EDEN IAS

ENVIRONMENT & ECOLOGY

UPSC PREP

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[INTRODUCTION]

PRINCIPLES OF ECOLOGY

Ecology is the scientific study of the relationship and interactions between organisms and their environment. The term ecology is derived from a Greek word Oekologie where **"oikos"** meaning "household"and **"logos"** means "the study of". Ecology is the study of how living things interact with each other and with their environment. It is a major branch of biology, but has areas of overlap with geography, geology, climatology, and other sciences.

Literally ecology is the study of organisms at home. **This term was introduced for the first time by a German Biologist Ernst Haeckel in 1869**. Charles Elton a modern Ecologist defined Ecology as the study of animals and plants in relation to their habit. Thus Ecology deals with various forms of interactions between the organisms and their environment. These interactions can be studied at the various levels of organizations in the living systems starting from the molecules such as DNA (genes) to a biological community and the whole biosphere. Each step of independent interaction is called a level of organization. Ecology encompasses study of individual, organisms, population, community, ecosystem, biome and biosphere which form the various levels of ecological organization.

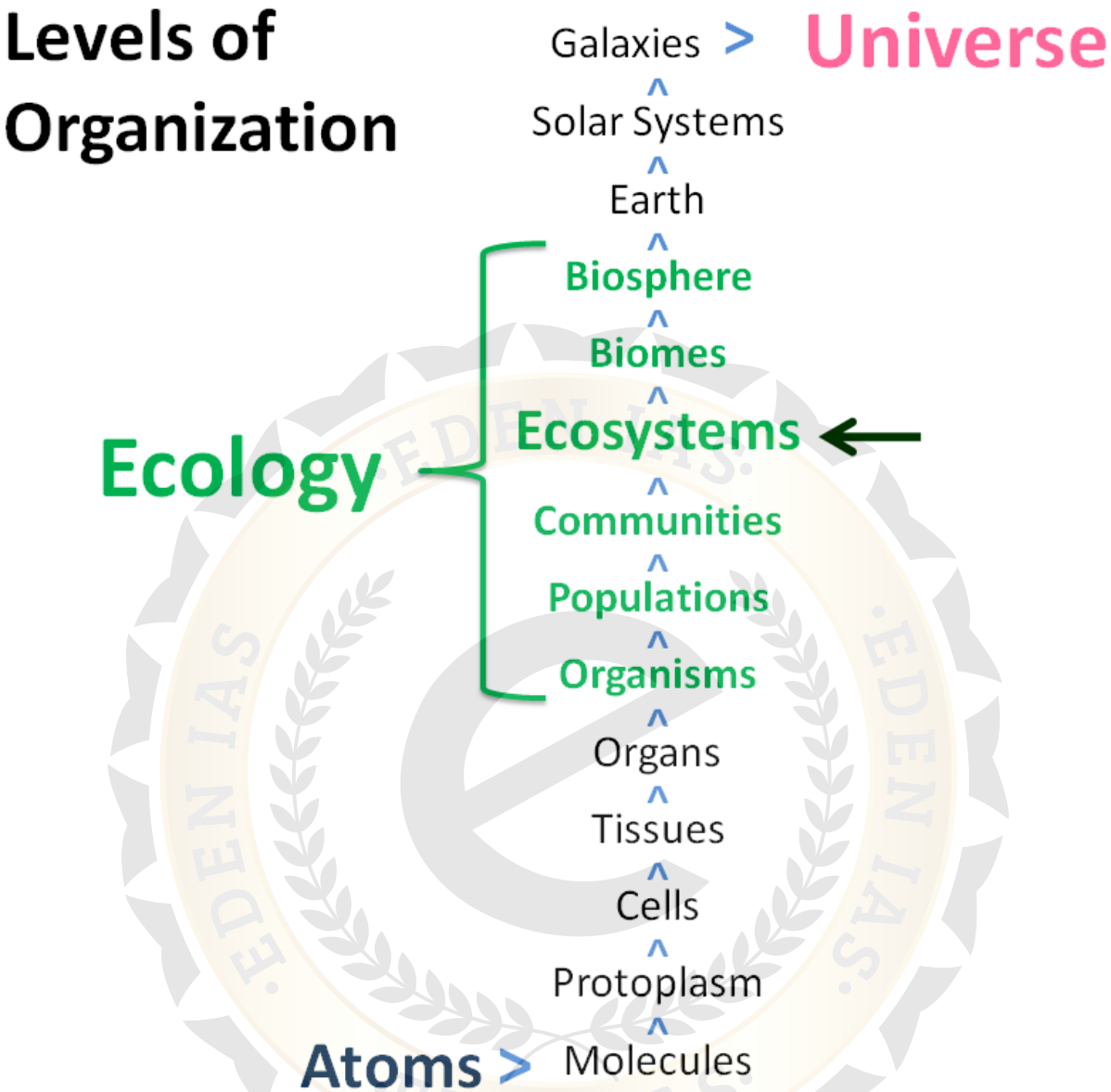
LEVELS OF ORGANISATION IN LIFE SCIENCES

From Organism to Biosphere is the concern of ecology. An organism is a self reproducing system capable of growing and maintaining itself and is directly influenced by the surrounding environment. A population is an assemblage of similar organisms belonging to the same species, living together at one place at a given time. A population always has a specific place of its living which is known as its habitat**. Population growth rate is the percentage variation between the number of individuals in a population at two different times. It can be positive due to birth and/or immigration or negative due to death and/or emigration. The number of individuals per unit area at a given time is termed as population density. In case of large, mobile animals like tigers, leopards, lions, deer etc., the density may be determined by counting individual animals directly or by the pugmarks (foot imprints) left by the animals in a defined area. Pugmarks of each individual animal are unique and different from others. Study of pug marks can provide the following information reliably if analyzed skillfully:**

- **Presence of different species in the area of study**
- **Identification of individual animals**
- **Population of large cats (tigers, lions etc.)**
- **Sex ratio and age (young or adult) [Even sex of tigers can be determined using pugmarks].**

A species is defined as a group of organisms which can interbreed and produce a successful offspring. These organisms may be separated in space and time into smaller groups called populations.

Biological community refers to the populations of different species occupying a common place of living. For example all the living organisms in a pond belong to one community. **A biological community along with its nonliving environment of energy and matter makes an ecosystem**. Ecosystem can range in size from a puddle of water to a stream or a patch of wood to entire forest or desert. **The study of groups of organisms in relation to their environment is called synecology**. Landscape ecology is the science of studying and improving relationships between ecological processes in the environment and particular ecosystems. **A landscape is a unit of land with a natural boundary having a mosaic of patches, which generally represent different ecosystems**. This is done within a variety of landscape scales, development spatial patterns, and organizational levels of research and policy. **Biomes are large areas on Earth with similar conditions, such as similar climates and similar living organisms**. There are two main categories of biomes viz. Terrestrial and Aquatic. Terrestrial biomes are usually defined by the type of vegetation that is present. The major climatic factors contributing to the vegetation types in these biomes are temperature and precipitation. Aquatic biomes are defined by the type of water they contain. There are many different classification systems used to determine biomes, each resulting in different numbers of biomes.



A thin layer on and around the earth which sustains life is called biosphere. Life exists in the diverse forms of living organisms. All these living organisms of the biosphere are directly or indirectly dependent on one another as well as on the physical components of the earth. The three physical components of the earth are atmosphere, lithosphere and hydrosphere (air, land and water).

Recently the term ecosphere is being used more commonly. It is used to denote biosphere (living components) along with its three abiotic components –atmosphere, hydrosphere and lithosphere of the earth as one entity (unit).

Ecosphere = Biosphere + Lithosphere + Hydrosphere + Atmosphere

In fact ecosphere is the largest worldwide ecosystem. Ecosphere is very huge and cannot be studied as a single entity. It is divided into many distinct functional units called ecosystem.

POPULATION

'Population' is defined as a group of freely interbreeding individuals of the same species present in a specific geographical area at a given time. A population has traits of its own which are different from those of the individuals forming the population. For example (i) an individual is born and dies but a population continues. Population may change in size depending on birth and death rates of the population. (ii) An individual is female or male, young or old but a population has a sex ratio which means, the ratio of male to female in the population which also has (iii) age structure, which means the various age groups into which the population may be divided.

The characteristics of any population depend on the following factors. (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.

Density: The number of individuals per unit area at a given time is termed Health population density which may vary from time to time and place to place. For example, you may notice more plant and animal species in the garden during the monsoon season. Density of a particular organism in a region is determined by selecting random samples from an area of particular dimension (size) called quadrat from that region. In case of large mobile animals like tigers, leopards, lions, deer etc, the density may be determined by counting individual animals directly or by the pugmarks (foot imprints) left by the animals in a defined area.

Birth Rate or Natality: The rate at which new individuals are born and added to a population under given environmental conditions is called natality. In case of humans, natality or birth rate is usually expressed in terms of births per thousand per year.

Death Rate or Mortality: Loss of individuals from a population due to death under given environmental conditions is called mortality. Mortality rate in human population may be expressed in terms of number of persons dead per thousand per year.

Dispersal: The movement of individuals of a population out of a region on a permanent basis is termed emigration. Immigration refers to the movement of individuals into a new area. Dispersal includes both emigration (going away permanently from an area) and immigration (influx of new individuals into the area).

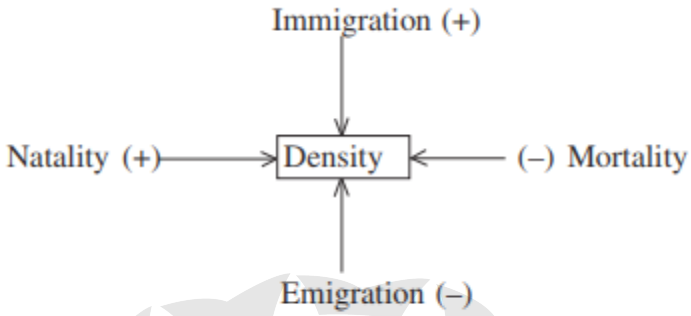
The density of a population thus basically depends on four factors: (i) natality, (ii) mortality, (iii) immigration and (iv) emigration

Age distribution: Natural populations include individuals of all age groups. Age distribution refers to the proportion of individuals of different age groups in a population. The population may be broadly divided into three age groups:

- **Pre-reproductive group:** comprising of juvenile individuals or children.
- **Reproductive group**: consisting of individuals capable of reproduction.
- **Post-reproductive group**: contains aged individuals who are incapable of reproduction.

A rapidly growing population will usually contain a large proportion of individuals in the reproductive age group; a stationary population (where there is no increase or decrease in population) contains an even distribution of all age groups, and a declining population contains a large proportion of old or individuals of post-reproductive age.

Sex ratio: Sex ratio is an important aspect of population. It refers to the ratio between female and male individuals in a population.



Parameters of Population

Population Growth Curves

The growth, stability or decline in number of individuals in a population is influenced by its relationship with the environment. Populations have characteristic patterns of growth with time, which is depicted by population growth curves. Two basic forms of population growth curves can be identified:

(i) **'J'shaped growth curve**

(ii) **'S' shaped or sigmoid growth curve**

J-shaped growth curve A curve on a graph that records the situation in which, in a new environment, the population density of an organism increases rapidly in an exponential or logarithmic form, but then stops abruptly as environmental resistance (e.g. seasonality) or some other factor (e.g. the end of the breeding phase) suddenly becomes effective. The actual rate of population change depends on the biotic potential and the population size. It may be summarized mathematically as:

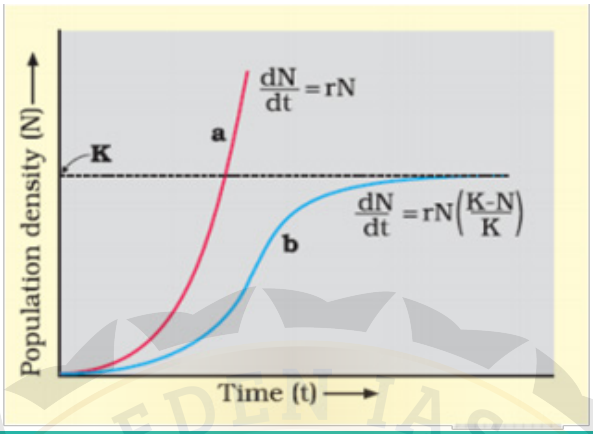
$$dN/dt = rN \text{ (with a definite limit on } N\text{)}$$

Where *N* is the number of individuals in the population, *t* is time, and *r* is a constant representing the intrinsic rate of increase (biotic potential) of the organism concerned.

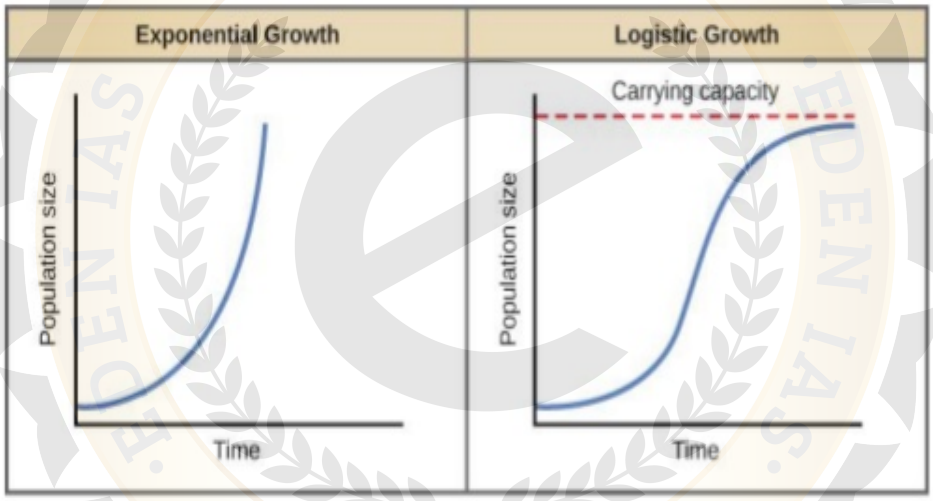
Population numbers typically show great fluctuation, giving the characteristic 'boom and bust' cycles of some insects, or the ones seen in algal blooms. This type of population growth is termed 'density-independent' as the regulation of growth rate is not tied to the population density until the final crash.

S-shaped growth curve (sigmoid growth curve) A pattern of growth in which, in a new environment, the population density of an organism increases slowly initially, in a positive acceleration phase; then increases rapidly, approaching an exponential growth rate as in the J-shaped curve; but then declines in a negative acceleration phase until at zero growth rate the population stabilizes. This decline reflects increasing environmental resistance which becomes proportionately more important at higher population densities. This type of population growth is termed density-dependent, since growth rate depends on the numbers present in the population. The point of stabilization, or zero growth rate, is termed the saturation value (symbolized by *K*) or carrying capacity of the environment for that organism. *K* represents the upper asymptote of the sigmoidal or S-shaped curve produced when changing population numbers are plotted over time. This can be expressed mathematically as

dN/dt =rN [(K-N)/K] ; where K= Carrying capacity



MATHEMATICAL EXPRESSION



When resources are unlimited, populations exhibit (a) exponential growth, shown in a J-shaped curve. When resources are limited, populations exhibit (b) logistic growth. In logistic growth, population expansion decreases as resources become scarce, and it levels off when the carrying capacity of the environment is reached. The logistic growth curve is S-shaped.

BIOTIC COMMUNITY

Community also called biological community, in biology, an interacting group of various species in a common location. For example, a forest of trees and undergrowth plants, inhabited by animals and rooted in soil containing bacteria and fungi, constitutes a biological community.

On the basis of size and degree of relative independence communities may be divided into two types: Major Communities and Minor Communities**.**

Major Communities: These are large sized and relatively independent. They depend only on the sun's energy from outside. Eg: Tropical evergreen forests.

Minor Communities: These are dependent on neighboring communities and are often called societies. They are secondary aggregations within a major community. Eg: A mat of lichen on a cow dung pad.

A community is bound together by the network of influences that species have on one another. Inherent in this view is the notion that whatever affects one species also affects many others - the "balance of nature". We build an understanding of communities by examining the two-way, and then the multi-way, interactions involving pairs of species or many species. Its structure, composition and distribution are determined by environmental factors such as soil type, position in the landscape, altitude, climate and water availability. Types of ecological communities listed under environmental laws include **woodlands, grasslands, shrublands, forests, wetlands, marine, ground springs and cave communities**.

The native plants and animals within an ecological community have different roles and relationships that, together, contribute to the healthy functioning of the environment. Protecting native communities also supports ecosystem services such as clean air, clear land and clean water. These all contribute to better productivity of our land and water, which benefits people and society. **A biological community superimposed over a natural environment is known as Ecosystem**

ACCLIMATISATION AND ADAPTATION

All living organisms need to have an environment where they can survive and flourish. Scientists refer to this place as the natural habitat. But since all species of plants and animals are connected with each other in the so-called food web, trespassing territories is unavoidable. As a result of this intrusion, any organism crossing boundaries either needs to adapt or acclimatise itself to its new surroundings.

Adaptation and acclimation are two terms commonly used to describe the adjustment done by either a plant or animal when it goes beyond its normal habitat. It also applies to changes that may occur inside its own environment which can render it unsuitable for survival if they fail to adjust.

Adaptation is centered on an organism's ability to change its physical and chemical make up to adjust to its habitat. This takes a long time to achieve and usually affects the whole group/population to which it belongs. It is part of the evolution process, which all living things must undergo in order to cope with the ever changing planet. One good example of adaptation is the camel and its ability to survive for long periods of time in the desert with very little water. **Adaptation for an animal is any genetically heritable trait that allows an individual to reproduce and pass on its genes**.

Transformations that occur in adaptation tend to be permanent until new changes are needed again. The rule 'survival of the fittest' best describe how the process works. When changes in the environment occur, like a rise in temperature, animals and plants that can't cope, eventually die leaving the stronger ones to survive and proliferate. These remaining members have adapted accordingly.

Acclimation, on the other hand, is temporary adjustment to gradual changes in the natural habitat. It only occurs in the lifespan of the organism and doesn't affect evolution patterns of its species. A good example of this behavior is when a fresh water fish is caught and placed in an aquarium. The location may change but since sea water is not used, the new habitat pretty much mimics the old one, although it may experience a slight change in temperature and the space to swim around. Eventually the fish learns to survive by acclimatising to its new surroundings. Acclimatisation is reversible, i.e. if the environment conditions return to normal the species might reacclimatize (or de-acclimatize) to attain the original conditions in which it was prior to the changes in the environmental variables. Adaptation is a natural and necessary process for survival of a species, while acclimation only happens when there are small changes in the habitat. **Adaptation is permanent, while acclimation is temporary.**

PHENOTYPE AND PHENOTYPIC PLASTICITY

Your genotype is your complete heritable genetic identity; it is your unique genome that would be revealed by personal genome sequencing. However, the word genotype can also refer just to a particular gene or set of genes carried by an individual. For example, if you carry a mutation that is linked to diabetes, you may refer to your genotype just with respect to this mutation without consideration of all the other gene variants that your may carry.

In contrast, your phenotype is a description of your actual physical characteristics. This includes straightforward visible characteristics like your height and eye color, but also your overall health, your disease history, and even your behavior and general disposition. Do you gain weight easily? Are you anxious or calm? Do you like cats? These are all ways in which you present yourself to the world, and as such are considered phenotypes. However, not all phenotypes are a direct result of your genotype; chances are that your personal disposition to cats is the result of your life's experience with pets rather than a mutation in a hypothetical cat fancier gene.

Most phenotypes are influenced by both your genotype and by the unique circumstances in which you have lived your life, including everything that has ever happened to you. We often refer to these two inputs as "**nature**," the unique genome you carry, and "**nurture**," the environment in which you have lived your life.

Thus the phenotype of an organism is the composite of the organism's observable characteristics or traits, including its morphology or physical form and structure; its developmental processes; its biochemical and physiological properties; its behavior, and the products of behavior.

An organism's phenotype results from two basic factors: the expression of an **organism's genetic code**, or its genotype, and **the influence of environmental factors**, which may interact, further affecting phenotype. When two or more clearly different phenotypes exist in the same population of a species, the species is called **polymorphic**

Phenotypic plasticity refers to some of the changes in an organism's behavior, morphology and physiology in response to a unique environment. **Phenotypic plasticity is the ability of one genotype to produce more than one phenotype when exposed to different environments**. Phenotypic plasticity encompasses all types of environmentally induced changes (e.g. morphological, physiological, behavioural, phenological) that may or may not be permanent throughout an individual's lifespan. The term was originally used to describe developmental effects on morphological characters, but is now more broadly used to describe all phenotypic responses to environmental change, such as acclimation (acclimatization), as well as learning. The special case when differences in environment induce discrete phenotypes is termed polyphenism (A polyphenic trait is a trait for which multiple, discrete phenotypes can arise from a single genotype as a result of differing environmental conditions. It is therefore a special case of phenotypic plasticity).

ECOTYPE

In evolutionary ecology, an ecotype, sometimes called ecospecies, describes a genetically distinct geographic variety, population or race within a species, which is genotypically adapted to specific environmental conditions. Usually species having wide range of distribution evolve genetically adapted local populations called Ecotypes. Typically, though ecotypes exhibit phenotypic differences (such as in morphology or physiology) stemming from environmental heterogeneity, they are capable of interbreeding with other geographically adjacent ecotypes without loss of fertility or vigor.

ADAPTATION IN PLANTS

Adaptation to light regime

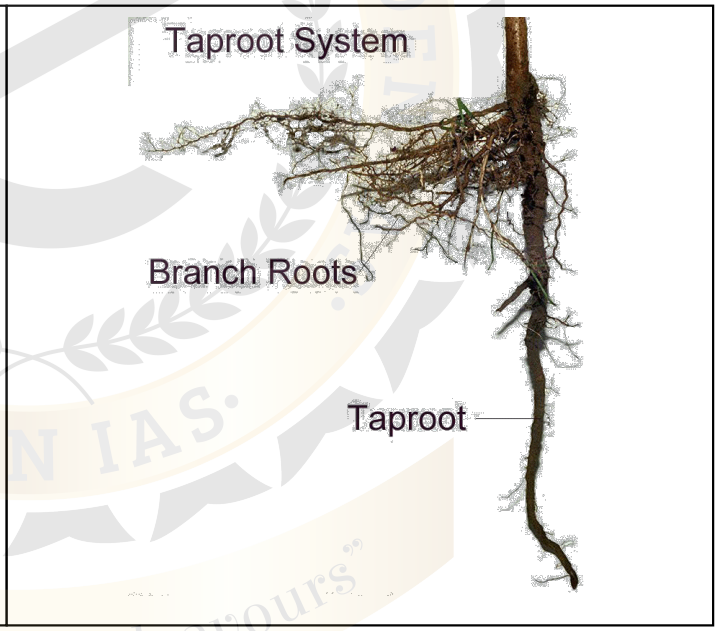
Plants may be classified ecologically according to their light requirements, those needing full sunlight for good growth are known as **heliophytes**, while those growing best in shade are known as **sciophytes**. However, some plants are more adaptable than others are, so there are heliophytes that can survive in partial shade and sciophytes which are not damaged by small spells of bright light. **Pioneer species of tropical forests are heliophytes**, while secondary species, which colonized the area after the establishment of heliophytic trees, are sciophytes. Examples of heliophytes are sugar cane, sunflower and maize.

Heliophytes are capable of a more efficient use of high light intensities than sciophytes. Heliophytes can never reach photosynthetic saturation under natural conditions, however intense the light. Sciophytes, on the other hand, can often reach saturation level at light intensities of only 20% full sunlight. The shading of heliophytes strongly reduces growth and reproduction and hence yields. Sciophytes are also known as **photophobous** plants and they reach their saturation level in only 20% sunlight. Shade-plants essentially follow strategies of optimum use of available energy and conservation of energy.

Adaptation to Water-Scarcity and Heat

Ephemerals: An **ephemeral plant** is one marked by short life cycles. The word ephemeral means transitory or quickly fading. In regard to plants, it refers to several distinct growth strategies. The first, **spring ephemeral**, refers to perennial plants that emerge quickly in the spring and die back to their underground parts after a short growth and reproduction phase. **Desert ephemerals** are plants which are adapted to take advantage of the short wet periods in arid climates. **Mud-flat annuals** take advantage of short periods of low water. In areas subjected to recurring human disturbance, such as plowing, **weedy ephemerals** are very short lived plants whose entire life cycle takes less than a growing season. In each case, the species has a life cycle timed to exploit a short period when resources are freely available. In simple words they complete their entire life cycle quickly during the optimal season (rainy season in arid/ semi-arid climates). During tough periods or dry spells ephemerals generally lie in a dormant stage.

Tap Roots: A taproot is a large, central, and dominant root from which other roots sprout laterally. Typically a taproot is somewhat straight and very thick, is tapering in shape, and grows directly downward. Taproots are also an important adaptation for searching for water. Tap roots can reach even upto the water table.



Xerophytes: A xerophyte is a species of plant that has adaptations to survive in an environment with little liquid water, such as a desert or an ice- or snow-covered region in the Alps or the Arctic. Popular examples of xerophytes are cacti, pineapple and some Gymnosperm plants. The structural features (morphology) and fundamental chemical processes (physiology) of xerophytes are variously adapted to conserve water, also common to store large quantities of water, during dry periods. Other species are able to survive long periods of extreme dryness or desiccation of their tissues, during which their metabolic activity may effectively shut down. Plants with such morphological and physiological adaptations are xeromorphic. Xerophytes such as cacti are capable of withstanding extended periods of dry conditions as they have deep-spreading roots and capacity to store water. The leaves are waxy and thorny that prevents loss of water and moisture. Even their fleshy stems can store water. Small leaves , sunken stomata, leathery leaf surfaces, thorns in place of leaves, leaves reduced to spines, no leaves etc all are xerophytic adaptations.

Many xerophytes may accumulate proline (an amino acid) in response to stress or chaperonins (Heat shock proteins)-these provide physiological adaptation to high temperature conditions-These proteins help other proteins to maintain their structure and avoid denaturation. **Denaturation** is a process in which proteins or nucleic acids lose the quaternary structure, tertiary structure, and secondary structure which is present in their native state, by application of some external stress or compound such as a strong acid or base, a concentrated inorganic salt, an organic solvent

Succulents: Succulent plants, also known as succulents, are plants that have some parts that are more than normally thickened and fleshy, usually to retain water in arid climates or soil conditions. The word "succulent" comes from the Latin word sucus, meaning juice, or sap. Succulent plants may store water in various structures, such as leaves and stems. Some definitions also include roots, thus geophytes that survive unfavorable periods by dying back to underground storage organs may be regarded as succulents. In horticultural use, the term "succulent" is sometimes used in a way which excludes plants that botanists would regard as succulents, such as cacti. Succulents are often grown as ornamental plants because of their striking and unusual appearance.

C4 Pathway of Photosynthesis: Carbon fixation or carbon assimilation is the conversion process of inorganic carbon (carbon dioxide) to organic compounds by living organisms. The most prominent example is photosynthesis, although chemosynthesis is another form of carbon fixation that can take place in the absence of sunlight. Organisms that grow by fixing carbon are called autotrophs. Autotrophs include photo-autotrophs, which synthesize organic compounds using the energy of sunlight, and litho-autotrophs, which synthesize organic compounds using the energy of inorganic oxidation. Heterotrophs are organisms that grow using the carbon fixed by autotrophs. The organic compounds are used by heterotrophs to produce energy and to build body structures. "Fixed carbon", "reduced carbon", and "organic carbon" are equivalent terms for various organic compounds. Six autotrophic carbon fixation pathways are known as of now. **C4 carbon fixation or the Hatch–Slack pathway is a photosynthetic process in some plants. It is the first step in extracting carbon from carbon dioxide to be able to use it in sugar and other biomolecules.** "C4" refers to the four-carbon molecule that is the first product of this type of carbon fixation. Plants having this pathway perform better in low-soil water environments because the key feature of C4 photosynthesis is the operation of a CO2-concentrating mechanism in the leaves, which serves to saturate photosynthesis and suppress photorespiration in normal air.

Adaptation to Aquatic Environments

Aquatic plants, hydrophytes, or hydrophytic plants, also called water-loving plants, are plants that are naturally adapted to growing in water or waterlogged soil. They may grow entirely or partly submerged, or floating on the water surface, or with their roots anchored to the ground in swamps or beside bodies of water.

They are able to thrive with watery places as their natural habitat due to special morphological and anatomical modifications. They may show the presence of Aerenchyma (large air spaces in the leaves and petioles) that helps in transportation of oxygen produced during photosynthesis. The presence of inflated petioles and leaves also impart buoyancy to the plants.

Roots are poorly developed or absent in free floating plants or hydrophytes. So they generally have emergent leaves (i.e. leaves projecting above the water surface) which help in exchange of gases and also provides buoyancy.

Adaptation in Saline Environment

Halophytes or halophytic plants, also called salt loving plants, are plants that can tolerate growing under saline conditions or in natural habitats which are excessively rich in salts. Included under the halophytic plant classification are the nipa (Nypa fruticans), talisay (Terminalia catappa), bakawan (Rhizophora mucronata) and many other mangrove species. Coconut (Cocos nucifera), cashew (Anacardium occidentale), jackfruit (Artocarpus heterophyllus) and tamarind (Tamarindus indica) have varying tolerance to salinity. The common table salt is in fact used as a fertilizer for coconut.

Halophytes under hot and dry conditions may become succulents and dilute the concentration of salts, with water stored in stems and leaves. The presence of salt glands often helps in excreting the extra salt back into the soil. **Osmoregulation also helps in preventing the concentration of salts**. Organic solutes like **glycerol, proline and sobritol help in osmoregulation.**

Since halophytes are exposed to saline and anaerobic conditions in wetlands, tidal marshes etc. they have developed special adaptations like **vivipary** (Seeds germinate while they are on trees) and **pneumatophores** (respiratory roots). Such roots help in taking oxygen from the atmosphere and transport it to the main roots. Plants often develop prop and stilt roots which give support to plants in wet substratum.

Adaptation to Oligotrophic Conditions

An Oligotrophic environment has deficiency of nutrients. An oligotroph is an organism that can live in an environment that offers very low levels of nutrients. Oligotrophic environments include deep oceanic sediments, caves, glacial and polar ice, deep subsurface soil, aquifers, ocean waters, and leached soils. In nutrient poor soils the nutrient accumulation in vegetation is high. Many plants growing in Oligotrophic conditions possess Mychorrhizae which have mutualistic association with roots. They help in efficient absorption of nutrients (eg phosphorus) from the soil. Endomychorrhizae dwell inside the roots of the plants whereas Ectomychorrhizae forms a mat outside the roots.

ADAPTATION IN ANIMALS

Migration

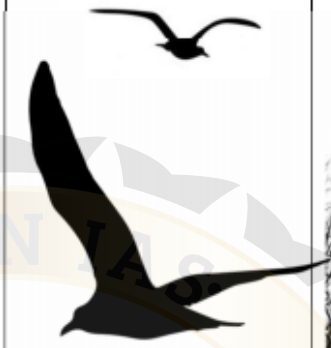
Animal migration is the regular movement of animals from one region to another. Usually migrations are seasonal, but that is not always the case. Migration is different from an animal's general wandering in that migration usually has these three features:

- Migration is movement of a greater distance than the animal normally travels within its home range and more or less on a daily basis for eg in search of prey or water.
- Migration is movement that is purposeful and directional.
- Migration is movement that has a defined beginning and end.

Scientists classify migrating animals into two groups based on their reason for migrating. The terms obligate migration and facultative migration are used to describe why a species migrates.

Obligate Migration	Facultative Migration
	
Individuals in these species MUST migrate each year for survival. *These migrations tend to be very consistent year to year in both their timing and their path. These are almost always **complete migrations**. The longest migrations are usually obligate migrations.*	*Individuals in these species "choose" to migrate or not. Their "choice" depends on resource availability.* *These migrations are usually done to find a great quantity of resources, even though resources in the current location have not run out. **Partial migrations** are typical in this case, and **interruptive migrations** are facultative as well. Facultative migrations are usually shorter in distance.*

Four additional terms classify migrations based on the different ways animals behave. **Complete migration, partial migration, differential migration,** and **interruptive migration** are all terms to describe which or when individuals within the species migrate. Use the visuals below to understand these terms.

Complete Migration	Partial Migration	Differential Migration	Interruptive Migration
			
ALL individuals of these species make the migration every year, as is the case for the Arctic Tern.	*SOME individuals of these species will migrate when the time comes, and some will not, as is the case for the American Robin.*	*These species have different migration patterns for different GROUPS. Young Herring Gulls migrate a shorter distance than older gulls. Male American Kestrels migrate a shorter distance and at a different time than female American Kestrels.*	*These species do not migrate at all some years, but some or all may migrate other years. Blue jays are an example of this, as they will suddenly all migrate if food runs out in their area.*

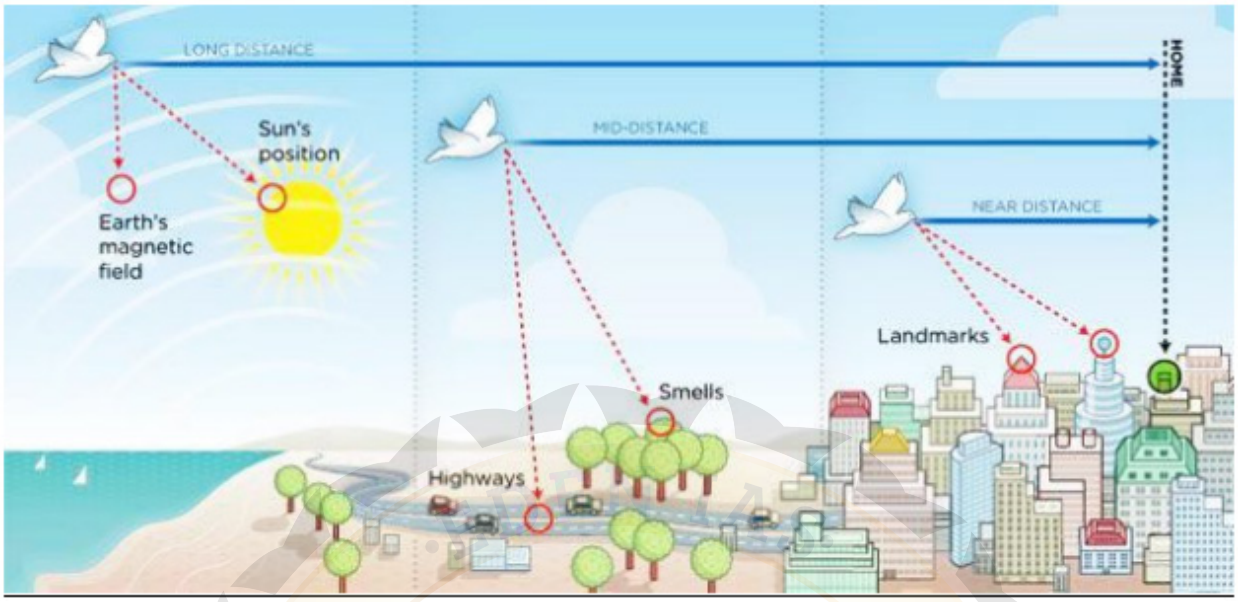
The motivation for migration is different for different species. The three most common reasons for animal migration are:

1. To move between sites that offer different necessary resources: sites for feeding, sites for breeding, sites for hibernation, etc.
2. To avoid seasonal environmental conditions such as droughts, floods, or freezing temperatures.
3. To follow the availability of their food source. This can tie in with seasonal conditions, as food sources (plants or prey) may be scarce seasonally.

How do they navigate?

How wild animals navigate during migration is a question that has fascinated humans for a long time! Some species are able to migrate vast distances (even across the world!) and they do not use a map, compass, or GPS device. In fact, some species are able to navigate through migration even though no living individual of that species has made the migration before!

Scientists studying migration have found a number of different ways creatures navigate. Each species uses different skills and techniques to find their way, and most species are limited and cannot use all the methods listed below. However, most species have been found to have multiple navigation skills, so that they can use different clues as they get closer to their destination or as conditions change. For example, a species that primarily uses the sun's position to navigate might turn to using the magnetic field to navigate if the day is cloudy.



Skills Used in Navigation:

- **Position of the Sun**: Some species can determine the direction they are moving in by looking at the position of the sun in the sky.
- **Earth's Magnetic Field**: Some species can sense the magnetic fields created by the Earth's magnetic north and south poles and distorted by landforms. These animals use the magnetic fields almost as car lanes, knowing the direction they are traveling by their position in the magnetic field.
- **Position of the Stars**: Some species have been shown to use the stars and constellations to navigate. Experiments done inside planetariums have shown that changing the orientation of the starry sky will change the direction these species try to go.
- **Smells**: Some species use scent to recognize familiar places.
- **Landmarks**: Some species use visual clues such as rivers, mountains, or even smaller landmarks to find their way.

Camouflage

Being able to blend into the environment is an adaptation known as camouflage. This adaptation helps animals blend in with their surroundings. Animals utilize camouflage to avoid detection by both predator and prey species. There are two types of camouflage viz. Mimesis and Crypsis. Mimesis is when animals are seen but resemble something else. The orchid flower mantis and the African twig mantis are two similar insect species that have developed mimesis camouflage for their very different environments.

Crypsis is a form of camouflage that helps animals avoid being seen at all. The arctic fox uses crypsis to hide from predators like polar bears, and to also sneak up on it favorite prey-lemmings.

Camouflage only works if it matches the environment. Animals that live in a variable environment must change their camouflage to continue to avoid detection. The least weasel is a fierce little hunter that can be found in Illinois –In the warm months the weasel's coat is brown, but in the winter it changes to white.

