mostly involve rewriting the PPP to minimise any negative environmental/sustainability impacts but could also involve establishing management guidelines for the implementation of the PPP, placing constraints on lower-tier PPP. (For instance, establishing criteria for identifying future developments away from sensitive sites or requiring SEA/EIA for lower-tier PPPs and projects). Or, developing environmentally beneficial shadow PPPs or projects. As such, mitigation in SEA is an ongoing process as illustrated in Figure

Figure
Mitigation in SEA
An SEA process involves the following stages:

(i) Screening: At this stage, responsible agencies carry out an appropriate assessment of all strategic decisions with significant environmental consequences.

(ii) Timing: At this stage, results of the assessment are available sufficiently early for use in the preparation of the strategic decision.

(iii) Environmental scoping: At this stage, all relevant information is provided to judge whether an initiative should proceed and objectives could be achieved in a more environmentally friendly way (i.e., through alternative initiatives or approaches).

(iv) Other factors: At this stage, sufficient information is available on other factors, including socio-economic considerations, either parallel to, or integrated in, the assessment.

(v) Review: At this stage, the quality of the process and information is safeguarded by an effective review mechanism.

(vi) Participation: At this stage, sufficient information on the views of all legitimate stakeholders (including the public affected) is available early enough to be used effectively in the preparation of the strategic decision.

(vii) Documentation: At this stage, results are identifiable, understandable and available to all parties affected by the decision.

(viii) Decision-making and accountability: At this stage, it should be clear to all stakeholders and all parties affected how the results were taken into account in decision-making.

(ix) Post-decision: At this stage, sufficient information on the actual impacts of implementing the decision is gained to judge whether or not the decision should be amended. (Adapted from Sadler, 1998b and Tonk & Verheem, 1998).
Note that though the stages are listed in a particular order, it does not mean that they occur in that very sequence. In other words, stages do overlap.

**METHODOLOGICAL DIFFERENCE BETWEEN EIA AND SEA ARE**

Scale of SEA is wider than EIA as there would be number of activities involved, larger extent of impacts to be assessed, and greater range of alternatives defined and also wider area of significance.

Time interval is longer in SEA this is between planning, approval, and implementation. Even data collection in SEA is time consuming stage

Alternatives chosen at project level can be easily differentiated and they are abstract in nature such as policy, not technical.

An SEA report should be regarded as a documentation of the processes used and available, where necessary, for later review. The real value in SEA is as a creative tool in the design cycle of the formulation and reformulation of PPPs, modifying them where necessary to respond to environmental/sustainability objective.

**BENEFITS AND CONSTRAINTS OF SEA**

Some of the benefits of SEA include the following:

- promoting integrated environment and development decision-making;
- facilitating the design of environmentally-sustainable policies and plans;
- providing for consideration of a larger range of alternatives than is normally possible in project EIA;
- taking account, where possible, of cumulative effects (particularly by focusing on the consequences of sectoral or regional-level developments) and global change;
- enhancing institutional efficiency (particularly, where EIA related skills, operational funds and institutional capacities are limited) by obviating the need for unnecessary project-level EAs;
- strengthening and streamlining project EA by incorporating environmental goals and principles into policies, plans and programmes that shape individual projects; identifying in advance the impacts and information requirements; resolving strategic issues and information requirements and reducing time and effort taken to conduct reviews.
- providing a mechanism for public engagement in discussions relevant to sustainability at a strategic level.

Some of the constraints of SEA include the following:
1) A level of institutional maturity is necessary, which allows for effective inter-sectoral dialogue, for environmental considerations to be taken into account in formulating, revising and implementing policies, plans and programmes effectively, and to influence decision-making.

2) Appropriate skills are needed, within government departments/agencies and private sectors (e.g., industry, environmental consulting companies) and amongst academics and NGOs.

3) There is a need for adequate capacity in these sectors (both human and financial resources).

In practice, the extent to which the benefits of SEA are achieved will also depend on a number of other important factors such as:

- provisions made for SEA, e.g., legal versus administrative;
- prior record of implementation and acceptance by decision-makers;
- degree to which overall strategies of sustainable development are in place;
- scope and level(s) of process application; with the broadest range of benefits being gained from SEA systems that include review of policies as well as plans and programmes. (Adapted from Dalal-Clayton and Sadler, 1995 and Sadler & Baxter, 1997.)

### 15. ENVIRONMENTAL CLEARANCE PROCEDURE IN INDIA

As the utility of EIA became clear, there was need to establish project clearance procedure. The first step in that direction was to define the EIA process. The EIA process in India is made up of the following phases:

- Screening.
- Scoping and consideration of alternatives.
- Baseline data collection.
- Impact prediction.
- Assessment of alternatives, delineation of mitigation measures and environmental impact statement.
- Public hearing.
- Environment management plan (EMP).
- Decision-making.
- Monitoring the clearance conditions.
The Ministry of Environment and Forests (MOEF) has published guidelines for different sectors, which outline the significant issues to be addressed in the EIA studies. In general, the following impacts of the project need to be assessed:

1) Air: The changes in ambient levels and ground level concentrations due to total emissions from point, line and area sources, effects on soils, materials, vegetation and human health are to be assessed.

2) Noise: The changes in ambient levels, due to noise generated from equipment and movement of vehicles, and their impact on fauna and human health are to be assessed.

3) Water: The availability to competing users, changes in quality, sediment transport and ingress of saline water are to be assessed.

4) Land: The changes in land use and drainage pattern, land quality including effects of waste disposal, shoreline/riverbank and their stability are to be assessed.

5) Biological: The level of deforestation/tree-cutting and shrinkage of animal habitat, the impact on fauna and flora (including aquatic species, if any) due to contaminants/pollutants and the impact on rare and endangered species, endemic species, and migratory path/route of animals are to be assessed, as also the impact on breeding and nesting grounds.

6) Socio-economic: The impact on the local community including demographic changes, economic status, human health and increased traffic are to be assessed.

For every project, possible alternatives need to be identified and environmental attributes compared. The alternatives identified must cover project location and process technologies including the no-project option and the alternatives need to be ranked for selection on the basis of optimum economic benefits to the community at large.

Once the alternatives have been reviewed, a mitigation plan supplemented with an environmental management plan (EMP) needs to be drawn up for the selected option to guide the proponent towards environmental improvements. Note that the EMP is a crucial input to monitoring the clearance conditions, and therefore, it must contain the details of monitoring.

A EIA report, thus, needs to provide clear information to the decision-maker on the different environmental scenarios without the project, with the project and with project alternatives. This includes uncertainties.

MOEF has issued sectoral guidelines and environmental appraisal questionnaires for obtaining the clearance and seeks the following documents:

- Filled in application form (as per Schedule II of EIA Notification).
- A summary of the project/feasibility report (1 copy).
- EIA (EIS)/EMP report (20 copies).
- Risk analysis on on-site emergency preparedness plan (20 copies) in case of projects involving hazardous substances.
- Site clearance from MOEF for site-specific projects mentioned in the EIA notification.
- Consent to establish from SPCB.
- NOC from the local authorities (e.g., District Collector).
- Commitment regarding the availability of water and electricity from the appropriate agencies.
- Approval of the Chief Controller of Explosives under the Petroleum Act and Rules for layout and storage of hazardous substances and from the Directorate of Industrial Safety and Health under the Factories Act and Rules.
- Comments/Observations/Recommendations of the Chief Wildlife Warden in case a wildlife habitat/migration path exists within 25 km of project site.
- Comprehensive summary rehabilitation plan, where displacement of more than 1,000 people is anticipated.
- Copy of the application forwarded to the state government, in case of diversion of forest land.
- Copy of the application forwarded to the state government in case the CRZ notification applies.
- Clearance from the Airport Authority of India, if applicable.
- Details of the public hearing conducted by SPCB and copies of the advertisements issued for public hearing.
- Filled-in environmental appraisal questionnaires issued by MOEF, along with the attachments (mentioned in the questionnaire).

MOEF has issued different questionnaires for different projects, and the law requires that the public must be informed and consulted on a proposed development after the completion of EIA report. Any one is entitled to have access to the executive summary of the EIA, and the affected persons such as bona fide local residents, local associations, environmental groups active in the area and any other person located at the project site/sites of displacement must be given an opportunity to make oral/written suggestions to the State Pollution Control Board (SPCB). The decision-making process involves consultation between the project proponent (assisted by a consultant) and the impact assessment authority (assisted by an expert group, if necessary). The decision on environmental clearance is arrived at through a number of steps including evaluation of EIA and the environmental management plan (EMP). In India, the project proponent during the project planning stage decides the type of projects, i.e., new establishment, expansion or modernisation. Later, the project proponent prepares a detailed project report/feasibility report and submits to the authorities concerned the executive summary containing the project details and findings of the EIA study, which is to be made available to the concerned public.
given a chance to present his or her proposal. If a project is accepted, the IAA prepares a set of recommendations and conditions for its implementation based on this assessment. Environmental clearance conditions and recommendations of IAA are made available to the public on request through SPCB and through a web site <http://envfor.nic.in>. During the implementation and operation of the project, the IAA is also responsible for the environmental monitoring process.

16. REVISED ENVIRONMENTAL CLEARANCE PROCEDURE IN INDIA

As the utility of EIA became clear, there was need to establish project clearance procedure. In 1994 a clearance procedure was issued that followed EIA Notification 1994. There were some constraints in the procedure that include:

- Burdensome procedure
- Disproportionate details sought with applications
- Delay in appraisal meetings
- Time consuming and requiring undue effort
- Reopening of technical issues during various stages of appraisal
- Poor quality of EIA studies by consultants
- Delays by other concerned agencies

Due to these reasons re engineering was done of the EIA process implementation based on project chosen. Background of this reengineering is that; MoEF conducted a review on previous EC process which is comprehensive under the Environmental Management Capacity Building Project in 2001, reformation in investment approvals and implementation procedures was set up by central government with the help of GOVINDARAJAN COMMITTEE. Due to consistency in studies with both the organizations there was a strong necessity for reforms in the EIA notification 1994.

A. OBJECTIVES OF EIA NOTIFICATION 2006

- To formulate a transparent, decentralized and efficient regulatory mechanism to: Incorporate necessary environmental safeguards at planning stage.
- Involve stakeholders in the public consultation process.
- Identify developmental projects based on impact potential instead of the investment criteria.
- It also stated that; all new projects listed in schedule, expansion and modernisation of existing projects and those activities that show change in product mix require environmental clearance before setting up.

B. According to the 1994 clearance procedure the MOEF has issued sectoral guidelines and environmental appraisal questionnaires and needed following documents:

1. Filled in application form (as per Schedule II of EIA Notification).
2. A summary of the project/feasibility report (1 copy).
3. EIA (EIS)/EMP report (20 copies).
4. Risk analysis on on-site emergency preparedness plan (20 copies) in case of projects involving hazardous substances.
5. Site clearance from MOEF for site-specific projects mentioned in the EIA notification.
6. Consent to establish from SPCB.
7. NOC from the local authorities (e.g., District Collector).
8. Commitment regarding the availability of water and electricity from the appropriate agencies.
9. Approval of the Chief Controller of Explosives under the Petroleum Act and Rules for layout and storage of hazardous substances and from the Directorate of Industrial Safety and Health under the Factories Act and Rules.
10. Comments/Observations/Recommendations of the Chief Wildlife Warden in case a wildlife habitat/migration path exists within 25 km of project site.
11. Comprehensive summary rehabilitation plan, where displacement of more than 1,000 people is anticipated.
12. Copy of the application forwarded to the state government, in case of diversion of forest land.
13. Copy of the application forwarded to the state government in case the CRZ notification applies.
14. Clearance from the Airport Authority of India, if applicable.
15. Details of the public hearing conducted by SPCB and copies of the advertisements issued for public hearing.
16. Filled-in environmental appraisal questionnaires issued by MOEF, along with the attachments (mentioned in the questionnaire).

C. DIFFERENCES BETWEEN THE EIA NOTIFICATION 1994 AND 2006

- No NOC for EC
- Revised Schedule based on potential impacts instead of investment criteria
- Categorization into A and B1 & B2 (given in annexure)
- Category A at Central level, Category B1, B2 at State Level (with exceptions)
- Check-list information in Form-1/Form-1-A
- Scoping to determine TORs for EIA, if required;
- Finality of TORs
- Scoping stage incorporate site clearance – No separate site clearance is required.
- Public consultation structured; to be conducted by SPCB and presided by DM (within 45 days); proceedings to be video graphed; MoEF to intervene if PH not held in time.
- Time limits with consequences at each stage
17. **STATE LEVEL ENVIRONMENT IMPACT ASSESSMENT AUTHORITY (SEIAA)** is an independent body members of which should be notified by MoEF on receiving nominations from all concerned states and UTs. Chairman and other member shall be experts fulfilling the eligibility criteria given in Appendix VI of Notification 2006. Chairman shall be an expert in EIA process. Member Secretary familiar with environmental laws shall be a serving officer of the State Government.

MoEF must notify SEIAAs within a time limit of 30 days from the date of receipt of nominations. Time period for Authority defined (3 years). Decision of the Authority shall be on the basis of consensus and lastly there would not be any funding from MoEF.

Steps in prior Environmental clearance process include Screening, Scoping, Public consultation, and Appraisal

The Environmental Clearance procedure was thoroughly restructured through issuance of said Environmental Clearance Notification by MoEF, New Delhi for making the environmental clearance procedure more transparent, less time consuming and decentralized as much as possible. Under this restructured Environmental Clearance notification, the industrial / developmental activities, which may cause serious spatial and temporal environmental impacts, have been scheduled to obtain prior Environmental Clearance. And also it has been decided that such activities shall be classified as category A or category B type projects. The existing Expert Appraisal Committees at central level at Ministry of Environment & Forests, New Delhi, shall screen - scope - appraise category A projects. Each state shall constitute State Environment Impact Assessment Authority (SEIAA) and the State Expert Appraisal Committee (SEAC) for carry out similar environmental procedure at State level. The SEIAA shall grant or refuse Environmental Clearance to any B type project after screening - scoping – appraisal of Environmental Clearance applications at state level.

18. **CONCLUSION**

In short, an environmental impact assessment is an integral part of any project planning and must be understood with respect to the requirement of each project. A project proponent has to first determine whether the activity requires environmental clearance and undertake EIA studies to meet the requirements of MOEF. In case of joint venture projects (with a foreign company) and/or for seeking funds from an international financial institution, an environment impact statement has to conform to the environmental assessment guidelines. You must have a fairly good knowledge of, and must be capable of anticipating, the requirements and implications on project schedules and cost. It is an inescapable fact today that a EIA report needs to be prepared in a manner that conforms to national and international regulations and guidelines. It must be seen as a proactive, rather than a purely conformist document.

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Information on international conventions and treaties in the area of sustainable development are given below.

1. **Agenda 21**
   Agenda 21 is a comprehensive plan of action to be taken globally, nationally and locally by organizations of the United Nations System, Governments, and Major Groups in every area in which human impacts on the environment. Agenda 21, the Rio Declaration on Environment and Development, and the Statement of principles for the Sustainable Management of Forests were adopted by more than 178 Governments at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil, 3 to 14 June 1992.
   
   The Commission on Sustainable Development (CSD) was created in December 1992 to ensure effective follow-up of UNCED, to monitor and report on implementation of the agreements at the local, national, regional and international levels. It was agreed that a five year review of Earth Summit progress would be made in 1997 by the United Nations General Assembly meeting in special session.
   
   The full implementation of Agenda 21, the Programme for Further Implementation of Agenda 21 and the Commitments to the Rio principles, were strongly reaffirmed at the World Summit on Sustainable Development (WSSD) held in Johannesburg, South Africa from 26 August to 4 September 2002.

2. **The Convention on Biological Diversity**
   The Convention on Biological Diversity, commonly referred to as the **Biodiversity Treaty**, was one of two major treaties opened for signature at the United Nations Conference on Environment and Development (UNCED) in 1992. The treaty defines biodiversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."
   
   Parties to the Biodiversity Treaty "affirm sovereign rights over the biological resources found within their countries, while accepting responsibility for conserving biological diversity and using biological resources in a sustainable manner," according to an International Union for the Conservation of Nature (IUCN) assessment of the treaty.
   
   **Having secured its 30th ratification in September 1993, the Biodiversity Treaty entered into force December 29, 1993.** One hundred sixty-seven nations have signed the treaty since it was opened for signature at UNCED.

3. **Stockholm Convention on Persistent Organic Pollutants (POPs (Signed in May, 2002 but to be ratified by India)**
   The Stockholm Convention is a global treaty to protect human health and the environment from persistent organic pollutants (POPs). POPs are chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of living organisms and are toxic to humans and wildlife. POPs circulate globally and can cause damage wherever they travel. In implementing the
Sustainable Development Conventions and Treaties

Convention, Governments will take measures to eliminate or reduce the release of POPs into the environment.

4. **Prior Informed Consent (PIC), Rotterdam Convention** (For certain Hazardous Chemicals in International Trade) (Ratified on 24th May, 2005) The Rotterdam Convention is a multilateral environmental agreement designed to promote shared responsibility and cooperative efforts among Parties in the international trade of certain hazardous chemicals, in order to protect human health and the environment from potential harm and to contribute to their environmentally sound use by facilitating information exchange about their characteristics, providing for a national decision-making process on their import and export and disseminating these decisions to Parties.

In other words, the Convention enables the world to monitor and control the trade in certain hazardous chemicals. It is not a recommendation to ban the global trade or use of specific chemicals. It is rather an instrument to provide importing Parties with the power to make informed decisions on which chemicals they want to receive and to exclude those they cannot manage safely.

If trade takes place, requirements for labeling and provision of information on potential health and environmental effects will promote the safe use of these chemicals.

5. **Cartagena Protocol on Biosafety** India has ratified it on January 17, 2003. The Cartagena Protocol on Biosafety, the first international regulatory framework for safe transfer, handling and use of living Modified Organisms (LMOs) was negotiated under the aegis of the Convention on the Convention on Biological Diversity.

The Protocol seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology. It establishes an advance informed agreement (AIA) procedure for ensuring that countries are provided with the information necessary to make informed decisions before agreeing to the import of such organisms into their territory. It further incorporates procedure for import of LMOs with respect to Food Feed and Product (FFP), Risk Assessment and Risk Management Framework and Capacity Building. The Protocol contains reference to a precautionary approach and reaffirms the precaution language in Principle 15 of the Rio Declaration on Environment and Development. The Protocol also establishes a Biosafety Clearing-House to facilitate the exchange of information on living modified organisms and to assist countries in the implementation of the Protocol.

The protocol was adopted on 29th January 2000. The protocol has been signed by 103 countries (except USA). The Cabinet (GOI) approved the proposal and India signed the Biosafety Protocol on 23rd January 2001. Subsequent to the Cabinet approval on 5th September 2002, India has acceded to the Biosafety Protocol on 17th January 2003. So far 43 countries have ratified the protocol. The Protocol will come into force on the 90th day after the date of deposit of the
Sustainable Development Conventions and Treaties

fiftieth instrument for ratification by countries that are Parties to the Convention.