Hibernation and Aestivation

The state of inactivity and a low metabolic process performed by the animals during the winters is known as **Hibernation**. It is also known as **winter sleep**. On the contrary, when animals take rest in shady and moist place during summer, it is called **Aestivation or Estivation**. Aestivation is also known as **summer sleep**.

The importance of this sleep is mainly related to the conservation of energy of one's body, survival during the extremes temperature, scarcity of food and water, etc. This sleep can be of long or short duration. During such naps, the use of energy by the animals gets reduced to 70-100 times lesser than the usual time or at an active state.

For going into hibernation or aestivation, animals go through the pre-preparation stage, where the animals store enough of food and water which may last for the long duration, but generally, the food is stored in the form of fat, which provides energy to survive.

These sleep proceeds gradually, as the metabolic activity, hearts beat and breathing rates also slows down. The electrical activity in the brain though stops, but still, the animals respond to stimuli such as sound, light, and temperature.

Though in some cases the animals awake, perhaps every two weeks to take fresh air and deep breathe, but when the season change, the arousal starts when the internal body system starts getting active slowly. It takes few hours for animals to get completely active.

BASIS FOR COMPARISON	HIBERNATION	AESTIVATION(ESTIVATION)
Meaning	Hibernation is the type of winter sleep, performed by the warm and cold-blooded animals.	Aestivation is the type of summer sleep, performed by cold-blooded animals.
Duration	It is for the whole winter.	It is of short duration.
Process	As hibernation is the sleep during the winter, the animals look out for the warmer place, their metabolic activities slow down, and it is the dormant stage.	Aestivation is a summer sleep, so animals search for the moist, shady and cool place to sleep.
Examples	Bats, birds, mammals, insects, etc.	Bees, snails, earthworms, salamanders, frogs, earthworms, crocodiles, tortoise, etc.
Importance	Hibernation helps in maintaining the body temperature and thus avoids any form of any internal body damage due to low temperatures.	Aestivation also helps in maintaining the body temperature by avoiding the excessive water loss and any internal body damaged due to high temperatures.

Mimicry

In evolutionary biology, mimicry is an evolved resemblance between an organism and another object, often an organism of another species. Mimicry may evolve between different species, or between individuals of the same species. Often, mimicry functions to protect a species from predators, making it an anti-predator adaptation. Mimicry evolves if a receiver (such as a predator) perceives the similarity between a mimic (the organism that has a resemblance) and a model (the organism it resembles) and as a result changes its behaviour in a way that provides a selective advantage to the mimic. The resemblances that evolve in mimicry can be visual, acoustic, chemical, tactile, or electric, or combinations of these sensory modalities. Mimicry may be to the advantage of both organisms that share a resemblance, in which case it is a form of mutualism; or mimicry can be to the detriment of one, making it prone to parasite attack or competition.

Batesian mimicry is a form of mimicry where a harmless species has evolved to imitate the warning signals of a harmful species directed at a predator. It is named after the English naturalist Henry Walter Bates, after his work on butterflies in the rainforests of Brazil. It is often contrasted with Müllerian mimicry, a form of mutually beneficial convergence between two or more harmful species. For example in Mullerian mimicry both the model and the mimic possess poison yet the mimic mocks the model mostly to avoid casualties.

BATESIAN MIMICRY

Monarch Butterfly (poisonous) Viceroy Butterfly (non- poisonous)

MULLERIAN MIMICRY

Red –postman Butterfly **Common Postman Butterfly**

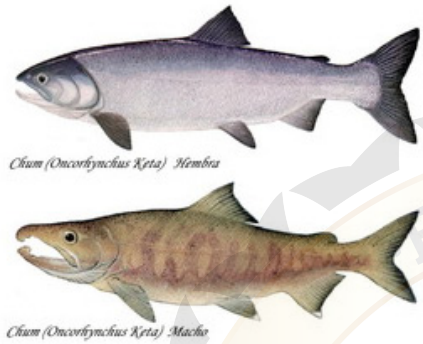
Warning Colouration

Warning coloration is when an animal has brightly colored body markings, and they do not blend with their surroundings. They bright colors warn predators to stay away. For example, the lion fish has brightly striped fins with poisonous spines that it displays to would-be attackers.

Dart Frog

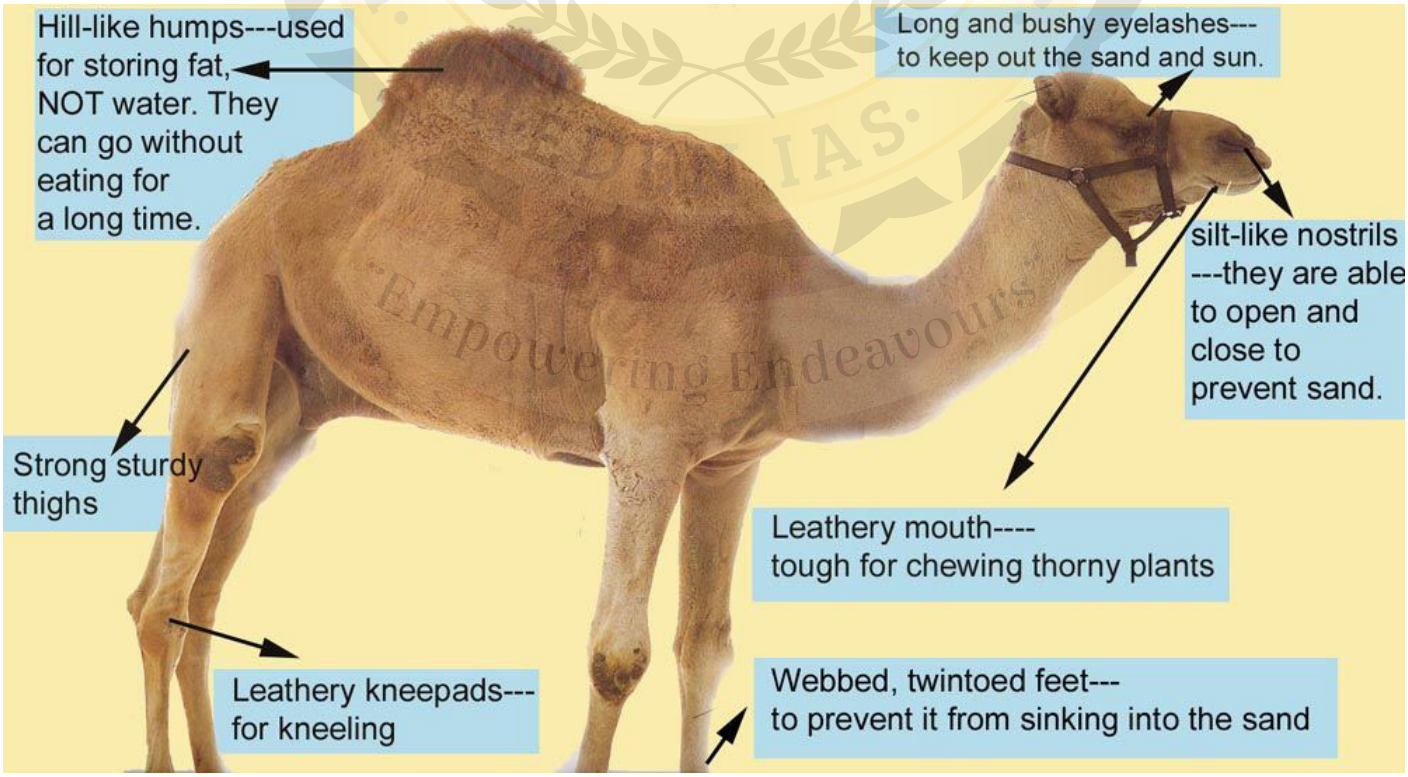
Counter Shading

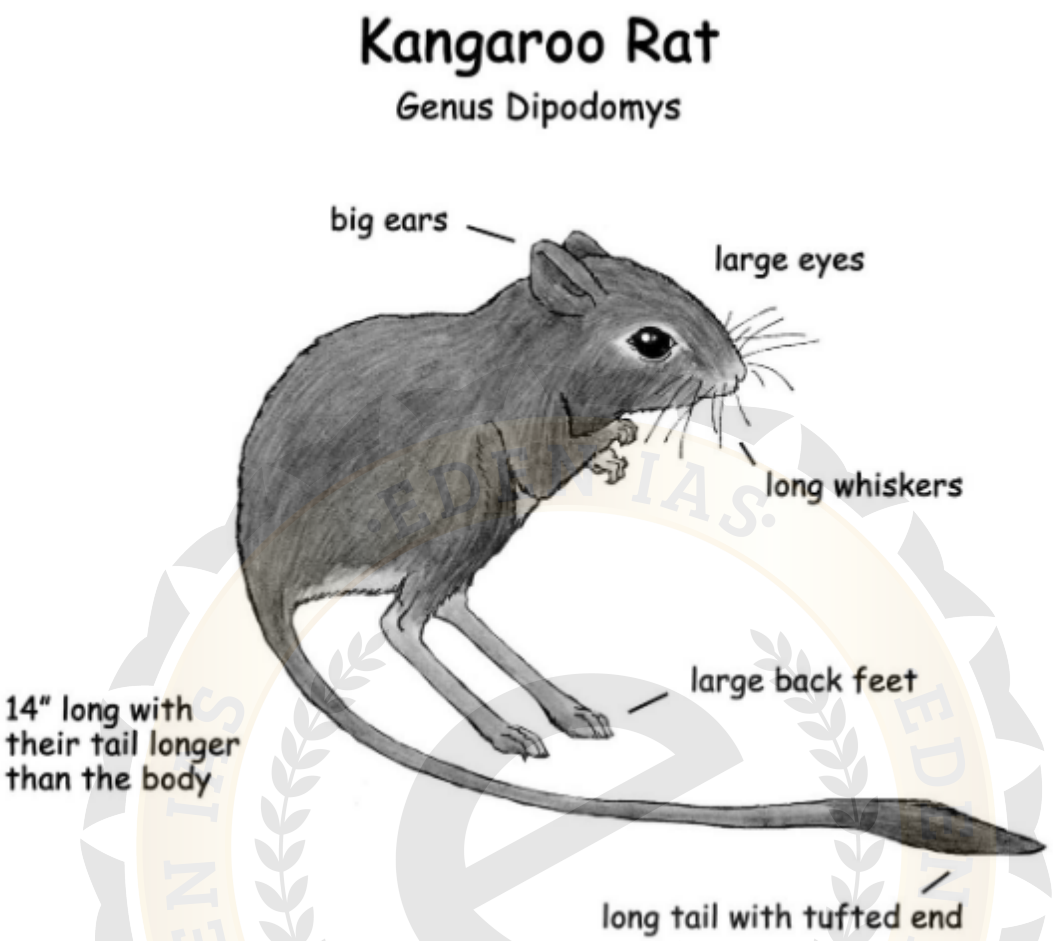
Counter shading is when the top side of an animal is a different color from the bottom side. Most fish have counter shading. When seen from above, the fish blends in the bottom of the lake, river, or ocean. The bottom side of the fish is silver-white. When seen from below, the fish blends with the water's surface and the sky. Some land animals have counter shading also. The underside of the animal is lighter than the top side.



Adaptation to Water Scarcity

Animals adapt to water scarce conditions by lowering body water loss as much as possible. The animals in arid climates often make optimum utilization of available water and can survive without the availability of water for days or months. The Camel is an excellent example. Kangaroo rat can survive without water for a very long period. It excretes solid urine and can go without water from birth to death if need arises





Adaptation to Cold conditions

For terrestrial ectotherms inhabiting temperate and polar regions of the earth, the subzero temperatures of winter pose a severe threat, since life processes in nature are incompatible with intracellular ice. Behavioral strategies allow some species to elude subzero exposure. For example, Monarch butterflies migrate to Mexico, various frog and turtle species choose underwater hibernation, and toads may dig one meter down into the earth to remain below the frost line. For many species, however, survival of the subzero temperatures of winter requires physiological and biochemical adaptations conferring cold hardiness.

At temperatures below the freezing point (FP) of body fluids, water exists in a metastable state, the probability of spontaneous nucleation increasing as temperature further decreases. The FP of body fluids of most animals (in the absence of cryo-protective measures) ranges from about -05°C for terrestrial animals to -1.7OC for marine animals adapted to full strength seawater. For survival at lower temperatures, cold hardy ectotherms have one of two options.

1) Freeze tolerance
2) Freeze avoidance

Many organisms develop cold hardening ice-nucleating proteins or anti-freeze proteins that lower freezing point of their body fluids.

UNIT-II

[ECOSYSTEM]

The term "**ecosystem**" was coined by British Ecologist **A. G. Tansley** in 1935, from "eco", meaning environment, and "system", meaning a complex of coordinated units.

A.G. Tansley defined ecosystem as 'a particular category of physical systems, consisting of organisms and inorganic components in a relatively stable equilibrium. F.R. Fosberg has defined ecosystem as 'a functioning, interacting system composed of one or more living organisms and their effective environment, both physical and biological'. According to R.L. Linderman the term ecosystem applies to 'any system composed of physical-chemical-biological processes, within a space-time unit of any magnitude'.

Ecosystem is a self sustaining unit of nature. It is defined as a functionally independent unit (of nature) where living organisms interact among themselves as well as with their physical environment. In nature two major categories of ecosystems exist: terrestrial and aquatic. Forests, deserts and grasslands are examples of terrestrial ecosystem. Ponds, lakes, wet lands and salt water are some example of aquatic ecosystem. Crop lands and aquarium are the example of manmade ecosystems. The interaction between the living organisms and their environment can be studied in a puddle of water or a hole in a tree, which are very small ecosystems or in large ecosystems such a forest, river or ocean. Irrespective of their sizes all ecosystems share many common characteristics.

An 'Ecosystem' is a region with a specific and recognizable landscape form such as forest, grassland, desert, wetland or coastal area. The nature of the ecosystem is based on its geographical features such as hills, mountains, plains, rivers, lakes, coastal areas or islands. It is also controlled by climatic conditions such as the amount of sunlight, the temperature and the rainfall in the region. The geographical, climatic and soil characteristics form its non-living (abiotic) component. These features create conditions that support a community of plants and animals that evolution has produced to live in these specific conditions. The living part of the ecosystem is referred to as its biotic component and the non-living part is known as abiotic component. Ecosystems are divided into terrestrial or land based ecosystems, and aquatic ecosystems in water. These form the two major habitat conditions for the Earth's living organisms.

The living community of plants and animals in any area together with the non-living components of the environment such as soil, air and water, constitute the ecosystem.

Some ecosystems are fairly robust and are less affected by a certain level of human disturbance. Others are highly fragile and are quickly destroyed by human activities. Mountain ecosystems are extremely fragile as degradation of forest cover leads to severe erosion of soil and changes in river courses. Island ecosystems are easily affected by any form of human activity which can lead to the rapid extinction of several of their unique species of plants and animals. Evergreen forests and coral reefs are also examples of species rich fragile ecosystems which must be protected against a variety of human activities that lead to their degradation. River and wetland ecosystems can be seriously affected by pollution and changes in surrounding landuse.

Stressing the importance of ecosystem C. C. Park says that 'ecosystems are regarded by many ecologists to be the basic units of ecology because they are complex, interdependent and highly organized systems and because they are the basic building blocks of the biosphere'.

CLASSIFICATION OF ECOSYSTEMS

Ecosystems may be identified and classified on various bases, with different purposes and objectives as outlined below:

On the basis of habitats

The habitats relate to physical environmental conditions of a particular spatial unit of the biosphere. These physical conditions determine the nature and characteristics of biotic communities and therefore there are spatial variations in the biotic communities.

Based on this premise the world ecosystems are divided into two major categories viz.:

(A) Terrestrial ecosystems, and

(B) Aquatic ecosystems.

There are further variations in the terrestrial ecosystems in terms of physical conditions and their responses to biotic communities.

Therefore, the terrestrial ecosystems are further divided into sub-categories of:

- Upland or mountain ecosystems
- Lowland ecosystems
- Forest ecosystems
- Warm desert ecosystems
- Cold desert ecosystems

These sub-ecosystems may be further divided into descending orders depending on specific purposes and objectives of studies.

(B) **The aquatic ecosystems are subdivided into two broad categories:**

(i) Freshwater (on continents) ecosystems and

(ii) Marine ecosystems.

Freshwater ecosystems are further divided into river ecosystems, marsh and bog ecosystems while marine ecosystems are divided into open ocean ecosystems, coastal estuarine ecosystem, coral reef ecosystem, or can be alternatively divided into ocean surface ecosystems and ocean bottom ecosystems.

On the basis of spatial scales

Ecosystems are divided into different types of various orders on the basis of spatial dimensions required for specific purposes. The spatial scales may be brought down from a continent to a single biotic life (plant or animal). **In 1973, Ellenberg declared that the world can be classified into different ecosystems in a hierarchical order- (I-II-III-IV)**

I. The Biosphere (The largest and all-encompassing ecosystem.)

The largest ecosystem is the whole biosphere which is subdivided into two major types:

A. Continental ecosystems, and

B. Oceanic or marine ecosystems.

II. 'Mega-ecosystems

- Marine ecosystems, related to saline water environment, such as oceans and seas,
- Fresh-water ecosystems, as in rivers and lakes,
- Semi-terrestrial ecosystems, related to wet soil and air,
- Terrestrial ecosystems, related to aerated soil and air, such as forests, grasslands, deserts,
- Urban-industrial ecosystems, that are man-made ecosystems, such as cities, cropland etc.

III. Each mega-ecosystem is further subdivided into-macro, meso and micro ecosystems.

A forest ecosystem is a macro division, a deciduous broad-leaf forest along with its fauna falls within the meso division, while a mountain deciduous broad-leaf forest falls within the micro division.

IV. Nano-ecosystems are even smaller ecosystems that are specially contained within larger ecosystems but have individual characteristics.

On the basis of uses

E.P. Odum (1959) has divided the world ecosystems on the basis of use of harvest methods and net primary production into two broad categories viz.:

(A) Cultivated ecosystems and

(B) Non-cultivated or natural ecosystems.

Cultivated ecosystems may be further subdivided into several categories on the basis of cultivation of dominant crops e.g., wheat field ecosystem, rice field ecosystem, sugarcane field ecosystem, fodder field ecosystem etc. Similarly, non-cultivated ecosystems can be subdivided into forest ecosystem, tall grass ecosystem, short grass ecosystem, desert ecosystem, see-weeds ecosystem etc.

On the basis of human interference

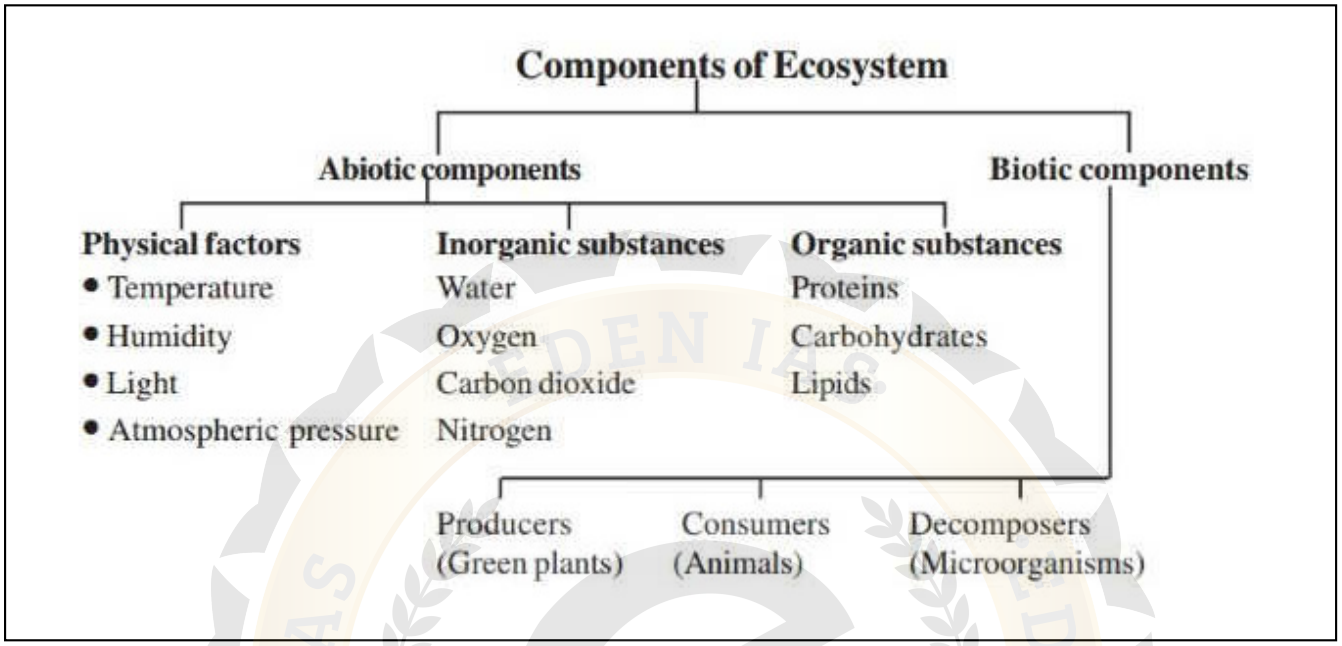
Depending on the level of human interference and the degree of the impact of anthropogenic activities, ecosystems can also be classified into —

(i) Natural Ecosystems, which are self-regulating systems, without much direct interference by humans. They include ecosystems such as forest, grassland, desert, sea, ocean, estuarine, lake, river coral reef etc.

(ii) Artificial Ecosystems or man-engineered ecosystems, such as in cities, irrigated croplands, green-houses, and, recently, in biotic ecosystems — canopied, air-conditioned, vegetative places where scientists live and grow crops and fruits for 2 or 3 months out of touch of the world. These experiments are conducted for future living in other planets or the man.

ECOSYSTEM-STRUCTURE AND FUNCTIONS

The components of the ecosystem are categorized into abiotic or non-living and biotic or living components. From structural point of view all ecosystems consist of following four basic components:



Abiotic Substances:

These include basic inorganic and organic compounds of the environment or habitat of the organism. The inorganic components of an ecosystem are carbon dioxide, water, nitrogen, calcium, phosphate, all of which are involved in matter cycles (biogeochemical cycles). The organic components of an ecosystem are proteins, carbohydrates, lipids and amino acids, all of which are synthesized by the biota (flora and fauna) of an ecosystem and reach ecosystems as their wastes, dead remains, etc, The climate, temperature, light, soil, etc., are other abiotic components of the ecosystem.

Producers:

Producers are autotrophic organisms like chemosynthetic and photosynthetic bacteria, blue green algae, algae and all other green plants. They are called ecosystem producers because they capture energy from non-organic sources, especially light, and store some of the energy in the form of chemical bonds, for later use. Algae of various types are the most important producers of aquatic ecosystems, although in estuaries and marshes, grasses may be important as producers. Terrestrial ecosystems have trees, shrubs, herbs, grasses, and mosses that contribute with varying importance to the production of the ecosystem.

Since heterotrophic organisms depend on plants and other autotrophic organisms like bacteria and algae for their nutrition, the amount of energy that the producers capture, sets the limit on the availability of energy for the ecosystem. Thus, when a green plant captures a certain amount of energy from sunlight, it is said to "produce" the energy for the ecosystem.

Consumers:

They are heterotrophic organisms in the ecosystem which eat other living creatures. There are herbivores, which eat plants, and carnivores, which eat other animals. They are also called phagotrophs or macroconsumers. Sometimes herbivores are called primary macroconsumers and carnivores are called secondary Macroconsumers.

Reducers or Decomposers:

Reducers, decomposers, saprotrophs or Macroconsumers are heterotrophic organisms that breakdown dead and waste matter. Fungi and certain bacteria are the prime representatives of this category. Enzymes are secreted by their cells into or onto dead plant and animal debris. These chemicals digest the dead organism into smaller bits or molecules, which can be absorbed by the fungi or bacteria (saprotrophs). The decomposers take the energy and matter that they harvest during this feeding process for their own metabolism. Heat is liberated in each chemical conversion along the metabolic pathway.

No ecosystem could function long without decomposers. Dead organisms would pile up without rotting, as would waste products. It would not be long before an essential element, phosphorus, for example, would be first in short supply and then gone altogether, because the dead corpses littering the landscape would be hoarding the entire supply.

Thus, the importance of the decomposers to the ecosystem is that they tear apart organisms and in their metabolic processes release to the environment atoms and molecules that can be reused again by autotrophic organisms. They are not important to the ecosystem from the energy point of view but from the material (nutrient) point of view. Energy cannot be recycled, but matter can be. Energy must be fed into ecosystem to keep up with the dissipation of heat or the increase in entropy.

Interactions of biotic and abiotic components result in a physical structure that is characteristic for each type of ecosystem. Identification and enumeration of plant and animal species of an ecosystem gives its species composition. Vertical distribution of different species occupying different levels is called stratification. For example, trees occupy top vertical strata or layer of a forest, shrubs the second and herbs and grasses occupy the bottom layers.

The components of the ecosystem are seen to function as a unit when you consider the following aspects:

(i) Productivity;

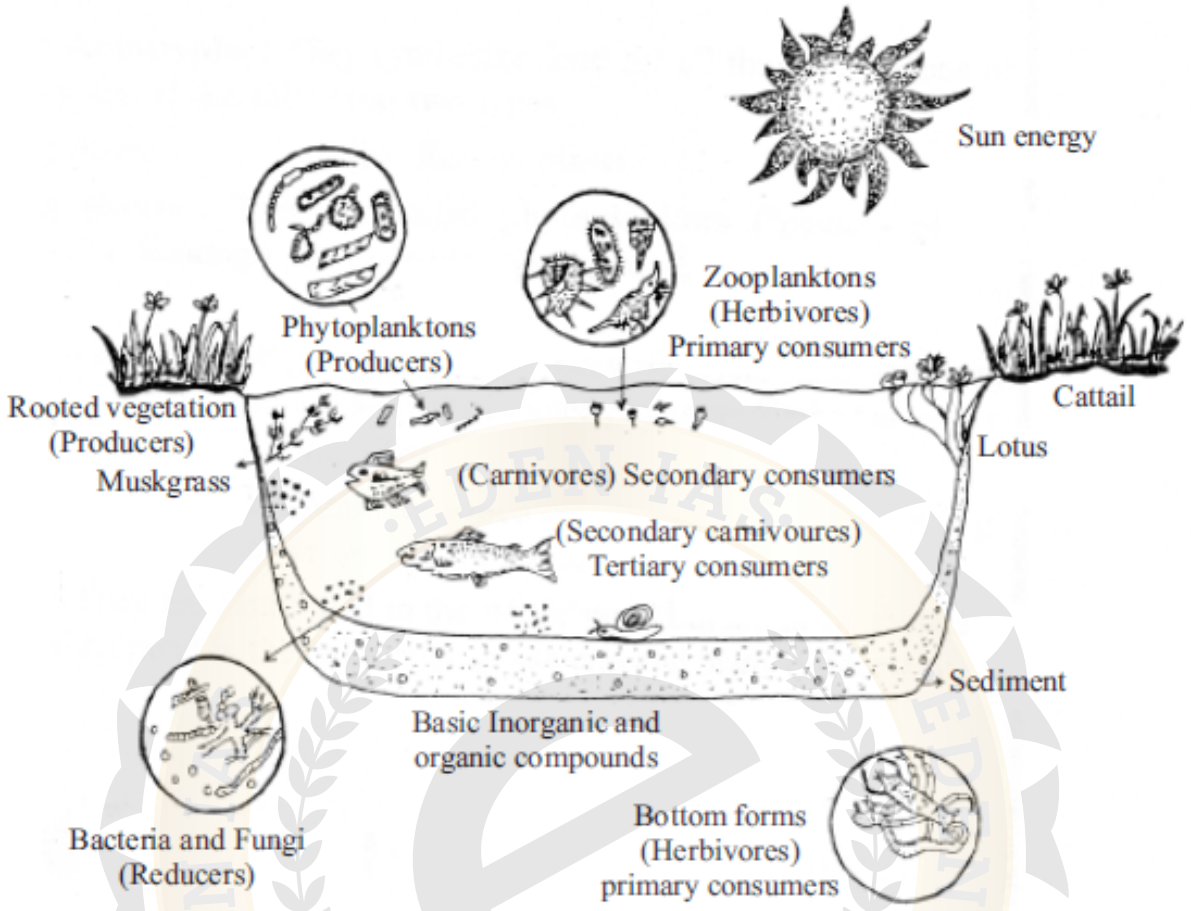
(ii) Decomposition;

(iii) Energy flow; and

(iv) Nutrient cycling.

To understand the ethos of an aquatic ecosystem let us take a small pond as an example. This is fairly a self-sustainable unit and rather simple example that explain even the complex interactions that exist in an aquatic ecosystem. A pond is a shallow water body in which all the above mentioned four basic components of an ecosystem are well exhibited. The abiotic component is the water with all the dissolved inorganic and organic substances and the rich soil deposit at the bottom of the pond.

The solar input, the cycle of temperature, day-length and other climatic conditions regulate the rate of function of the entire pond. The autotrophic components include the phytoplankton, some algae and the floating, submerged and marginal plants found at the edges. The consumers are represented by the zooplankton, the free swimming and bottom dwelling forms. The decomposers are the fungi, bacteria and flagellates especially abundant in the bottom of the pond. This system performs all the functions of any ecosystem and of the biosphere as a whole, i.e., conversion of inorganic into organic material with the help of the radiant energy of the sun by the autotrophs; consumption of the autotrophs by heterotrophs; decomposition and mineralisation of the dead matter to release them back for reuse by the autotrophs, these event are repeated over and over again. There is unidirectional movement of energy towards the higher trophic levels and its dissipation and loss as heat to the environment.



POND ECOSYSTEM

Abiotic Components

1. **Physical or climatic regime:** Pond receives solar radiation, which provides it heat and light energy to sustain life.

(a) **Light:** In case of shallow ponds with clear water sun light can penetrate up to the bottom. In deep ponds penetration of light depends on the transparency of water. The amount of dissolved/suspended particles, nutrients and number of animals and plants determine the transparency of water and control the penetration of light in it.

(b) **Temperature:** Heating effect of solar radiation leads to diurnal (day and night) or seasonal temperature cycles. In the tropical regions there are not much temperature variations. At higher latitudes there are remarkable seasonal temperature variations.

2. **Inorganic substances:** These are water, carbon, nitrogen, phosphorus, calcium and a few other elements like sulphur or phosphorus depending on the location of the pond. O2 and CO2 are in the dissolved state in water. All animals and plants depend on water for their food and exchange of gases.

3. Organic compounds: The commonly found organic matter in the pond is amino Health acids and humic acids and the breakdown products of dead animal and plant tissues. They are partly dissolved in water and the remaining are accumulated in sediment.

Biotic Components

1. **Producers or Autotrophs:** They synthesize food for all the heterotrophs of the pond. They are of the following two types viz. (a) Floating plants (b) Rooted plants

(a) **Floating plants:** They are called **phytoplankton** ("phyto"- plants, "plankton" - floating.) for example, *Spirogyra*, *Ulothrix*, diatoms and *Volvox*.

(b) **Rooted plants:** These plants occur in concentric layers from periphery to the deeper zones. Some examples of rooted plants are *Typha bulrushes*, *Sagittaria*, *Hydrilla*, *Rupia*, *Chara.*

2. **Consumers or Heterotrophs:** Animals, which feed directly on autotrophs (e.g. insect larvae, tadpole, snails) or on other animals (sunfish and bass)

3. **Decomposers:** They are distributed in the whole pond but are most abundant at the bottom of the pond in the sediment e.g. bacteria and many different types of microbes.

PRODUCTIVITY AND DECOMPOSITION

A constant input of energy is the basic requirement for any ecosystem to function and to sustain. This energy is mostly in the form of solar energy. **Primary production** is defined as the amount of biomass or organic matter produced by plants during photosynthesis. It is expressed in terms of **weight (gm)** or **energy (kcal).** The rate of biomass production is known as productivity. It is expressed in terms of **gm / m2/year** or **kcal/m2/year** to compare the productivity of different ecosystems. It can be divided into **Gross Primary Productivity (GPP)** and **Net Primary Productivity (NPP).** Gross Primary Productivity of an ecosystem is the rate of production of organic matter during photosynthesis. A considerable amount of GPP is utilized by plants in respiration. GPP minus **respiratory losses (R)** is the Net Primary Productivity (NPP). It is expressed as

$$\mathbf{NPP = GPP - R}$$

Net Primary Productivity is the available biomass for the consumption of heterotrophs (herbivores and decomposers). **Secondary Productivity** is defined as the rate of formation of new organic matter by consumers.

Primary productivity depends on the plant species inhabiting a particular area. It also depends on a variety of environmental factors, availability of nutrients and photosynthetic capacity of plants. Therefore, it varies in different types of ecosystems. The annual net primary productivity of the whole biosphere is approximately 170 billion tons (dry weight) of organic matter. Of this, despite occupying about 70 per cent of the surface, the productivity of the oceans are only 55 billion tons. Rest of course, is on land.

DECOMPOSITION

You may have heard of the earthworm being referred to as the farmer's 'friend'. This is so because they help in the breakdown of complex organic matter as well as in loosening of the soil. Similarly, decomposers break down complex organic matter into inorganic substances like carbon dioxide, water and nutrients and the process is called decomposition.

Dead plant remains such as leaves, bark, flowers and dead remains of animals, including fecal matter, constitute detritus, which is the raw material for decomposition. The important steps in the process of decomposition are fragmentation, leaching, catabolism, humification and mineralisation.

Detritivores (e.g., earthworm) break down detritus into smaller particles. This process is called fragmentation. By the process of leaching, water-soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts. Bacterial and fungal enzymes degrade detritus into simpler inorganic substances. This process is called as catabolism. It is important to note that all the above steps in decomposition operate simultaneously on the detritus. Humification and mineralisation occur during decomposition in the soil. Humification leads to accumulation of a dark coloured amorphous substance called humus that is highly resistant to microbial action and undergoes decomposition at an extremely slow rate. Being colloidal in nature it serves as a reservoir of nutrients. The humus is further degraded by some microbes and release of inorganic nutrients occurs by the process known as mineralisation.

Decomposition is largely an oxygen-requiring process. The rate of decomposition is controlled by chemical composition of detritus and climatic factors. In a particular climatic condition, decomposition rate is slower if detritus is rich in lignin and chitin, and quicker, if detritus is rich in nitrogen and water-soluble substances like sugars. Temperature and soil moisture are the most important climatic factors that regulate decomposition through their effects on the activities of soil microbes. Warm and moist environment favour decomposition whereas low temperature and anaerobiosis inhibit decomposition resulting in buildup of organic materials

ENERGY FLOW

Except for the deep sea hydro-thermal ecosystem, sun is the only source of energy for all ecosystems on Earth. Of the incident solar radiation less than 50 per cent of it is photosynthetically active radiation (PAR). We know that plants and photosynthetic bacteria (autotrophs), fix suns' radiant energy to make food from simple inorganic materials. Plants capture only 2-10 per cent of the PAR and this small amount of energy sustains the entire living world. So, it is very important to know how the solar energy captured by plants flows through different organisms of an ecosystem. All organisms are dependent for their food on producers, either directly or indirectly. So you find unidirectional flow of energy from the sun to producers and then to consumers. *Is this in keeping with the first law of thermodynamics?*

Further, ecosystems are not exempt from the Second Law of thermodynamics. They need a constant supply of energy to synthesise the molecules they require, to counteract the universal tendency toward increasing disorderliness.

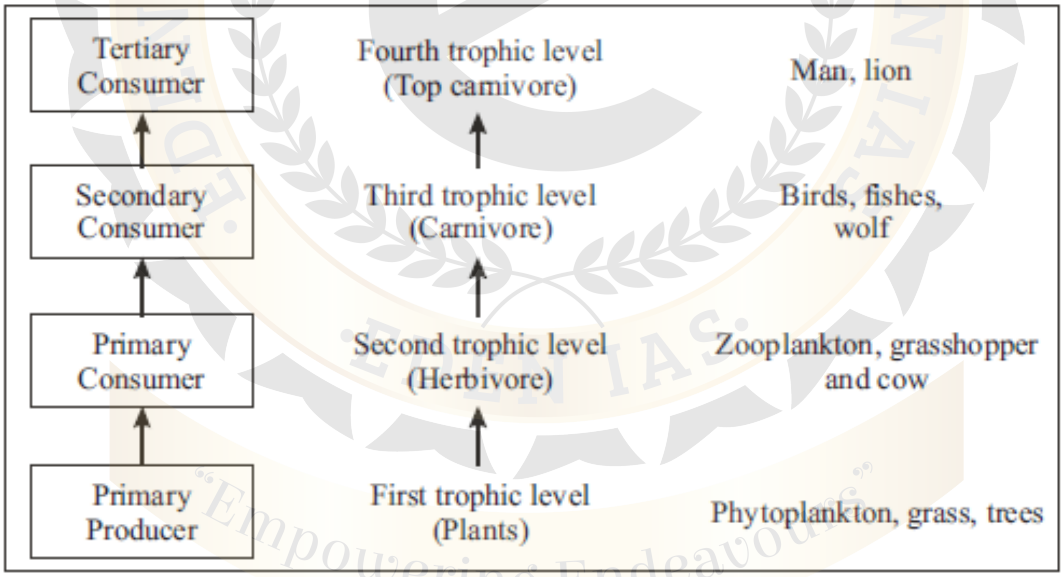
The green plants in the ecosystem-terminology are called producers. In a terrestrial ecosystem, major producers are herbaceous and woody plants. Likewise, primary producers in an aquatic ecosystem are various species like phytoplankton, algae and higher plants. You have read about the food chains and webs that exist in nature. Starting from the plants (or producers) food chains or rather webs are formed such that an animal feeds on a plant or on another animal and in turn is food for another. The chain or web is formed because of this interdependency. No energy that is trapped into an organism remains in it forever. The energy trapped by the producer, hence, is either passed on to a consumer or the organism dies. Death of organism is the beginning of the detritus food chain/web. All animals depend on plants (directly or indirectly) for their food needs. They are hence called consumers and also heterotrophs. If they feed on the producers, the plants, they are called primary consumers, and if the animals eat other animals which in turn eat the plants (or their produce) they are called secondary consumers. Likewise, you could have tertiary consumers too. Obviously the primary consumers will be herbivores.

Some common herbivores are insects, birds and mammals in terrestrial ecosystem and molluscs in aquatic ecosystem. The consumers that feed on these herbivores are carnivores, or more correctly primary carnivores (though secondary consumers). Those animals that depend on the primary carnivores for food are labelled secondary carnivores. A simple grazing food chain (GFC) is depicted as:

The detritus food chain (DFC) begins with dead organic matter. It is made up of decomposers which are heterotrophic organisms, mainly fungi and bacteria. They meet their energy and nutrient requirements by degrading dead organic matter or detritus. These are also known as saprotrophs (*sapro:* to decompose). Decomposers secrete digestive enzymes that breakdown dead and waste materials into simple, inorganic materials, which are subsequently absorbed by them.

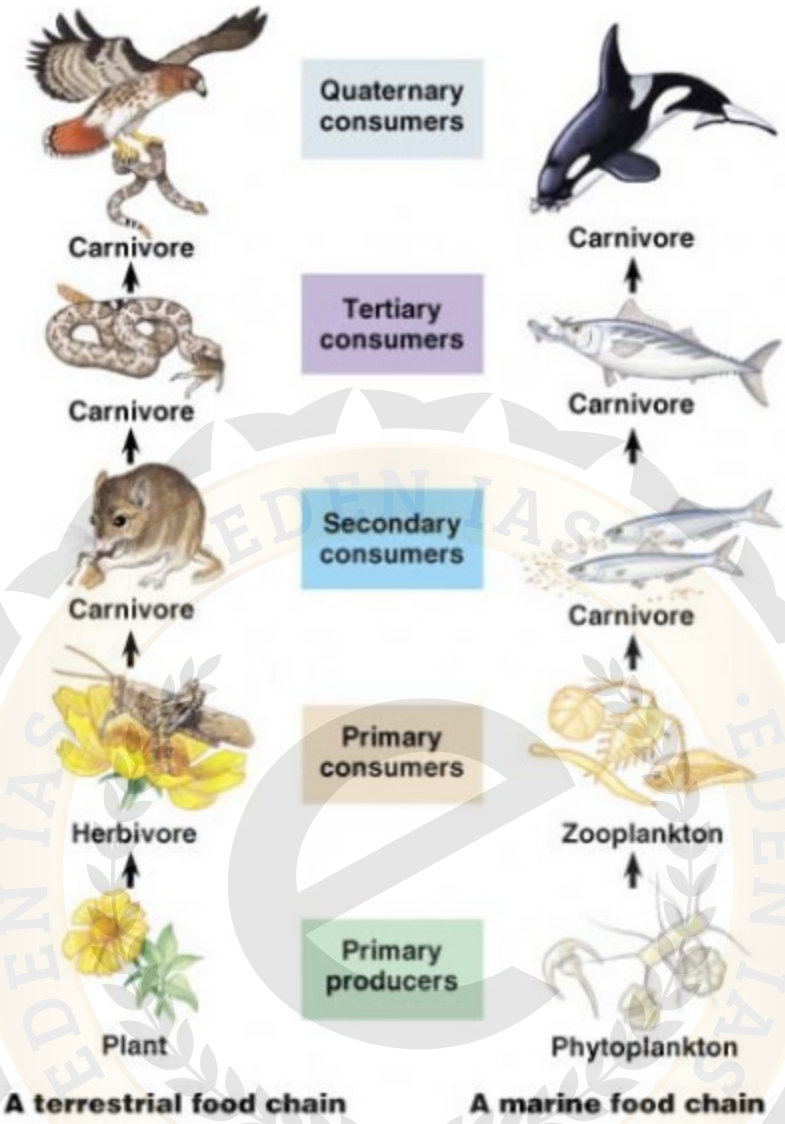
In an aquatic ecosystem, GFC is the major conduit for energy flow. As against this, in a terrestrial ecosystem, a much larger fraction of energy flows through the detritus food chain than through the GFC. Detritus food chain may be connected with the grazing food chain at some levels: some of the organisms of DFC are prey to the GFC animals, and in a natural ecosystem, some animals like cockroaches, crows, etc., are omnivores. This natural interconnection of food chains makes it a food web.

Organisms occupy a place in the natural surroundings or in a community according to their feeding relationship with other organisms. Based on the source of their nutrition or food, organisms occupy a specific place in the food chain that is known as their trophic level. Producers belong to the first trophic level, herbivores (primary consumer) to the second and carnivores (secondary consumer) to the third



Diagrammatic representation of trophic levels in an ecosystem

The important point to note is that the amount of energy decreases at successive trophic levels. When any organism dies it is converted to detritus or dead biomass that serves as an energy source for decomposers. Organisms at each trophic level depend on those at the lower trophic level for their energy demands. **Each trophic level has a certain mass of living material at a particular time called as the standing crop.** The standing crop is measured as the mass of living organisms (biomass) or the number in a unit area. The biomass of a species is expressed in terms of fresh or dry weight. Measurement of biomass in terms of dry weight is more accurate.



A TYPICAL TERRESTRIAL FOOD CHAIN AND AQUATIC FOOD CHAIN

The number of trophic levels in the grazing food chain is restricted as the transfer of energy follows 10 per cent law – only 10 per cent of the energy is transferred to each trophic level from the lower trophic level. In nature, it is possible to have so many levels – producer, herbivore, primary carnivore, secondary carnivore in the grazing food chain.

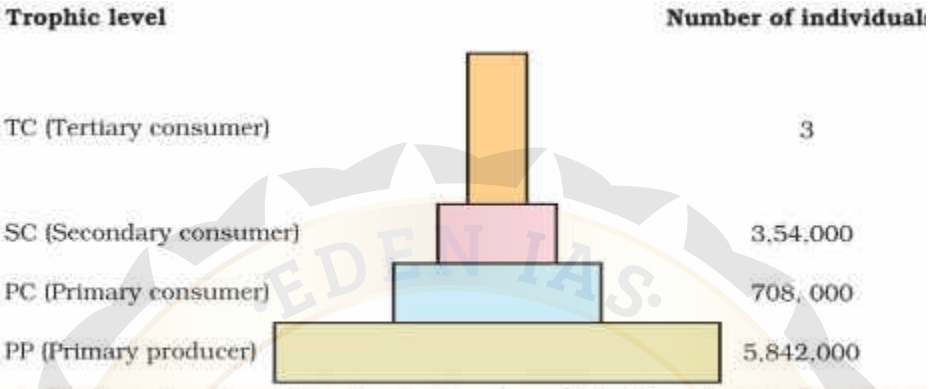
ECOLOGICAL PYRAMIDS

The pyramidal representation of trophic levels of different organisms based on their ecological position [producer to final consumer] is called as an ecological pyramid. The food producer forms the base of the pyramid and the top carnivore forms the tip. Other consumer trophic levels are in between. The pyramid consists of a number of horizontal bars depicting specific trophic levels. The length of each bar represents the total number of individuals or biomass or energy at each trophic level in an ecosystem. The ecological pyramids are of three categories.

a) **Pyramid of numbers,**
b) **Pyramid of biomass,** and
c) **Pyramid of energy or productivity.**

Pyramid of Numbers

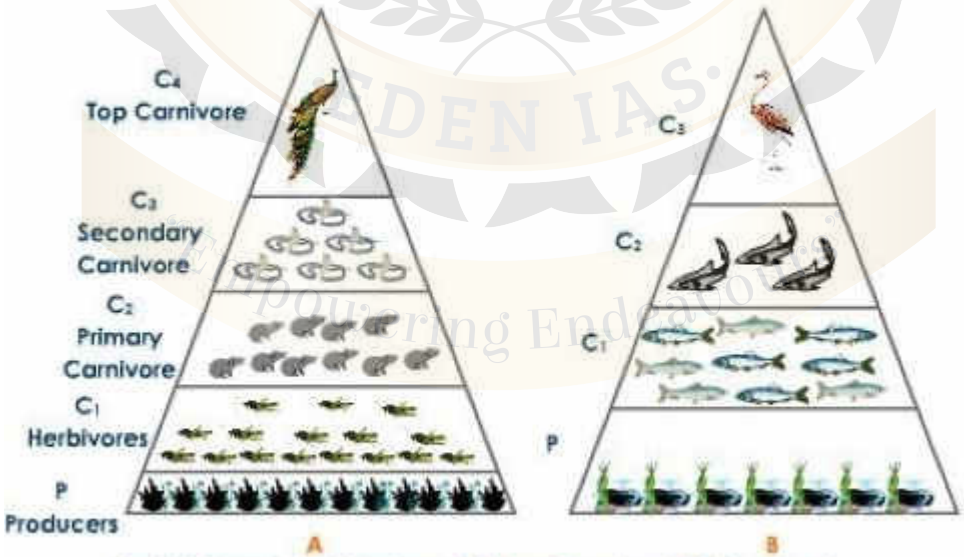
Pyramid of numbers represents the **total number of individuals of different species** (population) at each trophic level. Depending upon the size, the pyramid of numbers may not always be upright, and may even be completely inverted. It is very difficult to count all the organisms, in a pyramid of numbers and so the pyramid of number does not completely define the trophic structure for an ecosystem.



Pyramid of numbers in a grassland ecosystem. Only three top-carnivores are supported in an ecosystem based on production of nearly 6 millions plants

Pyramid of numbers – Upright

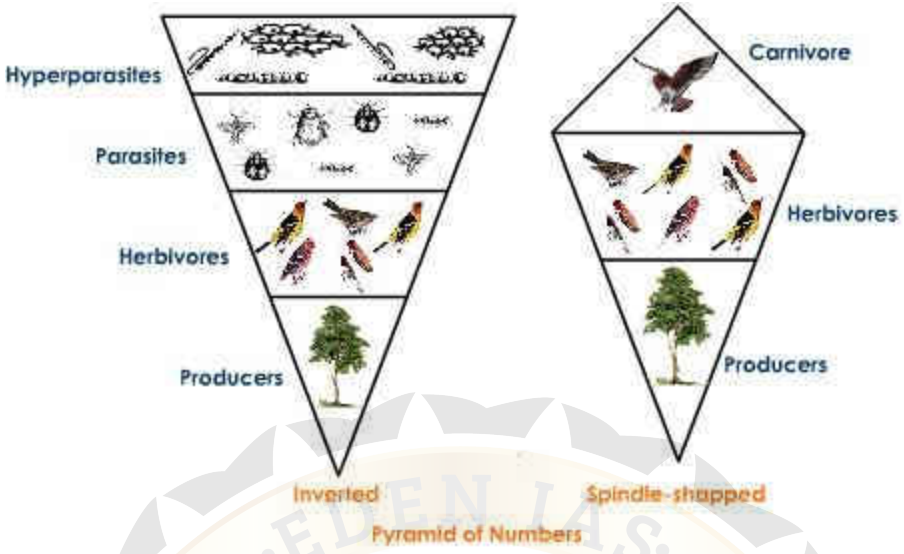
In this pyramid, the number of individuals is decreased from lower level to higher trophic level. This type of pyramid can be seen in **grassland ecosystem** and **pond ecosystem**. The grasses occupy the lowest trophic level (base) because of their abundance. The next higher trophic level is primary consumer – herbivore (example – grasshopper). The individual number of grasshopper is less than that of grass. The next energy level is primary carnivore (example – rat). The number of rats are less than grasshopper, because, they feed on grasshopper. The next higher trophic level is secondary carnivore (example – snakes). They feed on rats. The next higher trophic level is the top carnivore. (Eg: Hawk). With each higher trophic level, the number of individual decreases



Upright Pyramids of Numbers. (A) In a Grass Land (B) In a Pond

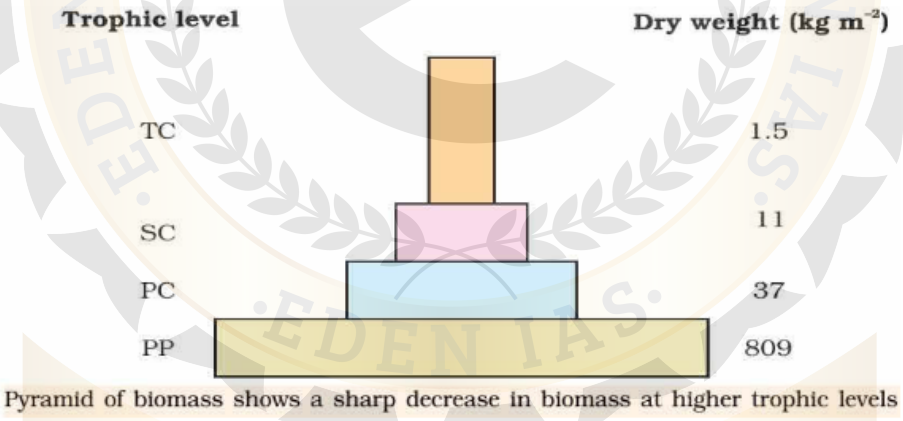
Pyramid of numbers – Inverted

In this pyramid, the number of individuals is increased from lower level to higher trophic level. E.g. Tree ecosystem.



Pyramid of Biomass

Pyramid of biomass is usually determined by collecting all organisms occupying each trophic level separately and measuring their **dry weight**. This overcomes the size difference problem because all kinds of organisms at a trophic level are weighed. Biomass is measured in g/m^2. The biomass of a species is expressed in terms of fresh or dry weight. Measurement of biomass in terms of dry weight is more accurate. Each trophic level has a certain mass of living material at a particular time called as the **standing crop**. The standing crop is measured as the mass of living organisms (biomass) or the number in a unit area.



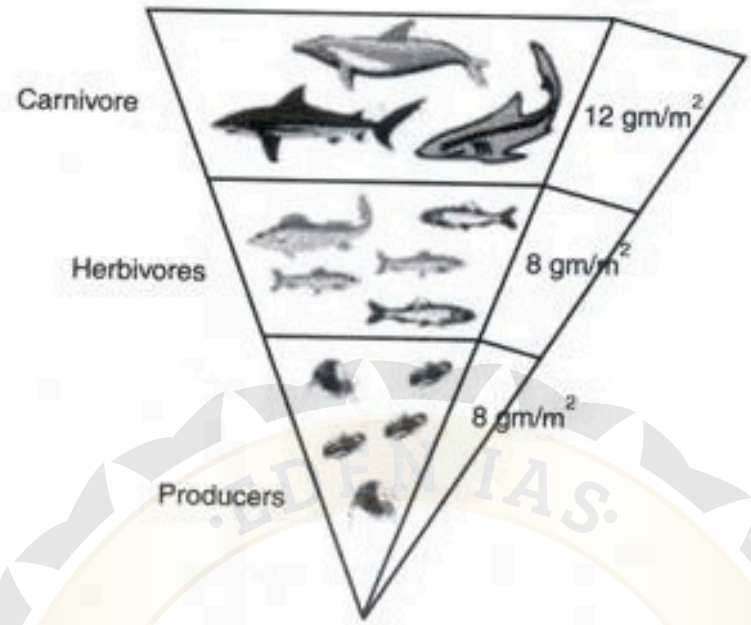
Pyramid of biomass shows a sharp decrease in biomass at higher trophic levels

Pyramid of Biomass – Upright

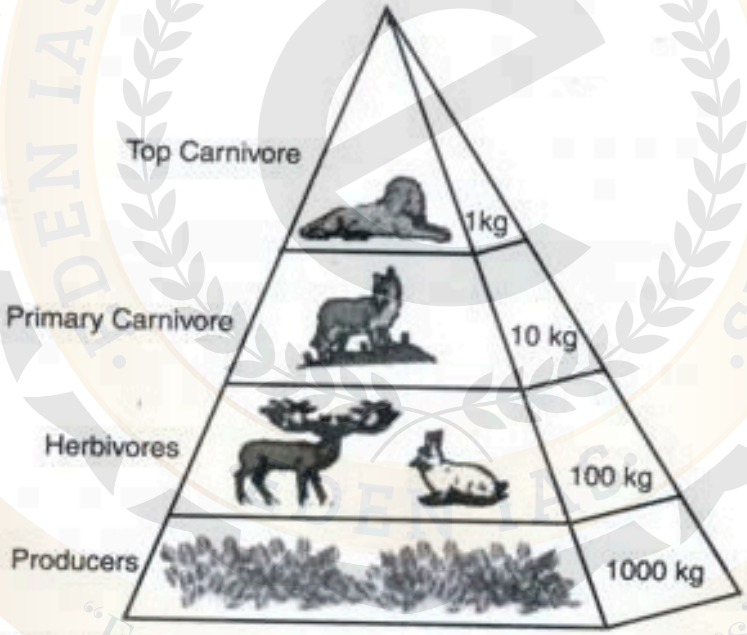
For most ecosystems on land, the pyramid of biomass has a large base of primary producers with a smaller trophic level perched on top. The biomass of producers (autotrophs) is at the maximum. The biomass of next trophic level i.e. primary consumers is less than the producers. The biomass of next higher trophic level i.e. secondary consumers is less than the primary consumers. The top, high trophic level has very less amount of biomass.

Pyramid of Biomass – Inverted

In contrast, in many aquatic ecosystems, the pyramid of biomass may assume an inverted form. [Pyramid of numbers for aquatic ecosystem is upright]. This is because the producers are tiny phytoplankton that grow and reproduce rapidly. Here, the pyramid of biomass has a small base, with the consumer biomass at any instant actually exceeding the producer biomass and the pyramid assumes inverted shape.



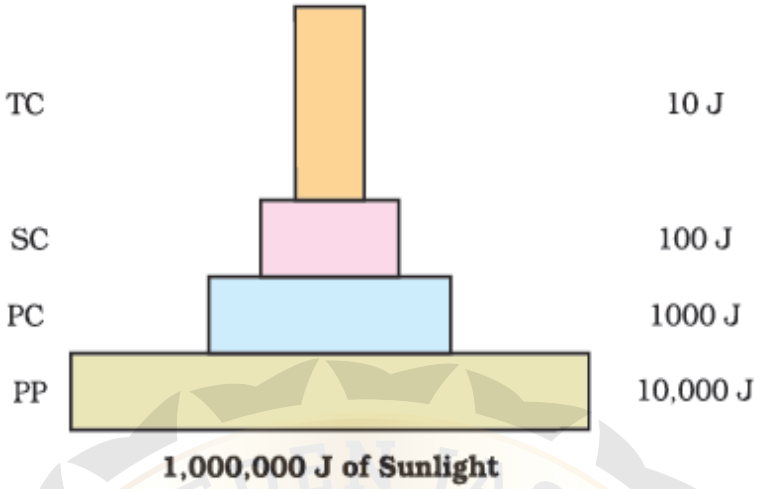
Inverted Pyramid of Biomass in Aquatic Ecosystem



Upright Pyramid of Biomass for Grassland Ecosystem

Pyramid of Energy

To compare the functional roles of the trophic levels in an ecosystem, an energy pyramid is **most suitable**. An energy pyramid represents the amount of energy at each trophic level and loss of energy at each transfer to another trophic level. Hence the pyramid is **always upward**, with a large energy base at the bottom.



AN IDEAL PYRAMID OF ENERGY

Observe that Primary Producers convert only 1% of the energy in the sunlight available to them into NPP

Suppose an ecosystem receives 1000 calories of light energy in a given day. Most of the energy is not absorbed; some is reflected back to space; of the energy absorbed only a small portion is utilized by green plants, out of which the plant uses up some for respiration and of the 1000 calories, therefore only 100 calories are stored as energy rich materials. Now suppose an animal, say a deer, eats the plant containing 100 calorie of food energy. The deer uses some of it for its own metabolism and stores only 10 calorie as food energy. A lion that eats the deer gets an even smaller amount of energy. Thus usable energy decreases from sunlight to producer to herbivore to carnivore. Therefore, the energy pyramid will always be upright. **Energy pyramid** concept helps to explain the phenomenon of **biological magnification** – the tendency for toxic substances to increase in concentration progressively with higher trophic levels.

Limitations of Ecological Pyramids

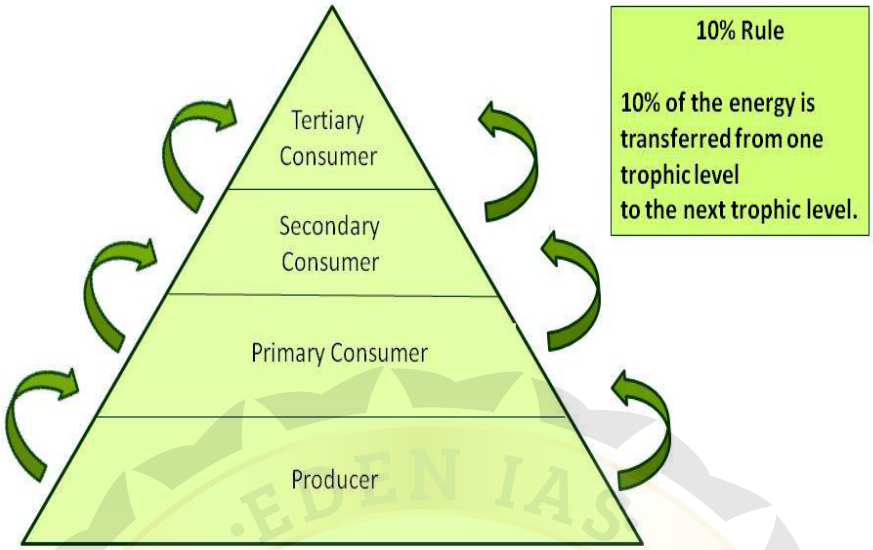
- It does not take into account the **same species belonging to two or more trophic levels**.
- It assumes a simple food chain, something that almost never exists in nature; it **does not accommodate a food web**.
- Moreover, saprophytes (plant, fungus, or microorganism that lives on decaying matter) are not given any place in ecological pyramids even though they play a vital role in the ecosystem.

ECOLOGICAL EFFICIENCIES

Ecological efficiency describes the efficiency with which energy is transferred from one trophic level to the next. The number of trophic levels in the grazing food chain is restricted as the transfer of energy follows 10 per cent law – only 10 per cent of the energy is transferred to each trophic level from the lower trophic level. The decrease at each subsequent trophic level is due to two reasons:

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

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



Some of the Efficiencies frequently used in ecology are

a) **Photosynthetic Efficiency** = [(GPP/Total Incident Solar Radiation) x 100] %

b) **Net Production Efficiency** = [(NPP/GPP) x 100] %

c) **Assimilation Efficiency** = [(Food energy assimilated/Food energy ingested) x 100] %

d) **Ecological Efficiency** = [(Energy at a trophic level/Energy at the previous trophic level) x 100] %

Higher value of Ecological Efficiency indicates less losses

ECOLOGICAL INTERACTIONS

"No man is an island." This saying is also true for organisms in an ecosystem. **No organism exists in isolation**. Individual organisms live together in an ecosystem and depend on one another. In fact, they have many different types of interactions with each other, and many of these interactions are critical for their survival.

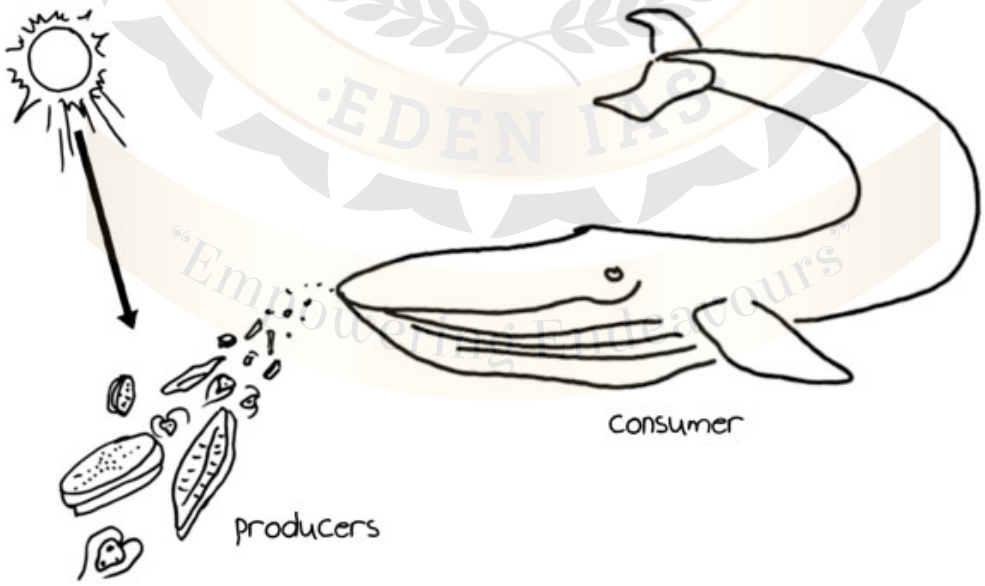
So what do these interactions look like in an ecosystem? One category of interactions describes the different ways organisms obtain their food and energy. Some organisms can make their own food, and other organisms have to get their food by eating other organisms. An organism that must obtain their nutrients by eating (consuming) other organisms is called a **consumer**, or a **heterotroph**. While there are a lot of fancy words related to the sciences, one of the great things is that many of them are based on Latin or Greek roots. For example, heterotroph becomes easier to remember when you realize that in Greek, "hetero" means "other" and "troph" means food; in other words, heterotrophs eat other organisms to get their food. They then use the energy and materials in that food to grow, reproduce and carry out all of their life activities. All animals, all fungi, and some kinds of bacteria are heterotrophs and consumers. .

Some consumers are **predators**; they hunt, catch, kill, and eat other animals, the prey. The **prey** animal tries to avoid being eaten by hiding, fleeing, or defending itself using various adaptations and strategies. These could be the camouflage of an octopus or a fawn, the fast speed of a jackrabbit or impala, or the sting of a bee or spines of a sea urchin. If the prey is not successful, it becomes a meal and energy source for the predator. If the prey is successful and eludes its predator, the predator must expend precious energy to continue the hunt elsewhere. Predators can also be prey, depending on what part of the food chain you are looking at. For example, a trout acts as a predator when it eats insects, but it is prey when it is eaten by a bear. It all depends on the specific details of the interaction. Ecologists use other specific names that describe what type of food a

consumer eats: **carnivores** and **herbivores** are meat eaters and plant eaters, respectively. **Omnivores** eat both animals and plants. Once again, knowing the Latin root helps a lot: "vor" means "to eat or devour," as in "voracious." Put "-vore" at the end of a scientific term for a kind of food, and you have described what an organism eats. For example, an **insectivore** is a carnivore that eats insects, and a **frugivore** is an herbivore that eats fruit. This may seem like a lot of terminology, but it helps scientists communicate and immediately understand a lot about a particular type of organism by using the precise terms.

Not all organisms need to eat others for food and energy. Some organisms have the amazing ability to make (produce) their own energy-rich food molecules from sunlight and simple chemicals. Organisms that make their own food by using sunlight or chemical energy to convert simple inorganic molecules into complex, energy-rich organic molecules like glucose are called **producers** or **autotrophs**. And here's another quick Greek lesson: "auto" means "self" and "troph" still means "food." So autotrophs are self-feeding; they make their own food. Plants, algae, and microscopic organisms such as phytoplankton and some bacteria, make energy-rich molecules (in other words, their food) from sunlight, water, and carbon dioxide during the process called **photosynthesis** ("photo" means "light, and "synthesis" means "to make" – photosynthesizers are using sunlight to make food). Some producers are **chemosynthesizers** (using chemicals to make food) rather than photosynthesizers; instead of using sunlight as the source of energy to make energy-rich molecules, these bacteria and their relatives use simple chemicals as their source of energy. Chemosynthesizers live in places with no sunlight, such as along oceanic vents at great depths on the ocean floor.

No matter how long you or a giraffe stands out in the sun, you will never be able to make food by just soaking up the sunshine; you will never be able to photosynthesize. You'll just get sunburned and thirsty and will still need to go eat another organism if you are hungry. Producers use the food that they make and the chemical energy it contains to meet their own needs for building-block molecules and energy so that they can do things such as grow, move, and reproduce. When a consumer comes along and eats a producer, the consumer gets the building-block molecules and the chemical energy that is in the producer's body. All other life depends on the energy-rich food molecules made by producers – either directly by eating producers, or indirectly by eating organisms that have eaten producers. Not surprisingly, ecologists also have terms that describe where in the food chain a particular consumer operates.



A **primary consumer** eats producers (e.g., a caterpillar eating a leaf); a **secondary consumer** eats primary consumers (e.g., a robin eating the caterpillar). And it can go even further: a **tertiary consumer** eats secondary consumers (e.g., a hawk eating the robin). A single individual animal can act as a different type of consumer depending on what it is eating. When a bear eats berries, for example, it is being a primary consumer, but when it eats a fish, it might be a secondary or a tertiary consumer, depending on what the fish ate!

All organisms play a part in the web of life and every living thing will die at some point. This is where **scavengers**, **detritivores** (which eat detritus or parts of dead things), and **decomposers** come in. They all play a critical role that often goes unnoticed when observing the workings of an ecosystem. They break down carcasses, body parts and waste products, returning to the ecosystem the nutrients and minerals stored in them. This interaction is critical for our health and health of the entire planet; without them we would be literally buried in dead stuff. Crabs, insects, fungi and bacteria are examples of these important clean-up specialists.

Another category of interactions between organisms has to do with close, usually long-term interaction between different types of organisms. These interactions are called symbiosis. The impacts of **symbiosis** can be positive, negative, or neutral for the individuals involved. Organisms often provide resources or services to each other; the interaction is mutually beneficial. These "win-win" symbiotic interactions are known as **mutualism (+ +)**. For example, ants living in a tree may protect the tree from an organism that would like to make the tree its next meal, and at the same time the tree provides a safe home for the ants. Symbiotic relationships are not always positive for both participants. Sometimes there are definite losers. In **parasitism (+ -)**, for example, the parasite benefits and the host is harmed, such as when a tick sucks blood out of a dog. **Predation (+ -)** is another winner-loser relationship but it is not symbiosis. The predator benefits and the prey is harmed lethally, but it is a short-term interaction. In parasitism, the parasite does not usually kill its host, but just feeds on it for a long time while it is living.

Other symbiotic interactions, called **commensalism (+ 0)**, are beneficial for one organism, but do not affect the other in a positive or a negative way. The interaction is seemingly neutral for one of the organisms. For example, a barnacle attached to a whale is able to travel thousands of miles collecting and filtering food from the moving water. The whale doesn't seem to be affected by the little hitchhikers. But then again, maybe those little hitchhikers are actually creating a tiny amount of additional drag as the whale moves through the water and therefore the whale has to expend just a little bit of additional energy. If so, that would be a negative impact for the whale. Often, further research reveals that what was originally thought to be neutral for one participant and therefore an example of commensalism actually has a very subtle positive or negative impact, so the classification is no longer commensalism, but rather mutualism or parasitism. Is a bird nest on a tree limb commensalism, or is there some slight advantage or disadvantage for the tree in having the nest there? It is possible to come up with plausible explanations either way; only detailed research could provide the necessary information to answer the question.

Competition is an interesting example of interactions. When two organisms compete or fight for the same limited resource such as food, shelter, a mate, or sunlight, there is usually a winner and a loser **(+ -)**, but if the competitors fight literally to the death and kill each other, the interaction has become negative for both **(- -)**. Competition is also an interesting example because it is just as likely to be **intraspecific** as **interspecific** (language alert: the prefix "intra" means "within" and the prefix "inter" means «between»). An intraspecific interaction occurs within a species (e.g., two bull elephant seals competing for a harem of females or two English ivy plants competing for space and sunlight), and an interspecific interaction occurs between members of different species (e.g., when two different species of corals compete for space and sunlight on a coral reef by trying to outgrow each other). If the competition is long-term and occurs between two different species, it would be another example of symbiosis.

Amensalism (- o)is a negative association between two species in which one species harms or restricts the other species without itself being adversely affected or harmed by the presence of the other species. Organisms that secrete antibiotics and the species that get inhibited by the antibiotics together form example of amensalism. For example the fungus called bread mould or Pencillium produces penicillin, an antibiotic, which inhibits the growth of a variety of bacteria. Pencillium benefits apparently by having greater availability of food when in the competition bacteria are removed.

Parasitism (+ -) is a type of interaction in which, one species is harmed and the other benefits. Parasitism involves small sized organisms or parasites living in or on another living species called the host from which the parasite gets its nourishment and often shelter. The parasite is benefited and the host is harmed. Many organisms like, bacteria and viruses are parasites of plants and animals. Plants like dodder plant (*Cuscuta*) and mistletoe (*Loranthus*) are parasites that live on flowering plants. Tape worm, round worm, malarial parasite, many bacteria, fungi, and viruses are common parasites of humans.

Type of Interaction	Effect on species 1	Effect on species 2	Definition
Mutualism	Positive	Positive	Both species 1 and species 2 are benefitted.
Competition	Negative	Negative	Species 1 and species 2 have a negative effect on each other.
Predation or parasitism	Positive	Negative	Species 1 is benefitted and species 2 is harmed.
Commensalism	Positive	None	Species 1 is benefited, but species 2 is neither benefitted nor harmed.
Amensalism	None	Negative	Species 1 has a negative effect on species 2, but species 1 is neither affected nor benefited.
Neutralism	None	None	Species 1 and species 2 interact without affecting each other.

ECOTONE, EDGE SPECIES & EDGE EFFECT

An ecotone is a zone of junction or a transition area between two biomes [diverse ecosystems]. It is where two communities meet and integrate. For e.g. the mangrove forests represent an ecotone between marine and terrestrial ecosystem. Other examples are grassland (between forest and desert), estuary (between fresh water and salt water) and river bank or marsh land (between dry and wet).

Characteristics of Ecotone

- It may be narrow (between grassland and forest) or wide (between forest and desert).
- As it is a zone of transition, it has conditions intermediate to the adjacent ecosystems. Hence it is a zone of tension.
- Usually, the number and the population density of the species of an outgoing community decrease as we move away from community or ecosystem.
- A well-developed ecotone contains some organisms which are entirely different from that of the adjoining communities.

Edge Species & Edge Effect

- In ecology, edge effects refer to the changes in population or community structures that occur at the boundary of two habitats (ecotone).
- Sometimes the number of species and the population density of some of the species in the ecotone is much greater than either community. This is called edge effect.
- The organisms which occur primarily or most abundantly in this zone are known as edge species.
- In the terrestrial ecosystems edge effect is especially applicable to birds. For example the density of birds is greater in the mixed habitat of the ecotone between the forest and the desert.

ECOLOGICAL NICHE

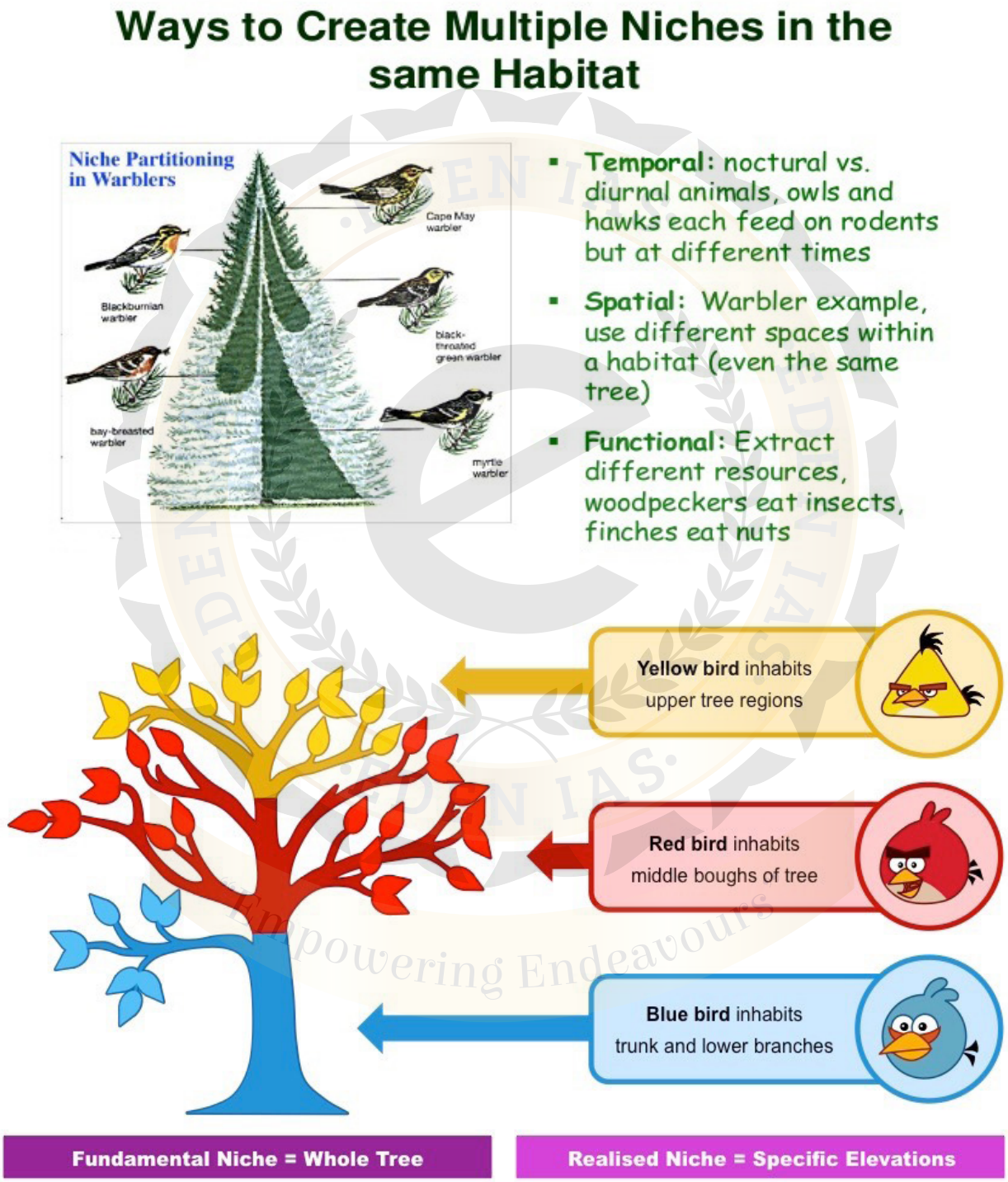
In ecology, a niche is the role or job of a species in a habitat. The word niche comes from the French word nicher, which means "to nest." A species carves out a niche for itself in a habitat by being able to adapt and diverge from other species. Modern-day ecologists study ecological niches in terms of the impact the species has on its environment, as well as the species' requirements. A niche refers to three things viz. the role played by an organism in a habitat, the resources utilized by the organism and the range of conditions it can tolerate.