6. **The Basel Convention on the Control of Transboundary Movements of Hazardous Waste** A global agreement, ratified by several member countries and the European Union for addressing the problems and challenges posed by hazardous waste. The Secretariat, in Geneva, Switzerland, facilitates the implementation of the Convention and related agreements. It also provides assistance and guidelines on legal and technical issues, gathers statistical data, and conducts training on the proper management of hazardous waste. The Secretariat is administered by UNEP.

Key objectives of the Basel Convention

- To minimize the generation of hazardous wastes in terms of quantity and hazardousness;
- To dispose of them as close to the source of generation as possible;
- To reduce the movement of hazardous wastes.
- The following categories of hazardous waste are covered by the Convention. Toxic, poisonous, explosive, corrosive, flammable, ecotoxic and infectious.

7. **Kyoto Protocol to the United Nations Framework Convention on Climate Change** The negotiation of the Kyoto Protocol and its rulebook:

When they adopted the Convention, governments knew that its commitments would not be sufficient to seriously tackle climate change. At COP 1 (Berlin, March/April 1995), in a decision known as the Berlin Mandate, Parties therefore launched a new round of talks to decide on stronger and more detailed commitments for industrialized countries. After two and a half years of intense negotiations, the Kyoto Protocol was adopted at COP 3 in Kyoto, Japan, on 11 December 1997.

The complexity of the negotiations, however, meant that considerable “unfinished business” remained even after the Kyoto Protocol itself was adopted. The Protocol sketched out the basic features of its “mechanisms” and compliance system, for example, but did not explain the all-important rules of how they would operate. Although 84 countries signed the Protocol, indicating that they intended to ratify, but many were reluctant to actually do so and bring the Protocol into force before having a clearer picture of the treaty’s rulebook. A new round of negotiations was therefore launched to flesh out the Kyoto Protocol’s rulebook, conducted in parallel with negotiations on ongoing issues under the Convention. This round finally culminated at COP 7 with the adoption of the **Marrakesh Accords**, setting out detailed rules for the implementation of the Kyoto Protocol. As discussed above, the Marrakesh Accords made considerable progress regarding the implementation of the Convention.

8. **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)** CITES, Convention on International Trade in Endangered Species of Wild Fauna and Flora, is an international agreement between Governments with currently 166 member countries. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival.
Because the trade in wild animals and plants crosses borders between countries, the effort to regulate it requires international cooperation to safeguard certain species from over-exploitation. CITES was conceived in the spirit of such cooperation. Today, it accords varying degrees of protection to more than 30,000 species of animals and plants, whether they are traded as live specimens, fur coats or dried herbs.

CITES was drafted as a result of a resolution adopted in 1963 at a meeting of members of IUCN (The World Conservation Union). The text of the Convention was finally agreed at a meeting of representatives of 80 countries in Washington DC., United States of America, on March 3, 1973, and on July 1, 1975 CITES entered in force.

9. Helsinki Protocol to LRTAP on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 percent

The Protocol to the Convention on Long-range Transboundary Air Pollution on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent was entered into force in 1987. Twenty-one ECE countries are Parties to this Protocol, which aims at abating one of the major air pollutants. As a result of this Protocol, substantial cuts in sulphur emissions have been recorded in Europe: Taken as a whole, the 21 Parties to the 1985 Sulphur Protocol reduced 1980 sulphur emissions by more than 50% by 1993 (using the latest available figure, where no data were available for 1993). Also individually, based on the latest available data, all Parties to the Protocol have reached the reduction target. Eleven Parties have achieved reductions of at least 60%. Given the target year 1993 for the 1985 Sulphur Protocol, it can be concluded that all Parties to that Protocol have reached the target of reducing emissions by at least 30%.

10. Sofia Protocol to LRTAP concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes (NOx Protocol)

In 1988 the Protocol concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes was adopted in Sofia (Bulgaria). This Protocol requires as a first step, to freeze emissions of nitrogen oxides or their Transboundary Fluxes. The general reference year is 1987 (with the exception of the United States that chose to relate its emission target to 1978).

Taking the sum of emissions of Parties to the NOx Protocol in 1994, or a previous year, where no recent data are available, also a reduction of 9% compared to 1987 can be noted. Nineteen of the 25 Parties to the 1988 NOx Protocol have reached the target and stabilized emissions at 1987 (or in the case of the United States 1978) levels or reduced emissions below that level according to the latest emission data reported.

The second step to the NOx Protocol requires the application of an effects-based approach. Applying the multi-pollutant, multi-effect critical load approach, a new instrument being prepared at present should provide for further reduction of emissions of nitrogen compounds, including ammonia, and volatile organic compounds, in view of their contribution to photochemical pollution,
acidification and eutrophication, and their effects on human health, the
environment and materials, by addressing all significant emission sources.
The collection of scientific and technical information as a basis for a further
reduction in nitrogen oxides and ammonia, considering their acidifying as well as
nitrifying effects, is under way.

11. **Geneva Protocol to LRTAP concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes (VOCs Protocol)** In November 1991, the Protocol to the Convention on Long-range Transboundary Air Pollution on the Control of Emissions of Volatile Organic Compounds (VOCs, i.e. hydrocarbons) or their Transboundary Fluxes, the second major air pollutant responsible for the formation of ground level ozone, was adopted. It has entered into force on 29 September 1997.

**This Protocol specifies three options for emission reduction targets that have to be chosen upon signature or upon ratification:**

(i) 30% reduction in emissions of volatile organic compounds (VOCs) by 1999 using a year between 1984 and 1990 as a basis. (This option has been chosen by Austria, Belgium, Estonia, Finland, France, Germany, Netherlands, Portugal, Spain, Sweden and the United Kingdom with 1988 as base year, by Denmark with 1985, by Liechtenstein, Switzerland and the United States with 1984, and by Czech Republic, Italy, Luxembourg, Monaco and Slovakia with 1990 as base year);

(ii) The same reduction as for (i) within a Tropospheric Ozone Management Area (TOMA) specified in annex I to the Protocol and ensuring that by 1999 total national emissions do not exceed 1988 levels. (Annex I specifies TOMAs in Norway (base year 1989) and Canada (base year 1988));

(iii) Finally, where emissions in 1988 did not exceed certain specified levels, Parties may opt for a stabilization at that level of emission by 1999. (This has been chosen by Bulgaria, Greece, and Hungary).

12. **The Montreal Protocol on Substances that Deplete the Ozone Layer**

The Montreal Protocol on Substances that Deplete the Ozone Layer is a landmark international agreement designed to protect the stratospheric ozone layer. The treaty was originally signed in 1987 and substantially amended in 1990 and 1992. The Montreal Protocol stipulates that the production and consumption of compounds that deplete ozone in the stratosphere--chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform--are to be phased out by 2000 (2005 for methyl chloroform). Scientific theory and evidence suggest that, once emitted to the atmosphere, these compounds could significantly deplete the stratospheric ozone layer that shields the planet from damaging UV-B radiation. The United Nations Environment Programme (UNEP) has prepared a Montreal Protocol Handbook that provides additional detail and explanation of the provisions. (CIESIN's Thematic Guide on Ozone Depletion and Global Environmental Change) presents an-in-depth look at causes, human and environmental effects, and policy responses to stratospheric ozone depletion.)

The Vienna Convention for the Protection of the Ozone Layer (1985), which outlines states' responsibilities for protecting human health and the
environment against the adverse effects of ozone depletion, established the framework under which the Montreal Protocol was negotiated.

13. **United Nations World Summit on Sustainable Development (WSSD)**
The United Nations World Summit on Sustainable Development (WSSD) took place in Johannesburg, South Africa, from 26 August to 4 September 2002. The Johannesburg Summit, as it was also known, presented an opportunity for world leaders to adopt concrete steps and identify quantifiable targets for better implementing Agenda 21. Specific areas of focus in the WSSD Plan of Implementation include conserving marine biodiversity, protecting vulnerable areas such as coral reefs and wetlands, reducing marine pollution, eliminating illegal fishing, and achieving better coordination across ocean-related United Nations and regional organizations.

14. **Convention on Wetlands 1971 (Ramsar Convention)**
The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The Ramsar Convention, as it has become commonly known, was the first intergovernmental treaty between nations for the conservation of natural resources. There are presently 150 Contracting Parties to the Convention, with 1558 wetland sites, totaling 130.5 million hectares, designated for inclusion in the Ramsar List of Wetlands of International Importance.

In 1992, more than 100 heads of state met in Rio de Janeiro, Brazil, for the United Nations Conference on Environment and Development (UNCED). The Earth Summit, as UNCED was also known, was convened to address urgent problems of environmental protection and socio-economic development. The assembled leaders signed the Convention on Biological Diversity 1992 and adopted Agenda 21, a plan for achieving sustainable development in the 21st century.

The United Nations Convention on the Law of the Sea was opened for signature on 10 December 1982 in Montego Bay, Jamaica. This marked the culmination of more than 14 years of work involving participation by more than 150 countries representing all regions of the world. The convention entered into force in accordance with its article 308 on 16 November 1994. Today, the Convention on the Law of the Sea is the primary international legal document regulating all marine sector activities. It provides detailed provisions governing access to the seas, protection and preservation of the marine environment, the sustainable management of living resources, and the exploitation of non-living resources.

17. **Convention Concerning the Protection of the World Cultural and Natural Heritage 1972 (World Heritage Convention)**
The most significant feature of the 1972 World Heritage Convention is that it links together in a single document the concepts of nature conservation and the preservation of cultural properties. The Convention recognizes the way in which
people interact with nature, and the fundamental need to preserve the balance between the two.

18. Global Program of Action for the Protection of the Marine Environment from Land-Based Activities (GPA)
Over 100 governments adopted the GPA. The GPA is aimed at preventing the degradation of the marine environment from land-based activities, with targets including sewage, persistent organic pollutants, radioactivity, metals, oils, nutrients, sediment mobilisation, litter and habitat destruction. The GPA is designed to be a source of practical guidance to states in taking actions within their respective policies, priorities and resources.

19. Jakarta Mandate on Marine and Coastal Biological Diversity
In view of their common concern for the conservation and sustainable use of marine and coastal biodiversity, the parties to the Convention on Biological Diversity 1992 agreed on a program of action for implementing the convention. The program, called the Jakarta Mandate on Marine and Coastal Biological Diversity, was adopted in 1995.

20. MINAMATA CONVENTION IS ON MERCURY

21. Durban Summit (COP 17): The United Nations Climate Change Conference, Durban 2011, delivered a breakthrough on the international community's response to climate change. In the second largest meeting of its kind, the negotiations advanced, in a balanced fashion, the implementation of the Convention and the Kyoto Protocol, the Bali Action Plan, and the Cancun Agreements. The outcomes included a decision by Parties to adopt a universal legal agreement on climate change as soon as possible, and no later than 2015.

22. PARIS AGREEMENT (COP 21):
Paris Agreement: essential elements
The Paris Agreement builds upon the Convention and – for the first time – brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort. The Paris Agreement’s central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives. The Agreement also provides for enhanced transparency of action and support through a more robust transparency framework. Nationally determined contributions
The Paris Agreement requires all Parties to put forward their best efforts through “nationally determined contributions” (NDCs) and to strengthen these efforts in
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the years ahead. This includes requirements that all Parties report regularly on their emissions and on their implementation efforts.

In 2018, Parties will take stock of the collective efforts in relation to progress towards the goal set in the Paris Agreement and to inform the preparation of NDCs.

There will also be a global stock take every 5 years to assess the collective progress towards achieving the purpose of the Agreement and to inform further individual actions by Parties.

**Taking the Paris Agreement forward**

Through decision 1/CP.21, Parties also decided on a work programme to be undertaken in preparation to the full implementation of the Paris Agreement

**136 Parties have ratified of 197 Parties to the Convention**

On 5 October 2016, the threshold for entry into force of the Paris Agreement was achieved. The Paris Agreement entered into force on 4 November 2016. The first session of the Conference of the Parties serving as the Meeting of the Parties to the Paris Agreement (CMA 1) took place in Marrakech, Morocco from 15-18 November 2016.

**Status of ratification**

The Paris Agreement entered into force on 4 November 2016, thirty days after the date on which at least 55 Parties to the Convention accounting in total for at least an estimated 55 % of the total global greenhouse gas emissions have deposited their instruments of ratification, acceptance, approval or accession with the Depositary.

SOURCE: [http://wgbis.ces.iisc.ernet.in/biodiversity/sdev/conv.htm](http://wgbis.ces.iisc.ernet.in/biodiversity/sdev/conv.htm) and [http://unfccc.int](http://unfccc.int)

**NATIONAL LEGISLATION**

At national level serious efforts have been made for the improvement and protection of environment by incorporating changes the constitution of India. Our constitution, originally, did not contain any direct provision regarding the protection of natural environment. However, after the United Nations Conference on Human Environment, held in Stockholm in 1972, Indian constitution was amended to include protection of the environment as a constitutional mandate.

Although India had an Elephant’s Preservation Act of 1879 and a Forest Act of 1927, environment related legislation came very late in 1972 with Wild Life Protection Act 1971. India is one of the twelve mega diversity countries.

The forty second amendment Clause (g) to Article 51A of the Indian constitution made it a fundamental duty to protect and improve the natural environment.

“It shall to be duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wild life and have compassion for living creatures.” There is a directive, given to the State as one of the Directive Principles of State Policy regarding the protection and improvement of the environment. Article 48A
The State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country).

The department of Environment was established in India in 1980 to ensure a healthy environment for the country. This later became the Ministry of Environment and Forests in 1985. This Ministry has overall responsibility for administering and enforcing environmental legislations and policies.

The Environment Protection Act of 1986 (EPA) came into force soon after the Bhopal Gas Tragedy and is considered umbrella legislation as it fills many lacunae in the existing legislations. Thereafter, a large number of environmental legislations have been passed to deal with specific environmental problems. For example in the recent past the use of CNG for public transport vehicles has been made mandatory in Delhi. This has reduced air pollution in Delhi.

POLLUTION RELATED ACTS

The main objective of this act is to provide prevention and control of water pollution and maintaining or restoring of wholesomeness and purity of water (in the streams or wells or on land).

(ii) The Water (Prevention and Control of Pollution) Cess Act of 1977
The Water Cess Act was passed to generate financial resources to meet expenses of the Central and State Pollution Boards. The Act creates economic incentives for pollution control and requires local authorities and certain designated industries to pay a cess (tax) for water effluent discharge. These revenues are used to implement the Water Act.

The Central Government, after deducting the expenses of collection, pays the central board and the states such sums, as it seems necessary. To encourage capital investment in pollution control, the Act gives a polluter a 70% rebate of the applicable cess upon installing effluent treatment equipment.

The Air (Prevention and Control of Pollution) Act of 1981 and amendment, 1987
To implement the decisions taken at the United Nations Conference on the Human Environment held at Stockholm in June 1972, Parliament enacted the nationwide Air Act. The main objectives of this Act are to improve the quality of air and to prevent, control and abate air pollution in the country.

Environment Acts
The most important legislation in this category is The Environment (Protection) Act of 1986. Through this Act Central Government gets full power for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating pollution.
Details of this Act are given below:

(i) The Environment (Protection) Act of 1986
In the wake of the Bhopal tragedy, the government of India enacted the Environment (Protection) Act of 1986. The purpose of the Act is to implement the decisions of the
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United Nations Conference on the Human Environment of 1972, in so far as they relate to the protection and improvement of the human environment and the prevention of hazards to human beings, other living creatures, plants and property. The Act is an “umbrella” for legislations designed to provide a framework for Central Government, coordination of the activities of various central and state authorities established under previous Acts, such as the Water Act and the Air Act. In this Act, main emphasis is given to “Environment”, defined to include water, air and land and the inter-relationships which exist among water, air and land and human beings and other living creatures, plants, micro-organisms and property. “Environmental pollution” is the presence of pollutant, defined as any solid, liquid or gaseous substance present in such a concentration as may be or may tend to be injurious to the environment. “Hazardous substances” include any substance or preparation, which may cause harm to human beings, other living creatures, plants, microorganisms, property or the environment.

The Environment (Protection) Act was the first environmental legislation to give the Central Government authority to issue direct orders, included orders to close, prohibit or regulate any industry, operation or process or to stop or regulate the supply of electricity, water or any other service to an industry, operation and process. Another power granted to the Central Government was to ensure compliance with the Act which included the power of entry for examination, testing of equipment and other purposes and power to analyze the sample of air, water, soil or any other substance from any place.

BIODIVERSITY RELATED ACTS
India is one of the few countries, which had a forest policy since 1984. To protect forest and wild life following legislations have been enacted.

The Wild Life (Protection) Act of 1972 and Amendment, 1982
In 1972, Parliament enacted the Wild Life Act (Protection) Act. The Wild Life Act provides for state wildlife advisory boards, regulations for hunting wild animals and birds, establishment of sanctuaries and national parks, regulations for trade in wild animals, animal products and trophies, and judicially imposed penalties for violating the Act. Harming endangered species listed in Schedule 1 of the Act is prohibited throughout India. Hunting species, like those requiring special protection (Schedule II), big game (Schedule III), and small game (Schedule IV), is regulated through licensing. A few species classified as vermin (Schedule V), may be hunted without restrictions. Wildlife wardens and their staff administer the act.

An amendment to the Act in 1982, introduced a provision permitting the capture and transportation of wild animals for the scientific management of animal population. India is a signatory to the Convention of International Trade in Endangered Species of Fauna and Flora (CITES, 1976). Under this convention, export or import of endangered species and their products are governed by the conditions and stipulations laid down therein. Indian government has also started some conservation projects for individual

The Forest (Conservation) Act of 1980
First Forest Act was enacted in 1927. This is one of the many surviving colonial legislations. It was enacted to consolidate the law related to forest, the transit of forest produce and the duty livable on timber and other forest produce. Subsequently, the Forest (Conservation) Act was promulgated in 1980 to make certain reforms over the preceding Act of 1927. The 1927 Act deals with the four categories of the forests, namely reserved forests, village forests, protected forests and private forests. A state may declare forestlands or waste lands as reserved forest and may sell the produce from these forests. Any unauthorized felling of trees quarrying, grazing and hunting in reserved forests is punishable with a fine or imprisonment, or both reserved forests assigned to a village community are called village forests.

The state governments are empowered to designate protected forests and may prohibit the felling of trees, quarrying and the removal of forest produce from these forests. The preservation of protected forests is enforced through rules, licenses and criminal prosecutions.

Forest officers and their staff administer the Forest Act. Alarmed at India’s rapid deforestation and resulting environmental degradation, Centre Government enacted the Forest (Conservation) Act in 1980. Under the provisions of this Act, prior approval of the Central Government is required for diversion of forestlands for non-forest purposes. An Advisory Committee constituted under the Act advises the Centre on these approvals.

Biodiversity Act 2000
The Biological Diversity Bill 2002 has been passed by the Lok Sabha on 2nd December, 2002 and by the Rajya Sabha on 11th December, 2002.

The main intent of this legislation is to protect India’s rich biodiversity and associated knowledge against their use by foreign individuals and organizations without sharing the benefits arising out of such use, and to check biopiracy. The Act provides for setting up of a National Biodiversity Authority (NBA), State Biodiversity Boards (SBBs) and Biodiversity Management Committees (BMCs) in local bodies. NBA and SBB are required to consult BMCs in decisions relating to use of biological resources or related knowledge within their jurisdiction and BMCs are to promote conservation, sustainable use and documentation of biodiversity.