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). 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 of the **competition** with one another until one is displaced.

> According to the competitive exclusion principle, two species cannot occupy the same ecological niche in a habitat if they are competing for the same resources. When species compete in a niche, natural selection will first move to lessen the dependence of the species on the shared resources. If one species is successful, it reduces the competition. If neither evolves to reduce competition, then the species that can more efficiently exploit the resource will win out, and the other species will eventually become extinct.

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.

A species' niche includes all of its interactions with the biotic and abiotic factors of its environment [habitat niche – where it lives, food niche – what is eats or decomposes & what species it competes with, reproductive niche – how and when it reproduces, physical & chemical niche – temperature, land shape, land slope, humidity & other requirement].



An ecological niche describes how an organism or population responds to the distribution of resources and competitors (for example, by growing when resources are abundant, and when predators, parasites and pathogens are scarce) and how it in turn alters those same factors (for example, limiting access to resources by other organisms, acting as a food source for predators and a consumer of prey).

Niche plays an important role in **conservation of organisms**. If we have to conserve species in its native habitat we should have knowledge about the niche requirements of the species and should ensure that all requirements of its niche are fulfilled.

KEYSTONE SPECIES

The keystone species concept is one of the best-known ideas in community ecology. Although it is true that many species potentially interact with one another in a food web, in nature there are big players and little players. The biggest players of all are referred to as keystone species. This is a species whose presence or absence, or substantial increase or decrease in abundance, profoundly affects other species in the community. Evidence usually comes from experiments in which one species is added to or removed from a community. The name derives from the center stone in an arch supporting its weight by inward-leaning stones. Removal of the keystone causes the arch to collapse. If Keystone species are removed the entire ecosystem may collapse.

FLAGSHIP SPECIES

- A flagship species is a species selected to act as an ambassador, icon or symbol for a defined habitat, issue, campaign or environmental cause.
- By focusing on, and achieving conservation of that species, the status of many other species which share its habitat – or are vulnerable to the same threats - may also be improved.
- Flagship species are usually relatively large, and considered to be 'charismatic' in western cultures.
- Flagship species may or may not be keystone species and may or may not be good indicators of biological process.

What is a priority species?

The terms "flagship" and "keystone" have generally consistent definitions across the conservation community, however "priority species" is a WWF term, and is solely for the purposes of planning and simple communication. For WWF, a "priority species" may be either a flagship or a keystone species and is chosen to represent an ecoregion or region.

A "priority species" is reflective of a key threat across that ecoregion - such that conservation of the species will contribute significantly to a broader threat mitigation outcome. It is often crucial to the economic and/or spiritual wellbeing of peoples within that ecoregion.

World Wide Fund

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

Headquarters: Gland, Switzerland

INDICATOR SPECIES

Indicator species, organism—often a microorganism or a plant—that serves as a measure of the environmental conditions that exist in a given locale. For example, greasewood indicates saline soil; mosses often indicate acid soil. Tubifex worms indicate oxygen-poor and stagnant water unfit to drink. The presence of certain species of plants suggests how well other species might grow in the same place.

A bioindicator is any species or group of species whose function, population, or status can reveal the qualitative status of the environment. For example, copepods and other small water crustaceans that are present in many water bodies can be monitored for changes that may indicate a problem within their ecosystem.

ECOLOGICAL SUCCESSION

Biotic communities are dynamic in nature and change over a period of time. **The process by which communities of plant and animal species in an area are replaced by another over a period of time is known as ecological succession**. Both the biotic and abiotic components are involved in this change. This change is brought about both by the activities of the communities as well as by the physical environment of that particular area.

Succession is a universal process of directional change in vegetation, on an ecological time scale. Succession occurs when a series of communities replace one another due to large scale destruction (natural or manmade). This process continues with one community replacing another, until a stable, mature community develops. Succession is a progressive series of changes which leads to the establishment of a relatively **stable climax community**. The physical environment often influences the nature, direction, rate and optimal limit of changes. During succession both the plant and animal communities undergo change. There are two types of successions (i) Primary succession and (ii) Secondary succession.

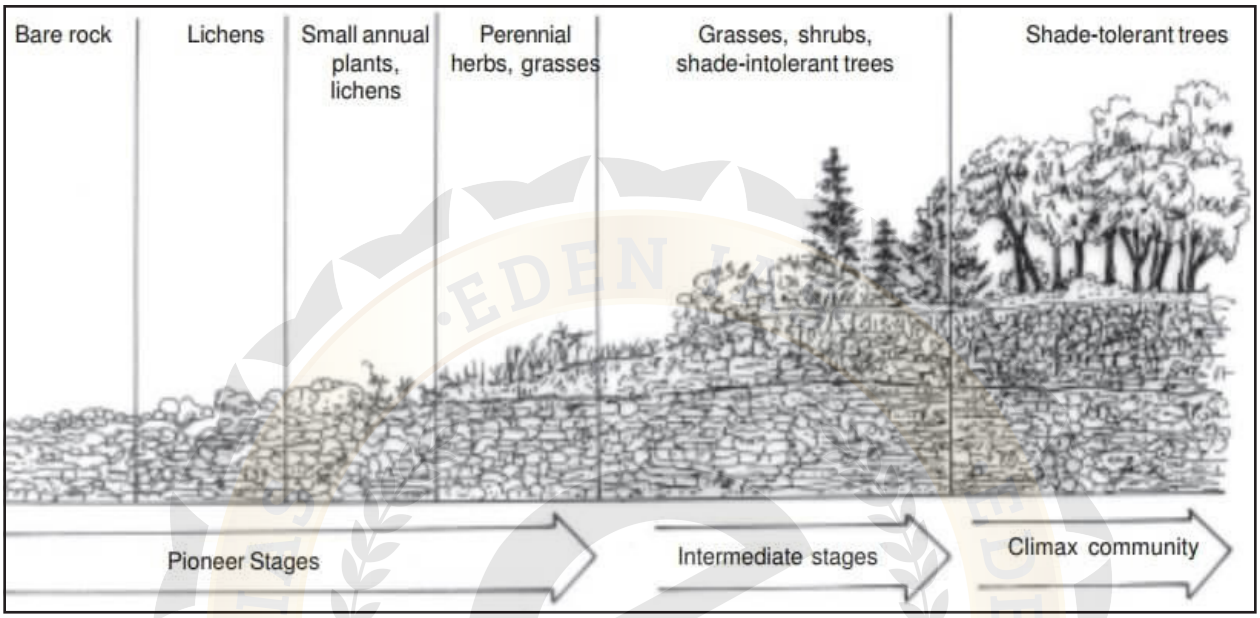
Primary Succession

Primary succession takes place over bare or unoccupied areas such as rock outcrop, newly formed deltas and sand dunes, emerging volcano islands and lava flows as well as glacial moraines (muddy area exposed by a retreating glacier) where no community has existed previously. The plants that invade the bare land, where soil is initially absent for the first time are called **pioneer species**. The assemblage of pioneer plants is collectively called **pioneer community**. A pioneer species generally shows high growth rate but short life span. The stages leading to the climax community are called **successional stages** or **seres**. Each transitional (temporary) community that is formed and replaced during succession is called a stage in succession or a **seral community**.

Primary succession is much more difficult to observe than secondary succession because there are relatively very few places on earth that do not already have communities of organisms. The community that initially inhabits a bare area is called **pioneer community**. The pioneer community after some time gets replaced by another community with a combination of different species. This second community gets replaced by a third community. This process continues sequence-wise in which a community is replaced by another community.

Succession is characterized by the following: increased productivity, the shift of nutrients from' the reservoirs, increased diversity of organisms with increased niche development, and a gradual increase in the complexity of food webs. Succession would occur faster in area existing in the **middle of the large continent**. This is because, here seeds of plants belonging to the different seres would reach much faster, establish and ultimately result in climax community. The terminal (final) stage of succession forms the community which is called as **climax community**. A climax community is stable, mature, more complex

and long lasting. The entire sequence of communities in a given area, succeeding each other, during the course of succession is termed **sere**. Succession that occurs on land where moisture content is low for e.g. on bare rock is known as **xerarch**. Succession that takes place in a water body, like ponds or lake is called **hydrarch**. In primary succession on a terrestrial site the new site is first colonized by a few hardy pioneer species that are often **microbes, lichens and mosses**. The pioneers over a few generations alter the habitat conditions by their growth and development.



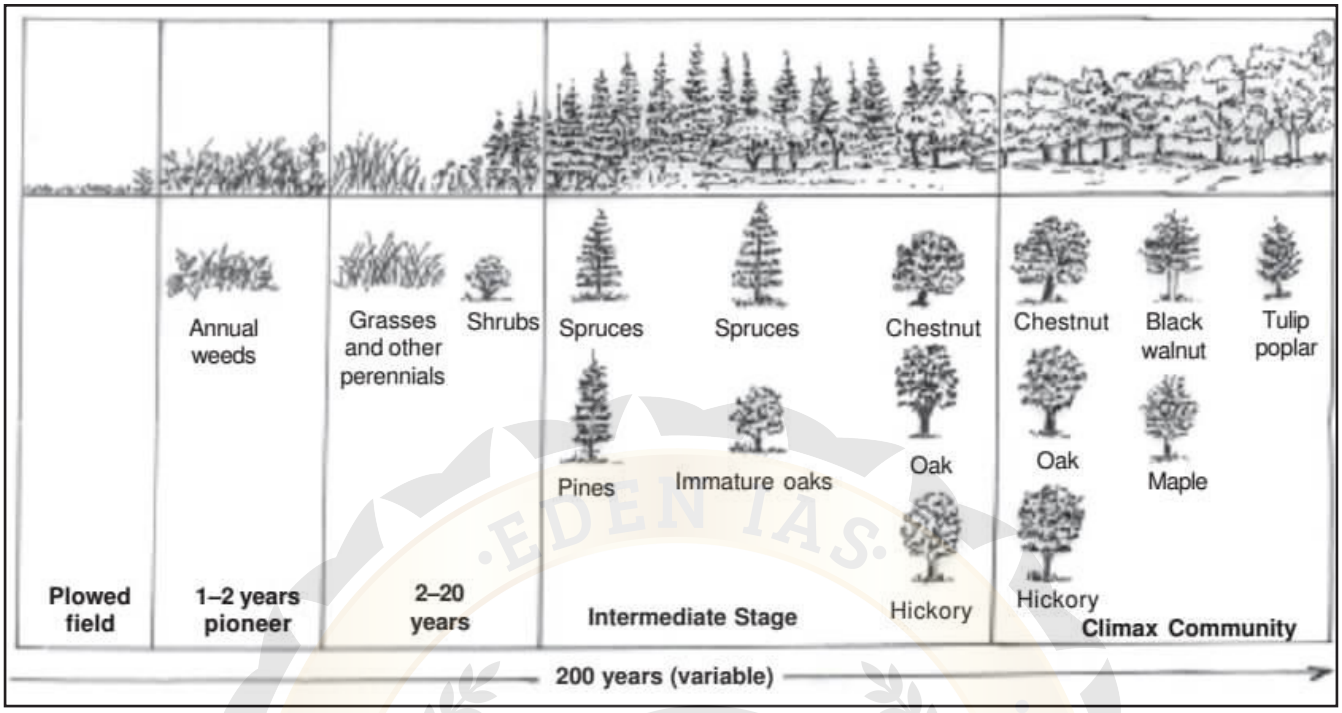
THE ORDERLY SEQUENCE OF PRIMARY SUCCESSION

These new conditions may be conducive to the establishment of additional organisms that may subsequently arrive at the site. The pioneers through their death any decay leave patches of organic matter in which small animals can live. The organic matter produced by these pioneer species produce organic acids during decomposition that dissolve and etch the substratum releasing nutrients to the substratum. Organic debris accumulates in pockets and crevices, providing soil in which seeds can become lodged and grow. As the community of organisms continues to develop, it becomes more diverse and competition increases, but at the same time new niche opportunities develops. **The pioneer species disappear as the habitat conditions change and invasion of new species progresses, leading to the replacement of the preceding community**.

Secondary Succession

Secondary succession is the development of a community which forms after the existing natural vegetation that constitutes a community is removed, disturbed or destroyed by a natural event like hurricane or forest fire or by human related events like tilling or harvesting land. A secondary succession is relatively fast as the soil has the necessary nutrients as well as a large pool of seeds and other dormant stages of organisms. **Secondary succession is the sequential development of biotic communities after the complete or partial destruction of the existing community**.

A mature or intermediate community may be destroyed by natural events such as floods, droughts, fires, or storms or by human interventions such as deforestation, agriculture, overgrazing, etc. This abandoned farmland is first invaded by hardy species of grasses that can survive in bare, sun baked soil. These grasses may be soon joined by tall grasses and herbaceous plants. These dominate the ecosystem for some years along with mice, rabbits, insects and seed-eating birds. Eventually, some trees come up in this area, seeds of which may be brought by wind or animals. And over the years, a forest community develops. Thus an abandoned farmland over a period becomes dominated by trees and is transformed into a forest.



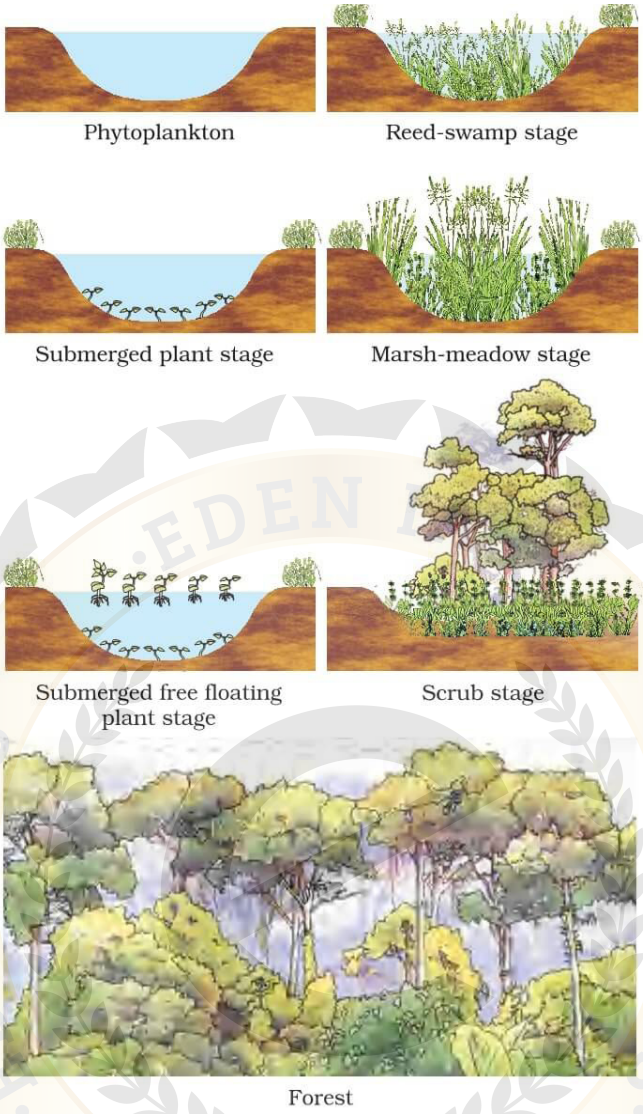
SECONDARY SUCCESSION ON LAND

Autogenic and Allogenic Succession

When succession is brought about by living inhabitants of that community itself, the process is called autogenic succession, while change brought about by outside forces is known as allogenic succession. Autogenic succession (caused by plants themselves) is succession driven by the biotic components of an ecosystem. In contrast, allogenic succession (caused by drought, fire, flooding etc.) is driven by the abiotic components of the ecosystem.

Autotrophic and Heterotrophic succession

Succession in which, initially the green plants are much greater in quantity is known as autotrophic succession; and the ones in which the heterotrophs are greater in quantity is known as heterotrophic succession.



Succession in Plants-Based on the nature of the habitat – whether it is water (or very wet areas) or it is on very dry areas – succession of plants is called **hydrarch or xerarch**, respectively. Hydrarch succession takes place in wetter areas and the successional series progress from hydric to the mesic (intermediate) conditions. As against this, xerarch succession takes place in dry areas and the series progress from xeric to mesic conditions. Hence, both hydrarch and xerarch successions lead to **medium water conditions (mesic)** – neither too dry (xeric) nor too wet (hydric). With time the xerophytic habitat gets converted into a **Mesophytic one**.

Succession in Water-In primary succession in water, the pioneers are the small phytoplanktons; they are replaced with time by free-floating angiosperms, then by rooted hydrophytes, sedges, grasses and finally the trees. The climax again would be a forest. With time the water body is converted into land.

AQUATIC ECOSYSTEMS

The aquatic ecosystems constitute the marine environments of the seas and the fresh water systems in lakes, rivers, ponds and wetlands. These ecosystems provide human beings with a wealth of natural resources. They provide goods that people collect for food such as fish and crustaceans. Natural aquatic systems such as rivers and seas break down chemical and organic wastes created by man. However, this function has limitations, as the aquatic ecosystem cannot handle great quantities of waste. Beyond a certain limit, pollution destroys this natural function. If aquatic ecosystems are misused or over utilized, their ability to provide resources suffers in the long term. Over-fishing leads to a fall in the fish catch.

River courses that are changed by dams to provide electricity affect thousands of people who do not get a continuous supply of water downstream for their daily use. When wetlands are drained, their connected rivers tend to cause floods. These are all examples of unsustainable changes in the use of natural resources and nature's ecosystems that are dependent on hydrological regimes.

Water is an important factor in all our ecosystems. Several ecosystems exist in freshwater and marine salt water. There is very little fresh water on earth, which is a key resource for people all over the world.

What is an aquatic ecosystem?

In aquatic ecosystems, plants and animals live in water. These species are adapted to live in different types of aquatic habitats. The special abiotic features are its physical aspects such as the quality of the water, which includes its clarity, salinity, oxygen content and rate of flow. **Aquatic ecosystems may be classified as being stagnant ecosystems, or running water ecosystems**. The mud gravel or rocks that form the bed of the aquatic ecosystem alter its characteristics and influence its plant and animal species composition. The aquatic ecosystems are classified into freshwater, brackish and marine ecosystems, which are based on the salinity levels. The fresh water ecosystems that have running water are streams and rivers. Ponds, tanks and lakes are ecosystems where water does not flow.

Wetlands are special ecosystems in which the water level fluctuates dramatically in different seasons. They have expanses of shallow water with aquatic vegetation, which forms an ideal habitat for fish, crustacea and water birds.

Marine ecosystems are highly saline, while brackish areas have less saline water such as in river deltas. Coral reefs are very rich in species and are found in only a few shallow tropical seas. The richest coral reefs in India are around the Andaman and Nicobar islands and in the Gulf of Kutch. Brackish water ecosystems in river deltas are covered by mangrove forests and are among the world's most productive ecosystems in terms of biomass production. The largest mangrove swamps are in the Sunderbans in the delta of the Ganges.

Types of Aquatic ecosystems

Fresh water ecosystems			Marine ecosystems	
Flowing water		Still water	Brackish water	Saline water
Streams	Rivers	Ponds, wetlands, lakes	Deltas	Coastal shallows, Coral reefs	Deep ocean

The Pond ecosystem

The pond is the simplest aquatic ecosystem to observe. There are differences in a pond that is temporary and has water only in the monsoon, and a larger tank or lake that is an aquatic ecosystem throughout the year. Most ponds become dry after the rains are over and are covered by terrestrial plants for the rest of the year. When a pond begins to fill during the rains, its life forms such as the algae and microscopic animals, aquatic insects, snails, and worms come out of the floor of the pond where they have remained dormant in the dry phase. Gradually more complex animals such as crabs frogs and fish return to the pond. The vegetation in the water consists of floating weeds and rooted vegetation on the periphery which grows on the muddy floor under water and emerges out of the surface of the water.

As the pond fills in the monsoon a large number of food chains are formed. Algae is eaten by microscopic animals, which are in turn eaten by small fish on which larger carnivorous fish depend. These are in turn

eaten by birds such as kingfishers, herons and birds of prey. Aquatic insects, worms and snails feed on the waste material excreted by animals and the dead or decaying plant and animal matter. They act on the detritus, which is broken down into nutrients which aquatic plants can absorb, thus completing the nutrient cycle in the pond. The temporary ponds begin to dry after the rains and the surrounding grasses and terrestrial plants spread into the moist mud that is exposed. Animals such as frogs, snails and worms remain dormant in the mud, awaiting the next monsoon.

Lake Ecosystem

A lake ecosystem functions like a giant permanent pond. A large amount of its plant material is the algae, which derives energy from the sun. This is transferred to the microscopic animals, which feed on the algae. There are fish that are herbivorous and are dependent on algae and aquatic weeds. The small animals such as snails are used as food by small carnivorous fish, which in turn are eaten by larger carnivorous fish. Some specialised fish, such as catfish, feed on the detritus on the muddy bed of the lake. Energy cycles through the lake ecosystem from the sunlight that penetrates the water surface to the plants. From plants energy is transferred to herbivorous animals and carnivores. Animals excrete waste products, which settle on the bottom of the lake. This is broken down by small animals that live in the mud in the floor of the lake. This acts as the nutrient material that is used by aquatic plants for their growth. During this process plants use Carbon from CO2 for their growth and in the process release Oxygen. This Oxygen is then used by aquatic animals, which filter water through their respiratory system.

Stream and River ecosystems

Streams and rivers are flowing water ecosystems in which all the living forms are specially adapted to different rates of flow. Some plants and animals such as snails and other burrowing animals can withstand the rapid flow of the hill streams. Other species of plants and animals such as water beetles and skaters can live only in slower moving water. Some species of fish, such as Mahseer, go upstream from rivers to hill streams for breeding. They need crystal clear water to be able to breed. They lay eggs only in clear water so that their young can grow successfully. As deforestation occurs in the hills the water in the streams that once flowed throughout the year become seasonal. This leads to flash floods in the rains and a shortage of water once the streams dry up after the monsoon. The community of flora and fauna of streams and rivers depends on the clarity, flow and oxygen content as well as the nature of their beds. The stream or river can have a sandy, rocky or muddy bed, each type having its own species of plants and animals.

Marine ecosystems

The Indian Ocean, the Arabian Sea and the Bay of Bengal constitute the marine ecosystems around peninsular India. In the coastal area the sea is shallow while further away, it is deep. Both these are different ecosystems. The producers in this ecosystem vary from microscopic algae to large seaweeds. There are millions of zooplankton and a large variety of invertebrates on which live fish, turtles and marine mammals. The shallow areas near Kutch and around the Andaman and Nicobar Islands are some of the most incredible coral reefs in the world. Coral reefs are only second to tropical evergreen forests in their richness of species. Fish, crustacea, starfish, jellyfish and the polyps that deposit the coral are a few of the thousands of species that form this incredible world under the shallow sea.

Deforestation of adjacent mangroves leads to silt being carried out to sea where it is deposited on the coral which then dies. There are many different types of coastal ecosystems which are highly dependent on the tide. The marine ecosystem is used by coastal fisherfolk for fishing which forms their livelihood.

In the past, fishing was done at a sustainable level. The marine ecosystem continued to maintain its abundant supply of fish over many generations. Now with intensive fishing by using giant nets and mechanised boats, fish catch in the Indian Ocean has dropped significantly.

Seashore ecosystems

Beaches can be sandy, rocky, shell covered or muddy. On each of these different types, there are several specific species which have evolved to occupy a separate niche. There are different crustacea such as crabs that make holes in the sand. Various shore birds feed on their prey by probing into the sand or mud on the sea shore. Several different species of fish are caught by fishermen. In many areas the fish catch has decreased during the last decade or two.

How are aquatic ecosystems used?

Man uses aquatic ecosystems for the clean freshwater on which his life is completely dependent. We need clean water to drink and for other domestic uses. Water is essential for agriculture. Fisherfolk use the aquatic ecosystems to earn a livelihood. People catch fish and crabs. They also collect edible plants. This is used locally as food or for sale in the market. Over fishing leads to a serious decline in the catch and a long-term loss of income for fisherfolk

Marshes and wetlands are of great economic importance for people who live on their fish, crustacea, reeds, grasses and other produce. Modern man impounds water in dams to be able to store it throughout the year. Agriculture and industry are highly dependent on large quantities of water. However this leads to problems for tribal people who have lived there before the dams were built as they are displaced to build large dams. These dams make rich people richer in the farmland and supports people in large urban centres that use enormous quantities of water. The poor tribal folk become even poorer as the natural resources they depend on are taken away as their lands are submerged under the water of the dam.

Dams are built across rivers to generate electricity. A large proportion of this energy is used by urban people, by agriculturists in irrigated farmlands and in enormous quantities for industry. Large dams have serious ill effects on natural river ecosystems. While water from dams used for irrigation has lead to economic prosperity in some areas, in semiarid areas that are artificially irrigated the high level of evaporation leads to severe salinisation as salts are brought up into the surface layers of the soil. This makes such lands gradually more and more saline and unproductive.

What are the threats to aquatic ecosystems?

Water pollution occurs from sewage and poorly managed solid waste in urban areas when it enters the aquatic ecosystem of lakes and rivers. Sewage leads to a process called eutrophication, which destroys life in the water as the oxygen content is severely reduced. Fish and crustacea cannot breathe and are killed. A foul odour is produced. Gradually the natural flora and fauna of the aquatic ecosystem is destroyed. In rural areas the excessive use of fertilisers causes an increase in nutrients, which leads to eutrophication. Pesticides used in adjacent fields pollute water and kills off its aquatic animals. Chemical pollution from industry kills a large number of life forms in adjacent aquatic ecosystems. Contamination by heavy metals and other toxic chemicals affects the health of people who live near these areas as they depend on this water.

CASE STUDY: - THREATS TO WETLANDS IN ASSAM

Almost 40% of all wetlands in Assam are under threat. A survey conducted by the Assam Remote Sensing Application Center (ARSAC), Guwahati, and the Space Research Center, Ahemadabad, has revealed that 1367 out of 3513 wetlands in Assam are under severe threat due to invasion of aquatic weeds and several developmental activities. The wetlands of Assam form the greatest potential source of income for the State in terms of fisheries and tourism. Though the wetlands of Assam have the capacity of producing 5,000 tonnes of fish per hectare per year, around 20,000 tonnes of fish have to be imported to meet local demands. This is primarily due to poor wetland management.

How can aquatic ecosystems be conserved?

For sustainable use of an aquatic ecosystem, water pollution must be prevented. It does not make sense to allow water to be polluted and then try to clean it up. Changing the nature of the aquatic ecosystem from a flowing water ecosystem to a static ecosystem destroys its natural biological diversity. Thus dams across rivers decrease the population of species that require running water, while favouring those that need standing water. Aquatic ecosystems, especially wetlands, need protection by including them in Sanctuaries or National Parks in the same way in which we protect natural forests. These sanctuaries in aquatic ecosystems protect a variety of forms of life as well as rare fish which are now highly endangered such as the Mahseer. Wetland Sanctuaries and National Parks are of greatest importance as this is one of the most threatened of our ecosystems. As the proportion of the earth's surface that is naturally covered by wetlands is very small compared to forests or grasslands, the wetland ecosystems are very highly threatened.

BIOTIC COMPONENT OF AN ECOSYSTEM

The biotic factors include the living organisms of the environment. They form the trophic structure (trophe, nourishment) of any ecosystem, where living organisms are distinguished on the basis of their nutritional relationships. From this standpoint, an ecosystem is two-layered:

(a) Autotrophic (self-nourishing) component:- This is the upper stratum and is often referred to as the "green belt". It comprises of the chlorophyll-containing plants, photosynthetic bacteria, chemosynthetic microbes, etc. They use simple inorganic substances along with the fixation of light energy, for the buildup of complex organic substances and are thus known as producers.

(b) Heterotrophic (other-nourishing) component: - This is the lower stratum or 'brown belt" of soils and sediments, decaying matter, roots etc. Here utilisation, rearrangement and decomposition of complex materials are the main features. As these organisms eat or consume other organisms, they are known as consumers. **The consumers are categorized into:**

(i) Macro-consumers:

Macro-consumers or phagotrophs (phago, to eat) are chiefly animals that consume other organisms or particulate organic matter. These organisms are further divided into primary, secondary and tertiary consumers. Herbivores that depend upon plant food are known as primary consumers. Secondary and tertiary consumers, when present, are either carnivores or omnivores.

(ii) Micro-consumers:

Micro-consumers or saprotrophs (sapro, to decompose) or decomposers or osmotrophs (osmo, to pass through a membrane) are chiefly bacteria and fungi, that obtain their food (energy) either by break-down of dead tissues or by absorbing dissolved organic matter extruded by or extracted from plants or other organisms. **The saprotrophs by their decomposing activity:**

1) Release inorganic nutrients that can be used by the producers.
2) Provide food for the macro-consumers.
3) Excrete hormone-like substances that inhibit or stimulate other biotic components of the ecosystem.

ECOSYSTEM DEGRADATION

Ecosystems are the basis of life itself! The natural ecosystems in the wilderness provide a variety of products and are regions in which a number of vital ecological processes are present, without which human civilization would not be able to exist.

Ecosystems are however frequently disrupted by human actions which lead to the extinction of species of plants and animals that can live only in the different natural ecosystems. Some species if eliminated seriously affect the ecosystem. These are called 'keystone' species. Extinction occurs due to changes in land use. Forests are deforested for timber, wetlands are drained to create more agricultural land and semi arid grasslands that are used as pastures are changed into irrigated fields. Pollution from industry and waste from urban settings can also lead to extinction of several species. The reason for the depletion of natural resources is twofold – our rapidly exploding population that needs to sustain itself on resources, and the growth of affluent societies, which consume and waste a very large proportion of resources and energy. Increasing extraction of resources is at the cost of natural ecosystems, leading to a derangement of their important functions. Each of us in our daily lives use a variety of resources.

If tracked back to their source, one finds that the resources were originally obtained from nature and natural ecosystems. Our insensitivity to using resources carefully has produced societies that nature can no longer sustain. If one thinks before wasting resources such as water, reusing and recycling paper, using less plastics that are non-degradable, culminatively this can have positive implications on the integrity of our natural resource base and conserve the resources that nature provides.

UNIT-III

[NUTRIENT CYCLING]

NUTRIENT CYCLING IN AN ECOSYSTEM

The materials or nutrients involved in the circulation within an ecosystem are grouped into three categories viz.:

(i) Macro-elements (which are required in large quantity by plants, e.g., oxygen, carbon and hydrogen),

(ii) Minor or micro- elements (which are required by plants in relatively large amounts e.g., nitrogen, phosphorous, potassium, calcium, magnesium and sulphur) and

(iii) Trace elements (which are required by plants in very small amounts, important being iron, zinc, manganese and cobalt).

The amount of nutrients, such as carbon, nitrogen, phosphorus, calcium, etc., present in the soil at any given time, is referred to as the standing state. It varies in different kinds of ecosystems and also on a seasonal basis. What is important is to appreciate that nutrients which are never lost from the ecosystems, are recycled time and again indefinitely. The movement of nutrient elements through the various components of an ecosystem is called nutrient cycling. Another name of nutrient cycling is biogeochemical cycles (bio: living organism, geo: rocks, air, water). Nutrient cycles are of two types:

a) **Gaseous and**

b) **Sedimentary**

The reservoir for gaseous type of nutrient cycle (e.g., nitrogen, carbon cycle) exists in the atmosphere and for the sedimentary cycle (e.g., sulphur and phosphorus cycle), the reservoir is located in Earth's crust. Environmental factors, e.g., soil, moisture, pH, temperature, etc., regulate the rate of release of nutrients into the atmosphere. The function of the reservoir is to meet with the deficit which occurs due to imbalance in the rate of influx and efflux.

The study of biogeochemical cycles may be approached on two scales:

(i) The cycling of all the elements together, or

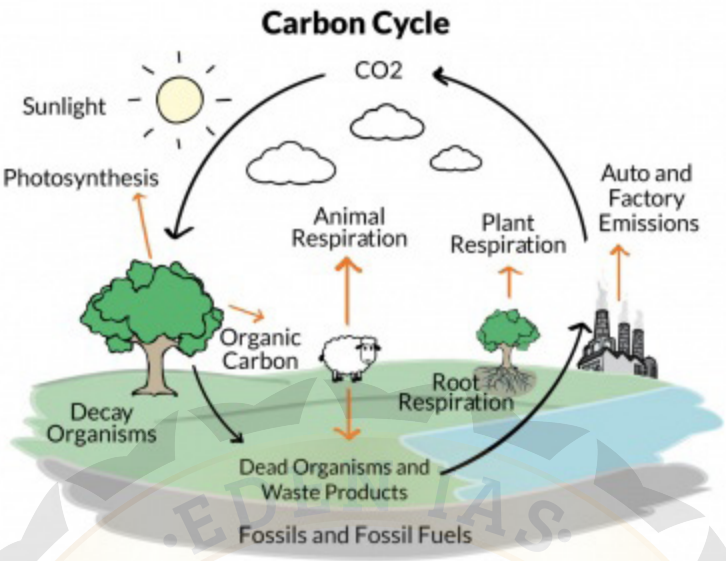
(ii) Cycling of individual elements e.g., carbon cycle, oxygen cycle, nitrogen cycle, phosphorous cycle, sulphur cycle etc.

Besides, hydrological cycle and mineral cycles are also included in the broader biogeochemical cycles.

CARBON CYCLE

Carbon is essential for the chemical processes that support life. It plays such an important role in life that sometimes we say that life is "carbon-based". But there is only a limited amount of carbon on the earth. So carbon is constantly cycling around the earth, turning up in a lot of different forms and places. The reactions that move carbon around make up a giant web called the carbon cycle.

When you study the composition of living organisms, carbon constitutes 49 per cent of dry weight of organisms and is next only to water. If we look at the total quantity of global carbon, we find that 71 per cent carbon is found dissolved in oceans. This oceanic reservoir regulates the amount of carbon dioxide in the atmosphere**. Do you know that the atmosphere only contains about 1per cent of total global carbon?**



Fossil fuels also represent a reservoir of carbon. Carbon cycling occurs through atmosphere, ocean and through living and dead organisms. According to one estimate 4 × 10^13 kg of carbon is fixed in the biosphere through photosynthesis annually. A considerable amount of carbon returns to the atmosphere as CO2 through respiratory activities of the producers and consumers. Decomposers also contribute substantially to CO2 pool by their processing of waste materials and dead organic matter of land or oceans. Some amount of the fixed carbon is lost to sediments and removed from circulation. Burning of wood, forest fire and combustion of organic matter, fossil fuel, volcanic activity are additional sources for releasing CO2 in the atmosphere. Human activities have significantly influenced the carbon cycle. Rapid deforestation and massive burning of fossil fuel for energy and transport have significantly increased the rate of release of carbon dioxide into the atmosphere

Plants get carbon by taking carbon dioxide from the air. They use the carbon dioxide and the energy from sunlight to make food. Animals get their carbon by eating those plants or by eating animals that have eaten those plants. When organisms breathe, they take oxygen from the air. During respiration, the oxygen reacts with food to provide energy. Respiration produces carbon dioxide which is released to the air.

Volcanic eruptions are a source of carbon. When a volcano erupts, it releases huge amounts of carbon dioxide. But remember- the earth needs it elements to stay in balance. So the effect of volcanoes is balanced by weathering which is a chemical reaction between rainwater and rocks that absorbs carbon dioxide from the air to create rock carbonate minerals.

Left to themselves, these natural processes are in perfect balance. But human activities can disturb the cycle and increase the amount of carbon dioxide in the atmosphere. This could cause problems in the future because carbon dioxide is vital for controlling the world's climate. Carbon Cycle describes the flow of carbon between living organisms and the non-living environment. Carbon cycles through the environment in the form of a gas, carbon dioxide (CO2). The atmosphere of Earth contains .04 percent CO2.

POINTS TO REMEMBER

i. Plants absorb CO2 from the atmosphere to use during photosynthesis.
ii. Organisms release CO2 into the air during respiration.
iii. In addition, there are several important non-organic storage areas of carbon in the environment.

a) A large portion of the Carbon on the Earth is stored in rocks.
b) The Earth's oceans hold a large amount of CO_2 because it easily dissolves in water.
c) Coal, oil, and limestone store carbon that once formed ancient organisms. Burning fossil fuels, like coal and oil, will release CO_2 into the atmosphere.

OXYGEN CYCLE

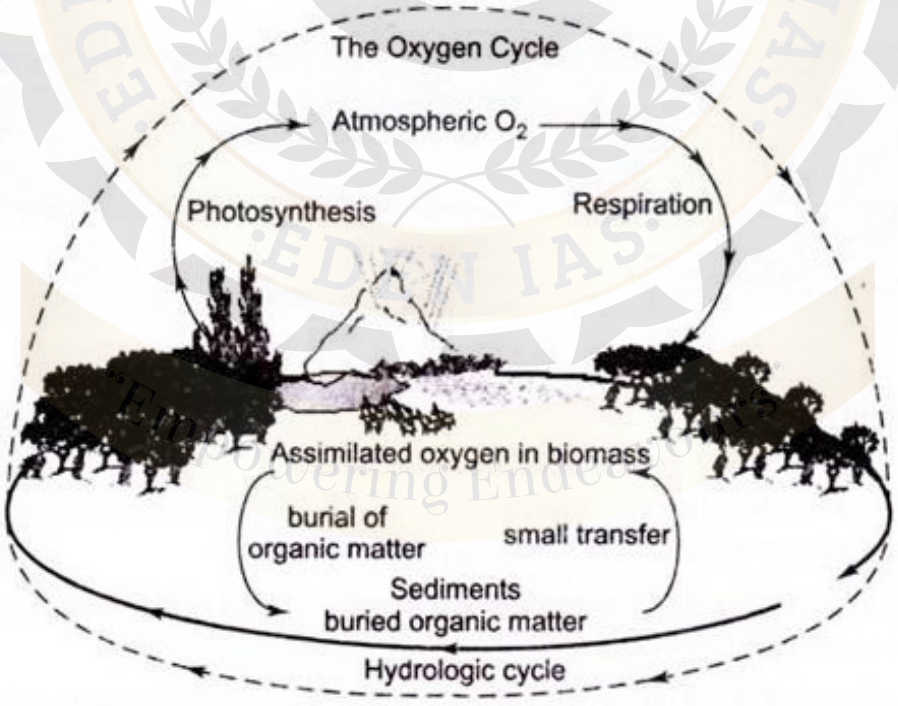
The oxygen cycle is the biogeochemical cycle that describes the movement of oxygen within and between its three main reservoirs; the atmosphere (air), the biosphere (living things), and the lithosphere (Earth's crust). The main driving factor of the oxygen cycle is photosynthesis, which is responsible for the modern Earth's atmosphere and life. The amount of oxygen in and around the earth is fixed. But this oxygen is fed again and again through the world's living systems in a never-ending circle called the oxygen cycle.

Our needs are just part of this cycle. The cycle involves a continual exchange of gases between the air and animals and plants. In a process called respiration, animals and plants take oxygen from air and give back carbon dioxide. In a process called photosynthesis, plants take carbon dioxide from air and water and give back oxygen. Respiration and photosynthesis are effectively opposite processes.

Respiration is an oxidation reaction, which takes oxygen from the air or from water. Photosynthesis is a reduction reaction. It adds oxygen gas to the air. Enormous quantities of oxygen are taken in by plants and animals every day, and huge quantities of oxygen are returned to the air by plants. These amounts exactly balance so that overall the amount of oxygen in the air stays the same.

Oxygen, like carbon and hydrogen, is a basic element of life. In addition, in the form of O3 ozone, it provides protection of life by filtering out the sun's UV rays as they enter the stratosphere. In addition to constituting about 20% of the atmosphere, oxygen is ubiquitous. It also occurs in combination as oxides in the Earth's crust and mantle, and as water in the oceans.

Early in the evolution of the Earth, oxygen is believed to have been released from water vapor by UV radiation and accumulated in the atmosphere as the hydrogen escaped into the earth's gravity. Later, photosynthesis became a source of oxygen. Oxygen is also released as organic carbon in CHO, and gets buried in sediments. The role of oxygen in life is described in the unit on Biological Systems.



Oxygen is highly reactive. A colorless, odorless gas at ordinary temperatures, it turns to a bluish liquid at -183° C. Burning or combustion is essentially oxidation, or combination with atmospheric oxygen.

The above Fig shows a very broad overview of oxygen cycling in nature. The environment of oxygen in numerous reactions makes it hard to present a complete picture. Oxygen is vital to us in many ways (beside the most obvious—for breathing). Water can dissolve oxygen and it is this dissolved oxygen that supports aquatic life. Oxygen is also needed for the decomposition of organic waste. Wastes from living organisms are "biodegradable" because there are aerobic bacteria that convert organic waste materials into stable inorganic materials. If enough oxygen is not available for these bacteria, for example, because of enormous quantities of wastes in a body of water, they die and anaerobic bacteria that do not need oxygen take over.

These bacteria change waste material into H2S and other poisonous and foul-smelling substances. For this reason, the content of biodegradable substances in waste waters is expressed by a special index called "biological oxygen demand" (BOD), representing the amount of oxygen needed by aerobic bacteria to decompose the waste.

HYDROLOGICAL CYCLE

The hydrological cycle is the circulation of water within the hydrosphere of Earth in different forms such as liquid, solid and gaseous states. This cyclical movement of water in different forms is called hydrological cycle. In the water cycle, movement of water takes place independently within different realms. Among these, vertical and horizontal movement of air transferring moisture from one place to other in the atmosphere, movement of water through sea streams in the hydrosphere and movement of water through rivers and glaciers towards the sea in the lithosphere are included. Similarly, vaporized water from soil and evapotranspirated water from plants reach's the groundwater through infiltration.

Water is stored in the following reservoirs:

- Atmosphere,
- Oceans,
- Lakes,
- Rivers,
- Glacier,
- Soils,
- Snowfields, and
- Ground water.

It moves from one reservoir to another by processes like evaporation condensation, precipitation, deposition, runoff, infiltration, sublimation, transpiration, and groundwater flow.

Water is stored in the atmosphere in all three states of matter. Water vapour in the atmosphere is commonly referred, to as humidity. If liquid and solid forms of water can overcome atmospheric updrafts they can fall to the Earth's surface as precipitation. The formation of ice crystals and water droplets occurs when the atmosphere is cooled to a temperature 'that causes condensation or deposition. Four processes that can cause atmospheric cooling are orographic uplift; convectional uplift; air mass convergence; and radiative energy loss.

Precipitation can be defined as any aqueous deposit, in liquid or solid form, that develops in a saturated atmospheric environment and generally falls from clouds. A number of different precipitation types have been classified by meteorologists including rain, freezing rain, snow, ice pellets, snow pellets, and hail. Fog represents the saturation of air near the ground surface. Classification of fog types is accomplished by the identification of the mechanism that caused the air to become saturated.

The distribution of precipitation on the Earth's surface is generally controlled by the absence or presence of mechanisms that lift air masses to cause saturation. It is also controlled by the amount of water vapour held in the air, which is a function of air temperature. In certain locations on the Earth, acid pollutants from the atmosphere are being deposited in dry and wet forms to the Earth's surface. Scientists generally call this process acid deposition. If the deposit is wet it can also be called acid precipitation.

Normally, rain is slightly acidic. Acid precipitation, however, can have a pH as low as 2.3. Evaporation and transpiration are the two processes that move water from the Earth's surface to its atmosphere. Evaporation is movement of free water to the atmosphere as a gas. It requires large amounts of energy. Transpiration is the movement of water through a plant to the atmosphere. Scientists use the term evapotranspiration to describe both processes.

In general, the following four factors control the amount of water entering the atmosphere via these two processes:

i. Energy availability;

ii. The humidity gradient away from the evaporating surface

iii. The wind speed immediately above the surface; and

iv. Water availability.

Agricultural scientists sometimes refer to two types of evapotranspiration:

a. Actual evapotranspiration, and

b. Potential evapotranspiration.

The growth of crops is a function of water supply. If crops experience drought, yields are reduced. Irrigation can supply crops with supplemental water. By determining both actual evapotranspiration and potential evapotranspiration a farmer can calculate the irrigation water needs of their crops.

The distribution of precipitation falling on the ground surface can be modified by the presence of vegetation. Vegetation in general, changes this distribution because of the fact that it intercepts some the falling rain. How much is intercepted is a function of the branching structure and leaf density of the vegetation.

Some of the water that is intercepted never makes it to the ground surface. Instead, it evaporates from the vegetation surface directly back to the atmosphere. A portion of the intercepted water can travel from the leaves to the branches and then flow down to the ground via the plant's stem. This phenomenon is called stem flow.

Another portion of the precipitation may flow along the edge of the plant canopy to cause canopy drip. Both of the processes described above can increase the concentration of the water added to the soil at the base of the stem and around the edge of the plant's canopy. Rain that falls through the vegetation, without being intercepted, is called through fall.

Infiltration is the movement of water from precipitation into the soil layer. Infiltration varies both spatially and temporally due to a number of environmental factors. After a rain, infiltration can create a condition where the soil is completely full of water. This condition is, however, only short-lived as a portion of this water quickly drains (gravitational water) via the force exerted on the water by gravity.

The portion that remains is called the field capacity. In the soil, field capacity represents a film of water coating all individual soil particles to a thickness of 0.06 mm. The soil water from 0.0002 to 0.06 mm (known as capillary water) can be removed from the soil through the processes of evaporation and transpiration. Both of these processes operate at the surface.

Capillary action moves water from one area in the soil to replace losses in another area (biggest losses tend to be at the surface because of plant consumption and evaporation). This movement of water by capillary action generally creates a homogeneous concentration of water throughout the soil profile.

Losses of water stop when the film of water around soil particles reaches 0.0002 mm. Water held from the surface of the soil particles to 0.0002 mm is essentially immobile and can only be completely removed with high temperatures (greater than 100 degrees Celsius). Within the soil system, several different forces influence the storage of water.

Runoff is the surface flow of water to areas of lower elevation. On the microscale, runoff can be seen as a series of related events. At the global scale runoff flows from the landmasses to the oceans. The Earth's continents experience runoff because of the imbalance between precipitation and evaporation.

Through flow is the horizontal subsurface movement of water on continents. Rates of through flow vary with soil type, slope gradient, and the concentration of water in the soil. Groundwater is the zone in the ground that is permanently saturated with water. The top of groundwater is known as the water table. Groundwater also flows because of gravity to surface basins of water (oceans) located at lower elevations.

The flow of water through a stream channel is commonly called stream flow or stream discharge. On many streams humans gauge stream flow because of the hazards that can result from too little or too much flow. Mechanical gauging devices record this information on a graph known as a hydrograph. In the online notes there is a representation of a hydro graph showing some of its typical features.

Oceans cover most of the Earth's surface. On average, the depth of the world's oceans is about 3.9 kilometers. However, maximum depths can be greater than 11 kilometers. The distribution of land and ocean surfaces on the Earth is not homogeneous. In the Southern Hemisphere there is 4 times more ocean than land. Ratio between land and ocean is almost equal in the Northern Hemisphere.

Water is continually cycled between its various reservoirs. This cycling occurs through the processes of evaporation, condensation, precipitation, deposition, runoff, infiltration, sublimation, transpiration, melting, and groundwater flow. The following Table describes the typical residence times of water in the major reservoirs.

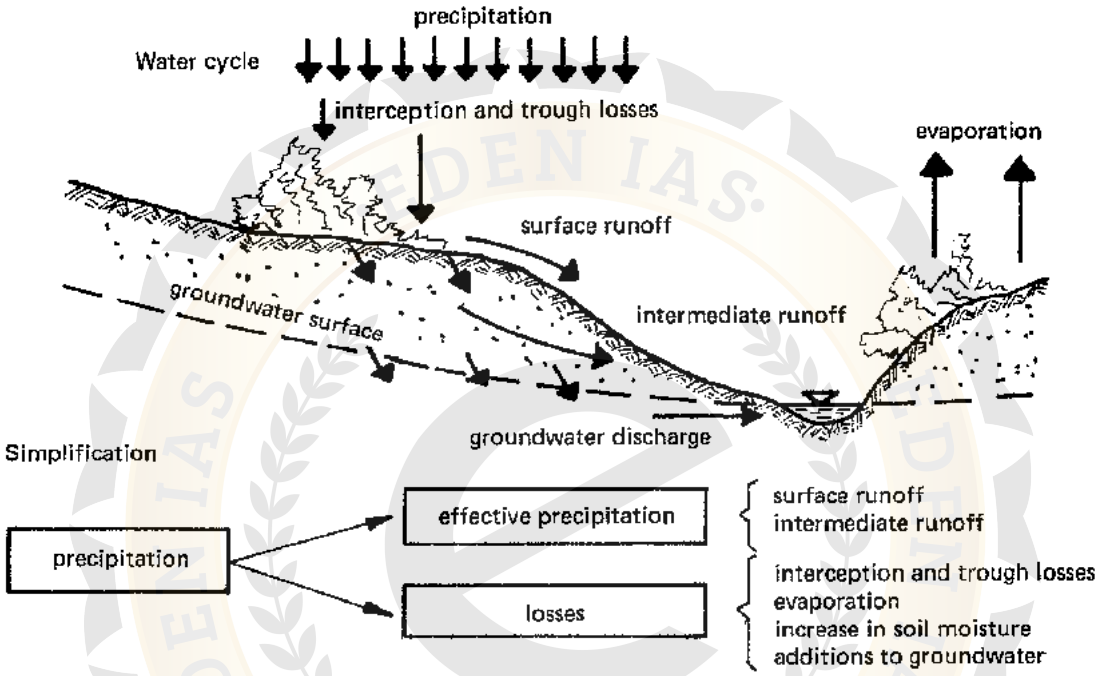
Reservoir	Average Residence Time
Glaciers	20 to 100 years
Seasonal Snow Cover	2 to 6 months
Groundwater: Shallow	100 to 200 years
Groundwater: Deep	10,000 years
Lakes	50 to 100 years
Rivers	2 to 6 months

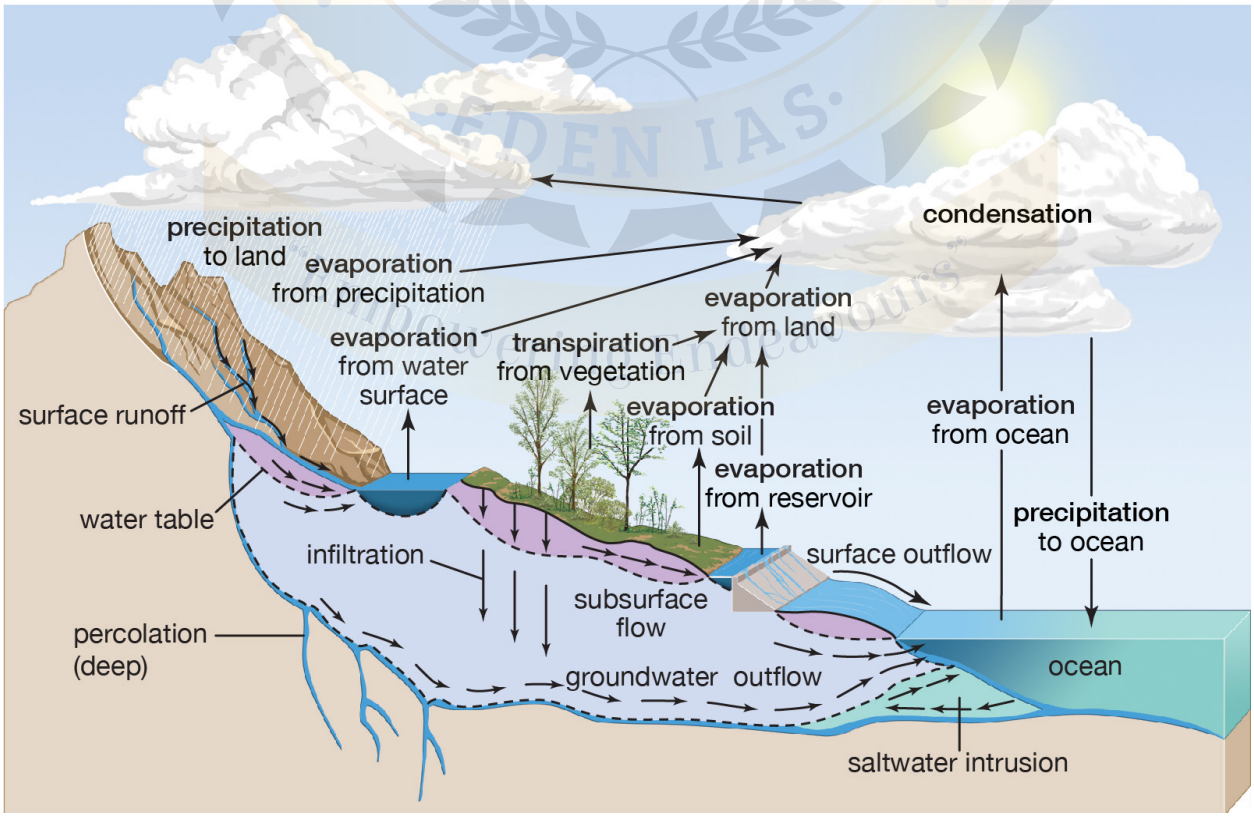
The water found in the ocean is primarily a byproduct of the lithospheric solidification of rock that occurred early in the Earth's history. A second source of water is volcanic eruptions. The dissolved constituents found in the ocean come from the transport of terrestrial salts in weathered sediments by leaching and stream runoff. Seawater is a mixture of water and various salts. Chlorine, sodium, magnesium, calcium, potassium, and sulfur account for 99 % of the salts in seawater.

The presence of salt in seawater allows ice to float on top of it. Seawater also contains small quantities of dissolved gases including carbon dioxide, oxygen, and nitrogen. These gases enter the ocean from the atmosphere and from a variety of organic processes. Seawater changes its density with variations in temperature, salinity, and ocean depth. Seawater is least dense when it is frozen at the ocean surface and contains no salts. Highest seawater densities occur at the ocean floor.

Atmospheric circulation drives the movement of ocean currents. Within each of the ocean, the patterns of these currents are very similar. In each basin, the ocean currents form several closed circulation patterns known as gyres. A large gyre develops at the subtropics centered at about 30 degrees of latitude in the Southern and Northern Hemisphere.

In the Northern Hemisphere, several smaller gyres develop with a center of rotation at 50 degrees. Similar patterns do not develop in the middle latitudes of the Southern Hemisphere. In this area, ocean currents are not bound by continental masses. Ocean currents differ from each other by direction of flow, by speed of flow, and by relative temperature.





The planetary water supply is dominated by the oceans (See Table below). Approximately 97 % of all the water on the Earth is in the oceans. The other 3 % is held as freshwater in glaciers and icecaps, groundwater, lakes, soil, the atmosphere, and within life.

Reservoir	Volume (Cubic km × 1,000,000)	Percent of Total
Oceans	1370	97.25
Ice caps and glaciers	29	2.05
Groundwater	9.5	0.68
Lakes	0.125	0.01
Soil moisture	0.065	0.005
Atmosphere	0.013	0.001
Streams and river	0.0017	0.0001
Biosphere	0.0006	0.0004

Hydrology is the study of the movement and distribution of water throughout the Earth, and thus addresses both the hydrologic cycle and water resources. Many processes work together to keep Earth's water moving in a cycle. There are five processes at work in the hydrologic cycle condensation, precipitation, infiltration, runoff, and evapotranspiration. These occur simultaneously and, except for precipitation, continuously.

Water vapour condenses to form clouds, which result in precipitation when the conditions are suitable. Precipitation falls to the surface and infiltrates the soil or flows to the ocean as runoff. Surface water (e.g., lakes, streams, oceans, etc.), evaporates, returning moisture to the atmosphere, while plants return water to the atmosphere by transpiration.

The water cycle technically known as the hydrologic cycle is the circulation of water within the Earth's hydrosphere, involving changes in the physical state of water between liquid, solid, and gas phases. The hydrologic cycle refers to the continuous exchange of water between atmosphere, land, surface and subsurface waters, and organisms. In addition to storage in various compartments (the ocean is one such compartment).

The multiple cycles that make up the Earth's water cycle involve five main physical actions:

i. Evaporation,

ii. Precipitation,

iii. Infiltration,

iv. Runoff, and

v. Subsurface flow.

i. Evaporation:

It occurs when radiant energy from the sun heats water, causing the water molecules to become so active that some of them rise into the atmosphere as vapour. It is the transfer of water from bodies of surface water into the atmosphere. This transfer entails a change in the physical nature of water from liquid to

gaseous phases. Along with evaporation can be counted transpiration from plants. Thus, this transfer is sometimes referred to as evapotranspiration. About 90% of atmospheric water comes from evaporation, while the remaining 10% is from transpiration. Transpiration occurs when plants take in water through the roots and release it through the leaves, a process that can clean water by removing contaminants and pollution. Evapotranspiration is water evaporating from the ground and transpiration by plants. Evapotranspiration is also the way water vapour re-enters the atmosphere

ii. Precipitation:

In cold air way up in the sky, rain clouds will often form. Rising warm air carries water vapour high into the sky where it cools, forming water droplets around tiny bits of dust in the air. Some vapour freezes into tiny ice crystals which attract cooled water drops. The drops freeze to the ice crystals, forming larger crystals we call snowflakes.

When the snowflakes become heavy, they fall. When the snowflakes meet warmer air on the way down, they melt into raindrops. In tropical climates, cloud droplets combine together around dust or sea salt particles. They bang together and grow in size until they're heavy enough to fall. Sometimes there is a layer of air in the clouds that is above freezing, or 32° F. Then closer to the ground the air temperature is once again below freezing. Snowflakes partially melt in the layer of warmer air, but then freeze again in the cold air near the ground. This kind of precipitation is called sleet. It bounces when it hits the ground.

If snowflakes completely melt in the warmer air, but temperatures are below freezing near the ground, rain may freeze on contact with the ground or the streets. This is called freezing rain, and a significant freezing rain is called an ice storm. Ice storms are extremely dangerous because the layer of ice on the streets can cause traffic accidents. Ice can also build up on tree branches and power lines, causing them to break and our lights to go out. There is another kind of precipitation that comes from thunderstorms called hail.

iii. Infiltration:

Under some circumstances precipitation actually evaporates before it reaches the surface. More often, though, precipitation reaches the Earth's surface, adding to the surface water in streams and lakes, or infiltrating the A portion of the precipitation that reaches the Earth's surface seeps into the ground through the process called infiltration.

Infiltration into the ground is the transition from surface water to groundwater. The infiltration rate will depend upon soil or rock permeability as well as other factors. Infiltrated water may reach another compartment known as groundwater (i.e., an aquifer). Groundwater tend to move slowly, so the water may return as surface water after storage within an aquifer for a period of time that can amount to thousands of years in some cases. Water returns to the land surface at lower elevation than where it infiltrated, under the force of gravity or gravity induced pressures.

iv. Runoff:

The amount of water that infiltrates the soil varies with the degree of land slope, the amount and type of vegetation, soil type and rock type, and whether the soil is already saturated by water. The more openings in the surface (cracks, pores, joints), the more infiltration occurs. Water that doesn't infiltrate the soil flows on the surface as runoff.

Precipitation that reaches the surface of the Earth but does not infiltrate the soil is called runoff. Runoff can also come from melted snow and ice. Also it includes the variety of ways by which land surface water moves down slope to the oceans. Water flowing in streams and rivers may be delayed for a time in lakes. Not all precipitated water returns to the sea as runoff; much of it evaporates before reaching the ocean or reaching an aquifer.

v. Sub-Surface Flow:

Surface flow incorporates movement of water within the earth, either within the recharge zone or aquifers. After infiltrating, subsurface water may return to the surface or eventually seep into the ocean.

Quantitative Analysis of the Hydrological Cycle

S.No.	Item	Symbol	Area (km^2)	Total quantity (km^2)	Annual average per unit area (mm)
A.	Preciptation				
1.	Precipitation ocean	P_0	360×10^4	3,46,000	961
2.	Precipitation land	P_L	150×10^6	99000	660
	Total precipitation	P	510×10^6	445,000	872
B.	Evaporation				
3.	Evaporation from ocean	E_0	360×10^6	383,000	1063
4.	Evaporation from land	E_L	150×10^6	62,000	413
	Total evaporation	E	510×10^6	445,000	872
C.	Runoff	R	150×10^6	37,000	247

$P = P_0 + P_L$

$E = E_0 + E_L$

The average global precipitation is 872 mm which is equivalent to 445,000 km^3 of water. The average atmospheric moisture is 14,000 km^2. This means that the atmospheric moisture is replaced 32 times in a year, or the residence time of atmosphere moisture is 10 days.

Water Budget Equation

The complete water cycle is global in nature. Many sub-cycles exist in hydrologic cycle. That is why water resources are a global problem with local roots. Total supply of fresh water available to the earth is limited. Catchment area affords a logical and convenient unit to study various aspects related to the hydrology and water resources of a region.

For a given problem area or catchment in an interval of time Δt, the continuity equation for water in its various phases is:

Mass inflow – Mass outflow = Change in storage

$$P - R - G - E - T = \Delta S$$

Where P- precipitation, primary input and the starting point in the analysis; R = runoff; G-groundwater; E – evaporation; T – transpiration. All terms in equation have dimensions of volume but can be expressed as depth over the catchment. Infiltration does not appear explicitly in the water budget equation, because it is loss to runoff but a gain to groundwater system.

Because the total quantity of water available to the earth is finite and indestructible the global hydrologic system may be looked upon as closed system. However, for a specific area on earth, the hydrologic subsystem for that area is open, meaning that the total amount of water in that area changes from time to time. Thus need to know availability of water within that area; a water budget analysis is conducted for this purpose.

Though the equation is simple but determining each term is exceedingly complex due to:

(a) Paths taken by particles of water are numerous and varied,

(b) The system and variables are changing continuously,

(c) Some terms are difficult to measure, and

(d) E, T and G are highly heterogeneous.

System Concept

Hydrologic phenomenon are complex may never be fully understood. However in the absence of knowledge they may be represented in a simplified way by means of the system concept. A system is a set of connected parts that form a whole. The hydrologic cycle may be treated as a system whose components are precipitation evaporation, etc. These components can be grouped into subsystems of the overall cycle; to analyse the total system, the simpler subsystem can be treated separately and results combined according to the interrelations between the subsystems.

A hydrologic system is defined as a structure or volume in space, surrounded by a boundary, that accepts water and other inputs, operates on them internally, and produces them as outputs.

$$\text{Input } I(t) \xrightarrow{\text{Operator}} \text{Output } O(t).$$

The structure or volume in space is the totality of the flow paths through which the water may pass as through put from the point it enters the system to the point it leaves. The boundary is a continuous surface defined in three dimensions enclosing the volume or structure.

A working medium enters the system as input, interacts with the structure and other media and leaves as output. Physical, chemical and biological processes operates on the working media within the system; the most common working media involved in hydrologic analysis are water, air and heat energy.

The objective of hydrology system analysis is to study the system operation and predict its output. A hydrologic system model is an approximation of the actual system; its inputs and outputs are measurable hydrologic variables and its structure is a set of equations linking the inputs and outputs.

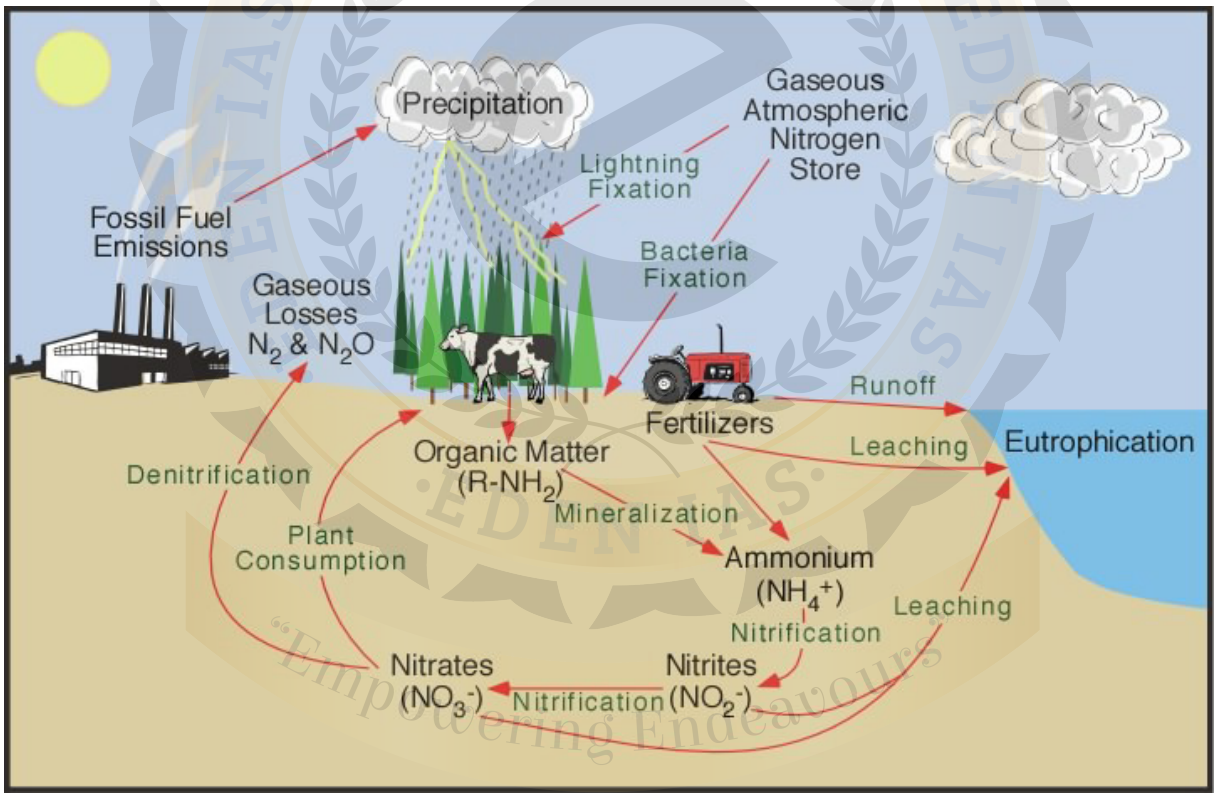
Central to the model structure is the concept of a system transformation is a transformation equation e.g. $I(t) \rightarrow O(t)$. If the surface and soil of watershed are examined in great detail the number of possible flow paths becomes enormous. Along any path, the shape, slope and boundary roughness may also vary in time as soil becomes wet. Also precipitation varies randomly in space and time.

Because of these great complications it is not possible to describe some hydrologic processes with exact physical laws. By using the system concept, effort is directed to the construction of a model relating inputs and outputs rather than to the extremely difficult task of exact representation of the system details, which may not be significant from a practical point of view or may not be known. Nevertheless, knowledge of the physical system helps in developing a good model and verifying its accuracy.

The procedure of developing working equations and models of hydrologic phenomenon are similar to that in fluid mechanics. In hydrology however there is generally a greater degree of approximation in applying physical laws because the system are larger and more complex and may involve several working media. Also most hydrologic systems are inherently random because their major input is precipitation a highly variable and unpredictable phenomenon. Consequently statistical analysis plays a larger role in hydrologic analysis.

NITROGEN CYCLE

Nitrogen is both the most abundant element in the atmosphere and, as a building block of proteins and nucleic acids such as DNA, a crucially important component of all biological life. The nitrogen cycle is a complex biogeochemical cycle in which nitrogen is converted from its inert atmospheric molecular form (N2) into a form that is useful in biological processes. The nitrogen cycle contains several stages:



NITROGEN CYCLE

Nitrogen fixation

Atmospheric nitrogen occurs primarily in an inert form (N2) that few organisms can use; therefore it must be converted to an organic – or fixed – form in a process called nitrogen fixation. Most atmospheric nitrogen is 'fixed' through biological processes. First, nitrogen is deposited from the atmosphere into soils and surface waters, mainly through precipitation. Once in the soils and surface waters, nitrogen undergoes a set of changes: its two nitrogen atoms separate and combine with hydrogen to form ammonia

(NH4+). This is done by microorganisms that fall into three broad categories: bacteria living in symbiotic relationships with certain plants, free anaerobic bacteria, and algae. Crops, such as alfalfa and beans, are often planted in order to remedy the nitrogen-depletion in soils, and nitrogen-fixing bacteria employ an enzyme, known as nitrogenase, to split atmospheric nitrogen molecules into individual atoms for combination into other compounds. A small amount of nitrogen is 'fixed' through a process of high energy fixation that occurs primarily as lighting strikes converting atmospheric nitrogen into ammonia (NH4+) and nitrates (NO3-). Nitrogen can also be fixed through man-made processes, primarily industrial processes that create ammonia and nitrogen-rich fertilizers.

Nitrification

While ammonia can be used by some plants, most of the nitrogen taken up by plants is converted by bacteria from ammonia – which is highly toxic to many organisms – into nitrite (NO2-), and then into nitrate (NO3-). This process is called nitrification, and these bacteria are known as nitrifying bacteria.

Assimilation

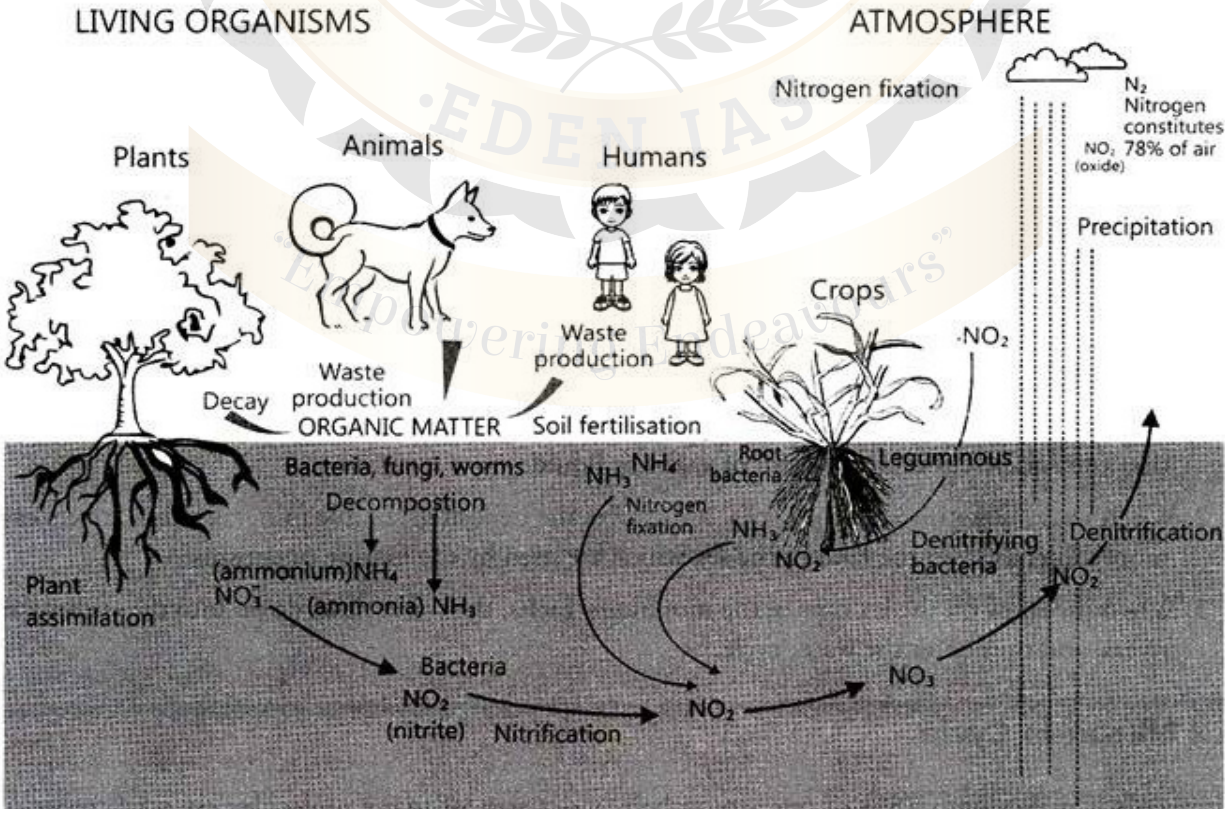
Nitrogen compounds in various forms, such as nitrate, nitrite, ammonia, and ammonium are taken up from soils by plants which are then used in the formation of plant and animal proteins.

Ammonification

When plants and animals die, or when animals emit wastes, the nitrogen in the organic matter reenters the soil where it is broken down by other microorganisms, known as decomposers. This decomposition produces ammonia which is then available for other biological processes.

Denitrification

Nitrogen makes its way back into the atmosphere through a process called denitrification, in which nitrate (NO3-) is converted back to gaseous nitrogen (N2). Denitrification occurs primarily in wet soils where the water makes it difficult for microorganisms to get oxygen. Under these conditions, certain organisms – known as denitrifiying bacteria – will process nitrate to gain oxygen, leaving free nitrogen gas as a byproduct.



Bacteria	What they do
Nitrogen fixing	Convert nitrogen in the air into nitrogen chemicals. Some live in root nodules.
Decomposers	Convert nitrogen chemicals (dead cells, urine & faeces) into ammonia (NH_3)
Nitrifying	Convert ammonia into: 1) Nitrite, NO_2^- 2) Nitrate, NO_3^-
Denitrifying	Convert nitrate into nitrogen gas

Plants generally take up nitrates and nitrites and then convert them into amino acids that are used to make proteins. Some other biochemical pathways are used to make the other complex compounds containing nitrogen. These proteins and other complex compounds are subsequently consumed by the animals.

Once the animal or the plant dies, other bacteria in the soil convert various compounds of nitrogen back into nitrates and nitrites. This nitrogen compound is then converted (by other set of bacteria) into the elemental nitrogen form and released into the atmosphere.