All foreign nationals or organizations require prior approval of NBA for obtaining biological resources and associated knowledge for any use. Indian individuals/ entities require approval of NBA for transferring results of research with respect to any biological resources to foreign nationals/organizations. Collaborative research projects and exchange of knowledge and resources under these projects are exempted provided they are drawn as per the policy guidelines of the Central Government and have its approval the objectives of conservation, sustainable use and benefit sharing. However, Indian citizens/entities/local people including vaids and hakims to have free access to use biological resources within the country for their own use, medicinal purposes and research purposes. While granting approvals, NBA will impose terms and conditions to secure equitable sharing of benefits. Before applying for any form of IPRs (Intellectual Property Rights) in or outside India for an invention based on research or information on a biological resource obtained from India, prior approval of NBA will be required.
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There is an enabling provision for setting up a framework for protecting traditional knowledge. The monetary benefits, fees, royalties as a result of approvals by NBA to be deposited in National Biodiversity Fund, which will be used for conservation and development of areas from where resource has been accessed, in consultation with the local self-government concerned. There is provision for notifying National Heritage Sites important from standpoint of biodiversity by State Governments in consultation with local self-government. There also exists provision for notifying items, and areas for exemption provided such exclusion does not violate other provisions. This is to exempt normally traded commodities so as not to adversely affect trade. This bill seeks to check biopiracy, protect biological diversity and local growers through three-tier structure of central and state boards and local committees. These will regulate access to plant and animal genetic resources and share the benefits. The proposed National Biodiversity Authority (NBA) will deal with all cases of access by foreigners. Its approval will be required before obtaining any intellectual property right on an invention based on a biological resource from India, or on its traditional knowledge. It will oppose such rights given in other countries. The NBA will enjoy the power of a civil court. In addition, centre may issue directives to state if it feels a naturally rich area is threatened by overuse, abuse or neglect.

ENVIRONMENT RELATED INSTITUTIONS AND ORGANISATIONS

HISTORICAL BACKGROUND TO ENVIRONMENTAL INSTITUTIONS IN INDIA
It is only in 1972 steps were initiated with the formation of the National Committee on Environmental Planning and Coordination (NCEPC) that gradually evolved as a separate department of environment and reached the full-fledged stage of Ministry of Environment and Forests in 1985. Initially the Constitution of India did not contain any provision towards the promotion/protection of environment. However, the 42nd amendment of the constitution in 1977 added some important clauses that entrusted the government the responsibility of providing a clean and well-protected environment.

NATIONAL ENVIRONMENTAL AGENCIES
The Ministry of Environment and Forest, Central Pollution Control Board, Indian Board for Wildlife are the main national environmental agencies.

Central Pollution Control Board
The Central Pollution Control Board (CPCB), is statutory organisation, was constituted in September, 1974 under the Water (Prevention and Control of Pollution) Act, 1974. Further, CPCB was entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981. It serves as a field formation and also provides technical services to the Ministry of Environment and Forests of the provisions of the Environment (Protection) Act, 1986.
Principal functions of the CPCB, as spelt out in the Water (Prevention and Control of Pollution) Act, 1974, and the Air (Prevention and Control of Pollution) Act, 1981, (i) to promote cleanliness of streams and wells in different areas of the States by prevention, control and abatement of water pollution, and (ii) to improve the quality of air and to prevent, control or abate air pollution in the country.
Air Quality Monitoring is an important part of the air quality management. The National Ambient Air Quality Monitoring (NAAQM) Programme has been established with the
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objectives to determine the present status of air quality, for controlling and regulating emission of air pollutants from industries and other sources to meet the air quality standards. It also provides background air quality data needed for setting of industries and town planning.

Fresh water is a finite resource essential for use in agriculture, industry, propagation of wildlife and fisheries and for human existence. India is a riverine country but there are numerous lakes, ponds and wells which are used as primary source of drinking water even without treatment. Most of the rivers being fed by monsoon rains, which are limited to only three months of the year, run dry throughout the rest of the year often carrying wastewater discharges from industries or cities or towns endangering the quality of our scarce water resources. The parliament of India in its wisdom enacted the Water (Prevention and Control of Pollution) Act, 1974 with a view to maintaining and restoring wholesomeness of our water bodies. One of the mandates of CPCB is to collect, collate and disseminate technical and statistical data relating to water pollution. Hence, Water Quality Monitoring (WQM) and Surveillance are of utmost importance.

The scheme of labeling of Environment Friendly Products is on anvil for household and other consumer products to meet certain environment criteria along with the quality requirements of Indian Standards. The scheme is known as Ecomark Scheme of India.

Environmental Governance and State Pollution Control Board
The umbrella Act, EPA (Environmental Protection Agency) 1986 added strength to all preceding provisions. Special stipulations were made for industrial, vehicular and noise pollution control in the country. In India, states do not pursue independent environmental policy of their own but adopt the policies formulated at the national level subject to such variations as may be necessary to suit to the local conditions. The central government has also been issuing guidelines to the states on various environmental matters.

INTERNATIONAL ENVIRONMENTAL AGENCIES
United Nations Environment Programme (UNEP), World Health Organisation (WHO) and Food and Agriculture Organisation (FAO) are some of the main international agencies.

United Nations Environment Programme (UNEP)
UNEP was created by United Nations General Assembly, as an outgrowth of the United Nations Conference on the Human Environment, held in Stockholm, Sweden that same year. The United Nations Conference on the Environment and Development took place in Rio de Janeiro in 1992 and the World Summit on Sustainable Development, held in Johannesburg in 2002 (also known as RIO+10) did not substantially change its configuration. It is headquartered in Nairobi (Kenya).
UNEP’s main mandate is to coordinate the development of environmental policy for keeping the global environment under review and bringing emerging issues to the attention of governments and the international community for action. Its activities cover a wide range of issues encompassing the atmosphere, marine and terrestrial ecosystems. UNEP has played a significant role in developing international
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environmental conventions, promoting environmental science and information and illustrating the way those can work with national governments and regional institution and Non-Governmental Organizations (NGOs). UNEP has also been active in funding and implementing environment related development projects for promoting sustainable development through sound environmental practices.

The implementation of UNEP’s work is done by the following seven divisions:
- Early Warning and Assessment
- Environmental Policy Implementation
- Technology, Industry and Economics
- Regional Cooperation
- Environmental Law and Conventions
- Global Environment Facility Coordination
- Communications and Public Information

Among UNEP’s many initiatives is the “Clean Up the World” campaign, which attempts to build awareness throughout the world regarding the huge impacts of our modern lifestyle.

UNEP has aided in the development of guidelines and treaties on issues such as the international trade in potentially harmful chemicals, transboundary air pollution, and contamination of international waterways. The World Meteorological Organization and the UNEP established the Intergovernmental Panel on Climate Change (IPCC) in 1988. UNEP is also one of several Implementing agencies for the Global Environment Facility (GEF).

World Health Organisation (WHO)

Constitution and history

The WHO’s constitution states that its objective “is the attainment by all peoples of the highest possible level of health.”. Its major task is to combat disease, especially key infectious diseases, and to promote the general health of the people of the world.

The World Health Organization (WHO)
It is one of the original agencies of the United Nations, its constitution formally coming into force on the first World Health Day, (7 April 1948), when it was ratified by the 26th member state. The WHO has 193 Member States.

Activities
Activities of WHO includes coordinating international efforts to monitor outbreaks of infectious diseases, such as SARS (Severe Acute Respiratory Syndrome), malaria, swine flu, and AIDS as well as to sponsor programs to prevent and treat such diseases. The WHO supports the development and distribution of safe and effective vaccines, pharmaceutical diagnostics and drugs. After over two decades of fighting smallpox, the WHO declared in 1980 that the disease had been eradicated - the first disease in history to be eliminated by human effort, WHO aims to eradicate polio within the next few years. In addition to its work in eradicating disease. WHO is devoting increasing attention to various health-environment related issues— for example, campaigns to boost the consumption of fruits and vegetables worldwide and to discourage tobacco use. Environment and health are closely related. The Principle of the Rio Declaration on Environment and Development, 1992 states “human beings are at the centre of concern
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for sustainable development. They are entitled to a healthy and productive life in harmony with nature.” Environmental hazards are responsible for an estimated 25% of the total burden of disease worldwide.

**HELI**

To tackle environment related health hazards WHO has developed Health Environment Link Initiative (HELI). HELI is a global effort by WHO and UNEP to support action by developing country policymakers on environmental threats to health. HELI encourages countries to address health and environment issues as integral to economic development. HELI supports valuation of ecosystem ‘services’ to human health and wellbeing – services ranging from climate regulation to provision or replenishment of air, water, food and energy sources and generally healthy living and working environments. HELI activities include country-level pilot projects.

**Food and Agriculture Organization of the United Nations (FAO)**

It is a specialised agency of the United Nations with a member states that leads international efforts to defeat hunger. Serving both developed and developing countries, FAO acts as a neutral forum where all nations meet as equals to negotiate agreements and debate policy. FAO is also a source of knowledge and information, and helps developing countries and countries in transition modernise and improve agriculture, forestry and fisheries practices, ensuring good nutrition and food security for all. Its Latin motto, *fiat panis*, translates into English as “let there be bread”. The FAO headquarters are located in ROME WHO member states appoint delegations to the World Health Assembly, WHO’s supreme decision-making body. All UN member states are eligible for WHO membership and according to the WHO web site, “Other countries may be admitted as members when their application has been approved by a simple majority vote of the World Health Assembly.”

**NON GOVERNMENTAL ORGANISATION**

**INTERNATIONAL UNION FOR CONSERVATION OF NATURE (IUCN)**

International Union for Conservation of Nature (IUCN) is the world’s oldest and largest global environmental network - a democratic membership union with more than 1,000 government and NGO member organizations, and almost 11,000 volunteer scientists in more than 160 countries. IUCN’s work is supported by over 1,000 professional staff in 60 offices and hundreds of partners in public, NGO and private sectors around the world. The Union’s headquarters are located in Gland, near Geneva, in Switzerland. IUCN works to develop pragmatic solutions to the most pressing environment and development challenges. It supports scientific research, manages field projects all over the world and brings governments, non-government organizations, United Nations agencies, companies and local communities together to develop and implement policy, laws and best practice.

**WORLDWIDE FUND FOR NATURE (WWF)**

The World Wide Fund for Nature (WWF) is an international non-governmental organization working on issues regarding the conservation, research and restoration of the environment, formerly named the World Wildlife Fund, which remains its official name in the United States and Canada. It is the world’s largest independent conservation organization with over 5 million supporters worldwide, working in more
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than 90 countries, supporting around 1300 conservation and environmental projects around the world. It is a charity, with approximately 60% of its funding coming from voluntary donations by private individuals. 45% of the fund’s income comes from the United States, the United Kingdom, and the Netherlands.

The mission of WWF is “to halt and reverse the destruction of our environment” Currently, much of its work focuses on the conservation of three biomes that contain most of the world’s biodiversity: forests, freshwater ecosystems and oceans and coasts. Among other issues, it is also concerned with endangered species, pollution and climate change.

The organization was formed as a charitable trust on September 11, 1961, in Morges, Switzerland, under the name World Wildlife Fund. It was an initiative of Julian Huxley and Max Nicholson, who had thirty years experience of linking progressive intellectuals with big business interests through the Political and Economic Planning think tank. In its deed of foundation, the organization stated its original mission to be the “conservation of world fauna, flora, forests, landscape, water, soils and other natural resources by the management of land, research and investigation, and publicity, coordination of efforts, cooperation with other interested parties and all other appropriate means.”

The initial focus of its activities was the protection of endangered species. As more resources became available, its operations expanded into other areas such as the preservation of biological diversity, sustainable use of natural resources, and the reduction of pollution and wasteful consumption.

In 1986, the organization changed its name to World Wide Fund for Nature, retaining the WWF initials, to better reflect the scope of its activities. However, it continues to operate under the original name in the United States and Canada Green peace

In 1971, motivated by their vision of a green and peaceful world, a small team of activists set sail from Vancouver, Canada, in an old fishing boat. These activists, the founders of Greenpeace, believed a few individuals could make a difference.

Their mission was to “bear witness” to US underground nuclear testing at Amchitka, a tiny island off the West Coast of Alaska, which is one of the world’s most earthquake-prone regions. Amchitka was the last refuge for 3000 endangered sea otters, and home to bald eagles, peregrine falcons and other wildlife. Even though their old boat, the Phyllis Cormack, was intercepted before it got to Amchitka, the journey sparked a flurry of public interest. The US still detonated the bomb, but the voice of reason had been heard. Nuclear testing on Amchitka ended that same year, and the island was later declared a bird sanctuary.

Greenpeace is the world’s largest grassroots environmental network, uniting 77 national member groups and some 5,000 local activist groups on every continent. With over 2 million members and supporters around the world, they campaign on today’s most urgent environmental and social issues. Based in Amsterdam, the Netherlands, Greenpeace has 2.8 million supporters worldwide, and national as well as regional offices in 41 countries.

Today, Greenpeace is an international organisation that prioritises global environmental campaigns.
Greenpeace’s cornerstone principles and core values are:
• to prevent environmental destruction in a peaceful, non-violent manner;
• financial independence from political or commercial interests;
• seek solutions for and promote open, informed debate about society’s environmental choices.

**TATA ENERGY RESEARCH INSTITUTE (TERI)**
TERI is a public interest research and advocacy organisation that promotes environmentally sound and equitable development strategies. It was formally established in 1974 with the purpose of tackling and dealing with the rapid depletion of the earth’s finite energy resources which are largely non-renewable, and on account of the existing methods of their use which are polluting.

TERI has been actively working for developing solutions to global problems in the fields of energy, environment and current patterns of development, which are largely unsustainable.

It organizes annual Delhi Sustainable Development Summit (DSDS), a major event focusing on sustainable development, the pursuit of the Millennium Development Goals (MDGs) and assessment of worldwide progress in these critical areas. TERI has also established a World Sustainable Development Forum (WSDF), which is guided by the patronage of a group of select world leaders. WSDF would extend the experience of each DSDS to other parts of the world and carry out careful evaluation and monitoring of developments worldwide, particularly in meeting the MDGs.

**NATIONAL NON-GOVERNMNETAL ORGANISATIONS (NGOS)**

**Centre for Science and Environment (CSE)**
The Centre for Science and Environment (CSE) is a public interest research and advocacy organisation based in New Delhi. CSE researches into lobbies for and communicates the urgency of development that is both sustainable and equitable. The challenge of environmental degradation due to extreme exploitation of natural resources on one hand and problems created by rapid industrialization on the other hand, is one of the important task taken up by CSE to bring about a balance of the two. CSE makes efforts to create awareness about problems and propose sustainable solutions.

Two of their interesting publications are ‘Down to Earth’ and ‘Gobar Times’ magazine for children.

**Kalpavriksh**
An NGO established in 1979 and works on environmental awareness, campaigns, litigation, research, and other areas.
Kalpavriksh believes that a country can develop meaningfully only when ecological sustainability and social equity are guaranteed, and a sense of respect for, and oneness with nature, and fellow humans is achieved. It is a non-hierarchical organisation and the group takes all decisions after appropriate debate and discussion.

**Development Alternatives**
Sustainable Development Conventions and Treaties

It is a non-profit organization engaged in research and action for sustainable
development. It was established in 1983 and is registered under the Societies
Registration Act with the Government of India.
The corporate objectives are to innovate and disseminate the means for creating
sustainable livelihoods on a large scale, and thus to mobilise widespread action to
eradicate poverty and regenerate the environment.

Sulabh International
Sulabh International is a social service organization which works to promote human
rights, environmental sanitation, and non-conventional sources of energy, waste
management and social reforms through education. It was founded by Dr Bindeshwar
Pathak in 1970. It has played a defining role in changing the mindset of the people of
India towards sanitation. It has played an important role in preventing the practice of
defecation in the open and have motivated people for using of toilets and following
sanitation practices. In October 2007, Sulabh announced the design of a cheap toilet
system that recycles human waste into biogas and fertiliser.
WHAT IS BIOLOGICAL DIVERSITY
Sum total of all the variety of living organisms on earth constitute biodiversity. Biological diversity is usually considered at three different levels – a) genetic diversity i.e. at genetic level, b) species diversity i.e. at the level of species, and c) ecosystem diversity i.e. at the level of ecosystem.

Genetic diversity
Each species, varying from bacteria to higher plants and animals, stores an immense amount of genetic information. For example, the number of genes is about 450-700 in mycoplasma, 4000 in bacteria (eg. Escherichia coli), 13,000 in Fruit-fly (Drosophila melanogaster); 32,000 – 50,000 in rice (Oryza sativa); and 35,000 to 45,000 in human beings (Homo sapiens sapiens). This variation of genes, not only of numbers but of structure also, is of great value as it enables a population to adapt to its environment and to respond to the process of natural selection. If a species has more genetic variation, it can adapt better to the changed environmental conditions. Lower diversity in a species leads to genetic uniformity of genetically similar crop plants. This homogeneity is desirable in producing uniform quality of grain. But genetic uniformity restricts adaptability of a species to environmental stress as all the plants have same level of resistance. With the above background, genetic diversity refers to the variety of genes contained within species of plants, animals and micro-organisms. New genetic variation in individuals occurs by gene and chromosomal mutation, and in organisms with sexual reproduction may be spread across the population by recombination. For instance, two brothers differ in their structure, although their parents are the same. The differences could be in alleles (different variants of the same gene), in entire gene (the traits determining particular characteristics) or in chromosomal structure. The amount of genetic variation (gene pool) present in an inter-breeding population is shaped or decided by the process of natural selection. Selection leads to certain genetic attributes being preferred and results in changes in the frequency of genes within this pool. This forms the basis of adaptation among the living organisms. India has high genetic diversity and is regarded as a Vavilov’s centre of high crop genetic diversity – so named after the Russian agro-botanist N I Vavilov, who identified eight such centres of origin of cultivated plants around the world in the 1950s.

15.1.2 Species diversity
Species diversity refers to the variety of species within a geographical area. Species diversity can be measured in terms of:
(a) **Species richness** – refers to the number of various species in a defined area.
(b) **Species abundance** – refers to the relative numbers among species. For example, the number of species of plants, animals and microorganisms may be more in an area than that recorded in another area.
(c) **Taxonomic or phylogenetic diversity** – refers to the genetic relationships between different groups of species. Kinds of species that are present in an area is also important. When taxonomically unrelated species are present in an area, the area represents greater species diversity as compared to an area represented by taxonomically related species. At the global level, an estimated 1.7 million species of living organisms have been described to date and many more are yet to be discovered. It has been currently estimated that the total number of species may vary from 5 - 50 millions. Species
diversity is not evenly distributed across the globe. The overall richness of species is concentrated in equatorial regions and tends to decrease as one moves from equatorial to polar regions. In addition, biodiversity in land ecosystems generally decreases with increasing altitude. The other factors that influence biodiversity are amount of rainfall and nutrient level in soil. In marine ecosystems, species richness tends to be much higher in continental shelves. India is a country of vast diversity (Fig. 15.2) and it is among the 12 “mega-diversity” countries in the world.

**Ecosystem diversity**

It refers to the presence of different types of ecosystems. For instance, the tropical south India with rich species diversity will have altogether different structure compared to the desert ecosystem which has far less number of plant and animal species. Likewise, the marine ecosystem although has many types of fishes, yet it differs from the freshwater ecosystem of rivers and lakes in terms of its characteristics. So such variations at ecosystem level are termed as ecosystem diversity.

As stated above, ecosystem diversity encompasses the broad differences between ecosystem, and the diversity of the habitats and ecological processes occurring within each ecosystem type. India has very diverse terrestrial and aquatic ecosystems ranging from ice-capped Himalayas to deserts, from arid scrub to grassland to wetlands and tropical rainforests, from coral reefs to the deep sea. Each of these comprises a great variety of habitats and interactions between and within biotic and abiotic components. The most diversity-rich are western-ghats and the north-eastern region. A very large number of species found in these ecosystems are **endemic** or found in these areas only in India i.e. they are found no where else except in India. The endemics are concentrated mainly in north-east, western-ghats, north-west Himalaya, and Andaman and Nicobar Islands. About 33% of the flowering plants recorded in India are endemic to our country. Indian region is also notable for endemic fauna. For example, out of recorded vertebrates, 53% freshwater fish, 60% amphibians, 36% reptiles and 10% mammalian fauna are endemic.

**Hot spots of biodiversity**

Biodiversity is not uniformly distributed across the geographical regions of the earth. Certain regions of the world are very rich in biodiversity. We call such areas as “mega diversity zones”. We also refer to them as “hot-spots”. For example, **India accounts for only 2.4 % of the land area of the world; but it contributes approximately 8% species to the global diversity** due to existence of such pockets. **Norman Myers**, a British Ecologist, developed the concept of hot spots in **1988 to designate priority areas for in situ conservation**. According to him, the hot spots are the richest and the most threatened reservoirs of biodiversity on the earth. The criteria for determining a hot spot are:

i) The area should support >1500 endemic species,

ii) It must have lost over 70 % of the original habitat

Twenty-five biodiversity hot spots have been identified in the world. These hot spots are characterized by posing exceptionally high biodiversity. For example the total area of these 25 hot spots cover 1.4% of the total land area, support 44% of plant and 35% terrestrial vertebrates
Among the 25 hot spots of the world, 2 are found in India namely western ghats and the eastern Himalayas. These two areas of the country are exceptionally rich in flowering plants, reptiles, amphibians, butterflies and some species of mammals.

The eastern Himalayan hot spot extends to the north – eastern India and Bhutan. The temperate forests are found at an altitude of 1780 to 3500 m. Many deep and semiisolated valleys are exceptionally rich in endemic plant species.

The Western Ghat region lies parallel to the western coast of Indian peninsula for almost 1600 km, in Maharashtra, Karnataka, Tamil Nadu and Kerala. These forests at low elevation (500 m above mean sea level) are mostly evergreen, while those at 500-1500 m height are generally semi-evergreen forests.

WHY IS BIOLOGICAL DIVERSITY IMPORTANT

The various benefits of biological diversity can be grouped under three categories: a) ecosystem services, b) biological resources, and c) social benefits.

**Ecosystem services**

**i) Protection of water resources:** Natural vegetation cover helps in maintaining hydrological cycles, regulating and stabilizing water run-off and acting as a buffer against extreme events such as floods and droughts. Vegetation removal results in siltation of dams and waterways. Wetlands and forests act as water purifying systems, while mangroves trap silt thereby reducing impacts on marine ecosystems.

**ii) Soil protection:** Biological diversity helps in the conservation of soil and retention of moisture and nutrients. Clearing large areas of vegetation cover has been often seen to accelerate soil erosion, reduce its productivity and often result in flash floods. Root systems allows penetration of water to the sub soil layer. Root system also brings mineral nutrients to the surface by nutrient uptake.

**iii) Nutrient storage and cycling:** Ecosystem perform the vital function of recycling nutrients found in the atmosphere as well as in the soil. Plants are able to take up nutrients, and these nutrients then can form the basis of food chains, to be used by a wide range of life forms. Nutrients in the soil, in turn, is replenished by dead or waste matter which is transformed by micro-organisms; this may then feed others such as earthworms which also mix and aerate the soil and make nutrients more readily available.

**iv) Pollution reduction:** Ecosystems and ecological processes play an important role in maintenance of gaseous composition of the atmosphere, breakdown of wastes and removal of pollutants. Some ecosystems, especially wetlands have the ability to breaking down and absorb pollutants. Natural and artificial wetlands are being used to filter effluents to remove nutrients, heavy metals, suspended solids; reduce the BOD
(Biological Oxygen Demand) and destroy harmful micro-organisms. Excessive quantities of pollutants, however, can be detrimental to the integrity of ecosystems and their biota.

**v) Climate stability:** Vegetation influences climate at macro as well as micro levels. Growing evidence suggests that undisturbed forests help to maintain the rainfall in the vicinity by recycling water vapor at a steady rate back into the atmosphere. Vegetation also exerts moderating influence on micro climate. Cooling effect of vegetation is a common experience which makes living comfortable. Some organisms are dependent on such microclimates for their existence.

**vi) Maintenance of ecological processes:** Different species of birds and predators help to control insect pests, thus reduce the need and cost of artificial control measures. Birds and nectar–loving insects which roost and breed in natural habitats are important pollinating agents of crop and wild plants. Some habitats protect crucial life stages of wildlife populations such as spawning areas in mangroves and wetlands. Without ecological services provided by biodiversity it would not be possible to get food, pure air to breathe and would be submerged in the waste produced.

**Biological resources of economic importance**

**i) Food, fibre, medicines, fuel wood and ornamental plants:** Five thousand plant species are known to have been used as food by humans. Presently about 20 species feed the majority of the world’s population and just 3 or 4 only are the major staple crops to majority of population in the world. A large number of plants and animals materials are used for the treatment of various ailments. The usage of medicinal plants in India has an ancient history, dating back to the pre-vedic culture, at least 4000 years B. C. The therapeutic values of herbal medicines led to evolution of Ayurveda which means “science of life”. It is estimated that at least 70 % of the country’s population rely on herbal medicines and over 7000 species of plants are used for medicinal purposes. Wood is a basic commodity used worldwide for making furniture and for building purposes. Fire wood is the primary source of fuel widely used in third world countries. Wood and bamboo are used for making paper. Plants are the traditional source of fibre such as coir, hemp, flax, cotton, jute.

**ii) Breeding material for crop improvement:** Wild relatives of cultivated crop plants contain valuable genes that are of immense genetic value in crop improvement programmes. Genetic material or genes of wild crop plants are used to develop new varieties of cultivated crop plants for restructuring of the existing ones for improving yield or resistance of crops plants. For example: rice grown in Asia is protected from four main diseases by genes contributed by a single wild rice variety.

**iii) Future resources:** There is a clear relationship between the conservation of biological diversity and the discovery of new biological resources. The relatively few developed plant species currently cultivated have had a large amount of research and selective breeding applied to them. Many presently under-utilised food crops have the potential to become important crops in the future. Knowledge of the uses of wild plants by the local people is often a source for ideas on developing new plant products.

**Social benefits**
i) Recreation: Forests, wildlife, national parks and sanctuaries, garden and aquaria have high entertainment and recreation value. Ecotourism, photography, painting, film making and literary activities are closely related.

ii) Cultural values: Plants and animals are important part of the cultural life of humans. Human cultures have co-evolved with their environment and biological diversity can impart a distinct cultural identity to different communities.

The natural environment serves the inspirational, aesthetic, spiritual and educational needs of the people, of all cultures. In a majority of Indian villages and towns, plants like Tulsi (Ocimum sanctum), Peepal (Ficus religiosa), Khejri (Prosopis cineraria) are planted and considered sacred and worshipped.

Research, Education and Monitoring
There is still much to learn on how to get better use from biological resources, how to maintain the genetic base of harvested biological resources, and how to rehabilitate degraded ecosystems. Natural areas provide excellent living laboratories for such studies, for comparison with other areas under systems of use and for valuable research in ecology and evolution.

UNIQUENESS OF INDIAN BIODIVERSITY AND ASSOCIATED REGIONAL SPECIFICITY
India is uniquely rich in all aspects of biodiversity including ecosystem, species and genetic biodiversity. For any one country in the world, it has perhaps the largest array of environmental situations by virtue of its tropical location, varied physical features and climate types. India has the widest variety of ecosystems. With only 2.4% of the land area, India accounts for 7-8% of the recorded species of the world. More than 45000 species of plants and 81,000 species of animals are found in India. India is also one of the eight primary centers of origin of cultivated plants and has a rich agricultural biodiversity. The trans-Himalayan region with its sparse vegetation has the richest wild sheep and goat community in the world. The snow leopard (Panthera uncia) and Black-necked Crane (Grus nigricollis) are found here. The Great Indian Bustard (Ardeotis nigriceps) which is highly endangered bird, is found in (Gujrat) region, rich in extensive grasslands. North-east India is one of the richest regions of biodiversity in the country. It is especially rich in orchids, bamboos, ferns, citrus, banana, mango and jute. India is also rich in coral reefs. Major reef formations in Indian seas occur in the Gulf of Mannar, Palk Bay, Gulf of Kutch, the Andaman and Nicobar Islands and the Lakshadweep. The threat to mangroves trees (growing in marshy lands) and coral reefs comes from the biotic pressure such as extraction for market demands, fishing, land-use changes in surrounding areas, and from pollution of water etc.

CAUSES OF BIODIVERSITY DEPLETION
Loss of species is a serious cause of concern for human survival. It has been observed that 79 species of mammals, 44 of birds, 15 of reptiles and 3 of amphibians are threatened. Nearly 1500 species of plants are endangered in India. The threat to survival or loss may be caused in the following three ways:
• **Direct ways**: Deforestation, hunting, poaching, commercial exploitation.
• **Indirect ways**: Loss or modification of the natural habitats, introduction of exotic species, pollution, etc.
• **Natural causes** - Climate change.

Among these causes, habitat destruction and over-exploitation are the main.

**i) Habitat (natural home) destruction** may result from clearing and burning forests, draining and filling of wetlands, converting natural areas for agricultural or industrial uses, human settlements, mines, building of roads and other developmental projects. This way the natural habitats of organisms are changed or destroyed. These change either kill or force out may species from the area causing disruption of interactions among the species. Fragmentation of large forest tracts (eg. the corridores) affects the species occupying the deeper part of the forest and are first to disappear. Apart from the direct loss of species during the development activities, the new environment is unsuitable for the species to survive. Over exploitation reduces the size of the population of a species and may push it towards extinction.

**ii) Introduction of exotic species**: Seeds catch on people's clothes. Mice, rats and birds hitch-hike on ships. When such species land in new places, they breed extra fast due to absence of any enemy and often wipe out the native species already present there. **Exotic species (new species entering geographical region) may wipe out the native ones.** A few examples are-

(i) Parthenium hysterophorus (Congress grass- a tropical American weed) has invaded many of the vacant areas in cities, towns and villages in India leading to removal of the local plants and the dependent animals.

(ii) Nile perch, an exotic predatory fish introduced into Lake Victoria (South Africa) threatened the entire ecosystem of the lake by eliminating several native species of the small Cichlid fish that were endemic to this freshwater aquatic system.

(iii) Water hyacinth clogs lakes and riversides and threatens the survival of many aquatic species. This is common in Indian plains.

(iv) Lantana camara (an American weed) has invaded many forest lands in various parts of India and wiped out the native grass species.

**iii) Pollution**: Air pollution, acid rain destroy forests. Water pollution kills fishes and other aquatic plants and animals. Toxic and hazardous substances drained into waterways kill aquatic life. Oil spills kill coastal birds, plants and other marine animals. Plastic trash entangles wildlife. It is easy to see how pollution is a big threat to biodiversity.

**iv) Population growth and poverty**: Over six billion people live on the earth. Each year, 90 million more people are added. All these people use natural resources for food, water, medicine, clothes, shelter and fuel. Need of the poor and often greed of the rich generate continuous pressure resulting in over-exploitation and loss of biodiversity.
### BIODIVERSITY CONSERVATION+
#### Soil and Land Degradation

**The World Conservation Union (IUCN)** (formerly known as International Union for the Conservation of Nature and Natural Resources, IUCN) has recognized eight Red List categories according to the conservation status of species.

<table>
<thead>
<tr>
<th>List</th>
<th>Category Definition</th>
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<tbody>
<tr>
<td>Extinct</td>
<td>A taxon is extinct when there is no reasonable doubt that the last individual has died.</td>
</tr>
<tr>
<td>Extinct in the wild</td>
<td>A taxon is extinct in the wild when exhaustive surveys in known and/or expected habitats have failed to record an individual.</td>
</tr>
<tr>
<td>Critically endangered</td>
<td>A taxon is critically endangered when it is facing high risk of extinction in the wild in immediate future. <strong>PIGMY HOG</strong></td>
</tr>
<tr>
<td>Endangered</td>
<td>A taxon is endangered when it is not critically endangered but is facing a very high risk of extinction in the wild in near future. <strong>RED PANDA</strong></td>
</tr>
<tr>
<td>Vulnerable</td>
<td>A taxon is vulnerable when it is not critically endangered or endangered but is facing high risk of extinction in the wild in the medium term future. <strong>BLACK BUCK</strong></td>
</tr>
<tr>
<td>Lower risk</td>
<td>A taxon is lower risk when it has been evaluated and does not satisfy the criteria for critically endangered, endangered or vulnerable.</td>
</tr>
<tr>
<td>Data deficient</td>
<td>A taxon is data deficient when there is inadequate information to make any direct or indirect assessment of its risk of extinction.</td>
</tr>
<tr>
<td>Not evaluated</td>
<td>A taxon is not evaluated when it has not yet been assessed against the above criteria.</td>
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### Status of threatened species

The IUCN Red List is an authentic source of information for this purpose. The 2000 Red List is the latest available. It uses a set of criteria, relevant to all species and all regions of the world, to evaluate the extinction risk of species. The 2000 Red List contains assessment of more than 18,000 species; 11,000 of which are threatened (5,485 animals and 5611 plants). Out of these, 1,939 are listed as critically endangered (925 animals, and 1,014 plants). **According to the Red List, in India, 44 plant species are critically endangered., 113 endangered and 87 vulnerable. Amongst animals, 18 are critically endangered, 54 endangered and 143 Vulnerable.**

### CONSERVATION OF BIODIVERSITY

Conservation is the planned management of natural resources, to retain the balance in nature and retain the diversity. It also includes wise use of natural resources in such a way that the needs of present generation are met and at the same time leaving enough for the future generations. Conservation of biodiversity is important to:-

- prevent the loss of genetic diversity of a species,
- save a species from becoming extinct, and
• protect ecosystems damage and degradation.

CONSERVATION STRATEGIES

Conservation efforts can be grouped into the following two categories:

1. **In-situ** (on-site) conservation includes the protection of plants and animals within their natural habitats or in protected areas. Protected areas are land or sea dedicated to protect and maintain biodiversity.

2. **Ex-situ** (off-site) conservation of plants and animals outside their natural habitats. These include botanical gardens, zoo, gene banks, seek bank, tissue culture and cryopreservation.

**In-situ methods**

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

• **National parks and sanctuaries**

  The Jim Corbett Tiger Reserve- Uttaranchal, Kanha National Park, Madhya Pradesh, Bandhavgarh National Park- Madhya Pradesh, Ranthambhor National Park-Sawai Madhopur Gir National Park-Sasangir (Gujarat)

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

Some of them are given below along with important species found there.

- Kaziranga sanctuary (Assam) – One-horned rhinoceros
- Manas sanctuary (Assam) – Wild buffaloes
Biodiversity Conservation

Soil and Land Degradation

- Gir forest (Gujarat) – Lions, chital, sambar, wild bears
- Kelameru bird sanctuary (Andhra Pradesh) – Pelicans and marine birds
- Bandipur sanctuary (Karnataka) – Indian bison, elephants, langurs
- Periyar sanctuary (Kerala) – Elephants, barking deer, sambhar
- Kanha National Park (Madhya Pradesh) – Tiger, leopards, wild dogs

- Simipal National Park (Orissa) – Mangroves, marine turtles lay eggs
- Bharatpur bird sanctuary (Rajasthan) – Ducks, herons
- Corbett National Park (Uttaranchal) – Tigers, barking deer, sambar, wild bear, rhesus monkey.
- Jaladpara sanctuary (West Bengal) – Rhinoceros

Biosphere Reserves

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

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

The main functions of the biosphere reserves are:

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

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

Soil and Land Degradation

their habitats.

- **Project Tiger – A success in species conservation**

  Tigers which were once abundant in Indian forests have been hunted. As a result tiger population within the country declined drastically from estimate of 40,000 at the turn of century to 1200 by the 1970. This led to initiate the Project Tiger in 1973 with the objective of conserving and rescuing this species from extinction. In 2007, there were more than 40 Project Tiger wildlife reserves covering an area of 37,761 km². Project Tiger helped to increase the population of these tigers from 1,200 in the 1970s to 3,500 in 1990s. However, a 2008 census held by Government of India revealed that the tiger population had dropped to 1,411. A total ban has been imposed on hunting of tigers and trading in tiger products at the national and international levels. Elaborate management plans are made for each of the tiger reserves for tiger habitat improvement and anti-poaching measures.

- **Project Elephant**

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

- **Crocodile breeding and management project**

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

- **Sacred forests and sacred lakes**

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

- **Ex-situ Conservation**

  (i) **Botanical gardens, zoos, etc.** To complement in-situ conservation efforts, ex-situ conservation is being undertaken through setting up botanic gardens, zoos, medicinal plant parks, etc by various agencies. The Indian Botanical Garden in Howrah (West Bengal) is over 200 years old. Other important botanical gardens are in Ooty, Bangalore and Lucknow. The most recent one is The Botanical Garden of Indian
Republic established at NOIDA, near Delhi in April, 2002. The main objectives of this garden are –
• ex-situ conservation and propagation of important threatened plant species,
• serve as a Centre of Excellence for conservation, research and training,
• build public awareness through education on plant diversity and need for conservation.

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

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

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

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

Legal measures: Market demand for some body parts like bones of tiger, rhino horns, furs, ivory, skins, musk, peacock feathers, etc results in killing the wild animals.

The Wildlife Protection Act (1972) contain provisions for penalties or punishment to prevent poaching and illegal trade. India is also a signatory to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The Convention entered into force on 1st July, 1975. In addition to this, India is also a signatory to Convention on Biological Diversity (CBD), which it signed on 29th December, 1993 at Rio de Janeiro during the Earth Summit. The Convention has three key objectives:
1. Conservation of biological diversity,
2. Sustainable use of biodiversity and
3. Fair and equitable sharing of benefits arising out of the utilization of genetic resources.
CONSERVATION OF SOIL AND LAND

SOIL EROSION AND LAND DEGRADATION

Rapid increase in human population has placed a great strain on the land and soil resources resulting in land degradation and soil erosion. Agents like air, wind and water erode the soil.

Soil is the uppermost layer of the earth’s crust, which can be dug or ploughed, and in which plants grow.

Land is a solid, substratum which supports human and many other organisms. On a worldwide basis more than 4.85 billion acres (1.96 billion hectares) or 17% of the earth under vegetation has been degraded by humans to various extent.