Unbalancing the Nitrogen Cycle

Because it takes a great deal of energy to convert atmospheric nitrogen into biologically useful forms, ecosystems have evolved to get by on fairly modest amounts of organic nitrogen. From forest fires to farming to burning fossil fuels, human activities have been altering the natural nitrogen cycle for centuries. Human practices that add reactive nitrogen (nitrogen that has been fixed) to ecosystems can change ecological balances. Farming, for example, is a relatively nitrogen intensive activity. Crops deplete nitrogen in the soil; therefore many farmers use man-made fertilizers in order to augment nitrogen levels. Unfortunately, in its nitrate form, nitrogen is extremely soluble and is readily leached from the soils into ground water reservoirs which feed into lakes and streams. In heavily agricultural areas, fertilizers are the primary source of nitrogen pollution. Where livestock is raised, animal wastes that are rich in nitrogen – if not properly managed – can also be carried by rainwater into nearby bodies of water.

In areas with large human populations, most of the reactive nitrogen that is introduced into the environment by human activity comes from food and food processing. As with other animals, human wastes are nitrogen rich. This is especially the case with the large amounts of food protein that most Americans consume. Waste treatment facilities permit significant quantities of reactive nitrogen from human wastes to reenter the water cycle.

There are a variety of consequences of nitrogen pollution. A major source of reactive nitrogen is atmospheric deposition which comes largely from transportation emissions, as nitrogen oxides (NOx) are

released through the exhaust. These emissions are a key ingredient in the formation of ground level ozone (smog). Another form of reactive nitrogen – nitric acid (HNO3) – is an important ingredient in the creation of acid rain.

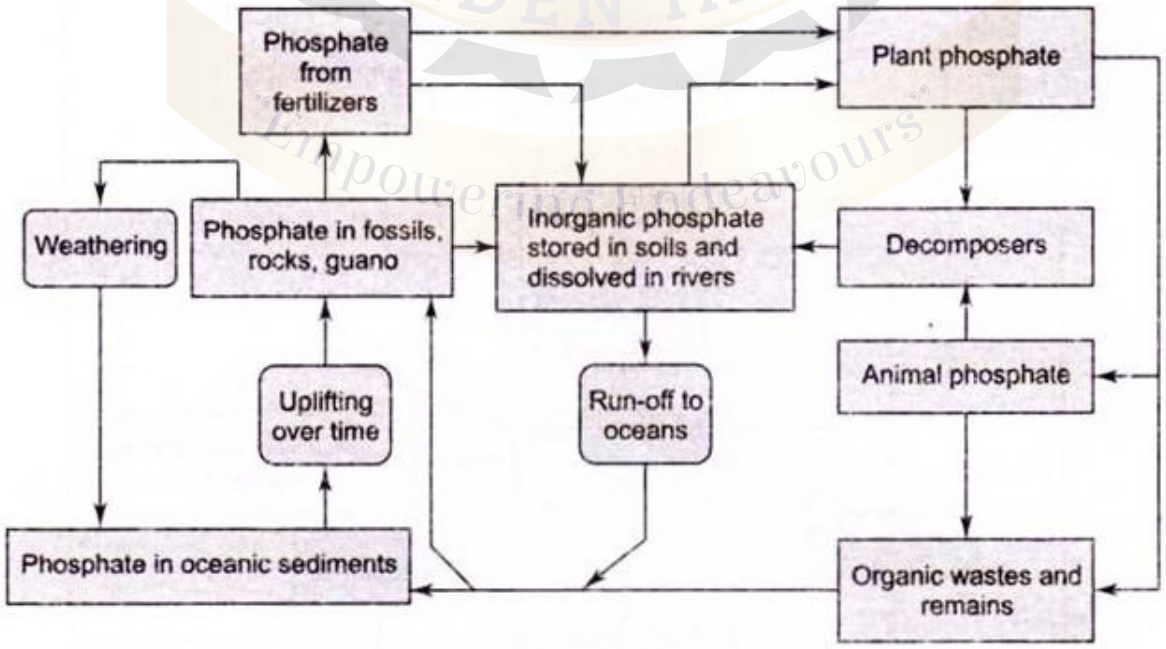
One of the most serious consequences of nitrogen pollution is over-nutrition, or eutrophication, of aquatic ecosystems. Nitrogen leaches into the soil, and eventually into standing bodies of water, causing an unnaturally high level of nitrogen in the water. This eutrophication harms aquatic ecosystems by fueling excessive algae growth, which overshadows the water surface and deprives other aquatic organisms of necessary sunlight. When the algae dies, the oxygen consumed in the decomposition process can further deprive other aquatic organisms of needed oxygen. In extreme cases, eutrophication can result in the total eradication of fishes in lakes and ponds.

PHOSPHORUS CYCLE

Phosphorus is an essential nutrient for plants and animals in the form of ions PO43- and HPO42-. It is a part of DNA-molecules, of molecules that store energy (ATP and ADP) and of fats of cell membranes. Phosphorus is also a building block of certain parts of the human and animal body, such as the bones and teeth.

Phosphorus can be found on earth in water, soil and sediments. Unlike the compounds of other matter cycles phosphorus cannot be found in air in the gaseous state. This is because phosphorus is usually liquid at normal temperatures and pressures. It is mainly cycling through water, soil and sediments. In the atmosphere phosphorus can mainly be found as very small dust particles. Phosphorus moves slowly from deposits on land and in sediments, to living organisms, and then much more slowly back into the soil and water sediment.

The phosphorus cycle differs from the other major biogeochemical cycles in that it does not include a gas phase; although small amounts of phosphoric acid (H3PO4) may make their way into the atmosphere, contributing—in some cases—to acid rain. The water, carbon, nitrogen and sulfur cycles all include at least one phase in which the element is in its gaseous state. Very little phosphorus circulates in the atmosphere because at Earth's normal temperatures and pressures, phosphorus and its various compounds are not gases. The largest reservoir of phosphorus is in sedimentary rock.



It is in these rocks where the phosphorus cycle begins. When it rains, phosphates are removed from the rocks (via weathering) and are distributed throughout both soils and water. Plants take up the phosphate ions from the soil. The phosphates then moves from plants to animals when herbivores eat plants and carnivores eat plants or herbivores. The phosphates absorbed by animal tissue through consumption eventually returns to the soil through the excretion of urine and feces, as well as from the final decomposition of plants and animals after death. When animals and plants die, phosphates return to the soils or oceans during decay. After that, phosphorus generally ends up in sediments or rock formations, remaining there for millions of years. Eventually, phosphorus is released again through weathering and the cycle starts over.

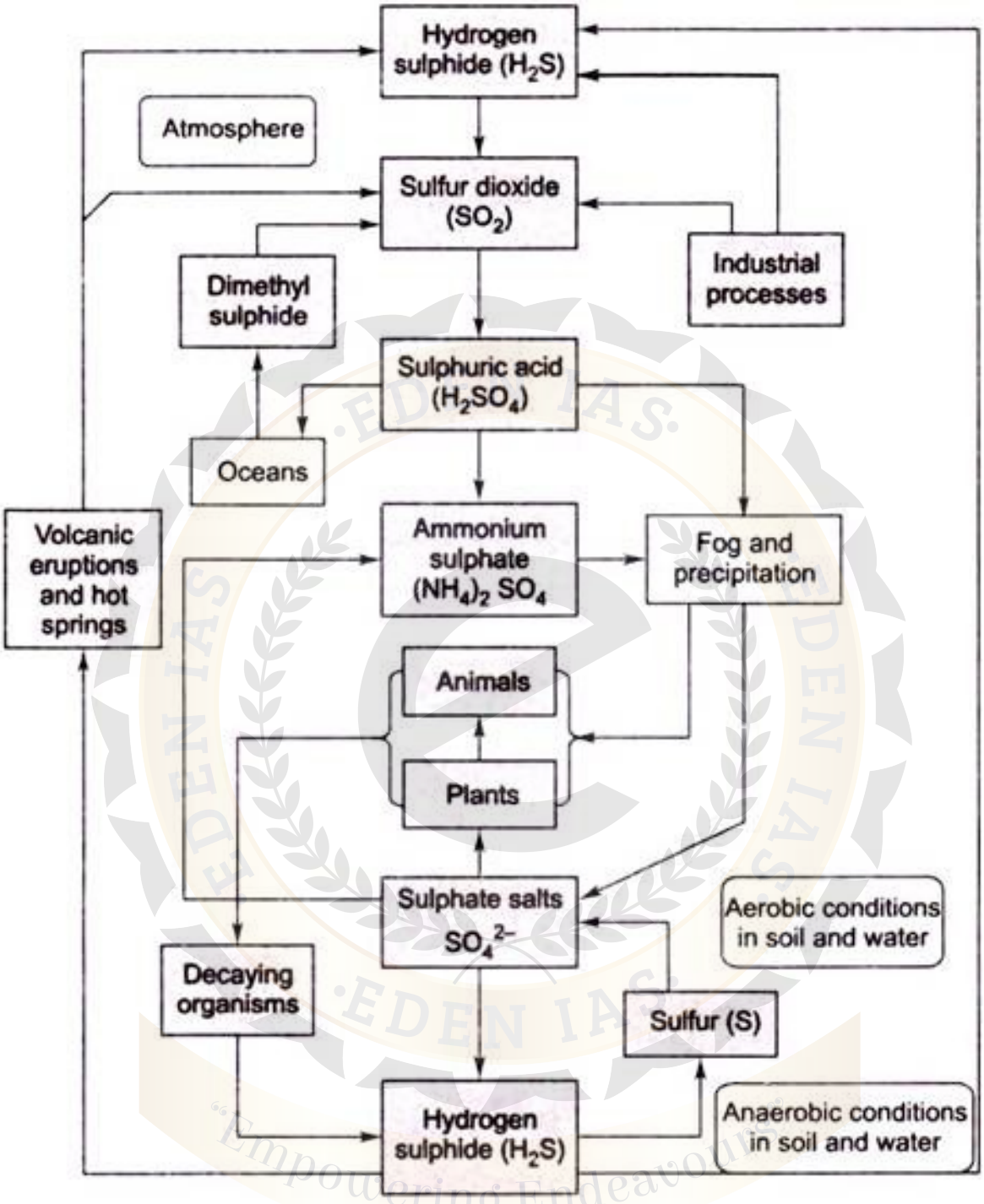
While obviously beneficial for many biological processes, in surface waters an excessive concentration of phosphorus is considered a pollutant. Phosphate stimulates the growth of plankton and plants, favoring weedy species over others. Excess growth of these plants tend to consume large amounts of dissolved oxygen, potentially suffocating fish and other marine animals, while also blocking available sunlight to bottom dwelling species. This is known as eutrophication.

Humans can alter the phosphorus cycle in many ways, including in the cutting of tropical rain forests and through the use of agricultural fertilizers. Rainforest ecosystems are supported primarily through the recycling of nutrients, with little or no nutrient reserves in their soils. As the forest is cut and/or burned, nutrients originally stored in plants and rocks are quickly washed away by heavy rains, causing the land to become unproductive. Agricultural runoff provides much of the phosphate found in waterways. Crops often cannot absorb all of the fertilizer in the soils, causing excess fertilizer runoff and increasing phosphate levels in rivers and other bodies of water. At one time the use of laundry detergents contributed to significant concentrations of phosphates in rivers, lakes, and streams, but most detergents no longer include phosphorus as an ingredient.

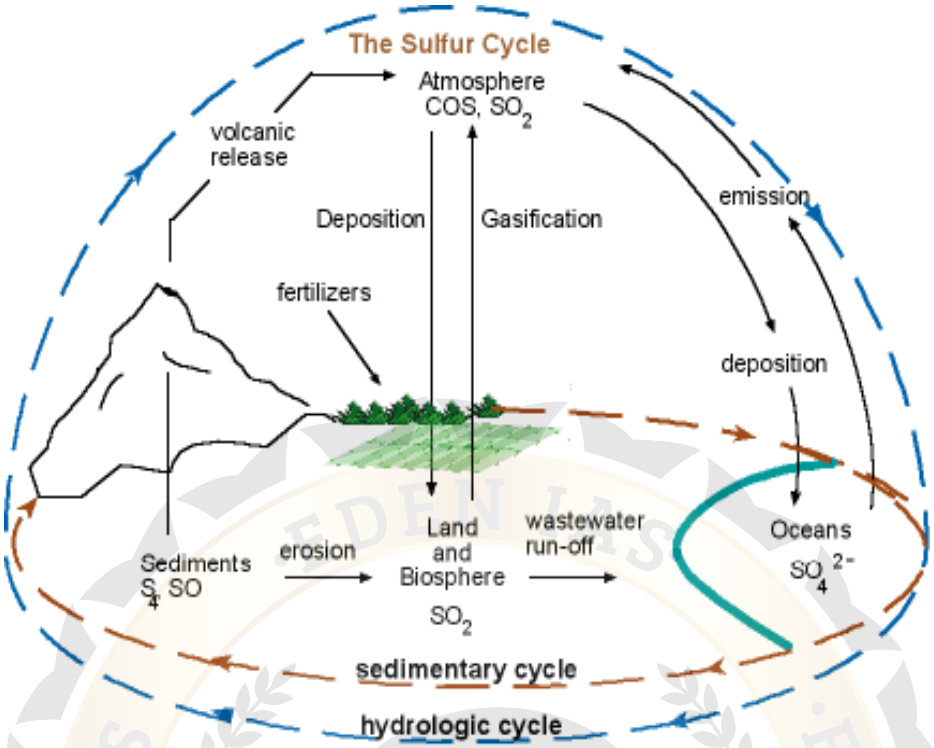
SULPHUR CYCLE

Sulfur (S), the tenth most abundant element in the universe, is a brittle, yellow, tasteless, and odorless non-metallic element. It comprises many vitamins, proteins, and hormones that play critical roles in both climate and in the health of various ecosystems. The majority of the Earth's sulfur is stored underground in rocks and minerals, including as sulfate salts buried deep within ocean sediments.

The sulfur cycle contains both atmospheric and terrestrial processes. Within the terrestrial portion, the cycle begins with the weathering of rocks, releasing the stored sulfur. The sulfur then comes into contact with air where it is converted into sulfate (SO4). The sulfate is taken up by plants and microorganisms and is converted into organic forms; animals then consume these organic forms through foods they eat, thereby moving the sulfur through the food chain. As organisms die and decompose, some of the sulfur is again released as a sulfate and some enters the tissues of microorganisms. There are also a variety of natural sources that emit sulfur directly into the atmosphere, including volcanic eruptions, the breakdown of organic matter in swamps and tidal flats, and the evaporation of water.



Sulfur eventually settles back into the Earth or comes down within rainfall. A continuous loss of sulfur from terrestrial ecosystem runoff occurs through drainage into lakes and streams, and eventually oceans. Sulfur also enters the ocean through fallout from the Earth's atmosphere. Within the ocean, some sulfur cycles through marine communities, moving through the food chain. A portion of this sulfur is emitted back into the atmosphere from sea spray. The remaining sulfur is lost to the ocean depths, combining with iron to form ferrous sulfide which is responsible for the black color of most marine sediments.



Since the Industrial Revolution, human activities have contributed to the amount of sulfur that enters the atmosphere, primarily through the burning of fossil fuels and the processing of metals. One-third of all sulfur that reaches the atmosphere—including 90% of sulfur dioxide—stems from human activities. Emissions from these activities, along with nitrogen emissions, react with other chemicals in the atmosphere to produce tiny particles of sulfate salts which fall as acid rain, causing a variety of damage to both the natural environment as well as to man-made environments, such as the chemical weathering of buildings. However, as particles and tiny airborne droplets, sulfur also acts as a regulator of global climate. Sulfur dioxide and sulfate aerosols absorb ultraviolet radiation, creating cloud cover that cools cities and may offset global warming caused by the greenhouse effect. The actual amount of this offset is a question that researchers are attempting to answer.

UNIT-IV

[BIODIVERSITY]

GENETIC, SPECIES AND ECOSYSTEM DIVERSITY

Biological diversity deals with the degree of nature's variety in the biosphere. This variety can be observed at three levels; the genetic variability within a species, the variety of species within a community, and the organisation of species in an area into distinctive plant and animal communities which constitutes ecosystem diversity.

Genetic diversity

Each member of any animal or plant species differs widely from other individuals in its genetic makeup because of the large number of combinations possible in the genes that give every individual specific characteristics. Thus, for example, each human being is very different from all others. This genetic variability is essential for a healthy breeding population of a species. If the number of breeding individuals is reduced, the dissimilarity of genetic makeup is reduced and in-breeding occurs. Eventually this can lead to the extinction of the species. The diversity in wild species forms the **'gene pool'** from which our crops and domestic animals have been developed over thousands of years. Today the variety of nature's bounty is being further harnessed by using wild relatives of crop plants to create new varieties of more productive crops and to breed better domestic animals. Modern biotechnology manipulates genes for developing better types of medicines and a variety of industrial products.

Species diversity

The number of species of plants and animals that are present in a region constitutes its species diversity. This diversity is seen both in natural ecosystems and in agricultural ecosystems. Some areas are more rich in species than others. Natural undisturbed tropical forests have a much greater species richness than plantations developed by the Forest Department for timber production. A natural forest ecosystem provides a large number of non-wood products that local people depend on such as fruit, fuel wood, fodder, fiber, gum, resin and medicines. Timber plantations do not provide the large variety of goods that are essential for local consumption. In the long-term the economic sustainable returns from non-wood forest products is said to be greater than the returns from felling a forest for its timber. Thus the value of a natural forest, with all its species richness is much greater than a plantation. Modern intensive agricultural ecosystems have a relatively lower diversity of crops than traditional agro-pastoral farming systems where multiple crops were planted. At present conservation scientists have been able to identify and categorise about 1.8 million species on earth. However, many new species are being identified, especially in the flowering plants and insects. Areas that are rich in species diversity are called 'hotspots' of diversity. India is among the world's 15 nations that are exceptionally rich in species diversity

Ecosystem diversity

There are a large variety of different ecosystems on earth, which have their own complement of distinctive inter linked species based on the differences in the habitat. **Ecosystem diversity can be described for a specific geographical region, or a political entity such as a country, a State or a district**. Distinctive ecosystems include landscapes such as forests, grasslands, deserts, mountains, etc., as well as aquatic ecosystems such as rivers, lakes, and the sea. Each region also has man-modified areas such as farmland or grazing pastures. An ecosystem is referred to as 'natural' when it is relatively undisturbed by human activities or 'modified' when it is changed to other types of uses, such as farmland or urban areas. Ecosystems are most natural in wilderness areas. If natural ecosystems are overused or misused their productivity eventually decreases and they are then said to be degraded. India is exceptionally rich in its ecosystem diversity.

ALPHA, BETA AND GAMMA DIVERSITY

In ecology, **alpha diversity (α-diversity)** is the mean species diversity in sites or habitats at a local scale. The term was introduced by **R. H. Whittaker** together with the terms **beta diversity (β-diversity)** and **gamma diversity (γ-diversity).** A comparison of diversity between ecosystems, usually measured as the amount of species change between the ecosystems usually along a gradient is known as **beta-diversity**.

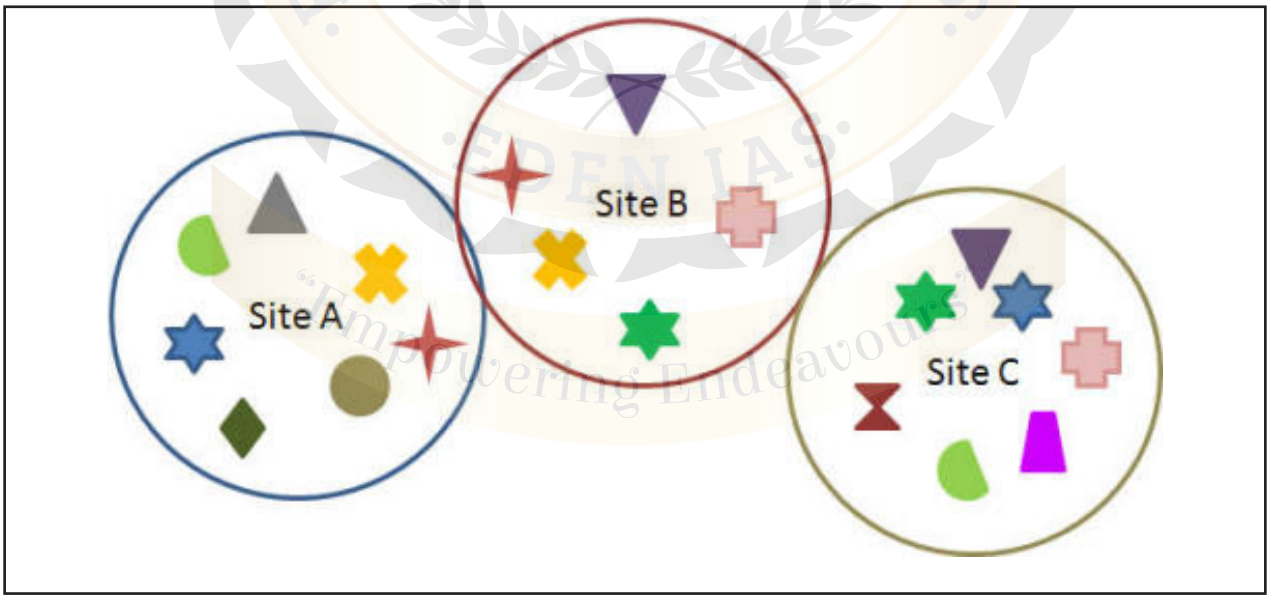
Beta diversity as a measure of species turnover overemphasizes the role of rare species as the difference in species composition between two sites or communities is likely reflecting the presence and absence of some rare species in the assemblages. Beta diversity can also be a measure of nestedness, which occurs when species assemblages in species-poor sites are a subset of the assemblages in more species-rich sites. **Gamma diversity (γ-diversity) is the total species diversity in a landscape.** Whittaker's idea was that the total species diversity in a landscape (γ) is determined by two different things, the mean species diversity in sites or habitats at a more local scale (α) and the differentiation among those habitats (β). According to this reasoning, alpha diversity and beta diversity constitute independent components of gamma diversity.

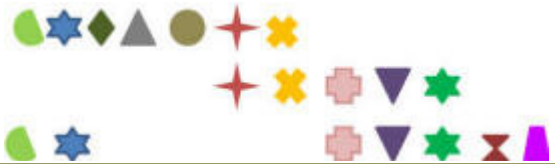
In ecology, **zeta diversity (ζ-diversity),** first described in **2014** measures the degree of overlap in the type of taxa present between a set of observed communities. It was developed to provide a more generalized framework for describing various measures of diversity, and can also be used to test various hypotheses pertaining to biogeography.

Alpha Diversity = richness and evenness of individuals within a habitat unit. For example in the figure below, **Alpha Diversity** of Site A = 7 species, Site B = 5 species, Site C = 7 species.

Beta Diversity = expression of diversity between habitats or along a gradient. In the example below, the greatest **Beta Diversity** is observed between Site A and C with 10 species that differ between them and only 2 species in common.

Gamma Diversity = landscape diversity or diversity of habitats within a landscape or region. In this example, the gamma diversity is 3 habitats with 12 species total diversity.



Site A = 7 Species Site B = 5 Species Site C = 7 Species		A vs B = 8 species B vs C = 4 species A vs C = 10 species

VALUE OF BIODIVERSITY

Environmental services from species and ecosystems are essential at global, regional and local levels. Production of oxygen, reducing carbon dioxide, maintaining the water cycle, protecting soil are important services. The world now acknowledges that the loss of biodiversity contributes to global climatic changes. Forests are the main mechanism for the conversion of carbon dioxide into carbon and oxygen. The loss of forest cover, coupled with the increasing release of carbon dioxide and other gases through industrialization contributes to the 'greenhouse effect'.

Global warming is melting ice caps, resulting in a rise in the sea level which will submerge the low lying areas in the world. It is causing major atmospheric changes, leading to increased temperatures, serious droughts in some areas and unexpected floods in other areas. Biological diversity is also essential for preserving ecological processes, such as fixing and recycling of nutrients, soil formation, circulation and cleansing of air and water, global life support (plants absorb CO2 , give out O2), maintaining the water balance within ecosystems, watershed protection, maintaining stream and river flows throughout the year, erosion control and local flood reduction. Food, clothing, housing, energy, medicines, are all resources that are directly or indirectly linked to the biological variety present in the biosphere.

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

Consumptive use value

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

Productive use value Marketable goods

The biotechnologist uses biorich areas to 'prospect' and search for potential genetic properties in plants or animals that can be used to develop better varieties of crops that are used in farming and plantation programs or to develop better livestock. To the pharmacist, biological diversity is the raw material from which new drugs can be identified from plant or animal products. To industrialists, biodiversity is a rich store-house from which to develop new products. For the agricultural scientist the biodiversity in the wild relatives of crop plants is the basis for developing better crops. Genetic diversity enables scientists and farmers to develop better crops and domestic animals through careful breeding. Originally this was done by selecting or pollinating crops artificially to get a more productive or disease resistant strain. Today this is increasingly being done by genetic engineering, selecting genes from one plant and introducing them into another. New crop varieties

Commonly used modern drugs derived from plant sources:

DRUG	PLANT SOURCE	USE
Atropine	Belladonna	Anticholinergic: reduces intestinal pain in diarrhoea.
Bromelain	Pineapple	Controls tissue inflammation due to infection.
Caffeine	Tea, Coffee	Stimulant of the central nervous system.
Camphor	Camphor tree	Rebefacient: increases local blood supply.
Cocaine	Cocoa	Analgesic and local anesthetic: reduces pain and prevents pain during surgery.
Codeine	Opium poppy	Analgesic: reduces pain.
Morphine	Opium poppy	Analgesic: controls pain.
Colchicine	Autumn crocus	Anticancer agent.
Digitoxin	Common foxglove	Cardiac stimulant used in heart diseases.
Diosgenin	Wild yams	Source of female contraceptive: prevents pregnancy.
L-Dopa	Velvet bean	Controls Parkinson's Disease which leads to jerky movements of the hands
Ergotamine	Smut-of-rye or ergot	Control of haemorrhage and migraine headaches.
Glaziovine	ocotea glaziovii	Antidepressant: Elevates mood of depressed patients.
Gossypol	Cotton	Male contraceptive.
Indicine N-oxide	heliotropium indicum	Anticancer agent.
Menthol	Mint	Rubefacient: increases local blood supply and reduces pain on local application.
Monocrotaline	Cotolaria sessiliflora	Anticancer agent.
Papain	Papaya	Dissolves excess protein and mucus, during digestion.
Penicillin	Penicillium fungi	General antibiotic, skills bacteria and controls infection by various micro-organisms.
Quinine	Yellow cinochona	Antimalarial.
Reserpine	Indian snakeroot	Reduces high blood pressure.
Scopolamine	Thorn apple	Sedative.
Taxol	Pacific yew	Anticancer (ovarian).
Vinblastine, vincristine	Rosy periwinkle (Vinca rosea) (Sadaphali)	Anticancer agent: Controls cancer in children.

are being developed using the genetic material found in wild relatives of crop plants through biotechnology. Even today, species of plants and animals are being constantly discovered in the wild. Thus these wild species are the building blocks for the betterment of human life and their loss is a great economic loss to mankind. Among the known species, only a tiny fraction has been investigated for their value in terms of food, or their medicinal or industrial potential. Preservation of biodiversity has now become essential for industrial growth and economic development. A variety of industries such as pharmaceuticals are highly dependent on identifying compounds of great economic value from the wide variety of wild species of plants located in undisturbed natural forests. This is called biological prospecting.

Social values

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

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

Ethical and moral values

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

Aesthetic value

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

Option value

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

BIODIVERSITY AT GLOBAL, NATIONAL AND LOCAL LEVELS

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

Most of the world's bio-rich nations are in the South, which are the developing nations. In contrast, the majority of the countries capable of exploiting biodiversity are Northern nations, in the economically developed world. These nations however have low levels of biodiversity. Thus the developed world has come to support the concept that biodiversity must be considered to be a 'global resource'. However, if biodiversity should form a 'common property resource' to be shared by all nations, there is no reason to exclude oil, or uranium, or even intellectual and technological expertise as global assets. India's sovereignty over its biological diversity cannot be compromised without a revolutionary change in world thinking about sharing of all types of natural resources.

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

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

INDIA-A MEGA DIVERSE LANDSCAPE

Geological events in the landmass of India have provided conditions for high levels of biological diversity. A split in the single giant continent around 70 million years ago, led to the formation of northern and southern continents, with India a part of Gondwanaland - the southern landmass, together with Africa, Australia and the Antarctic. Later tectonic movements shifted India northward across the equator to join the Northern Eurasian continent.

As the intervening shallow Tethys Sea closed down, plants and animals that had evolved both in Europe and in the Far East migrated into India before the Himalayas had formed. A final influx came from Africa with Ethiopian species, which were adapted to the Savannas and semi-arid regions. Thus India's special geographical position between three distinctive centres of biological evolution and radiation of species is responsible for our rich and varied biodiversity. Among the biologically rich nations, India stands among the top 10 or 15 countries for its great variety of plants and animals, many of which are not found elsewhere. India has 350 different mammals (rated eight highest in the world), 1,200 species of birds (eighth in the world), 453 species of reptiles (fifth in the world) and 45,000 plant species, of which most are angiosperms, (fifteenth in the world). These include especially high species diversity of ferns (1022 species) and orchids (1082 species). India has 50,000 known species of insects, including 13,000 butterflies and moths. It is estimated that the number of unknown species could be several times higher.

It is estimated that 18% of Indian plants are endemic to the country and found nowhere else in the world. Among the plant species the flowering plants have a much higher degree of endemism, a third of these are not found elsewhere in the world. Among amphibians found in India, 62% are unique to this country. Among lizards, of the 153 species recorded, 50% are endemic. High endemism has also been recorded for various groups of insects, marine worms, centipedes, mayflies and fresh water sponges.

Apart from the high biodiversity of Indian wild plants and animals there is also a great diversity of cultivated crops and breeds of domestic livestock. This is a result of several thousand years during which civilizations have grown and flourished in the Indian subcontinent. The traditional cultivars included 30,000 to 50,000 varieties of rice and a number of cereals, vegetables and fruit. The highest diversity of cultivars is concentrated in the high rainfall areas of the Western Ghats, Eastern Ghats, Northern Himalayas and the North-Eastern hills.

	India's World Ranking	Number of species in India
Mammals	8th	350
Birds	8th	1200
Reptiles	5th	453
Amphibia	15th	182
Angiosperms	15th-20th	14,500

Gene-banks have collected over 34,000 cereals and 22,000 pulses grown in India. India has 27 indigenous breeds of cattle, 40 breeds of sheep, 22 breeds of goats and 8 breeds of buffaloes.

BIODIVERSITY HOTSPOTS

The British biologist **Norman Myers** coined the term "biodiversity hotspot" in 1988 as a biogeographic region characterized both by exceptional levels of plant endemism and by serious levels of habitat loss. In 1990 Myers added a further eight hotspots, including four Mediterranean-type ecosystems. **Conservation International** (CI) adopted Myers' hotspots as its institutional blueprint in 1989, and in 1996, the organization made the decision to undertake a reassessment of the hotspots concept. Three years later an extensive global review was undertaken, which introduced quantitative thresholds for the designation of biodiversity hotspots.

The earth's biodiversity is distributed in specific ecological regions. There are over a thousand major ecoregions in the world. Of these, 200 are said to be the richest, rarest and most distinctive natural areas. These areas are referred to as the Global 200. It has been estimated that 50,000 endemic plants which comprise 20% of global plant life, probably occur in only 18 '**hot spots**' in the world. **Countries which have a relatively large proportion of these hot spots of diversity are referred to as 'megadiversity nations'.**

The rate at which the extinction of species is occurring throughout our country remains obscure. It is likely to be extremely high as our wilderness areas are shrinking rapidly. Our globally accepted national 'hot spots' are in the forests of the **North-East** and **the Western Ghats**, which are included in the world's most biorich areas. The **Andaman and Nicobar Islands** are extremely rich in species and many subspecies of different animals and birds have evolved. Among the endemic species i.e. those species found only in India, large proportions are concentrated in these three areas. The Andaman and Nicobar Islands alone have as many as 2200 species of flowering plants and 120 species of ferns. Out of 135 genera of land mammals in India, 85 (63%) are found in the Northeast. The Northeast States have 1,500 endemic plant species. A major proportion of amphibian and reptile species, especially snakes, are concentrated in the Western Ghats, which is also a habitat for 1,500 endemic plant species. Coral reefs in Indian waters surround the Andaman and Nicobar Islands, Lakshadweep Islands, the Gulf areas of Gujarat and Tamil Nadu. They are nearly as rich in species as tropical evergreen forests!

World's 35 Biodiversity Hotspots

I. Africa

1. **Cape Floristic Region**
2. **Coastal Forests of Eastern Africa**
3. **Eastern Afromontane**
4. **Guinean Forests of West Africa**
5. **Horn of Africa**
6. **Madagascar and the Indian Ocean Islands**
7. **Maputaland-Pondoland-Albany**
8. **Succulent Karoo**

II. Asia-Pacific

9. **East Melanesian Islands**
10. **Himalaya**
11. **Indo-Burma**
12. **Japan**
13. **Mountains of Southwest China**
14. **New Caledonia**
15. **New Zealand**
16. **Philippines**
17. Polynesia-Micronesia
18. Southwest Australia
19. Forests of Eastern Australia (new)
20. Sundaland
21. Wallacea
22. Western Ghats and Sri Lanka

III. Europe and Central Asia

23. **Caucasus**
24. **Irano-Anatolian**
25. **Mediterranean Basin**
26. **Mountains of Central Asia**

IV. North and Central America

27. **California Floristic Province**
28. **Caribbean Islands**
29. Madrean Pine-Oak Woodlands
30. **Mesoamerica**

V. South America

31. **Atlantic Forest**
32. **Cerrado**
33. **Chilean Winter Rainfall-Valdivian Forests**
34. Tumbes-Chocó-Magdalena
35. **Tropical Andes**

MAJOR BIODIVERSITY HOTSPOTS IN THE WORLD

BIODIVERSITY HOTSPOTS IN INDIA

- **Himalaya:** Includes the entire Indian Himalayan region (and that falling in Pakistan, Tibet, Nepal, Bhutan, China and Myanmar)
- **Indo-Burma:** Includes entire North-eastern India, except Assam and Andaman group of Islands (and Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China)
- **Sundalands:** Includes Nicobar group of Islands (and Indonesia, Malaysia, Singapore, Brunei, Philippines)
- **Western Ghats and Sri Lanka:** Includes entire Western Ghats (and Sri Lanka)

THREATS TO BIODIVERSITY

Man has begun to overuse or misuse most of these natural ecosystems. Due to this 'unsustainable' resource-use, once productive forests and grasslands have been turned into deserts and wastelands have increased all over the world. Mangroves have been cleared for fuelwood and prawn farming, which has led to a decrease in the habitat essential for breeding of marine fish. Wetlands have been drained to increase agricultural land. These changes have grave economic implications in the longer term.

The current destruction of the remaining large areas of wilderness habitats, especially in the super diverse tropical forests and coral reefs, is the most important threat worldwide to biodiversity. Scientists have estimated that human activities are likely to eliminate approximately 10 million species by the year 2050. There are about 1.8 million species of plants and animals, both large and microscopic, known to science in the world at present. The number of species however is likely to be greater by a factor of at least 10. Plants and insects as well as other forms of life not known to science are continually being identified in the worlds' 'hotspots' of diversity.

Unfortunately at the present rate of extinction about 25% of the worlds' species will undergo extinction fairly rapidly. This may occur at the rate of 10 to 20 thousand species per year, a thousand to ten thousand times faster than the expected natural rate! Human actions could well exterminate 25% of the world's species within the next twenty or thirty years. Much of this mega extinction spasm is related to human population growth, industrialization and changes in land-use patterns. A major part of these extinctions will occur in 'biorich' areas such as tropical forests, wetlands, and coral reefs. The loss of wild habitats due to rapid human population growth and short term economic development are major contributors to the rapid global destruction of biodiversity.

Island flora and fauna having high endemism in small isolated areas surrounded by sea have so far been most seriously affected by human activity, which has already led to extinction of many island plants and animals (the dodo is a famous example). Habitat loss also results from man's introduction of species from one area into another, disturbing the balance in existing communities. In the process, the purposely or accidentally introduced organisms (Eupatorium, Lantana, Hyacinth, Congress grass or Parthenium) have led to the extinction of many local species. Loss of species occurs due to the destruction of natural ecosystems, either for conversion to agriculture or industry, or by over-extraction of their resources, or through pollution of air, water and soil. In India, forests and grasslands are continuously being changed to agricultural land. Encroachments have been legalized repeatedly. Similarly natural wetland systems have been drained to establish croplands resulting in loss of aquatic species. Grasslands that were once sustainably used by a relatively smaller number of human beings and their cattle are either changed to other forms of use or degraded by overgrazing.

CASE STUDY
Kokkare Bellure – Karnataka: Co-existence (Man and Wildlife)

The pelican, which is an endangered species breeds in large numbers at Kokkare Bellur which is one of the ten known breeding sites in India. Kokkare Bellure is a village in Karnataka in Southern India. In December every year, hundreds of spot billed pelicans, painted storks, ibis and other birds migrate to this area to establish breeding colonies on the tall tamarind trees in the center of the village. The local people have protected the birds, believing that they bring good luck with regard to rain and crops. The villagers collect a rich supply of the natural fertilizer that collects below the nests – the guano. The droppings of fish-eating birds are rich in nitrates. The owners of the trees inhabited by the birds dig deep pits under the trees, into which the guano falls. Silt from nearby lakes and ponds are mixed with the guano which is used in their fields and sold as fertilizer. They have now planted trees around their homes to encourage nesting.

Our natural forests are being deforested for timber and replanted using teak, sal or other single species for their timber value. Such plantations do not support the same biological diversity as a multi-storied natural forest, which has a closed canopy and a rich understorey of vegetation. When excessive firewood is collected from the forest by lopping the branches of trees, the forest canopy is opened up and this alters local biodiversity. Foraging cattle retard the regeneration of the forest as seedlings are constantly trampled. Increasing human population on the fringes of our Protected Areas degrade forest ecosystems. This is a major factor to consider in evaluating the quality of the ecosystem.

Repeated fires started by local grazers to increase grass growth ultimately reduces regeneration and lowers the diversity of plant species. Without alternate sources of fodder this pressure cannot be decreased. Another factor that disrupts forest biodiversity is the introduction of exotic weeds which are not a part of the natural vegetation. Common examples in India are lantana bushes, Eupatorium shrubs and 'congress' grass. These have been imported into the country from abroad and have invaded several large tracts of our natural forests. These weeds spread at the expense of the diverse range of indigenous undergrowth species.

The impact on the diversity of insect, bird and other wildlife species, though not adequately studied, is quite obvious. In our country a variety of traditional farming techniques have evolved over several centuries. Cultivation by slash and burn in the Himalayas, and 'rab' by lopping of tree branches to act as a wood-ash fertilizer in the Western Ghats, are two such systems. When human population in these areas was low, these were sustainable methods of agriculture.

Unfortunately these areas now have a large number of people who subsist largely on forest agriculture. These methods are now unsustainable and are leading to a loss of forest biodiversity. Overharvesting of fish, especially by trawling is leading to serious depletion of fish stocks. Turtles are being massacred off the coast of Orissa. The rare whale shark, a highly endangered species, is being killed off the coast of Gujarat. Poaching: Specific threats to certain animals are related to large economic benefits. Skin and bones from tigers, ivory from elephants, horns from rhinos and the perfume from the must deer are extensively used abroad. Bears are killed for their gall bladders. Corals and shells are also collected for export or sold on the beaches of Chennai and Kanyakumari. A variety of wild plants with real or at times dubious medicinal value are being over harvested. The commonly collected plants include Rauvolfia, Nuxvomica, Datura, etc. Collection of garden plants includes orchids, ferns and moss.

The Rights of Species

We do not see all the varied functions that biodiversity plays in our lives because they are not obvious. We rarely see how they are controlling our environment unless we study nature. Thus we tend to take short-term actions that can have serious impacts on biodiversity leading to even extinction of species by disturbing their habitats. Man has no right to do so. We only share this planet with millions of other species that also have a right to survive on earth. It is morally wrong to allow man's actions to lead to the extinction of species.

ENDANGERED AND ENDEMIC SPECIES OF INDIA

To appreciate the endemic and endangered species of India it is important to understand the wide variety of plant and animal species that are found in the country. Of the well-known species, there are several which are endangered by human activity. The endangered species in the country are categorised as Vulnerable, Rare, Indeterminate and Threatened. Other species are found only in India and are thus endemic or restricted to our country. Some of these may have very localized distribution and are considered highly endemic.

Several plant and animal species in the country are now found in only one or a few Protected Areas. Among the important endangered animals are charismatic species such as the tiger, the elephant, the rhino, etc. The less well-known major mammals restricted to a single area include the Indian wild ass, the Hangul or Kashmir stag, the Golden langur, the pygmy hog and a host of others. There are also endangered bird species such as the Siberian crane, the Great Indian Bustard, the Florican and several birds of prey. During the recent past, vultures which were common a decade ago, have suddenly disappeared and are now highly threatened.

Equally threatened are several species of reptiles and amphibia. Many invertebrates are also threatened, including a large number of species that inhabit our coral reefs. Many plant species are now increasingly threatened due to changes in their habitats induced by human activity. Apart from major trees, shrubs and climbers that are extremely habitat specific and thus endangered, there are thousands of small herbs which are greatly threatened by habitat loss.

Several orchids are yet another group of plants that are under threat. Many plants are threatened due to overharvesting as ingredients in medicinal products. To protect endangered species India has created the Wildlife Protection Act. This includes lists of plants and animals categorised according to the threat on their survival. We know so little about the species diversity of our country. There are several groups of which we know very little. Most of us are only aware of the plight of a few glamorous large mammals, but we need to appreciate the threat to the less known species of plants and animals. We need to find ways to support the conservation of our incredible wildlife for future generations.

Common Plant Species

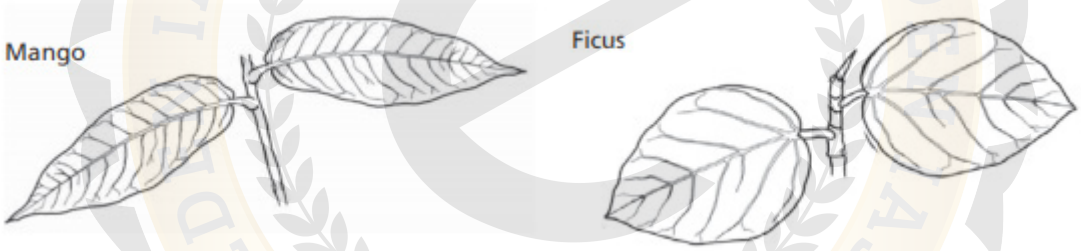
Teak: This tree is from the Southwest parts of peninsular India. It is a common tree in deciduous forests. It yields a much sought after timber used for making excellent furniture. During the early British period it was cut down from many forest tracts to build ships. As the stocks were diminishing, the British selected areas which they called Reserved Forests where teak was planted for the Government's use. Teak is grown extensively by the Forest Department and is a highly priced wood. The teak tree is identified by its large leaves, which grow to more than 40 or 50cms long and 20cms wide. It has tiny flowers and fruit. In the winter, the trees shed all their leaves. In the growing season, which begins in April and extends through the monsoon, teak forests are bright green and shady. Most natural teak forests have various other species

of plants and have a large number of wild animals. Some areas of teak forests that have exceptional populations of wildlife have been included in our National Parks and Wildlife Sanctuaries.

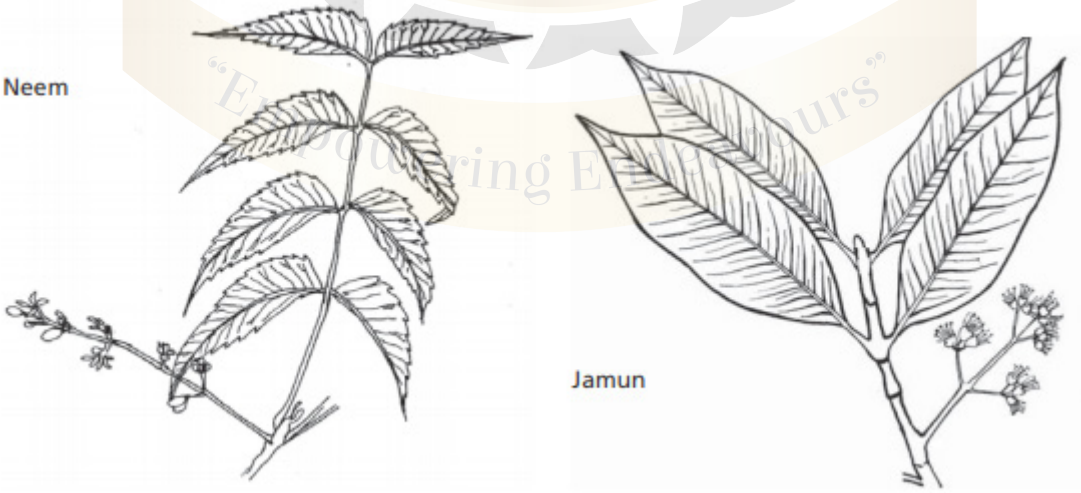
Sal: This is a common species of several types of forests of the Northeastern region of India, extending into Madhya Pradesh and Orissa. It has bright green foliage and its canopy remains green nearly throughout the year. Sal wood is hard and durable. Sal gets a large number of seeds which are used in making cosmetics. The sal forests are rich in wild mammals, birds, reptiles and insect life. Several areas are included in our network of National Parks and Sanctuaries.

Mango: This has become one of our most popular horticultural species with different varieties grown all over the country. The wild mango tree has small tangy fruit and a big seed in comparison to the large pulpy fruit used in horticulture. The mango tree is an evergreen species and gets small flowers that are pollinated by insects. In the forest, fruit dependent animals such as monkeys, squirrels and fruit eating birds relish its ripe fruit.

Ficus species: Peepal, Banyan and many other ficus species form a part of this group of important trees. They are all ecologically of great importance as many different species of insects, birds and mammals live on ficus berries. The flowers are inside the berries. They are pollinated by a specific wasp which lays its eggs inside the berries on which the larvae feed and grow. The ficus trees bear berries throughout the year, thus supplying nutritious food to several animal species when other trees have no fruit. Ficus species are thus known as 'keystone' species in the ecosystem and support a major part of the food web in several ecosystems. Ficus trees such as Peepal and Banyan are considered sacred and are protected in India.



Neem: This species is known as Azadirachta Indica. It has been traditionally used in indigenous medicine. It has small yellow fruit. The leaves and fruit are bitter to taste. It is used extensively as an environmentally friendly insecticide. It grows extremely well in semi-arid regions and can be planted in afforestation programs where soil is poor and rainfall is low.



Tamarind: One of the best known Indian trees, it grows to a large size and is known to live for over 200 years. Its familiar fruit is a curved pod with sour pulp and contains a number of squarish seeds. The pulp

in the fresh fruit is either green or red. As it ripens, it turns sticky and brown and separates from the skin. The tree is commonly cultivated as a shade tree and for its edible sour fruit which contains high concentrations of vitamin C. It is used as an additive in food to give a tangy flavour. It is valued for its timber as well as for fuelwood.

Babul: This is a thorny species that is characteristic of semi arid areas of Western India and the Deccan plateau. It grows sparsely in tracts of grassland and around farms. It is used for fodder and fuelwood. It remains green throughout the year even under the driest conditions and is browsed by wild animals and cattle. It has small leaves and bright yellow flowers and small seedpods with multiple seeds. Its main characteristic is its long sharp, straight thorns which prevent excessive browsing of its older branches.

Zizyphus: These are the typical small trees and shrubs that are found in the arid and semi arid areas of India. Z. mauritiana and Z. jujuba are the most frequent species. It is a favourite of frugivorous birds. The tree fruits extensively and is eaten by a variety of birds and mammals. The popular fruit is commonly collected and sold in local markets.

Jamun: This tree is an evergreen species which has a tasty purple fruit. It is a favourite with not only people but also with many wild birds and mammals. It grows in many parts of India and has several varieties with fruit of different sizes.

Tendu is a mid-sized, deciduous tree, common in dry deciduous forests throughout the Subcontinent. There are around 50 Indian species. Its bark exfoliates in large rectangular scales. It branches profusely forming a dense crown. The leaves are elliptical and leathery and its young leaves are extensively used for making 'bidis'. The fruit is brownish yellow and astringent. Tendu leaf collection necessitates burning undergrowth and slashing the branches of the trees to get at the leaves. The resulting disturbance to wildlife is a serious issue in Protected Areas.

Jackfruit: A tree that is planted around many villages and has huge fruit growing from its branches. The fruit has a prickly skin. The fruit when unripe is cooked. Once ripe it is eaten raw after it turns into a sweet, sticky, golden-yellow fruit which has a strong smell.

Flame of the Forest (Butea monosperma): This tree grows in many parts of India. It has bright orange flowers when it is leafless, thus it is called 'flame of the forest'. The flowers are full of nectar which attracts monkeys and many nectar dependent birds.

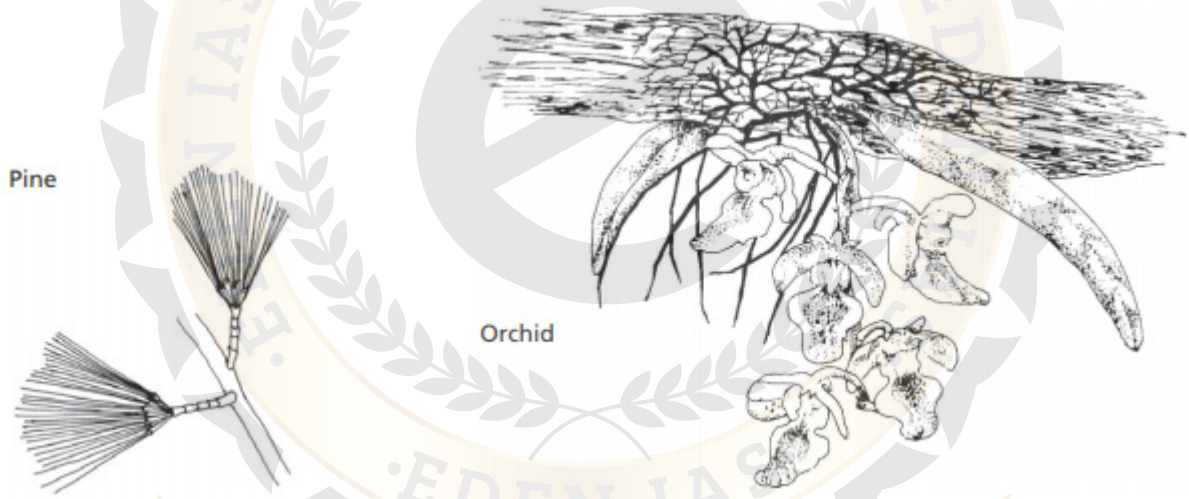
Coral Tree (Erythrina): A common deciduous tree that is leafless in February when it gets bright scarlet flowers that are used for their nectar by many birds such as mynas, crows and sunbirds that act as its major pollinators. Its long black seed pods contain several shiny brown seeds which germinate well. This tree can also be propagated by cutting and planting its young branches. It is a rapid grower and usually begins to flower in four or five years time.

Amla: This deciduous medium sized tree is known for its sour, green-yellow fruit which is rich in vitamin C. It is used as a medicine, in pickles and for dying and tanning. It is frequently referred to as the Indian 'olive', to which it has no similarity either in appearance or taste.

Dipterocarps: This group of trees grows in evergreen forests of the southern part of the Western Ghats and in the Northeast of India, in high rainfall areas. It grows to an enormous height with a wide girth. The seed has a pair of wing like structures which aid in wind dispersal.

Quercus (Oak) is a large tree and is economically an important genus which includes many trees known for their beautiful shape and their changing seasonal colours. There are 30 to 40 Indian species of this genus found in the temperate areas throughout the Himalayas. The fruit is a large, hard, solitary characteristic nut (acorn). Oaks provide the finest hardwoods of great strength and durability and were once used for building ships and bridges. It is a famous wood for high quality furniture. Some of its species are excellent fodder plants.

Pine: There are 5 species of true pines that are found in India in the Himalayan region. The timber of these trees is frequently used in construction, carpentry and the paper industry. Pine resin is used to make turpentine, rosin, tar and pitch. Pine oils are obtained by distillation of leaves and shoots. Pine leaves are thin and needle-like. The male and female spores are produced in woody cones. Dispersal of pollen is aided by each grain having two wings.



Cycas: These plants are uncommon in India and have a palm-like appearance. Cycads along with conifers make up the gymnosperms. They are among the most primitive seed plants, and have remained virtually unchanged through the past 200 million years. There are five species found in India, mostly in high rainfall areas.

Coconut: This tall stately palm has a more or less straight trunk with circular markings. It mostly grows in coastal plains. The base is surrounded by a mass of fine roots. It produces the familiar coconut, filled with liquid and a soft white edible, initially jelly like material that hardens when the fruit ripens. It is a common ingredient of food in India, especially in the Southern States. It is extensively cultivated along the coastal regions and islands of India. Most parts of the tree yield several useful products such as broomsticks from its leaves and fiber from the husk of dried coconuts.

Orchids: This is the largest group of flowering plants in the world with over 18,000 known species. Of these, 1500 species are found in India, making it one of the largest plant families in the country with a high concentration of a staggering 700 species in the Northeastern States. These plants are terrestrial or epiphytic herbs. Flowers show a range of bright colours and great variations in structure. In some species, one of the petals is distinct from the others and is called a lip or labellum. This colourful petal attracts pol-

linators. In India a large number of orchid species are found in the Western Ghats, the Northeast, and the Andaman and Nicobar Islands. Orchids are however seen in several ecological conditions except extremes such as very cold or very hot and dry ecosystems.

Drosera: This is a small insectivorous plant, usually 5 or 6cms in height, which has tiny hair which secrete a sticky droplet of fluid on which insects get stuck. The leaf winds around the struggling insect which is then slowly digested. The plant has pretty flowers. It grows in shallow poor quality soil. It is a rare plant and is found in small patches.

Lotus: An aquatic floating plant with a large rhizome, which is rooted in mud. Its leaves are circular flat and covered with a waxy coating which protects it from water. The flower grows on an erect stalk with several petals ranging from pink violet to white. The fruit is a spongy cone with multiple round seeds. It is widely distributed in wetland habitats and shallow parts of lakes and marshy areas. The rhizome, stalks of the leaves and seeds are considered delicacies. The fruit is used for dry decorations. The flower has been a traditional motif in Indian art. The lotus is the National flower of India.

Grasses: Grasses form the second largest group of flowering plants in the world. They are a very important group of plants as they are used for various purposes such as making fiber, paper, thatching material for roofs, oil, gum, medicines and many other useful products. The economically important grasses include sugarcane, bamboo and cereals like rice, wheat, millets, maize, etc. Grasses are important as they provide fodder for domestic animals.

Bamboo: This is a group of large grasslike species that grow as a clump to great heights in many forests of India. It is extremely useful and is used for constructing huts and making several useful household articles in rural areas such as baskets, farm implements, fences, household implements, matting, etc. The young shoots are used as food. It is extensively used in the pulp and paper industry as a raw material. Bamboos flower after more than two decades. The plant then dies. The flowering produces thousands of seeds which results in the slow regrowth of the bamboo. Bamboo is a favorite food of elephants and other large herbivores of the forest such as gaur and deer.

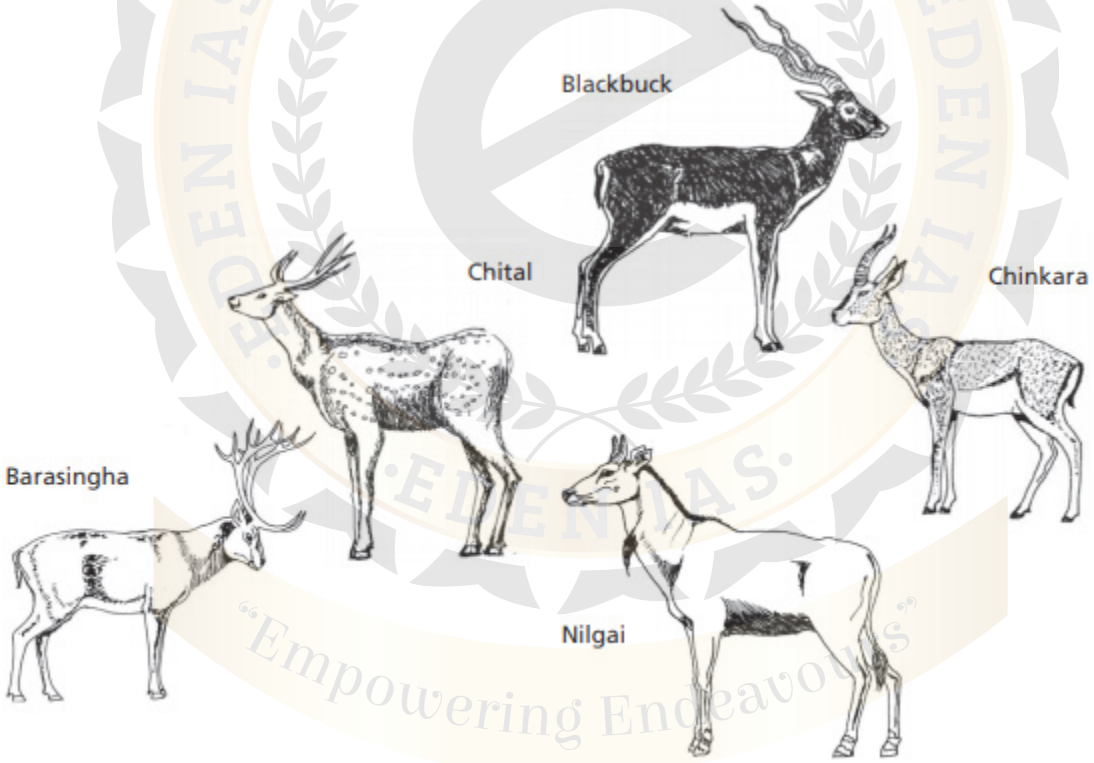
Wild relatives of crop plants: All our present day cultivated varieties of rice, which are grown for food, come from wild varieties of rice, many of which have originated in India, China and Indonesia. Rice forms one of the staple foods of the world. Although wild varieties are not used as food crops, they are important as they contain genes, which can be used to develop disease or pest resistance in crops. Many local varieties of rice have already been lost, as most farmers now grow only high yielding varieties.

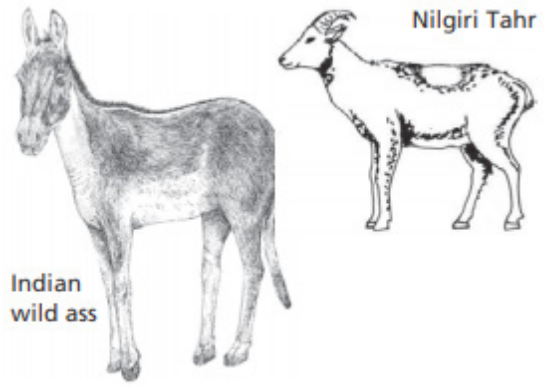
Common Animal Species

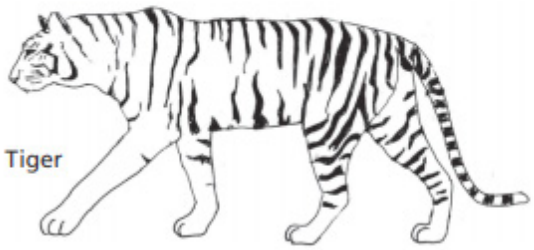
Mammals: The common deer species found in India include the sambar, chital, barasingha and barking deer. **Sambar** lives in small family parties especially in hilly forested areas and feed mainly on shrubs and leaves of low branches. They are dark brown in colour and have large thick antlers, each having 3 branches. Chital or spotted deer live in large herds in forest clearings where they graze on the grass. They have a rust brown body with white spots which camouflages them in the forest. Each antler has three branches called tines.

The rare **Hangul** deer is found only in Kashmir. It has a magnificent spread of antlers with 6 branches on each antler. The **Barasingha**, or **swamp deer**, has wide hoofs that enable this beautiful animal to live in boggy areas of the Terai. Each antler has 6 or more branches. The tiny **barking deer** lives in many forest areas all over India. It has two ridges on its face and a short antler with only two branches. Its call sounds like the bark of a dog.

The **blackbuck** is the only true antelope found in India. It lives in large herds. The males are black on top and cream below and have beautiful spiral horns that form a 'V' shape. The **chinkara**, also known as the **Indian gazelle**, is a smaller animal and is pale brown in colour it has beautiful curved horns. The rare **Chausingha, or four horned antelope**, is the only animal in the world that has four horns. The **nilgai** is the largest of the dryland herbivores. The males are blue-gray. Nilgai have white markings on the legs and head. They have short strong spike-like horns.



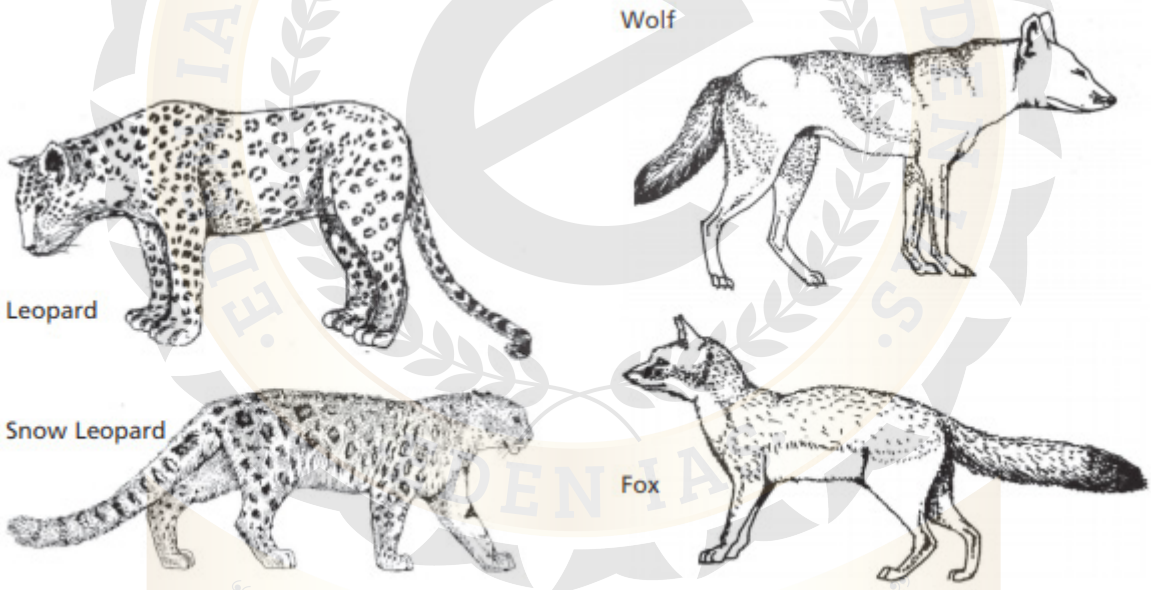




A very special rare species is the **Indian wild ass**, endemic to the Little Rann of Kutch. Himalayan pastures support several species of wild goats and sheep, many of them restricted to the region, like the goral and the Himalayan tahr. A single species, the **Nilgiri tahr** is found in the Nilgiri and Annamalai hills in south India. The **rhinocerous** is now restricted to Assam but was once found throughout the Gangetic plains. The wild buffalo is now also restricted to the Terai. **The elephant** is distributed in the Northeastern and Southern States. It is threatened by habitat loss and poaching for ivory. **Gaur** is found in patches in several well-wooded parts of India.

The best known predator of our forests is the **tiger**. Its gold and black stripes hide it perfectly in the forest undergrowth. It preys on herbivores such as sambar or chital or less frequently on domestic animals. The tiger kills only three or four times a month. Its numbers have declined due to poaching for its superb skin, and for the supposed magical value of its teeth, claws and whiskers. In the recent past it has been extensively killed for the supposed medicinal properties of its bones that are used in Chinese medicine.

The Asiatic lion is now found only in the Gir forests of Gujarat. The **leopard** is more adaptable than the tiger and lives both in thick forests and degraded forest areas. It's beautiful ring like markings camouflage it so perfectly that its prey cannot see its stealthy approach. The smaller jungle cat, which is a light brown animal and the leopard cat, which is a little bigger than a domestic cat, are very rare. The most typical predator of the HImalayas is the **snow leopard**, which is very rare and poached for its beautiful skin which is pale grey with dark grey ring-like markings.

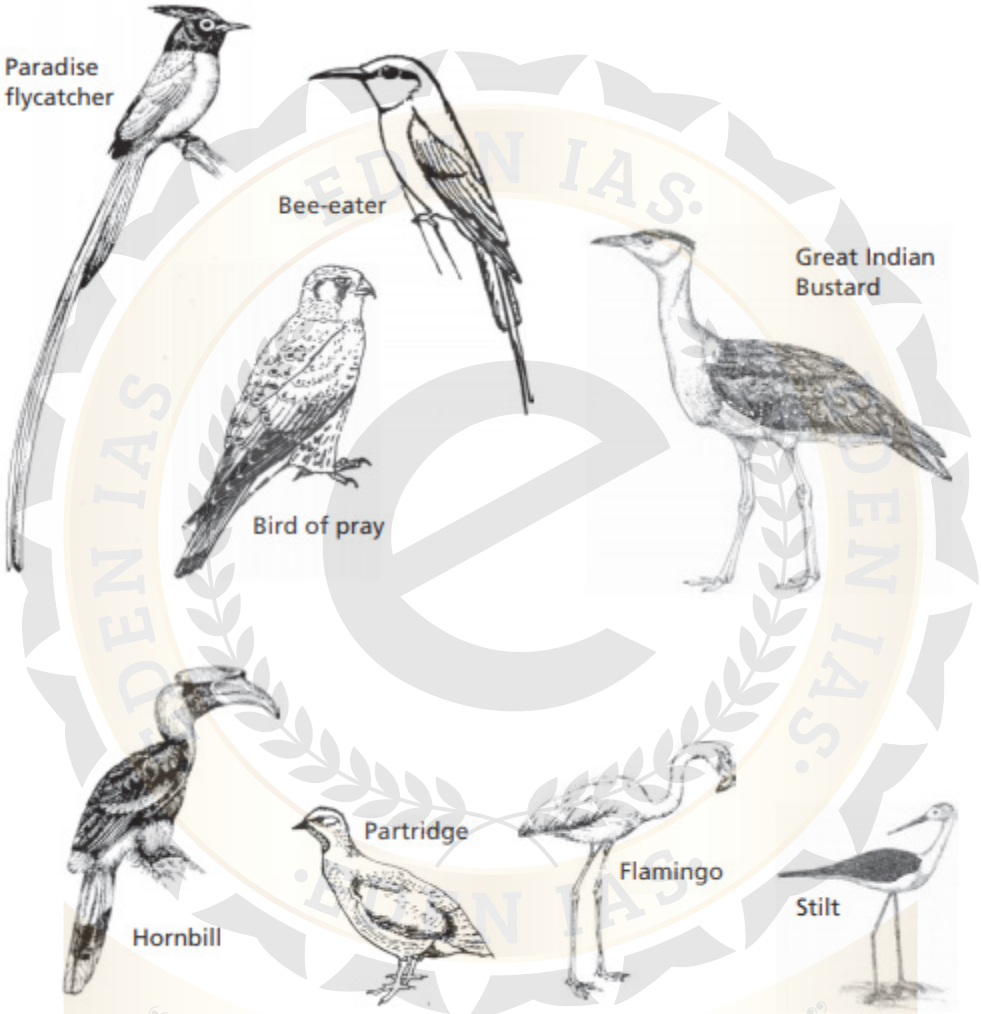


The **wolf, jackal, fox and the wild dog** or **'dhole'** form a group called **canids**. Another threatened predator is the Himalayan wolf. The wolves are now highly threatened as they have become increasingly dependent on shepherd's flocks. Thus shepherds constantly find ways to kill the **wolves.**

One of the common monkey species of the forest is the **bonnet macaque**, which has a red face, a very long tail and a whorl of hair on the scalp which looks like a cap. Our other common monkey is the rhesus macaque, which is smaller and has a shorter tail than the bonnet. A rare macaque is the **lion-tailed macaque** found only in a few forests of the southern Western Ghats and Annamalai ranges. It is black in colour, has long hair, a grey mane and a tassel at the end of its tail that looks like a lion's tail. The **common langur** has a black face and is known as the **Hanuman monkey**. The rare **golden langur** is golden yellow in colour and lives along the banks of the Manas River in Assam. The capped langur is an uncommon species of Northeast India. The rare **black nilgiri langur** lives in the southern Western Ghats, Nilgiris and Annamalais.

Birds: There are over 1200 bird species found in India in different habitats. Most of our forest birds are specially adapted to life in certain forest types. Some Himalayan species however can also be seen in the Western Ghats. There are several species of **Hornbills** that live on fruit. They have heavy curved beaks with a projection on top. **Frugivores** such as **parakeets, barbets** and **bulbuls** live on fruit and are often seen eating Ficus fruits such as those of banyan and peepal.

Insectivorous birds of many species live on forest insects. They include various species of **flycatchers**, bee-eaters, and others. The male **paradise flycatcher** is a small beautiful white bird with a black head and two long white trailing tail feathers. The female is brown and does not have the long tail feathers.

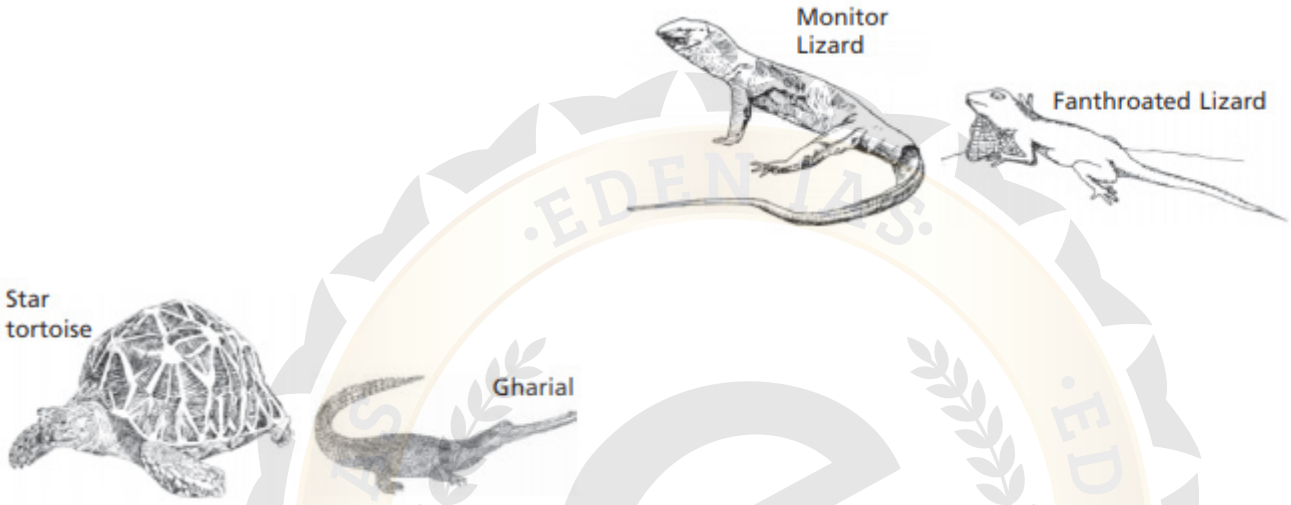


There are several **eagles, falcons** and **kites** many of which are now endangered. Grasslands support many species of birds. The most threatened species is the **Great Indian bustard**, a large, brown stately bird with long legs which struts about through grasslands looking for locusts and grasshoppers. Another rare group of threatened birds are the floricans. There are many species of **quails, partridges, larks, munias** and other grain eating birds that are adapted to grasslands.

There are several species of aquatic birds such as **waders, gulls** and **terns**, which live along the seashore and go out fishing many kilometers to the sea. Many of these birds have lost their coastal habitats due to pollution. **Aquatic birds** in freshwater are those with long legs and are known as waders such as stilts and sandpipers. The other group form birds that swim on water such as several species of **ducks** and **geese.**

There are many species of spectacular large birds associated with water or marshy areas. These include different species of **storks, cranes, spoonbills, flamingo** and **pelicans**. Many aquatic species are migrants. They breed in Northern Europe or Siberia and come to India in thousands during winter.

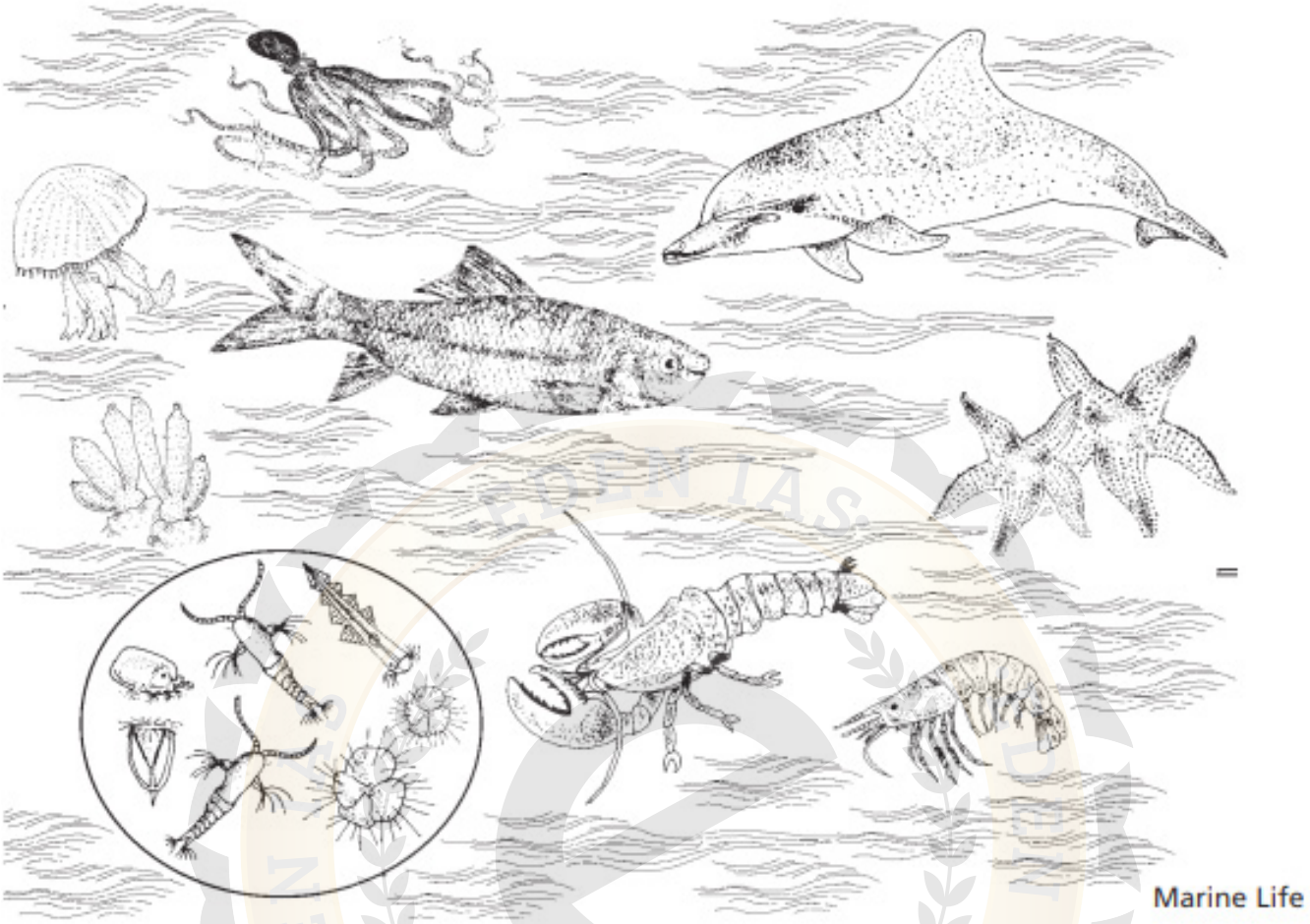
Reptiles: India has a wide variety of lizards, snakes and turtles, with a high level of endemism. The lizards include the common **garden lizard**, **Fan throated lizard, Chamelion, Skink, Common Monitor** and **Water Monitor**. Some of these are threatened due to trade in reptile skins. Indian snakes include the **Rock Python**, **Russell's viper** and **the Vine snake**. We rarely appreciate the fact that only a few species of snakes are poisonous and most snakes are harmless. The **Star tortoise** and Travancore tortoise are now rare. The **Olive Ridley** and **Flapshell turtle** are the well-known turtles of India. Many turtles are becoming increasingly rare due to poaching of adults and eggs. The crocodile is our largest reptile which is poached for its prized skin. The **gharial** is endemic to India and is highly threatened.