SOIL EROSION

Soil erosion is the loosening and displacement of topsoil particles from the land. Soil erosion is a natural process that occurs on all lands. Soil erosion may occur at a slow or fast rate.

LAND DEGRADATION

Land degradation is the deterioration in the quality of land. Degradation of land results in loss of crop production capacity of the land.

PACE OF SOIL EROSION

Soil erosion in nature may be (a) a slow process (or geological erosion) or (b) a fast process promoted by deforestation, floods, tornadoes or other human activities. These two processes are explained below:

(a) Geological erosion

Geological erosion (Geo: earth) is a slow process that continues relatively unnoticed and has been occurring for millions of years. The first phase of this soil forming process is called weathering which is a physico-chemical process that leads to the break down of rocks by wind and water into small fragments and formation of soil particles.

(b) Accelerated (Speeded up) erosion
Accelerated soil erosion occurs when the protective vegetation cover is destroyed. This may occur due to natural causes like flooding or due to human activities. One of the main human activity responsible for accelerated soil erosion is cultivation of land. Land under cultivation is more vulnerable to natural agencies like wind and water. Human activities accelerate removal of surface soil by wind and/or water at a faster rate. The rate and extent of accelerated soil erosion is much higher as compared to natural geological soil erosion.

**TYPES OF SOIL EROSION**

Soil erosion is classified on the basis of the physical agent responsible for erosion. The various types of soil erosion are consequently referred to as: (a) Water erosion (b) Wind erosion.

(a) **Water erosion**

Running water is one of the main agents, which carries away soil particles. Soil erosion by water occurs by means of raindrops, waves or ice. Soil erosion by water is termed differently according to the intensity and nature of erosion. (i) Raindrop erosion (ii) Sheet erosion (iii) Rill erosion (iv) Steam banks erosion (v) Erosion due to land slides (vi) Coastal erosion.

(i) **Raindrop erosion**

Raindrops falling on land surface cause detachment of the soil particles. The loose soil particles are washed away by flowing water. Raindrops thus initiate water erosion. An average size of raindrop is approximately 5 mm in diameter falling through the air hits the soil at a velocity of 32 km/hr. Larger raindrops and gusts of wind hit the soil surface even at higher velocities. Raindrops behave like tiny bombs when falling on exposed soil, displace soil particles and destroy soil structure. Presence of vegetation on land prevents raindrops from falling directly on the soil thus erosion of soil in areas covered by vegetation is prevented. With continued rainfall the displaced soil particles fill in the spaces between soil particles and so prevent water form seeping into the soil. After some time this result in accumulation of water called ‘ponding’ on the land. This water begins to flow. This flowing water is called **runoff** and is muddy due to the displaced soil particles in it. As the water moves in further erodes the soil surface. Similarly, the melting snowdrops cause soil erosion.

(ii) **Sheet erosion**

The detachment and transportation of soil particles by flowing rainwater is called sheet or wash off erosion. This is very slow process and often remain not noticed.

(iii) **Rill erosion**

In rill erosion finger like **rills** appear on the cultivated land after it has undergone sheet Erosion. These rills are usually smoothened out every year while forming. Each year the rills slowly increase in number become wider and deeper. When rills increase in size they are called **gullies**. Ravines are deep gullies.

(iv) **Stream bank erosion**

The erosion of soil from the banks (shores) of the streams or rivers due to the flowing water is called bank erosion. In certain areas where river changes its course, the river banks get eroded at a rapid rate. Stream bank erosion damages the adjoining agricultural lands, highways and bridges.
Landslide: Sudden mass movement of soil is called landslide. Landslides occur due to instability or loss of balance of land mass with respect to gravity. Loss in balance occurred mainly due to excessive water or moisture in the earth mass. Gravity acts on such an unstable landmass and causes the large chunks of surface materials such as soil and rocks slide down rapidly.

Coastal erosion: Coastal erosion of soil occurs along sea shores. It is caused by the wave action of the sea and the inward movement of the sea into the land

Consequences of soil erosion:
1. The fine particles of the topsoil which contain the bulk of nutrients and organic matter needed by the plants are lost from soil erosion. Erosion removes the most fertile part of soil. The less fertile subsoil is left.
2. Erosion may result in removal of seeds or seedlings so that the soil becomes bare. Bare soil is more vulnerable to erosion both by wind and water:
3. Removal of seeds and seedlings reduces the ability of soil to store water.
4. Sheet, rill, gully and stream bank erosion also cause siltation of rivers, streams and fields. Deposition of silt results in damage of crops and pastures, and sedimentation of water bodies like streams, dams, reservoirs etc.
5. Sedimentation of water bodies deteriorate water quality and damage aquatic habitats and organisms.
6. Gully erosion also results in loss of large volumes of soil. Wider deep gullies sometimes reach 30 m and thus severely limit land use.
7. Large gullies disrupt normal farm operation.
8. Stream bank erosion not only causes loss of land, but also changes the course of a river or stream.
9. Stream banks erosion also damage public roads.
10. Mass movement of land or landslides also inhibits farm production and land use.
11. It also causes mortality in animals and humans.
12. Coastal erosion causes the adjoining land to become covered by sand.

Prevention of soil erosion
1. It is essential to retain vegetation cover that soil is not exposed to rain. Vegetation cover is important because roots of plants hold soil particles together. Plants intercept rainfall and protect soil from direct impact of raindrops.
2. Cattle grazing should be controlled.
3. Crop rotation and keeping the land fallow (not planting anything in the soil for sometime) should be adopted.
4. Vegetation and soil management should be improved in order to increase soil organic matter.
5. To prevent stream bank erosion runoff water should be stored in the catchment for as possible by maintaining vegetation cover and as by constructing dams for storing water.
6. For prevention or reduction of coastal erosion, protective vegetation along the beaches should be re-established. The best method of controlling coastal dune erosion is not to disturb the dunes and the coastal system. Further, construction of buildings and other development should be located behind the dune system.

Wind erosion
Soil erosion by wind is more common in areas where the natural vegetation has been
destroyed. Such conditions occur mainly in arid and dry areas along the sandy shores of oceans, lakes and rivers. The loose soil particles are blown and transported from wind by following three ways:

(i) **Siltation**: blown by wind in a series of short bounces.
(ii) **Suspension**: transported over long distances in the form of suspended particles.
(iii) **Surface creep**: transported at ground level by high velocity winds.

**Consequences of wind erosion**
1. Wind erosion removes the finer soil material including organic matter, clay and slit, in a suspension (colloidal) form and leaving behind coarser, less fertile material. See once again.
2. Productive capacity of the soil is lost as most of the plant nutrients which remain attached smaller colloidal soil fraction are lost.
3. Wind erosion also damages roads and fertile agricultural fields by depositing large quantities of air blown soil particles.

**Remedial strategies for prevention of soil erosion**
1. The vegetation cover over sandy soils should be kept above 30%. Access of wind to the soil should be controlled by leaving the stubble or mulch on the soil. (Stubble is the remains of crop left after harvesting).
2. Wind speed can be broken or controlled by planting trees in form of a shelter belt.
3. The practice of leaving the land fallow (i.e. not planting anything in the field) and use of machinery should be modified. This can be done by using direct-drilling techniques (ploughing the field) and by using direct-drilling techniques.
4. Over grazing by cattle should be avoided.

**SOIL EROSION CAUSED BY HUMAN ACTIVITIES**
Certain human activities accelerate soil erosion.
- Deforestation
- Farming
- Mining
- Developmental work, human settlements and transport.

**Deforestation**
Deforestation includes cutting and felling of trees, removal of forest litter. Browsing and trampling by livestock, forest fires, also leads to cause deforestation etc. Deforestation leads to erosion. Deforestation further leads to land degradation, nutrient and the disruption of the delicate soil plant relationship.

**Farming**
Agriculture is a major human activity that causes soil erosion. Crops are grown, harvested, land reploughed, exposed to wind and rain intermittently. All this prevents replenishment of moisture. Agriculture also causes the worst type of soil erosion on farmland in the form of wash-off or sheet erosion. On the arid and semiarid areas, sand blows and sand shifts act in a similar fashion as sheet erosion does, where water is the chief agent. Consequently, a creeping effect of desertification sets in and the fertility of the land is lost progressively.

The following agricultural practices can lead to accelerated soil erosion:
1. **Tilling or ploughing** increases the chances of erosion because it disturbs the natural soil surface and protective vegetation.

2. **Continuous cropping**: Continuous cropping of the same land and extending of cultivation of marginal and sub-marginal lands encourages soil erosion.

3. **Cultivation on mountain slopes**: Cultivation on mountain slopes without appropriate land treatment measures such as bounding, terracing and trenching cause soil erosion and loss of soil nutrients.

4. **Monoculture**: Monoculture refers to the practice of planting of the same variety of crop in the field. Monoculture practices can lead to soil erosion in three ways.

   (i) A monoculture crop is harvested all at one time, which leaves the entire fields bare exposing it to both water and wind.

   (ii) Without vegetation natural rainfall is not retained by the soil and flows rapidly over the surface rather than into the ground. It also carries away the top soil which results in soil erosion and degradation.

   (iii) In the event any disease or pest invades the field, the entire crop is usually wiped out leaving the bare soil susceptible to water and wind.

5. **Overgrazing**: It means too many animals are allowed to feed on a piece of grassland. Trampling and grazing by cattle destroys the vegetation of the area. In the absence of adequate vegetative cover the land becomes highly susceptible to both wind and water erosion.

6. **Economic activities**: Soil erosion also occurs due to economic activities. The extraction of useful natural resources such as metals, minerals and fossil fuels etc., from the land causes serious disturbance to the land leading to soil erosion and drastic changes in the landscape.

7. **Developmental activities**: Soil erosion may also occur because of various developmental activities such as housing, transport, communication, recreation, etc. Building construction also promotes soil erosion because accelerated soil erosion takes place during construction of houses, roads, rail tracks etc. The construction of such facilities causes massive disturbance to land, resulting in soil erosion and disruption of natural drainage system.

**LAND DEGRADATION**

Degraded land is classified on the basis of productive capacity of the land. Slight degradation refers to the condition that where crop yield potential is reduced by 10%. Moderate degradation refers to 10-50% reduction in yield potential and in severely degradation means that the land has yield potential is lost more than 50% of its potential yield capacity (productive capacity).

Some causes of land degradation are:

- use of agrochemical (chemical fertilizers and pesticides)
- excessive irrigation
- cultivation of high yielding plant varieties.

**Agrochemical and their harmful effects on land**

Agrochemicals are applied to the soil for two main reasons namely to:

(i) replenish or replace soil nutrients by using chemical fertilisers.

(ii) destroy plant pests by using toxic chemicals called pesticides.

(i) **The adverse effect of use of chemical fertilizer**
Plants take up nutrients from soil. Repeated crop cultivation depletes nutrients in the soil removed from it. Therefore, nutrients in soil have to be augmented periodically by applying chemical fertilizers. However, excess use of chemical fertilizers and pesticides leads to the following problems:

**Widespread imbalance in the soil nutrients**: Most of the chemical fertilizers used in modern agriculture contain macronutrients like nitrogen, phosphorus and potassium (NPK). Excessive addition of NPK to the soil however causes the plants to absorb more micronutrients from the soil. As a result soil becomes deficient in micronutrients like zinc, iron, copper etc, and the soil productivity decreases.

**Eutrophication of water bodies**: Fertilizer which is not used by plants is washed down with rainwater and carried into water bodies, resulting in eutrophication or algal bloom leading to death of aquatic life.

**Health problems**: About one fourth of the applied fertilizer is not used by the crop plants and is leached down into the soil and underground water aquifer. The chemical which usually leaches down is nitrate whose increased concentration in the drinking water may cause serious health problems. Excess nitrates in water is harmful especially in bottle-fed infants in whom cause the disease, methaemoglobinaemia.

(i) **The adverse affects of the use of plant protection chemicals**
Toxic chemical used to kill pests of cultivated crops (Fig. 17.10). Toxic chemicals like insecticides, herbicides, fungicides, rodenticides are generally used to kill insects, weeds, fungi and rodents in order to protect crop plants from their attack. These poisonous chemicals are collectively called biocides (agents that kill organism) they are not selective i.e., they not only kill the target pests but may also kill other non/not target and other useful organisms. Moreover, Biocides tend to remain active long after destroying the target organisms i.e. pests, weeds, fungi or rodents. It is persistence that makes these chemicals harmful to us.

Continued application of biocides cause various problems which are as follows:
1. They contaminate food materials and drinking water.
2. They disrupt the balance of the natural ecosystem by killing non-target often-useful organisms.
3. The continuous use of biocides results in a gradual increase of the immunity of the pest to these chemicals. The biocides after a period of time become ineffective against the pest leading to excessive multiplication of the pests.
4. Most of these chemicals are persistent and not biodegradable and so they persist in the plant or animal body once they enter the food chain. Their concentration in the organisms multiplies progressively through the food chain due to biological magnification.

**Problems due to excessive irrigation**
Excessive irrigation of soil may leads to water logging and accumulation of salt in the soil. Both these degrade the soil.

(i) **Water logging**: Excessive irrigation of land without proper drainage raises the water table. This causes the soil to become drenched with water or water logged. This waterlogged soil cannot support good plant growth due to lack of air particularly oxygen in the soil, which is essential for respiration of plant roots. Water logged soils
lack mechanical strength and cannot support the weight of plants which fell down and gets logged thus become submerged in the mud. This result in loss of productivity of the soil.

**ii) Salt affection:** In areas of high temperature, excessive irrigation of land usually causes the accumulation of salt in the soil. This is because water evaporates fast leaving behind traces of salt in the soil. As cycles of irrigation are repeated the left over salt accumulated and forms a thick layer of grey or white effervescence on the surface. The productivity of salt affected soil is low. Plants in saline soil are unable to absorb nutrients and so face water stress (lack of water) even when moisture is abundant in the soil.

**Impact of high yielding plant varieties on leads to soil degradation**
High Yielding Varieties (HYV) have helped to increase food production but at the same time they have greatly impacted to the environment are man made varieties of agricultural plants, fodder plants, forest trees, livestock and fishes. This means that the HYV have been raised and modified by us by means various breeding techniques in order to increase productivity. The HYVs require adequate irrigation and extensive use of fertilizers, pesticides to be successful.

**AGRICULTURE TECHNOLOGIES FOR PREVENTING SOIL DEGRADATION**

**Organic farming or green manures**
Instead of applying chemical fertilizer for supplementing the nitrogen content of soil, we can use the natural process that involves the use of nitrogen fixing bacteria in the legume root nodules. In addition to this, the use of organic forms of fertilizers such as cow dung, agricultural wastes also improves the nutrients status of soils. This may also help to reduce the excessive and prolonged use of chemical fertilizers and thus minimize their toxic effects.

**Bio fertilizers**
Micro-organisms are important constituents of fertile soils. They participate in the development of soil structure, add to the available nutritional elements and improve the physical conditions of soil. A large variety of micro-organisms are being used as biofertilisers for improving the nutritional status of crop fields.

**Biological pest control (biological control)**
The natural predators and parasites of pests play a significant role in controlling plant pests and pathogens. They are nowadays used by farmers to control or eliminate plant pests. The biological control agents of pests do not enter in the food chain or poison animals and so are not likely to harm mankind. Biological control of pests is an ecologically sound alternative to chemical pest control.
The cottony cushion scale pest (Icerya purcahlsi) is controlled biologically on a large scale by its predator, the lady bird beetle At present some 15,000 naturally occurring micro-organisms or microbial byproducts have been identified as potentially useful biological pesticides.

**MEASURES FOR PREVENTING SOIL EROSION AND LAND DEGRADATION**
(a) **Tree planting**  
To prevent wind erosion, trees should be planted in such a way so that they break the force of the wind. The trees not only cover soil from the sun, wind and water, they also help to hold the soil particles.

(b) **Cultivation and farming techniques**  
Certain cultivation and farming techniques also reduce soil erosion. These include:

(i) **Cultivation of land at the right angles to the direction of wind** helps to reduce soil erosion by wind.

(ii) **Ploughing style**: The ploughing style substantially reduces the amount of erosion. Tilling the field at right angles to the slope called counter ploughing in soil of the land helps prevent or reduce soil erosion. The ridges that are created act like tiny dams and hold the water and helps its seepage into the soil instead of let it run down freely the slopes causing soil pollution. Contour ploughing can reduce soil erosion by upto 50%.

(iii) **Strip Farming**: This method is another method of soil erosion. This involves planting the main crops in widely spaced rows and filling in the spaces with another crop to ensure complete ground cover. The ground is completely covered so it retards water flow which thus soaks down into the soil, consequently reducing erosion problems.

(iv) **Terracing**: It is another method of reducing or preventing soil erosion on mountain slopes. In this method, terraces are created on the steep slopes. This is another way of preparing the fields for planting and preventing soil erosion. Terracing is usually done on slopes, by leveling off areas on the slope to prevent the flow of water down it. There are disadvantages to terracing however, in that the terraces themselves can be easily eroded and they generally require a lot of maintenance and repair.

(v) The time or season at which a field is tilled can also have a major effect on the amount of erosion that takes place during the year. If a field is ploughed in the fall, erosion can take place all winter long, however if the ground cover remains until spring, there is not as much time for the erosion to take place.

(vi) **No-till cultivation** is also used as a preventive method for soil erosion. Specialize machinery are available that can loosen the soil, plant seeds and take care of weed control all at once with minimum disturbance to the soil. Since all of these aspects are taken care of at one time there is less time for erosion to occur. However there is an adverse effect due to this practice as weed and insect populations can increase since they are not continuously being removed and so can compete or destroy crops.

(vii) **Polyvarietal cultivation** also helps in controlling soil erosion. In this method the field is planted with several varieties of the same crop. As the harvest time vary for different varieties of the crops they are selectively harvested at different time. As the entire field is not harvested at one time and so it is not bare or exposed all at once and the land remains protected from erosion.

(viii) **Addition of organic matter to the soil** is also an important method for reducing soil erosion. This is achieved by ploughing in crop residues or entire the crop grown specifically for being ploughed into the ground. Microbes in the soil decompose the organic matter and produce polysaccharides which...
are sticky and act in gluing in the soil particles together and thus help the soil to resist erosion.
1. Carrying capacity is the maximum pressure or load that a system can withstand or take up before breaking down.

2. Carrying capacity of the environment may be defined as maximum use of human activities that the environment can tolerate.

3. **Sustainable development** is “development that meets the needs of the present taking care of the needs of future generations”. Human activities like agriculture, industrialization etc. affect sustainability of biosphere. Human activities meant to improve the quality of life are usually accompanied by environmental degradation.

4. Rapid growth of population coupled with demand and needs of man for material comforts has put tremendous pressure on earth and its environment.

5. Most dangerous consequence of population is poverty. Poverty is a major threat to human health and environment. One method of eliminating poverty is by taking care of equitable i.e. far and just distribution of resources.

6. Resource is anything useful or can be made useful to humans to meet their needs and wants.

7. Resources that belong to no one in particular become common property. Examples air, water, rivers, forest, oceans, mountains etc. People are apathetic and careless for them or their maintenance. Each of us must treat the common natural resources with same amount of care as one treats the personal things.

8. Privately owned industries, agricultural land, houses, building, offices, gardens etc. are cared for and looked after by the owners.

9. Ecological foot print is a measure of area of earth required per person (to produce resources) and waste production.

10. ‘**Green revolution**’ is substantial increase in yield of crop using high yielding varieties of seeds, and providing enough fertilizer and pesticides and good irrigation.

11. **Prof. Norman Borlaug helped India in bringing in ‘Green revolution’.**

12. **Dr. M.S. Swaminathan, internationally renowned Indian Agricultural Scientist and the father of “Green Revolution” in India, made India a food surplus country.**

13. Animal husbandry is a branch of agriculture which deals with proper care and breeding of domestic animals.

14. Animals are also attacked by diseases causing organisms (Pathogens) like bacteria, virus and fungi. Common diseases of cattle are (i) foot and mouth disease, (ii) anthrax, (iii) rinderpest and (iv) cow pox and (v) tuberculosis.

15. **Aquaculture (Blue revolution)** is a sustainable way of harvesting aquatic edible, crustaceans (lobsters and prawns). It helps to save the oceans or marine ecosystem from getting damaged.

16. Sustainable agriculture systems are those that are least toxic and least energy consuming, yet maintain productivity and profitability.

17. Agricultural practices like crop rotation, inter cropping, polyculture and proper soil management with mulches and cover crops to maintain soil moisture are integral part of sustainable agriculture.

18. Bio fertilizers are plant nutrients of biological origin like algae, bacteria, fungi which have no harmful effect on soil and environment.

19. Organic farming is a type of agriculture which avoids synthetic inorganic fertilizers, pesticides, growth regulators and livestock feed additives.
20. Organically grown food products are free from harmful chemicals, or typical
flavours and preservatives.
21. **Vermi compost can be prepared at the backyard of your home, in one
   corner to your school field or may be public park which will produce
   manure as well as clean up the environment from garbage accumulation.**
22. Integrated Pest Management (IPM) is a grand idea to control pest and diseases.
   This increases production, saves the environment from pollution and harmful
   effects of pesticides and saves money which is usually spent on buying
   pesticides.
23. Biotechnology technique is used to produce plants by gene transfer (transgenics)
   which can be a direct answer to grow plants resistant to diseases, pests, tolerant
to cold draught and flooding etc. One can design a plant to suit this condition.
24. **The three Rs of waste management are reduce, reuse and recycle.**
25. Each step of the “fuel cycle” is associated with hazard or risk. The steps are
   mining, processing, transportation and nuclear power and energy.
26. Two important nuclear disaster are Three Mile Island (USA) and Chernobyl
   (Ukrain).
27. LCA is actually a concept which considers the entire life cycle of a product.
28. The ecolabel is issued by Central Pollution Control Board (CPCB) is symbolized a
   kitchen or “an Earthern Pot” indicating that on life cycle analysis basis.
A. NON RENEWABLE ENERGY SOURCE

Since the discovery of fossil fuels, they are one of the most important mineral energy sources. These are a finite energy resource that means they are non-renewable resources and once consumed they are lost forever. There are three major forms of fossil fuels: coal, oil, and natural gas and on worldwide basis they provide approximately 90% of energy consumed.

1. Fossil fuels

Since the industrial revolution, the major energy resources for the world have been fossil fuels formed from the remains of plants and animals lived in the distant past. Fossil fuels represent stored solar energy captured by plants in the past geological times. Coal, petroleum, and natural gas are called fossil fuels, as they are the remains of prehistoric plants, animals, and microscopic organisms that lived millions of years ago. These remain under the effect of intense heat and pressure underneath the earth's crust over long geological time and got transformed into fossil fuels. For example, the gas cylinder which you see in your kitchen or coal you burn was once the sunlight captured by phototrops. During the Carboniferous period 275-350 million years ago, conditions in the world were suitable for formation of large deposits of fossil fuels.

The terms ‘resource’ and ‘reserves’ are often used when discussing the amount of a mineral or fossil fuel resource a country has at its disposal. From a technical point of view the term resource when used as a measurement of mineral or fuel refers to the total amount of a mineral or fuel in a country or on earth. Generally only a small fraction can be recovered. On the other hand reserve means the deposits of energy fuel or minerals that are economically and geologically feasible to extract with current and foreseeable technology.

a) COAL

Coal is formed from plants and vegetation buried, ‘in situ’ or drifted in from outside to a place, which got covered by deposits of sediments. Coal is a solid fossil fuel and a sedimentary rock composed primarily of carbon. There are three basic grades of coal: i) lignite (brown coal), ii) bituminous (soft coal) and iii) anthracite (hard coal). An estimated nine metres of peat is needed to produce and form a 0.3 metre vein of coal and it would require 300 hundred years to accumulate that much of peat.

Formation of coal

Coal is the result of plant material that grew in fresh water swamps approximately three hundred million years ago. As this plant material died and accumulated, peat also called peat bog was formed. Since the plant material accumulated under water, in the swamps decay was inhibited due to lack of oxygen. Oceans inundated many of the areas of peat and sediments from the sea were deposited, over the peat. The weight of these sediments and the heat of the earth gradually changed the composition of the peat bog and coal was formed. Today peat also is used as source of fuel in some parts of the world though its high water content makes it a low-grade fuel.
Peat is changed into coal after many centuries of being compressed by the weight of sediments. It first changes into a low-grade coal known as lignite (brown coal). The percentage of carbon in the lignite is higher than in peat. Continued pressure and heat from the earth changes lignite into bituminous soft coal. If the heat and pressure were great enough then anthracite coal (hard coal) would be formed which has the highest heat and carbon content. Accordingly energy content is greatest in anthracite coal and lowest in lignite. The sulphur content of coal is important because on burning low sulphur coal emits less sulphur dioxide (SO2) so more desirable as a fuel for power plants.

The coal is used as a source of energy for domestic uses, locomotive engines, various types of furnaces in the industries, thermal power generation, extraction of metals and minerals, production of gas, tar etc. The type of coal determines its use. In India coal supplies nearly 63% of commercial energy as electrical energy generation by coal fired thermal power stations. In industry coal is used principally to purify iron, manufacture of steel.

Problems
Coal is most abundant fossil fuel on earth, but there are problems associated with its mining, transportation and use. Coal is mined from both (i) surface mines, and (ii) underground mines.

(a) Surface mining
Surface mining disrupts and drastically changes the natural landscape and destroys the natural vegetation and the habitat of many species, some of which may already be endangered. Mining operations, involving digging, blasting, removal of rocks and soil lying over the coal seam, cause serious problems of air and noise pollution. Surface mining may also cause soil erosion and silt loading (the discharge of silts into streams) and nallas that disrupt and pollute the aquatic ecosystems as well as ground water in places where aquifers are located near or associated with coal seams.

(b) Underground mining
Underground mining may cause collapse or land subsidence in the mining areas during or after mining operations are over. In case of some mines acid mine drainage from the mine waste and OBD piles polluted long stretches of streams. Coal fires in underground mines may happen which naturally caused give out much smoke and hazardous fumes caused several respiratory disease to people living nearby.

Apart from these problems, burning of coal in thermal power plants for generation of electricity and in industry is the prime source of air pollution.

b) PETROLEUM OR MINERAL OIL

Oil and gas were formed from the remains of plants and animals that once lived in the sea. For over millions of years these remains remained buried under mud and rock under great pressure and at high temperatures. Under these conditions marine biomass gradually changed into oil and gas. Oil and gas are primarily found along geologically young tectonic belt at plate boundaries, where large depositional basins are more likely to occur. Petroleum or crude oil (oil as it comes out of the ground), is a thick dark liquid consisting of a mixture of hundreds of combustible hydrocarbons along with small
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amounts of sulphur, oxygen and nitrogen impurities. It is also known as conventional oil or light oil. Deposits of crude oil and natural gas are usually trapped together under the sea floor or earth’s crust on land. After it is extracted, crude oil is transported to a refinery by pipelines, trucks or ships (oil tanker). In refineries oil is heated and distilled to separate it into components with different boiling points. The important components are gases, gasoline, aviation fuel, kerosene, diesel oil, naphtha, grease and wax and asphalt. Some of the products of oil distillation are called petro-chemicals which are used as raw material for the manufacture of pesticides, plastics, synthetic fibers, paints and medicines etc.

The consumption of petroleum products is rising worldwide. In India the demand has risen from 57 million tonnes in 1991-1992 to 107 million tonnes in year 2000. ‘The India Hydrocarbon Vision 2025’, gives the projected need for petroleum products for India to be 368 million tonnes by 2025.

c) NATURAL GAS

Natural gas, primarily consist of methane, is often found above reservoirs of crude oil. The natural gas is a mixture of 50 to 90% by volume of methane (CH4), the simplest hydrocarbon. It also contains small amounts of heavier gaseous hydrocarbons such as ethane (C2H6), propane (C3H8) and butane (C4H10) and also small amounts of highly toxic hydrogen sulphide (H2S). Natural gas is formed through geological processes similar to the processes of crude oil formation described earlier except the organic material gets changed to more volatile hydrocarbons than those found in oil. Almost every oil well produces liquid petroleum along varying amounts of natural gas. However, there are large gas deposits without any liquid petroleum being associated with them.

Conventional natural gas
It lies above most reservoirs of crude oil. These deposits can be tapped/used only through pipeline. But the natural gas that comes out along with oil is often looked as unwanted by-product and is burned off. Burning of associated natural gas represents a waste of a valuable energy resource and emissions carbon dioxide into the atmosphere from its burning. But after the gas is processed it is piped or compressed into cylinders for use by consumers. This gas is also used for the production of petrochemicals and fertilizers.

Unconventional natural gas
It is found by itself in other underground reservoirs. So far it is very expensive to get natural gas from such unconventional sources but technology is being developed to extract the gases economically.

When a natural gas field is tapped, propane and butane gases, present in natural gas are liquefied and removed as liquefied petroleum gas (LPG). LPG is stored in pressurized tanks or cylinders for use as cooking gas. At a very low temperature natural gas can be converted to liquefied natural gas (LNG). This highly inflammable liquid can be shipped to other countries in refrigerated tanker ships. The production and consumption demand of natural gas has been rising in India for both industrial and domestic uses.
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After the gas is processed it is piped or compressed into cylinders for use by the consumers.

**Problems associated with oil and gas**

Leakage of natural gas from pipelines, storage tanks and distribution tanks is potential cause of explosion. Methane being major component of natural gas, happens to be a green house gas and its leakage contributes to global warming. But being a clean fuel has advantages over coal and oil and preferred as a better fuel option or energy resource.

Extraction of oil and gas may cause sinking of land or subsidence. For example, in Long Beach Harbor area, in Los Angeles, USA, intensive oil extraction beginning in 1928 caused severe land subsidence. Over the well sites, the ground dropped 9 metres. Extensive subsidence created a need for flood control measures along the coastline. Damage to buildings, roads and other structures were estimated at 100 million dollars. Another major problem in the past with onshore oil wells has been brine (salt water). Typically, for every barrel of oil production ten barrels of brine are also extracted. In early days the brine was simply discarded into nearby streams or on the soil. Today most brine is reinjected into the well. However, brine can contaminate fresh water aquifers if the casing lining the well is missing or corroded.

Apart from these two problems, oil also contaminates the oceans. About half of the oil that contaminates the ocean comes from natural seepage from offshore deposits (annually approximately 600,000 metric tonnes of oil seeps into the ocean from natural sources). 20% of the oil contaminating the ocean comes from oil well, blowouts, pipeline breaks and tankers. The rest comes from oil disposed off inland and carried into the ocean by rivers. Leakage from offshore wells also occurs during the transfer of oil to shore and also during normal operations.

The harmful effects of oils contamination are felt both in fresh water and marine water environments. Oil kills aquatic plants and animals. After a major spill it may take two to ten years for the organisms to recover. Combustion of oil and gas also cause air pollution. Even though the natural process of fossil fuel formation is continuing today, but the rate of production is very low. For all practical purposes the world’s supply of fossil fuels is limited to what was formed 300 million years ago. When this supply is exhausted we will have no more supply. As a result of realization, people have started exploring and use alternative sources of energy.

**Location of fossil fuel deposits in India**

India has large reserves of coal and lignite is found in West Bengal, Bihar, Orissa, Madhya Pradesh, Andhra Pradesh as well as in Assam and Tamil Nadu. Oil and natural gas are exploited both from inland and offshore sites. Some of the major oil reserves are located in West coast, Gujarat, Godavari and Krishna delta on the East coast, Assam and Rajasthan. Fossil fuel deposits are also found in India in limited amounts.
ENERGY CONSERVATION

Uses of natural gas

- Natural gas is a relatively clean fuel burns readily to produce large amount of heat that is why natural gas is used as the main fuel for domestic and industrial heating purposes. It is used as a fuel in thermal power plants for generating electricity and a feedstock for manufacture of fertilizers.
- Compressed Natural Gas (CNG) is being increasingly used as a fuel in transport vehicles (buses, trucks and cars). CNG is a good alternative to petrol and diesel because it causes less pollution. These days in Delhi and some other cities are using since the use of CNG as an alternative fuel for automobiles has started, air pollution levels have decreased perceptibly.
- Natural gas is used as a source of hydrogen gas needed in fertilizer industry. When natural gas is heated strongly, the methane present in it decomposes to form carbon and hydrogen. This hydrogen gas is combined with nitrogen gas to manufacture of ammonia (NH3). Reaction of ammonia with acids, forms ammonium salts. These ammonium salts are used as fertilizers.
- Natural gas is used as a source of carbon used in tyre industry. When natural gas is strongly heated, then methane gets in it decomposed to form carbon and hydrogen. The carbon thus formed is called carbon black and used as filler in the manufacture of tyres.

Advantages of natural gas

Natural gas is a clear and environmental friendly fuel and used directly for cooking purpose in homes. It can be supplied directly to the homes and factories through a network of underground pipelines thus eliminate the need for additional storage and transport. Natural gas burns with smokeless flame and on burning does not produce any poisonous gas or pollute the environment friendly gas.

2. NUCLEAR ENERGY SOURCES

Nuclear energy is the energy of the atomic nucleus. Radioactive minerals are used to generate nuclear energy through high technological methods.

Radioactive minerals

Radioactive minerals used for generating energy are alternative to fossil fuels. Similar to other minerals, availability of ore of radioactive material is finite and limited. However, a very small quantity of radioactive minerals can generate large amounts of energy. Antoine Henri Becquerel discovered radioactivity in 1896 and his name lives on in the units used to measure it – Becquerel’s (Bq). One Becquerel = 1 radioactive decay which is a very small amount.

It may surprise you to know that every substance is radioactive to some extent. For example,

- One loaf of bread = 70 Bq
- One kg of coffee = 1000 Bq
- One adult human = 3000 Bq
- Ten kilogram of granite = 1200 Bq
- One kilogram of 50 year old high level radioactive waste = 10,000,000,000,000 Bq.

There are two methods which can be used to release energy from radioactive minerals:
ENERGY CONSERVATION

i) Nuclear fission – In this process, the nucleus of heavy atom namely of uranium (U235) or plutonium (P239) breaks apart into smaller fragments, releasing an enormous amount of energy.

ii) Nuclear fusion – In this process, small nucleus like those of isotopes of hydrogen, namely deuterium and tritium etc. fuse or join together to form heavier nuclei, releasing vast amounts of energy.

Nuclear fission

Radioactive mineral, which generates nuclear energy through fission, may be considered a non-renewable alternative source of energy as it is an ore and is found in limited quantities. Nuclear fission occurs because the atom of radioactive minerals contains nuclei that are unstable and break or split apart releasing energy. Whenever a neutron strikes a nucleus of U-235, energy is released, krypton and barium are produced, and several neutrons are released. These new neutrons may strike other atoms of U-235 to produce a chain reaction. When this nuclear disintegration takes place particles from the nucleus including neutrons fly out. The neutron may cause other atomic nuclei to split releasing more neutrons and more energy. Once begun this chain reaction continuous to release energy until the fuel is spent or the neutrons are prevented from striking other nuclei.

In the reactor of a nuclear power plant, the rate of nuclear chain reaction is controlled and the heat generated is used to produce high pressure steam, which spins turbine that generate electricity. Heat produced here is carried away by water coolant and transferred by way of heat exchanger to the water in a steam-generating unit. The steam produced powers a turbine that produces electricity. Cooling water is used to condense the steam after it has gone through the turbine.

Two other nuclear technologies for generating electricity from nuclear fuel in a safe and economic way have also been proposed, but so far they have not proved operationally successful. These are: (i) nuclear breeder reactor, (ii) fusion reactor.

(i) Nuclear breeder reactor
The nuclear reactors operating today use uranium very inefficiently. About 1% uranium is actually used to produce steam for generating electricity. A nuclear reactor that can utilize between 40% and 70% of its nuclear fuel is called a breeder reactor. Breeder reactors convert more abundant uranium -238 or thorium -232 fissionable isotopes, Plutonium- 239 or Uranium -233 respectively, that can sustain a nuclear chain reaction.

(ii) Nuclear fusion reactor
The principle for nuclear fusion involves uniting two small atoms to form a large atom with the release of an enormous amount of energy. The energy produced by stars and the sun is the result of nuclear fusion. Generation of energy by this method so far, however, has not been possible though lot of research has focused on the fusion reaction of deuterium (D) and tritium (T) (two isotopes of hydrogen) which fuse at about 100 million degrees.

The advantage of using nuclear material for energy generation instead of coal and oil, is that it produces very little pollution. It requires less strip-mining as nuclear fuel have highly concentrated form of energy. Moreover the cost of transportation of nuclear fuels
ENERGY CONSERVATION

is much lower than that for coal and oil required for generation of an equivalent amount of energy.

- Hydrogen bomb is based on the principle of uncontrolled fusion reaction
- Atom bomb is based on the principle of nuclear fission

The Chernobyl disaster in USSR and Three Mile Island plant in USA accident have raised serious concern about the safety of nuclear power plants.

Location of radioactive mineral ore in India
In India, monazite that is the main source of thorium, is found in commercial quantities on the Travancore coast between Kanya Kumari and Quilon, while uranite or pitchblende mineral of uranium is found in Gaya (Bihar), Ajmer (Rajasthan) and Nellore (Andhra Pradesh). Utilisation of radioactive minerals is expanding and investigations are being carried out on such deposits to provide definite indications of magnitude, and potential for exploitation.

It is, important to realize that none of these resources can last for ever. It has become, necessary to rely on replenishable and regenerative resource base as well as on those types of technologies, which improve energy use efficiency.

Mostly of the conventional energy sources which are replenishable are called **inexhaustible or renewable** energy sources that include firewood, cattle dung, farm or agricultural wastes etc. Since these energy sources are generally of plant and animal origin, they can be grown and produced. But if they are used recklessly and irresponsible manner, they may get exhausted and may become non renewable.

B. RENEWABLE SOURCES OF ENERGY

(a) Conventional source of energy, which are easily available and have been in usage for long time.
(b) Non conventional source of energy, that are other than the usual or that are different from those in common practice.

**Sources of energy**

<table>
<thead>
<tr>
<th>Conventional non-renewable energy</th>
<th>Conventional renewable energy</th>
<th>Non conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mostly fossil fuels found under the ground.</td>
<td>Mostly non-fossil fuels seen above the ground.</td>
<td>1. Solar energy</td>
</tr>
<tr>
<td>Coal, oil, natural gas etc. are examples.</td>
<td>Fire wood, cattle dung from the vegetable wastes, wood charcoal etc. are the examples.</td>
<td>2. Hydro power</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Wind energy</td>
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<td>4. Nuclear energy</td>
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<td>5. Hydrogen energy</td>
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<td>6. Geothremal energy</td>
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<td>7. Bio gas</td>
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<td></td>
<td></td>
<td>8. Tidal energy</td>
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<td></td>
<td></td>
<td>9. Bio-fuel</td>
</tr>
</tbody>
</table>
ENERGY CONSERVATION

Most of the renewable resources of energy are directly or indirectly related to sun or solar energy. Renewable sources of energy or non-conventional energy sources include sunlight, wind, water and biomass (firewood, animal dung, crop residue, agricultural wastes, biodegradable waste from cities and towns). Energy received from sun is known as solar energy, energy generated by water is hydel energy and energy obtained from underground hot dry rocks, magma, hot water springs or natural geysers etc is called geothermal energy. Tidal energy is derived from waves and tidal waves of oceans and seas.

RENEWABLE OR NON-CONVENTIONAL SOURCES OF ENERGY - I

The rapidly depleting possible fuel sources of energy and escalating demand of energy have made it necessary to look for alternative sources of energy that are known as renewable or inexhaustible. We can define inexhaustible energy resources as ‘those resources which can be harnessed without depletion’. Most of these resources are free from pollution and some of them can be used at all places. These renewable energy resources are also known as non-conventional or inexhaustible or alternate energy sources. These energy sources are solar, flowing water, wind, hydrogen and geothermal. We get renewable solar energy directly from the sun and indirectly from moving water, wind and biomass. Like fossil fuels and nuclear power, each of these alternatives renewable sources of energy has their own advantages and disadvantages.

1. SOLAR ENERGY

Sun is an abundant source of energy and it is inexhaustible. In the broadest sense, solar energy supports all life on earth and is the basis for almost every form of energy we use. The sun makes plants grow, which are burned as fuel or rot in swamps and are compressed underground for millions of years to become coal and oil. Heat from the sun causes temperature differences between areas, causing the wind to blow. Water evaporates because of the sun, water vapours are carried to high elevations, and when the water vapours condense and precipitate as rainfall. The water rushes down towards the sea through rivers, spin turbines is too made for generating electricity. It thus becomes clear that hydroelectricity is an indirect form of solar energy. However direct solar energy can be used as heat, light, and electricity through the use of solar cells. The sun is often regarded as the ultimate answer to our energy problems. Sun provides a continuous supply of energy that far exceeds our current energy demand. It is free of cost, available in plenty, found everywhere and has no political barrier. Actually fossil fuels also represent sunlight stored millions of years ago. However, we are only able to trap and make use of a very small fraction of this abundant energy source. Solar energy use can be classified as: i) direct solar energy use; solar energy is captured directly as sunlight and used for heating, generating electricity and cooling ii) indirect use of solar energy derived from natural processes driven by the sun, for example wind, biomass, waves, hydroelectric power.

a. Direct solar energy

Solar energy is abundant, everlasting and available free of cost. Direct use of solar energy can be used through various devices broadly directed into three types of systems a) passive, b) active c) photovoltaic.
a) Passive solar energy
As you know some of the earliest uses of solar energy were passive in nature such as to evaporate sea water for producing salt and to dry food and clothes. In fact solar energy is still being used for these purposes. The more recent passive uses of solar energy is for cooking, heating, cooling and for the daylighting of homes and buildings. The effectiveness of passive solar energy depends on good building design; no mechanical means are employed in passive use of solar energy.

Passive use of solar energy for cooking
The energy from the sun can be harnessed, to cook food without any large, complex systems of lenses or mirrors. We all know that when sunshine falls on a dark surface, it is absorbed and transformed into heat energy. Glass is bad conductor of heat but if a shallow glass covered chamber painted black inside and insulated all around is exposed to sun for some time the inside temperature would soon exceeds upto 100oC which is sufficient to cook food. On a hot summer day the temperature inside the solar box cooker will easily becomes 140o C. Solar cooker takes 5-6 hours to cook food. The solar box cooker is the poor man's device for direct use of renewable source of energy. In Indian conditions with plentiful sunshine we can use a solar box cooker for cooking of food. The great advantage of solar cooking is its convenience because the food will never get overcooked or burnt. Apart from its “load-and-forget” quality, the food cooked in the solar cooker is also more tender and retains most of the nutritive values. But this comes at a cost is a slow process and take longer time i.e. solar cooking.

India may be justifiably proud that the world’s largest solar steam cooking system is operating in the Brahmakumaris’ Ashram at Mount Abu in India. Here the solar energy is concentrated by a battery of concentrators /mirrors to convert water into superheated steam. The system can cook for 10,000 people. It was constructed at a costs one crore of rupees excluding the labour of the ashram inmates.

Passive use of solar energy for daylighting
Daylighting is using natural sunlight to light building interiors. Day lighting technologies are designed to maximize natural light for illuminating the interior of buildings. These may be in the form of core lighting when the building may have a central atrium to allow entry of maximum sunlight.
The most recent technology is hybrid solar lighting which collects sunlight and send it though optical fibres into buildings where it is combined with electric light in “hybrid” light fixtures. There are sensors in the room which keep a steady lighting level by adjusting the electric lights based on the sunlight available. This new generation of color lighting combines both electric and solar power.

Passive solar systems are maintenance free. There are no moving parts and so no energy is expended for heating or cooling a building and hence, there are no operating costs. The only major problem is that passive solar heating, cooling and lighting system can be used only in specially designed buildings. Daylighting of business and commercial buildings provides a higher quality of light and improves productivity and health and at the same time results in substantial saving on electric bills.
ENERGY CONSERVATION

(b) **Active use of solar energy**
Active solar heating and cooling systems rely on solar collectors which are usually mounted on roofs. Such systems also require pumps and motors to move the fluids or blow air by fan in order to deliver the captured heat. A number of different active solar heating systems are available. The main application of these systems is to provide hot water, primarily for domestic use. Active solar heating is extensively used in India, Japan, Israel, Australia and Southern United States having sunny climate.

**Solar energy to produce electricity**
Solar energy is used to generate high temperature heat or electricity. Solar collectors in sunny deserts can produce high temperature heat to spin turbines for producing electricity but cost of such devices are high. Several solar thermal systems can collect and transform radiant energy received from the sun into high temperature thermal (heat) energy, which can be used directly or converted into electricity. Huge arrays of computer-controlled mirrors called **heliostats** track the sun and focus sunlight on a central heat collection tower.

**Solar energy for cooling**
A solar collector can also be used for cooling. In this system, energy from the sunlight powers a small heat engine similar to an electric motor of a refrigerator. The heat engine drives a piston that compresses a special vapour into a liquid; the liquid then revapourizes and draws heat out of the surrounding air.

(c) **Solar cells or photovoltaic technology**
Solar energy can be converted directly into electrical energy (direct current, DC) by photovoltaic (PV) cells commonly called solar cells. Photovoltaic cells are made of silicon and other materials. When sunlight strikes the silicon atoms it causes electrons to eject. A typical solar cell is a transparent wafer that contains a very thin semiconductor. Sunlight energizes and causes electrons in the semiconductor to flow, creating an electrical current. Solar cells can provide electricity to remote villages. India is the world’s largest market for solar cells.

PV cells can be used for -
(i) domestic lighting.
(ii) street lighting.
(iii) village lighting.
(iv) water pumping.
(v) electrification.
(vi) desalination of salty water.
(vii) powering of remote telecommunication repeater stations and
(viii) railway signals.

2. **INDIRECT SOLAR ENERGY**
A large number of energy sources such as wind, tide and hydroelectric ultimately depend on solar energy

a) **Wind energy**
About 2% of the sunlight striking the earth is converted into the kinetic energy of moving air called wind. The uneven absorption of the solar radiation by the earth’s surface causes differences of temperature, density and pressure which produce air
ENERGY CONSERVATION

movements at local, regional and global levels powered by wind energy. The kinetic energy of the wind can be harnessed by converting it into mechanical energy or electrical energy using suitable devices. The wind has been used to power ships, grind grains, pump water for irrigation and do other types of work.

In present times the greatest potential for using wind is for the production of electricity. Wind turbines, like wind mills are mounted on a tower to capture the most of the wind energy. Wind mills can be used to drive generators to producing electricity. To produce electricity wind is used to turn the shaft of a turbine which is attached to a generator that produces electricity. Thus wind turbines transform wind energy into mechanical power which can be used to generate electricity.

Wind turbines can be used single or in clusters. When wind turbines occur in clusters they are called ‘wind farms’. Small wind turbines called aero generators and can be used to charge large batteries.

Five nations - USA, Germany, Denmark, Spain and India - account for 80% of the world’s installed wind energy capacity. **India rank 5th in the world with a total wind power capacity if 1080 MW out of which 1025 MW have been established in commercial projects.** In India the states of Tamil Nadu and Gujarat lead in the field of wind energy. **At the end of March 2000 India had 1080 MWs capacity wind farms, of which Tamil Nadu contributed 770 MW capacity, Gujarat has 167 MW followed by Andhra Pradesh, which has 88 MW installed wind farms.** There are about a dozen wind pumps of various designs, which provide water for afforestation, irrigation, domestic purpose, used in various tasks of the country.

Recently, there has been a renewed interest in wind as a source of energy. India is the fifth largest producer of wind power in the world. Countries engaged in development of wind energy include Great Britain, Netherlands, Greece, Spain, Denmark, USA (California) and India. **Andhra Pradesh generates maximum energy through wind power.** Other states generating energy through wind are Tamil Nadu, Gujarat, Karnataka, Kerala, Madhya Pradesh and Maharashtra. A total of 26 project sites have been developed in these states resulting in a capacity of 57MW.

b. Tidal energy
Tidal power projects attempt to harness the energy of tides as they flow in and out. The main criteria for a tidal power generation site are that the mean tidal range must be greater than 5 metres. The tidal power is harnessed by building a dam across the entrance to a bay or estuary creating a reservoir. As the tide rises, water is initially prevented from entering the bay. Then when tides are high and water is sufficient to run the turbines, the dam is opened and water flows through it into the reservoir (the bay), turning the blades of turbines and generating electricity. Again when the reservoir (the bay) is filled, the dam is closed, stopping the flow and holding the water in reservoir when the tide falls (ebb tide), the water level in the reservoir is higher than that in the ocean. The dam is then opened to run the turbines (which are reversible), electricity is produced as the water is let out of the reservoir. The dams built to harness the tidal power adversely effect the vegetation and wildlife. A dam is built across an estuary or bay, allowing the incoming and outgoing waters to flow through small openings fitted with propellers that run electric turbines. **To date the numbers of tidal electric plants are limited to forty.** La Rance in France is the...
only commercial power station operating in the world. In India a major power project costing Rs. 5000 crores is proposed to be set up in the Hanthal Creek in the Gulf of Kutch in Gujarat.

c. Hydropower Energy

The energy in moving waters is one of the most widely used renewable energy source. In earlier times the kinetic energy of flowing rivers and streams was trapped by means of water wheels that were used to grind grain, saw wood and manufacture textiles. It was only in 1800s that the energy of water was converted into electricity. Hydroelectric power uses the kinetic energy of moving water to make electricity. Generation of electricity by using the force of falling water is called hydro electricity or hydel power. It is cheaper than thermal or nuclear power. Dams are built to store water at a higher level; which is made to fall to rotate turbines that generate electricity. Hydroelectricity or hydropower is the fourth largest source of commercial energy production and consumption globally. The basic principle behind hydropower energy is the damming of rivers to create artificial in waterfalls, sometimes natural waterfalls are also used. The falling water is used to turn the turbines that drive electrical generators. One of the greatest advantages of hydropower is that once the dam is built and turbines become operative, it is relatively cheap and clean source of energy. Hydropower also has some disadvantages, building of dam seriously disturbs and damages the natural habitats and some of them are lost forever. Human habitations also get disturbed making people homeless.

RENEWABLE SOURCES OF ENERGY-II

Alternative resources such as biomass, geothermal and hydrogen are source of vast energy resources. These energy sources are renewable because they are regenerated within a reasonable time period. Moreover these energy resources can be used with minimal environmental degradation and offer us a chance to develop a truly sustainable energy policy. Its for these reasons there is growing interest in renewable energy resources. This lesson deals with these renewable energy resources.

1. BIOMASS

Energy from biomass is the oldest fuel used by human’s. Our ancestors burned wood to keep the cave warm. Biomass is a renewable energy resource derived from plants and animal waste. The energy from biomass (biomass conversion) is released on burning or breaking the chemical bonds of organic molecules formed during photosynthesis. Thus biomass represents an indirect form of solar energy. Biomass fuels can be used directly or they can be transformed into more convenient form and then used. More than one million people in the world still use wood as primary source of energy for cooking.

Sources of biomass
It is derived from numerous sources, including the by-products from the timber industry, agricultural crops and their by products, raw material from the forest, major parts of household waste and wood.
Solid Biomass fuels
Wood logs and pellet
Sarchol
Agricultural waste
(stalks and other plant debris)
Timbering waste
(branches, treetops and wood chips)
Animal waste (dung)
Aquatic plants (kelp and water hyacinths)
Urban waste (paper, cardboard and other combustible materials)

Gaseous Biofuels
Synthetic natural gas (biogas)
Wood gas
Methane – 70%
CO2-30%

Liquid Biofuels
Ethanol, Methanol
Gasoho, Biodiesel

- biomass can be burnt directly as a source for cooking, heating, lighting, generating steam, for industrial use for producing electricity.
- can be used to generate gaseous fuels (gasification).
- can be converted into alcohol (liquid biofuels) by distillation.

Methane and biogas can be produced from urban wastes in landfills and sewage at waste water treatment plants. In some facilities, manure from livestock and other organic waste is converted by microorganisms in specially designed digestion chamber to form methane (CH4), which is burned to produce electricity, used in fuel cell, or used as fuel for vehicles. Molasses obtained from sugarcane is fermented to produce ethanol, that can be used in automobiles.

Uses of biomass
- Traditional use of biomass is more than its use in modern application. In the developed world biomass is once again becoming important for applications such as combined heat and power generation.
- In addition, biomass energy is gaining significance as a source of clean heat for domestic heating and community heating applications. In fact, in countries like Finland, USA and Sweden use of biomass energy is increasing biomass fuels used in India account for about one third of the total fuel used in the country, and it amount to 90% of the rural households.
- Instead of burning loose biomass directly, it is more practical to compress it into briquettes (compressing them into blocks of a chosen shape) improve its utility and convenience of use. Such biomass in the biomass briquettes can be used as fuel in place of coal in traditional chulhas and furnaces or in a gasifier. A gasifier converts solid fuels into a more convenient-to-use gaseous fuel called producer gas.

Advantages of biomass energy
Burning of biomass does not increase atmospheric carbon dioxide because to begin with biomass was formed by atmospheric carbon dioxide and the same amount of carbon
dioxide is released on burning. Biomass is an important source of energy and the most
important fuel worldwide after coal, oil and natural gas. Biomass is renewable and free
from net CO2 (carbon dioxide) emissions and is abundantly available on the earth in
the form of firewood, agricultural residues, cattle dung, city garbage etc. Bio-energy, in
the form of biogas, which is derived from biomass, is expected to become one of the key
energy resources for global sustainable development.

Bagasse as biofuel
Indian sugar mills are rapidly turning to bagasse, the leftover of cane after it is crushed
and its juice extracted, to generate electricity. This is mainly being done to clean up the
environment, cut down power costs and earn additional revenue. According to current
estimates, about 3500 MW of power can be generated from bagasse in the existing 430
sugar mills in the country. Around 270 MW of power has already been commissioned
and more is under construction.

Biogas plant
The biogas plant consists of two components: a digester (or fermentation tank) and a
gas holder. The digester is a cube-shaped or cylindrical waterproof container with an
inlet into which the fermentable mixture is introduced in the form of liquid slurry. The
gas holder is normally an airproof steel container that, by floating like a ball on the
fermentation mix, cuts off air to the digester (anaerobiosis) and collects the gas
generated. In one of the most widely used designs, the gas holder is equipped with a gas
outlet, while the digester is provided with an overflow pipe to lead the sludge out into a
drainage pit.

Any biodegradable (that which can be decomposed by bacteria) substance can be
fermented anaerobically (in absence of oxygen) by methane-producing (methanogenic)
bacteria. Cowdung or faeces are collected and put in a biogas digester or fermenter (a
large vessel in which fermentation can take place). A series of chemical reactions occur
in the presence of methanogenic bacteria (CH4 generating bacteria) leading to the
production of CH4 and CO2.

Methanogenesis is a microbial process, involving many complex, and differently
interacting species, but most notably, the methane-producing bacteria. The biogas
process consists of three stages; hydrolysis, acidification and methane
formation.

Potential of biogas in India
In India, the dissemination of large-scale biogas plants has began in the mid-seventies
and the process has become consolidated with the establishment of the National Project
on Biogas Development (NPBD) in 1981. Against the estimated potential of 12 million
biogas plants, 2.9 million family type and 2700 community, institutional and
nightsoil-based plants have been set up till December 1999. This is estimated to have
helped in a saving of 3 million tonnes of fuelwood per year and manure containing
nitrogen equivalent to 0.7 million tonnes of urea. However, in terms of total dung that is
available in the country, the potential is much more.
The bovine population in India is 260 millions. As an adult, bovine produces an average of 10 kg of dung per day. If it is assumed that 75% of the dung is collected, nearly 2 millions tonnes of dung would be available everyday. This dung can feed as many as 40 millions biogas plants which can be considered the ultimate potential for biogas technology. But even this high potential of biogas is based on animal dung only. However, all organic matter can technically be used to generate methane; if the scientific experiments that are going on in the country to develop alternative feedstocks (such as water hyacinth, kitchen waste, and poultry waste) become successful, potential for biogas generation could be virtually unlimited. It can be mentioned in this context that human waste is an excellent source of biogas which would enhance the potential; substantially. With such high potential, which can be routed to hitherto unemphasized applications of shaft power and electricity generation, biogas can make a significant contribution to the development of small industries and agriculture, and thus to the overall advancement of the rural areas.

**Biogas in Rashtrapati Bhavan**
GOING Green starts from the top, and in the capital the President’s Estate is taking the lead. Besides lighting an entire auditorium wing with solar power, the Rashtrapati Bhavan is using cow dung-fuelled biogas in its kitchen for the President’s bodyguards.

**Petro crops (Plants)**
Petroleum and wood are chief energy resources from time immemorial, but they have been overused and not being replenished fast enough. This is cause for concern. There is a need for alternative energy providing sources that can be regenerated. Recent researches suggest that hydrocarbon producing plants can become alternative energy sources, which can be inexhaustible and ideal for liquid fuel. These plants called petroplants/petrocrops can be grown on land which are unfit for agriculture and not covered with forests.

Use of non-conventional energy source in India. (%)

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind energy</td>
<td>67.37</td>
</tr>
<tr>
<td>Waste to energy</td>
<td>0.94</td>
</tr>
<tr>
<td>Small hydro</td>
<td>13.1</td>
</tr>
<tr>
<td>Biomass</td>
<td>15.97</td>
</tr>
<tr>
<td>Solar photovoltaic</td>
<td>2.62</td>
</tr>
</tbody>
</table>

The most critical step in bioenergy production is the selection of plant species that produce substances from which useful products can be extracted in an economically viable way. Many such promising species belong to the families Asclepiadaceae, Asteraceae, Anacardiaceae Euphorbiaceae, Convolvulaceae, Caprifoliaceae, Lamiaceae, and Moraceae. Jatropa curcas is an important petro plant

This biocrude can be obtained by tapping the latex, followed by coagulation, or by extraction of the dry biomass using a suitable solvent in cases where latex tapping is not possible. Biocrude is a complex mixture of liquids, terpenoids, triglycerides, phytosterols waxes, and other modified isoprenoid compounds. It can be catalytically upgraded for use as liquid fuels. Hydro cracking of biocrude can convert it into several useful products like gasoline (automobile fuel), gas oil and kerosene.
2. GEOTHERMAL ENERGY

We live between two great sources of energy, the hot rocks beneath the surface of the earth and the sun in the sky. Our ancestors knew the value of geothermal energy; they bathed and cooked in hot springs. Today we have recognized that this resource has potential for much broader application. Geothermal energy is natural heat from the interior of the earth that can be used to generate electricity as well as to heat up buildings. The core of the earth is very hot and it is possible to make use of this geothermal energy. These are areas where there are volcanoes, hot springs, and geysers, and methane under the water in the oceans and seas. In some countries, such as in the USA water is pumped from underground hot water deposits and used for heating of houses. The utilization of geothermal energy for the production of electricity dates back to the early part of the twentieth century. For 50 years the generation of electricity from geothermal energy was confined to Italy and interest in this technology was slow to spread elsewhere. In 1943 geothermal hot water was used for the first time in Iceland. At present in 21 countries the internal heat of earth is used to produce electricity. However, at the global level, geothermal energy supplies less than 0.15% of the total energy supply.

Geothermal resource falls into three major categories:
 i) Geopressurized zones, ii) hot-rock zones and iii) Hydrothermal convection zones. Of these three only the first is currently being exploited on a commercial basis.

Geothermal energy in India

In India, Northwestern Himalayas and the western coast are considered geothermal areas. The Geological Survey of India has already identified more than 350 hot spring sites, which can be explored as areas to tap geothermal energy. Satellites like the IRS-1 have played an important role, through infrared photographs of the ground, in locating geothermal areas. The Puga valley in the Ladakh region has the most promising geothermal field. An experimental 1-kW generator is already in operation in this area. It is being used mainly for poultry farming, mushroom cultivation, and pashmina-wool processing, all of which need higher temperature.

Geothermal manifestations are wide spread in India in the form of 340 hot spring sites.

Environmental impact of geothermal energy

Geothermal energy can pose several environmental problems which includes on-site noise, emissions of gas and disturbance at drilling sites, disposal sites, roads and pipelines and power plants during its development.

The steam contains hydrogen sulphide gas, which has the odour of rotten eggs, and cause air pollution. The minerals in the steam are also toxic to fish and they are corrosive to pipes, and equipment, requiring constant maintenance.

3. HYDROGEN ENERGY

Many scientists believe that the fuel for the future is hydrogen gas. When hydrogen gas burns in the air or in fuel cells, it combines with oxygen gas to produce non-polluting water vapour and fuel cells directly convert hydrogen into electricity. Widespread use of
hydrogen as fuel would greatly reduce the problem of air pollution and danger of global warming because there will not be any CO2 emission. Hydrogen may be a clean source of energy but getting large amount of pure hydrogen for commercial purposes is a problem because hydrogen is present in combination with other elements such as oxygen, carbon and nitrogen thus hydrogen has to be produced from either water or organic compounds like methane etc. requiring large amounts of energy that is hydrogen as a fuel has to be produced using energy present. This is a very costly proposition. Producing hydrogen from algae in large scale cultures will be a good idea. You have studied about the process of photosynthesis where green (plant) cells break down water molecule in the presence of sunlight to produce oxygen gas and hydrogen thus produced go to reduce CO2 to carbohydrate. Hydrogen produced via photosynthesis. CO2 will not emit. Carbon dioxide in future it may be possible to control photosynthesis so that green algae are able to produce hydrogen through the process of photosynthesis. Hydrogen is a pollution free, cost effective manner and if technologies such as fuel cells can be made cost effective, then hydrogen has the potential to provide clean, alternative energy for diverse uses, including lighting, power, heating, cooling, transportation and many more.

FUEL CELL TECHNOLOGY

Fuel cells are highly efficient power-generating systems that produce electricity by combining fuel (hydrogen) and oxygen in an electrochemical reaction or fuel cells are electrochemical devices that convert the chemical energy of a fuel directly and very efficiently into electricity (DC) and heat, thus doing away with combustion.

Hydrogen Fuel Cells

Hydrogen and phosphoric acid are the most common type of fuel cells, although fuel cells that run on methanol, ethanol, and natural gas are also available. The most suitable fuel for such cells is hydrogen or a mixture of compounds containing hydrogen. A fuel cell consists of an electrolyte sandwiched between two electrodes. Oxygen passes over one electrode and hydrogen over the other, and they react electrochemically to generate electricity, water, and heat. Traditional methods generating electricity require combustion of fuel and the resultant heat is used to produce steam to run turbines which generate electricity. This method involves loss of heat and thus not very efficient.

In chemical fuel cells on the other hand, chemical energy is converted directly into electricity, thus are more efficient and do not produce harmful gases. Both oxygen and hydrogen are added to the fuel cell in an electrolyte solution. The reactants remain separated from one another and, upon ionization, migrate through the electrolyte solution from one electrode to another. The flow of electrons from the negative to the positive electrode is diverted along its path into an electrical motor, supplying current to keep the motor running. In order to maintain this reaction, hydrogen and oxygen are added as needed. Wast products are only oxygen and water when hydrogen is used in a fuel cell. Using natural gas methane (CH4) in fuel cells produces some pollutants, but the amount is only about 1% of what would be produced by burning fossil fuels in an internal combustion engine or a conventional power plant.
Additionally, the efficiency of a fuel cell is largely independent of its size and energy output. For these reasons, fuel cells are well-suited for automobiles, homes, and large-scale power plants. They can also be used to store energy to be used as needed. Fuel cells are in use particularly in Canada’s Ballard’s Power Systems in Canada and Germany’s Daimler-Benz in Germany are world leaders in the application of fuel cell technology for meeting transportation needs. Such buses are already in operation in Vancouver in Canada and in Illinois in USA. Though rapid progress has been made; high initial cost is still the biggest hurdle in the widespread commercialization of fuel cells.

**Fuel cell technology in India**
Fuel cell systems are excellent options for small-scale decentralized power generation. Fuel cells can supply combined heat and power to buildings, hospitals, airports and military installations at remote locations. Fuel cells have efficiency levels up to 55% as compared to 35% of conventional power plants. The emission of green house gases is significantly low CO2 as water vapor is being the only emission. Fuel cell systems are modular (i.e. additional capacity can be added whenever required with relative ease) and can be set up wherever power is required.

**Fuel cell technology and environment**
Fuel cells are efficient and clean energy producer. Fuel cells have been used in space flights and being introduced in electric vehicles for reducing urban air pollution. Compared to vehicles powered by the internal combustion engine, fuel cell powered vehicles have very high-energy conversion efficiency, (almost double that of currently used engines) and near-zero pollution. Fuel-cell-powered EV’s (electric vehicles) score over battery operated EV’s in terms of increased efficiency and easier and faster refueling.

**ENERGY AND ECONOMIC DEVELOPMENT**
Energy development is an integral part of economic development. Economically developed countries use more energy per unit of economic output and have much more per capita energy consumption as compared to developing countries. Energy has been universally recognized as one of the most important inputs for economic growth and human development. Growth of economy will stand global competitiveness withstand only when it will depend on cost effective or cheaper and environment friendly energy sources. Energy intensity is an indicator to show how efficiently energy is used in the economy. India’s energy intensity is much higher than the emerging economies of other Asian countries. Energy sector in India has been receiving high priority in the planning process. Government of India has recognized the fact that the energy sector can become a major constraint or hurdle in the achievement of a high growth rate or Gross Domestic Product (GDP). It has therefore called for an increase in the reform process and adoption of an integrated energy policy.
Table 31.1: Limitations of alternate sources of energy

<table>
<thead>
<tr>
<th>Source of energy/Fuel</th>
<th>Production</th>
<th>Advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear energy</td>
<td>Nuclear fission (splitting of atom) and Nuclear fusion</td>
<td>No air pollution Fuel efficient</td>
<td></td>
</tr>
<tr>
<td>Hydroelectric power or Hydropower</td>
<td>Dams built on river for electricity generation</td>
<td>World’s hydroelectric capacity high</td>
<td></td>
</tr>
<tr>
<td>Solar energy</td>
<td>From natural sunlight</td>
<td>Environment friendly Ample or unlimited availability,</td>
<td></td>
</tr>
<tr>
<td>Wind energy</td>
<td>Fans for directing winds in use from long for irrigation crops</td>
<td>No pollution Available for free</td>
<td></td>
</tr>
<tr>
<td>Tidal energy</td>
<td>Harnessing tidal power by suitable structures</td>
<td>Free and clean</td>
<td></td>
</tr>
<tr>
<td>Geothermal energy</td>
<td>Wells drilled to trap steam which powers electrical generators. Steam naturally produced from underground water which gets heated due to very high temperature that region.</td>
<td>Environment friendly</td>
<td></td>
</tr>
<tr>
<td>Biomass (1) Fuel wood</td>
<td>Cutting trees for fuel wood and burning them straight away</td>
<td>Cheap so popular in under developed and developing countries</td>
<td></td>
</tr>
<tr>
<td>(2) Biomass conversion</td>
<td>Obtaining energy from chemical energy. Stored in biomass (or live material). Burned directly for cooking or to produce electricity converted to ethanol or methane (biogas)</td>
<td>Renewable energy</td>
<td></td>
</tr>
<tr>
<td>Solid waste</td>
<td>Waste sorted and burnable material separated</td>
<td></td>
<td>Causes air pollution for burning releases CO₂ and other gases. Waste such as bleached paper and plastics have chlorine containing compounds which form. dioxins which are highly toxic and suspected to be carcinogenic.</td>
</tr>
</tbody>
</table>

31.8 Concept of Energy Auditing

Energy auditing is a systematic approach to monitor industrial energy consumption and to find out the sources of energy wastage. It consists of activities that seek to identify conservation opportunities before conducting or developing any energy saving program.
WATER TREATMENT

Methods of water treatment

Water is treated by a variety of physical and chemical methods. Treatment of surface water begins with intake screens to prevent fish and debris from entering the treatment plant and damaging pumps and other components. Conventional treatment of water primarily involves clarification and disinfections. Clarification removes most of the turbidity, making water crystal clear. Disinfection, usually the final step in the treatment of drinking water, destroys pathogenic microbes. In addition, to clarification and disinfection, the processes of softening, aeration, carbon adsorption, and defluridation may be used for certain public water sources. Desalination processes i.e. removal of excess salt from water are used in areas where fresh water supplies are not readily available or the ground water is saline.

(a) Clarification or sedimentation

Impurities in water are either dissolved or suspended. The suspended material reduces clarity, and the easiest way to remove it is to let suspended particles settle.

• Coagulation and flocculation

Suspended particles cannot be removed completely by plain settling. Large, heavy particles settle out readily, but smaller and lighter particles do not settle easily. Such particles are called colloidal particles. To remove such smaller particles, alum is added. Alum causes flocculation. Flocculation is a process through which all the finer insoluble particles form large particles called flocs. These flocs then can easily settle and thus are removed from water. Aluminium sulphate (alum) is the most common coagulant used for water purification. Other chemicals, such as ferric sulphate or sodium aluminate, may also be used. The flocculation tank has wooden paddle-type mixers that slowly rotate on a horizontal motordriven shaft. After flocculation the flocs are allowed to settle in a settling tank. From here the supernatant is passed through sand filters. Microstrainers are used mainly to remove algae from surface water supplies before conventional gravity-flow filtration.

• Filtration

Even after coagulation and flocculation, sedimentation does not remove enough suspended impurities from water to make it crystal clear. Filtration is a physical process that removes these impurities from water by percolating it downward through a layer or bed of porous, granular material such as sand. Suspended particles become trapped within the pore spaces of the filter media, which also remove harmful protozoa and natural colour. Most surface water supplies require filtration after the coagulation and sedimentation steps. When clogged by particles removed from water, the filter bed must be cleaned by backwashing. In the backwash process, the direction of flow through the filter is reversed. Clean water is forced upward through the media, expanding the filter bed slightly and carrying away the impurities in wash troughs. The backwash water is distributed uniformly across the filter bottom by an under drain system of perforated pipes or porous tile blocks. Because of its reliability, the rapid filter is the most common type of filter used to treat public water supplies. However, other types of filters may be used, including pressure filters, diatomaceous earth filters, and microstrainers. As pressure filter has a granular media bed, but, instead of being open at the top like gravity-flow rapid filter, it is enclosed in a cylindrical steel tank. Water is pumped
through the filter under pressure. In diatomaceous earth filters a natural powder like material composed of the shells of microscopic organisms called diatoms is used as a filter media. The powder is supported in a thin layer on a metal screen or fabric, and water is pumped through the layer. Pressure filters and diatomaceous earth filters are used most often for industrial applications or for public swimming pools.

**Microstrainers** consist of a finely stainless steel wire cloth mounted on a revolving drum that is partially submerged in the water. Water enters through an open end of the drum and flows out through the screen, leaving suspended solids behind. Captured solids are washed into a hopper when they are carried up out of the water by the rotating drum. Microstrainers are used mainly to remove algae from surface water supplies before conventional gravityflow filtration.

(b) **Disinfection**

Disinfection destroys pathogenic bacteria and is essential to prevent the spread of water borne disease. Typically the final process in drinking water treatment, it is accomplished by applying either chlorine, ozone or ultraviolet radiation to clarified water.

- **Chlorination**
  The addition of chlorine or chlorine compounds to drinking water is called chlorination. Chlorine compounds may be applied in liquid and solid forms—for instance, liquid sodium hypochlorite or calcium in tablet or granular form, however, the direct application of gaseous chlorine from pressurized steel containers is usually the most economical methods for disinfecting large volumes of water. Taste or odour problems are avoided with proper dosages of chlorine at the treatment plant, and a residual concentration can be maintained throughout the distribution system to ensure a safe level at the points of use. Chlorine can combine with certain naturally occurring organic compounds in water to produce chloroform and other potentially harmful byproducts. The risk of this is very small, however, when chlorine is applied after coagulation, sedimentation, and filtration.

- **Ozone**
  Ozone gas may also be used for disinfection of drinking water. However, since ozone is unstable, it cannot be stored and must be produced on-site, making the process more expensive than chlorination. Ozone has the advantage of not causing taste or odour problems. It also leaves no residue in the disinfected water. The lack of an ozone residue, however, makes it difficult to monitor its continued effectiveness as water flows through the distribution system.

29.4.3 Other methods of water purification

Sometimes natural contaminants like fluorides, iron or arsenic are present in water. These impurities are harmful to human health. There are methods to remove these impurities.

- **Removal of fluoride**
  Fluoride is generally present in all natural water. Its concentration up to certain level is not harmful. Beyond that level, the bones start disintegrating. This disease is called fluorosis. We have fluoride problem in many parts of our country. Bureau of Indian Standards prescribes 1.0 mg/l as desirable and 1.5 mg/l as maximum permissible limit
for drinking water. Any water containing high level of fluoride needs to be treated for removal of fluoride in order to make it safe. The simple treatment technique which can be adopted at household level is described below:

- **Domestic defluoridation**
  Defluoridation at domestic level can be carried out in a container (bucket) of about 60 litre capacity. The bucket should have a tap 3-4 cm above the bottom for withdrawal of treated water after treatment. The water for treatment is taken in the container, is mixed within adequate amount of aluminum sulphate (alum) solution, lime or sodium carbonate and bleaching powder depending upon its alkalinity (concentration of bicarbonates and carbonates in water) and fluoride contents. Alum solution is added first and mixed well. Lime or sodium carbonate solution is then added and water is stirred for 20 minutes, then it is allowed to settle for nearly one hour and then withdrawn through tap for consumption. The settle sludge is discarded. Normally 100 to 600 ml of alum solution is required to be added in 40 litres of water containing fluoride ranging from 2 to 9 mg/l in order to remove it to acceptable level.

- **Defluoridation at community level**
  The community used technique for community water supply is called **Nalgonda Technique** developed by National Environmental Engineering Research Institute (NEERI), Nagpur. It has following components:
  - Reactor(s)
  - Sump well
  - Sludge drying bed.
  This is a batch method for community up to 200 population. The tank is equipped with mechanical agitator operated manually or by electric motor. Water is pumped or poured into the tank and required amount of alum, lime or sodium bicarbonate and bleaching powder is added with constant stirring. The contents are stirred slowly for ten minutes and allowed to settle for two hours. The defluoridated supernatant water is withdrawn and supplied. The sludge from the bottom is discarded.

- **Removal of iron**
  In many parts of our country we have problem of excess iron in drinking water especially in North-East regions. Iron causes bad taste and odour to the drinking water. Bureau of Indian Standards prescribes desirable limit for iron as 0.3 mg/l. Removal of iron is essential.
  - **At domestic level**
    This is the simplest unit developed by NEERI. It involves aeration of raw water over a series of coke, marble/calcite bed followed by slow sand filtration. No chemical is required for treatment. Upto 200 l/hr of water can be treated.
  - **At community level**
    The treatment is a sequential processes of aeration, reaction-cum-setting and filtration. The main part of the treatment plant is a vertical cylindrical vessel having following chambers:
    1. aeration-cum-oxidation chamber
    2. settling-cum-filtration chamber
    3. final collection chamber for treated water
    Water from the hand pump is sprinkled from the top. This will ensure contact with air...
for complete aeration. A major part of iron is oxidized here. Then the water is made to react with oxidizing media (lime stone). The remaining iron is oxidized in this chamber. By aeration and further oxidation the dissolved iron is converted to insoluble ferric hydroxide. The insoluble iron can thus be easily removed through filtration. Then it is passed through filter media (sand and gravel filter). The filtrate water contains iron in an acceptable range.

- **Removal of arsenic**
  Arsenic is found in ground water in some parts of West Bengal. Arsenic is highly toxic in nature,. It may cause a number of skin disorders or even cancer. Bureau of Indian Standards prescribes desirable limit for arsenic as 0.05 mg/l. Removal of arsenic is essential. The treatment technology developed by Institute of Public Health and Hygiene, Kolkata is commonly used. The technology is based on oxidation, coagulation, flocculation, sedimentation and filtration. Bleaching powder and alum are used for removal of arsenic. It consists of three chambers. In the first chamber the chemicals are added. The mixture is then passed to next chamber called settling tank, where it is allowed to settle for 2 hours. The supernatant is then passed through a slow sand filter. The filtrate water generally contains arsenic in the acceptable range.