Amphibia: Most of the amphibians found in India are frogs and toads. These include several species like the **Indian Bull frog, Tree frog**, etc. **These amphibians are mostly found in the hotspots in the Northeast and the Western Ghats.** It is now thought that global warming and increasing levels of UV radiation may be seriously affecting amphibian populations in some areas.

Invertebrates: Invertebrates include a variety of taxa that inhabit both terrestrial and aquatic ecosystems. Microscopic animals like protozoa and zooplankton form the basis of the food chain in aquatic habitats. Coral is formed by colonies of polyp like animals.

Worms, molluscs (snails), spiders, crabs, jellyfish, octopus are a few of the better known invertebrates found in India. There are more than a million insect species on earth that are known to science. They include **grasshoppers, bugs, beetles, ants, bees, butterflies** and **moths**. India is rich in its butterfly and moth species.



Marine Life

Marine Life: Marine ecosystems are most frequently associated with fish and crustacea like **crabs** and **shrimp,** which we use as food. The other species that are endangered include the marine turtles, which are reptiles, and whales that are mammals. There are a large number of species of **freshwater fish** found in our Indian rivers and lakes that are now threatened by the introduction of fish from abroad as well as due to being introduced from one river into another. Fish are also now seriously affected by pollution. Marine fisheries are being over harvested in our coastal waters and the fish catch has decreased seriously over the last few years. Mechanized boats with giant, small-meshed nets are a major cause of depleting this resource. There are many endangered fish such as the Mahseer which once grew to over a meter in length. Many species of marine animals such as the whales, sharks and dolphins that live in the Indian Ocean are now threatened by extinction due to fishing in the deep sea.

BIODIVERSITY CONSERVATION

Biodiversity at all its levels, genetic species and as intact ecosystems can be best preserved insitu by setting aside an adequate representation of wilderness as 'Protected Areas'. These should consist of a network of National Parks and Wildlife Sanctuaries with each distinctive ecosystem included in the network. Such a network would preserve the total diversity of life of a region.

In the past National Parks and Sanctuaries in India were notified to preserve major wildlife species such as tigers, lions, elephants, and deer. The objective of these areas should be expanded to the preservation of relatively intact natural ecosystems, where biological diversity – from microscopic unicellular plants and animals, to the giant trees and major mammals – can all be preserved.

Project Tiger: Project Tiger was launched by the Government of India with the support of WWF-International in 1973 and was the first such initiative aimed at protecting this key species and all its habitats. Project Tiger was initiated in nine Tiger Reserves in different ecosystems of the country covering an area of 16339 sq km.

Project Elephant: Project Elephant was launched in 1992 to ensure the long-term survival of a viable population of elephants in their natural habitats in north and northeastern India and south India. It is being implemented in several states. In spite of this, our elephant herds are at threat as their habitat is shrinking and their migration routes are disrupted by human activities.

Crocodile Conservation: Crocodiles have been threatened as their skin is used for making leather articles. This led to the near extinction of crocodiles in the wild in the 1960s in India. A Crocodile Breeding and Conservation Program was initiated in 1975 to protect the remaining population of crocodilians in their natural habitat and by creating breeding centers. It is perhaps one of the most successful ex situ conservation breeding projects in the country. Crocodiles have been extensively bred in over 30 captive breeding centers, zoos and other sites where successful breeding takes place. Thousands of crocodiles of all three species have been bred and restocked in 20 natural water bodies

However species cannot be protected individually as they are all inter dependent on each other. Thus the whole ecosystem must be protected. The biologist's view point deals with areas that are relatively species rich, or those where rare, threatened or endangered species are found, or those with 'endemic' species which are not found elsewhere. As rare endemic species are found only in a small area these easily become extinct due to human activity. Such areas must be given an added importance as their biodiversity is a special feature of the region. Animals such as elephants require different types of habitat to feed in during different seasons. They utilize open grasslands after the rains when the young grass shoots are highly nutritious. As the grasses dry, the elephants move into the forest to feed on foliage from the trees. A Protected Area that is meant to protect elephants must therefore be large enough and include diverse habitat types to support a complete complement of inter linked species.

Wildlife Sanctuaries and National Parks of India:

There are 589 Protected Areas in India of which 89 are National Parks and 500 are Wildlife Sanctuaries. They include a variety of ecosystems and habitats. Some have been created in order to protect highly endangered species of wild plants and animals found nowhere else in the world.

The **Great Himalayan National Park** is the largest sanctuary in this ecosystem and is one of the last homes of the beautiful snow leopard. **Dachigam Sanctuary** is the only place where the rare Hangul or Kashmir stag is found. There are several Sanctuaries in the Terai region, **Kaziranga National Park** is the most famous which has elephant, wild buffalo, gaur, wild boar, swamp deer, and hog deer, in large numbers, as well as tiger and leopard. Its bird life is extremely rich and includes ducks, geese, pelicans and storks. **The Manas Sanctuary**, in addition to the above Terai species, also includes the rare golden langur and the very rare pygmy hog, the smallest wild boar in the world. The florican is found only in a few undisturbed grasslands in the Terai sanctuaries. In the sal forests of Madhya Pradesh, there are several Protected Areas. **Kanha** offers a wonderful opportunity to observe wild tigers from elephant back. It is the only Protected Area in which a sub species of the Barasingha is found. **Bharatpur** is one of the most famous water bird sanctuaries in the world. Thousands of ducks, geese, herons, and other wading birds can be seen here. This is the only home of the very rare Siberian crane which migrates to India every

winter. During the last 20 years, the 30 or 40 Siberian cranes have dwindled to only 2 or 3. During 2002-3 no cranes were seen and it is possible that this beautiful bird will never again come to India. In the Thar Desert, the wild life is protected in the **Desert National Park**. Here large numbers of black buck, neelgai and chinkara can be seen. The Great Indian Bustard lives in these arid lands. **Ranthambor** was the most well known sanctuary for observing tigers in the wild till about 3 or 4 years ago. Since then many tigers have been killed by poachers.

The **Great and the Little Rann of Kutch** have been made into sanctuaries to protect the very rare wild ass, the flamingo, the star tortoise and the desert fox. In Gujarat, the **Gir Sanctuary** protects the last population of the majestic Asiatic lion. This thorn and deciduous forest is also the home of large herds of chital, sambar, and nilgai. The Sanctuaries of the Western Ghats and associated hill ranges protect some of the most diverse forest types in the country. The few examples of highly threatened species include the Malabar giant squirrel, the flying squirrel and a variety of hill birds, several species of amphibians, reptiles and insects. These regions are also rich in highly endemic plant life.

Sanctuaries such as **Bhimashankar, Koyana, Chandoli** and **Radhanagari** preserve this rich flora in Maharashtra, **Bandipur**, **Bhadra, Dandeli, Nagarhole**, etc. in Karnataka, and **Eraviculum, Perambiculum, Periyar, Silent Valley**, in Kerala. In the Nilgiri Hills the rich forest Sanctuaries protect some of the last pockets of the Indian elephant in South India. Examples include **Bandipur, Madhumalai, Wynad** and **Bhadra**. During the last 10 years, a large number of the great tusker elephants of this region have been ruthlessly killed for their ivory.

Now very few of these magnificent animals are left in these jungles. Two important sanctuaries meant for preservation of coastal ecosystems are the **Chilka Lake** and **Point Calimere**. **The Sunderbans** protect the largest mangrove delta in India. The **Marine National Park** in Gujarat protects shallow areas in the sea, islands, coral reefs and extensive mudflats. Over a hundred Protected Areas have been created in the Andaman and Nicobar Islands to preserve their very special island ecosystems.

CASE STUDY
Orissa – Olive Ridley Turtles

Every year at **Gahirmatha** and two other sites on the Orissa coast, hundreds of thousands of Olive Ridley turtles congregate on the beach, between December and April, for mass nesting. **This is the largest nesting site for the Olive Ridleys in the world.**

There are severe threats to these nesting sites. Shrinking nesting sites, construction of roads and buildings close to these rookeries, and other infrastructure development projects hamper nesting. Trawler fishing is another large threat to the turtles. After its 'discovery' in 1974, the beach was notified as a Sanctuary (the **Bhitarkanaika Sanctuary**) and was closed for hunting. Recognising the threats to turtles from fishing by large trawlers, the Orissa Marine Fisheries Regulation Act was passed in 1982.

This Act prohibits trawling within 10 km of the coastline throughout the state and makes it mandatory for all trawlers to use Turtle Excluder Devices (TEDs). In 2001, the State Government of Orissa declared that a five month period between January to May should constitute a no-fishing season for a distance of 20 km from the coastline.

Apart from these initiatives, Operation Kachhapa is being coordinated by the Wildlife Protection Society of India, Delhi and Wildlife Society of Orissa with many local NGOs as partners. The Orissa Forest Department, WII, Dehra Dun and the Coast Guard are also involved in the Project.

The need for an Integrated Protected Area System (IPAS)

Protected Areas, to be effective, must be established in every biogeographic region. A relatively larger representation must be included of highly fragile ecosystems, areas of high species diversity or high endemism. Protected Areas must also be integrated with each other by establishing corridors between adjacent areas wherever possible so that wildlife can move between them. In our country, which has a rapidly growing human population, it is not easily feasible to set aside more and more land to create Protected Areas. The need to provide a greater amount of land for agricultural and other needs has become an increasing cause of concern in land and resource management. This forms a major impediment for creating new Protected Areas.

Having said this, there is an urgent need to add to our Protected Areas to preserve our very rich biological diversity. Much of the natural wilderness has already undergone extensive changes. The residual areas that have high levels of species richness, endemism or endangered plants and animals must be notified as National Parks and Wildlife Sanctuaries. Other areas can be made into Community Conserved Areas which are managed by local people.

The International Union for Conservation of Nature and Natural Resources states that it is essential to include at least 10% of all ecosystems as Protected Areas if biodiversity is to be conserved in the long-term. India has only 5% of land in its 589 Protected Areas. However much of this includes plantations of sal or teak, which were developed for timber in the past and are thus relatively poor in diversity and have a low level of 'naturalness'.

There are only a few good grasslands left in our country that are notified as Protected Areas. Some are overgrazed wastelands in areas that were once flourishing grasslands. Most of these areas have a low biological value and need careful management to allow them to revert to a more 'natural' state, with their full complement of plants and animals. Only a few wetlands have been made into Sanctuaries. These require better management. A major strategy to reduce impacts on the biodiversity of the PAs should be to provide a sustainable source of resources for local people living around them. A Protected Area curtails their traditional grazing practices and access fuelwood sources.

These resources must be provided by developing them in buffer areas. Plantations of fuel wood and good grassland management in areas outside Protected Areas can help reduce the pressure on the habitat of wildlife in the Protected Area. Management must ensure that local people derive a direct economic benefit from the presence of the PA. Involving local people in Protected Area management and developing tourist facilities that support the income generation for local people helps in involving their support for the Protected Area.

A carefully designed management plan which incorporates an '**ecodevelopment**' component aimed at providing a source of fuel wood, fodder and alternate income generation for local people is an important aspect of PA management. There are several species of plants and animals that survive without protection outside our current network of PAs. As it is not practical to notify more PAs without affecting the lives of people, alternate strategies such as Community Reserves or Community Conserved Areas need to be created. These should be managed by local people to bring about the conservation of biodiversity while using the area's resources in an equitable and sustainable way. A Community Conserved Area must have specific conservation goals that can be achieved without compromising the area's **utilitarian** potential.

A major drive for conservation of biological diversity can only come from a mass environmental education program on the value of protecting our dwindling biological resources.

Ex-situ conservation

Conservation of a species is best done by protecting its habitat along with all the other species that live in it in nature. This is known as in-situ conservation, which is conserving a species in its own environment

by creating National Parks and Wildlife Sanctuaries. However, there are situations in which an endangered species is so close to extinction that unless alternate methods are instituted, the species may be rapidly driven to extinction. This strategy is known as ex-situ conservation, i.e. outside its natural habitat in a carefully controlled situation such as a botanical garden for plants or a zoological park for animals, where there is expertise to multiply the species under artificially managed conditions. These breeding programs for rare plants and animals are however more expensive than managing a Protected Area.

There is also another form of preserving a plant by preserving its germ plasm in a gene bank so that it can be used if needed in future. This is even more expensive. When an animal is on the brink of extinction, it must be carefully bred so that inbreeding does not lead to the genetic makeup becoming weak. Breeding from the same stock can lead to poorly adapted progeny or even inability to get enough offspring.

Modern breeding programs are done in zoos that provide for all the animal's needs, including enclosures that simulate their wild habitats. There may also be a need to assist breeding artificially. Thus while most zoos are meant to provide visitors with a visual experience of seeing a wild animal close up, and provide the visitors with information about the species, a modern zoo has to go beyond these functions that include breeding of endangered species as a conservation measure. In India, successful ex situ conservation programs have been done for all our three species of crocodiles.

This has been highly successful. Another recent success has been the breeding of the very rare pygmy hog in Gauhati zoo. **Delhi zoo has successfully bred the rare Manipur brow antlered deer**. However the most important step of a successful breeding program is the reintroduction of a species into its original wild habitat. This requires rehabilitation of the degraded habitat and removal of the other causes such as poaching, disturbance, or other manmade influences that have been the primary cause of reducing the population of the species.

Conservation of cultivars and livestock breeds

There were an estimated thirty thousand varieties of rice grown in India till about 50 years ago. Now only a few of these are still grown. The new varieties which are now being cultivated everywhere have been developed using germ plasm of these original types of rice. If all the traditional varieties vanish completely it will be difficult to develop new disease resistant varieties of rice in the future. Several varieties have been preserved in gene banks. However, this is both very expensive and risky. Encouraging farmers to continue to grow several traditional varieties is thus an important concern for the future of mankind. At present gene bank collections have over 34 thousand cereals and 22 thousand pulses.

In the past, domestic animals were selected and bred for their ability to adapt to local conditions. Traditional agropastoralists in India have selectively bred livestock for 2 to 3 thousand years. India has 27 breeds of cattle, 40 breeds of sheep, 22 breeds of goats, and 8 breeds of buffaloes. These traditional breeds must be maintained for their genetic variability

CASE STUDY
Beej Bachao Andolan (Save the Seeds Movement)

This movement began in the Himalayan foothills. The members have collected seeds of diverse crops in Garhwal. The movement has successfully conserved hundreds of local rice varieties, rajma, pulses, millets, vegetables, spices and herbs. Many different varieties are being grown as an outcome of this program in local farmer's fields. This has also been supported by local women's groups who felt these varieties were better than those provided by the green revolution. In contrast, men who were interested in cash returns in a short time found it difficult to appreciate the benefits of growing indigenous varieties.

Flagship species

A flagship species is a species chosen to represent an environmental cause, such as an ecosystem in need of conservation. These species are chosen for their vulnerability, attractiveness or distinctiveness in order to engender support and acknowledgement from the public at large.

Example: Indian tiger, African elephant, giant panda of China, mountain gorilla of Central Africa, orangutan of Southeast Asia and the leatherback sea turtle.

Species evenness refers to how close in numbers each species in an environment is. Mathematically it is defined as a diversity index, a measure of biodiversity which quantifies how equal the community is numerically. So if there are 40 foxes, and 1000 dogs, the community is not very even. But if there are 40 foxes and 42 dogs, the community is quite even. The evenness of a community can be represented by **Pielou's evenness index**:

$$J' = \frac{H'}{H'_{\max}}$$

Where ***H'*** is the number derived from the Shannon Diversity Index and *H'max* is the maximum possible value of ***H'*** (If every species was equally likely) equal to:

$$H'_{\max} = -\sum_{i=1}^{S} \frac{1}{S} \ln \frac{1}{S} = \ln S.$$

J' is constrained between 0 and 1. The less evenness in communities between the species (and the presence of a dominant species), the lower ***J'*** is and vice versa. **S** is the total number of species. Other indices have been proposed by authors where e.g. Hurlburt›s evenness index.

UNIT-V

[BIOMES]

MAJOR DETERMINANTS OF BIOMES

Climate, topography, and soil—and parallel influences in aquatic environments—determine the changing character of plant and animal life, as well as ecosystem functioning, over the surface of the earth. Although no two locations harbor exactly the same assemblage of species, we can group biological communities and ecosystems into categories based on climate and dominant plant form, which give them their overall character. These categories are referred to as biomes. Ecosystems belonging to the same biome type in different parts of the world develop a similar vegetation structure and similar ecosystem functioning, including productivity and rates of nutrient cycling, under similar environmental conditions. Thus, biomes provide convenient reference points for comparing ecological processes on a global scale. Ecosystems of the woodland/shrubland biome characteristic of Mediterranean climates (cool, wet winters and hot, dry summers), for example, look similar and function similarly whether in southern California, southern France, Chile, South Africa, or Australia.

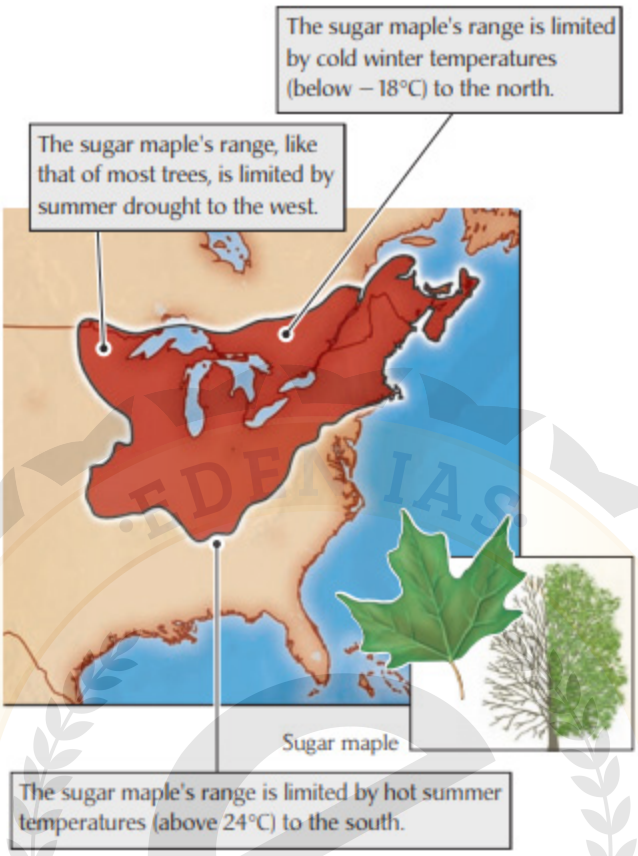
The biome concept is a useful tool that enables ecologists throughout the world to work together toward understanding the structure and functioning of large ecological systems.

That biomes can be distinguished reflects the simple fact that no single type of plant can endure the whole range of conditions at the surface of the earth. **If plants had such broad tolerance of physical conditions, the earth would be covered by a single biome.** To the contrary, trees, for example, cannot grow under the dry conditions that shrubs and grasses can tolerate, simply because the physical structure, or growth form, of trees creates a high demand for water. The grassland biome exists because grasses and other herbs (called forbs) can survive the cold winters typical of the Great Plains of the United States, the steppes of Russia, and the pampas of Argentina.

Climate is the major determinant of plant growth form and distribution

We can classify ecosystems into biomes because climate, along with other influences, determines the plant growth form best suited to an area, and because plants with particular growth forms are restricted to particular climates. These principles establish the close relationship between climate and vegetation. Keep in mind, however, that there are other, less conspicuous similarities among areas of the same biome type, including biological productivity, nutrient regeneration in soils, and the structure of animal communities. One cannot understand the adaptations of an organism independently of the environment in which it lives. Different physical conditions characterize each biome, and its inhabitants are adapted to live under those conditions.

The leaves of deciduous forest trees growing in the temperate seasonal forest biome are typically broad and thin, providing a large surface area for light absorption but little protection from desiccation or frost. In contrast, the leaves of many desert species are small and finely divided to dissipate heat, and some desert species have no leaves at all. Because of these adaptations, the vegetation of the temperate seasonal forest and subtropical desert biomes differs dramatically. These differences extend to the spacing of plants as well as their form. In temperate forests, trees form closed canopies, and the entire surface of the ground is shaded. In drier environments, including deserts, woodlands, and savannas, trees and shrubs are more widely spaced owing to competition among their root systems for limited water, and this spacing allows drought resistant grasses to grow in the gaps between trees. In the most extreme deserts, much of the soil surface is bare because the scarce water cannot support an uninterrupted expanse of vegetation.



Given that organisms are adapted to the physical conditions of their biome, it is not surprising that the ranges of many species are limited by those same physical conditions. In terrestrial environments, temperature and moisture are the most important variables, particularly for plants. The distributions of several species of maples in eastern North America show how these factors operate. The sugar maple (Acer saccharum), a common forest tree in the northeastern United States and southern Canada, is limited by cold winter temperatures to the north, by hot summer temperatures to the south, and by summer drought to the west.

The distributions of species are limited by physical conditions of the environment.

Thus, the sugar maple is confined to roughly the northern portion of the temperate seasonal forest biome in North America. Attempts to grow sugar maples outside their normal range fail because these trees cannot tolerate average monthly summer temperatures above about 24°C or winter temperatures below about 218°C. The western limit of the sugar maple, determined by dryness, coincides with the western limit of forest in eastern North America. Because temperature and rainfall interact to control the availability of moisture, sugar maples require less annual precipitation at the northern edge of their range (about 50 cm) than at the southern edge (about 100 cm). To the east, the range of the sugar maple stops abruptly at the Atlantic Ocean

Climate defines the boundaries of terrestrial biomes

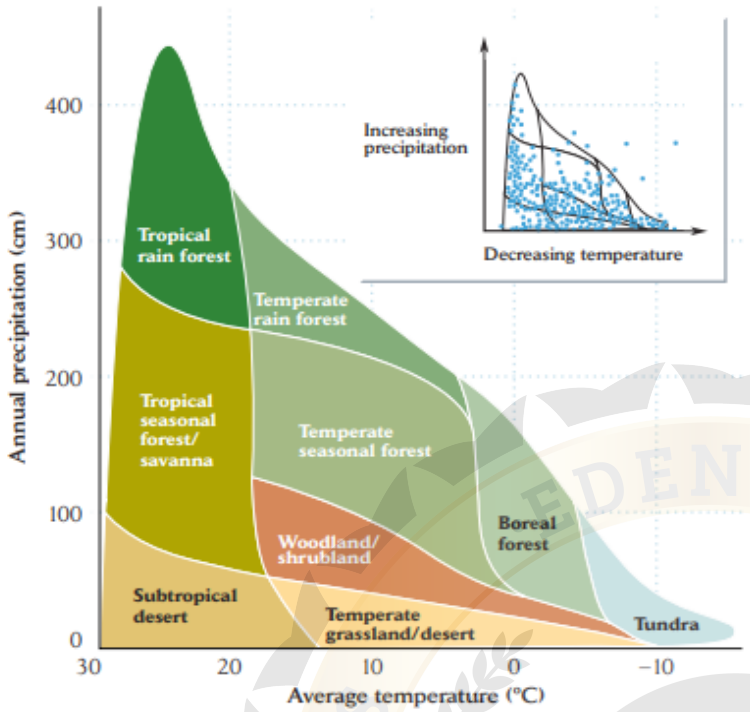
One of the most widely adopted climate classification schemes is the climate zone system developed by the **German ecologist Heinrich Walter**. This system, which has nine major divisions, is based on the annual cycle of temperature and precipitation. The important attributes of climate and characteristics of vegetation in each of these zones are set out in the following figure. The values of temperature and precipitation used to define climate zones correspond to the conditions of moisture and cold stress that are particularly important determinants of plant form. For example, within tropical latitudes, the tropical

climate zone is distinguished from the equatorial climate zone by the occurrence of water stress during a pronounced dry season. The subtropical climate zone, which occurs at somewhat higher latitudes, is perpetually water-stressed.

Biome name	Climate zone		Vegetation
Tropical rain forest	I	Equatorial: Always moist and lacking temperature seasonality	Evergreen tropical rain forest
Tropical seasonal forest/savanna	II	Tropical: Summer rainy season and "winter" dry season	Seasonal forest, scrub, or savanna
Subtropical desert	III	Subtropical (hot deserts): Highly seasonal, arid climate	Desert vegetation with considerable exposed surface
Woodland/shrubland	IV	Mediterranean: Winter rainy season and summer drought	Scerophyllous (drought-adapted), frost-sensitive shrublands and woodlands
Temperate rain forest	V	Warm temperate: Occasional frost, often with summer rainfall maximum	Temperate evergreen forest, somewhat frost-sensitive
Temperate seasonal forest	VI	Nemoral: Moderate climate with winter freezing	Frost-resistant, decidous, temperate forest
Temperate grassland/desert	VII	Continental (cold deserts): Arid, with warm or hot summers and cold winters	Grasslands and temperate deserts
Boreal forest	VIII	Boreal: Cold temperate with cool summers and long winters	Evergreen, frost-hardy needle-leaved forest (taiga)
Tundra	IX	Polar: Very short, cool summers and long, very cold winters	Low, evergreen vegetation, without trees, growing over permanently frozen soils

Heinrich Walter classified the climate zones of the world according to the annual cycle of temperature and precipitation. The biome names given to these zones under Whittaker's classification scheme are shown in the left-hand column.

The typical vegetation types in these three climate zones are evergreen rain forest (equatorial), seasonal forest or savanna (tropical), and desert scrub (subtropical), respectively. We will look at Walter's climate zones in more detail below. Many classification schemes for biomes exist. Walter's is based first on climate, with boundaries between climate zones drawn to match changes between major vegetation types. Cornell University ecologist **Robert H. Whittaker defined biomes first by their vegetation type, and then devised a simple climate diagram on which he plotted the approximate boundaries of his biomes with respect to average temperature and precipitation.**



Whittaker's biomes are delineated according to average temperature and precipitation. Whittaker plotted the boundaries of observed vegetation types with respect to average temperature and precipitation. In climates intermediate between those of forest and desert biomes, climatic seasonality, fire, and soils determine whether woodland, grassland, or shrubland develops. Inset: Average annual temperature and precipitation for a sample of localities more or less evenly distributed over the land area of the earth. Most of the points fall within a triangular region that includes almost the full range of climates. Only the climates of high mountains do not fall within the triangle

The result is similar to Walter's scheme, as one would expect, and their nine biome types correspond directly. When plotted on Whittaker's diagram, most locations on earth fall within a triangular area whose three corners represent warm moist, warm dry, and cool dry climates. (Cold regions with high rainfall are rare because water does not evaporate rapidly at low temperatures and because the atmosphere in cold regions holds little water vapor.) At tropical and subtropical latitudes, where average temperatures range between 20°C and 30°C, vegetation ranges from rain forest, which is wet throughout the year and generally receives more than 250 cm (about 100 inches) of rain annually (Walter's equatorial climate zone), to desert, which generally receives less than 50 cm of rain (Walter's subtropical climate zone).

Intermediate climates support seasonal forests (150–250 cm rainfall), in which some or all trees lose their leaves during the dry season, or scrub and savannas (50–150 cm rainfall). Plant communities at temperate latitudes follow the pattern of tropical communities with respect to rainfall, falling conveniently into four vegetation types: temperate rain forest (as in the Pacific Northwest of North America), temperate seasonal forest, woodland/shrubland, and temperate grassland/desert. At higher latitudes, precipitation varies so little from one locality to another that vegetation types are poorly differentiated by climate. Where average temperature falls between 0°C and 5°C, boreal forest predominates. Where average annual temperatures are below 5°C, all plant communities may be lumped into one type: tundra. Toward the drier end of the precipitation spectrum within each temperature range, fire plays a distinct role in shaping plant communities. The influence of fire is greatest where moisture availability is intermediate and highly seasonal. Deserts and moist forests burn infrequently because deserts rarely accumulate enough plant debris to fuel a fire and moist forests rarely dry out enough to become highly flammable.

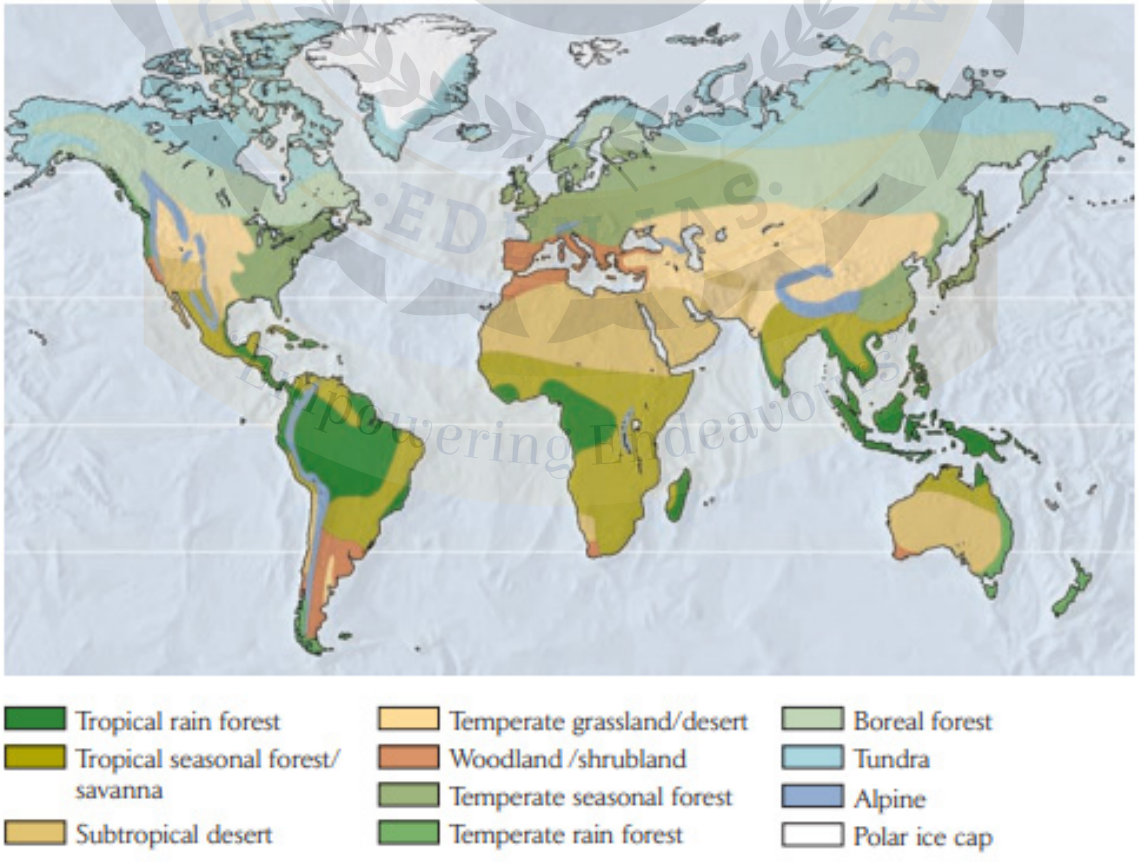
Grassland and shrubland have the combination of abundant fuel and seasonal drought that make fire a frequent visitor. In these biomes, fire is a dominating factor to which all community members must be adapted and, indeed, for which many are specialized. Some species require fire for germination of their seeds and growth of their seedlings. Toward the moister edges of African savannas and North American prairies, frequent fires kill the seedlings of trees and prevent the encroachment of forests, which could be sustained by the local precipitation if it were not for fire. Burning favors perennial grasses and forbs with extensive root systems and meristems (growth centers) that can survive underground. (Grasses tolerate grazing for the same reason.) After an area has burned, grass and forb roots sprout fresh shoots

and quickly establish new vegetation above the surface of the soil. In the absence of frequent fires, tree seedlings become established and eventually shade out savanna and prairie vegetation. As in all classification systems, exceptions appear, and boundaries between biomes are fuzzy. Moreover, not all plant growth forms correspond to climate in the same way; as mentioned earlier, Australian eucalyptus trees form forests under climatic conditions that support only scrubland or grassland on other continents. Finally, plant communities reflect factors other than temperature and rainfall. Topography, soils, fire, seasonal variations in climate, and herbivory all leave their mark. The overview of the major terrestrial biomes in this chapter emphasizes the distinguishing features of the physical environment and how these features are reflected in the form of the dominant plants.

GLOBAL DISTRIBUTION OF MAJOR BIOMES

Walter's climate zones are one of several systems of biome classification. While these systems differ in the number of biomes recognized, and some emphasize biological characteristics more than the physical environment, they all present essentially the same picture of ecosystem variation over the surface of the earth. For example, the World Wildlife Fund recognizes fourteen biomes, rather than Walter's nine, adding (i) temperate and (ii) tropical coniferous forests, both characterized by seasonal climates but tending to be drier and existing on poorer soils than biomes with broad-leaved trees; (iii) montane grasslands and shrublands, including the puna and páramo zones of the high Andes; (iv) seasonally flooded grasslands and savannas in both tropical and temperate regions, and (v) mangrove wetlands, which comprise a specialized vegetation type within the marine intertidal zone.

Its system is designed to identify the major ecological regions of the earth whose conservation would preserve the largest part of the diversity of the earth's ecosystems. The worldwide distribution of biome types arranged by any system follows the same general patterns of temperature and precipitation over the earth. We shall consider the biomes and general ecological characteristics of each of the major Walter climate zones in the series of vignettes that follow.



Global distribution of the major biomes

Temperate climate zones have average annual temperatures between 5°C and 20°C

The climates within temperate latitudes are characterized by average annual temperatures in the range of 5°–20°C at low elevations. Such climates are distributed approximately between 30°N and 45°N in North America and Asia and between 40°N and 60°N in Europe, which is warmed by the Gulf Stream and by westerly winds. Frost is an important factor throughout the temperate latitudes, perhaps even defining their general character. Within those latitudes, biomes are distinguished primarily by total amounts and seasonal patterns of precipitation. The length of the frost-free season, which is referred to as the growing season, and the severity of frost are also important.

Temperate seasonal forest biome (climate zone VI)

Often referred to as deciduous forest, the temperate seasonal forest biome occurs under moderate conditions with winter freezing. In North America, this biome is found principally in the eastern United States and southeastern Canada; it is also widely distributed in Europe and eastern Asia. This biome is poorly developed in the Southern Hemisphere because the larger ratio of ocean surface to land moderates winter temperatures and prevents frost. In the Northern Hemisphere, the length of the growing season in this biome varies from 130 days at higher latitudes to 180 days at lower latitudes. Precipitation usually exceeds evaporation and transpiration; consequently, water tends to move downward through soils and to drain from the landscape as groundwater and as surface streams and rivers. Soils are often podsolized, tend to be slightly acidic and moderately leached, and are brown in color owing to abundant organic matter.

Deciduous trees are the dominant plant growth form. The vegetation often includes a layer of smaller trees and shrubs beneath the dominant trees as well as herbaceous plants on the forest floor. Many of these herbaceous plants complete their growth and flower early in spring, before the trees have fully leafed out. Warmer and drier parts of the temperate seasonal forest biome, especially where soils are sandy and nutrient poor, tend to develop needle-leaved forests dominated by pines.

The most important of these ecosystems in North America are the pine forests of the coastal plains of the Atlantic and Gulf States of the United States; pine forests also exist at higher elevations in the western United States. Because of the warm climate in the southeastern United States, soils there are usually lateritic and nutrient poor. The low availability of nutrients and water favors evergreen, needle-leaved trees, which resist desiccation and give up nutrients slowly because they retain their needles for several years. Because soils tend to be dry, fires are frequent, and most species are able to resist fire damage.

Temperate rain forest biome (climate zone V)

In warm temperate climates near the Pacific coast in northwestern North America, and in southern Chile, New Zealand, and Tasmania, mild winters, heavy winter rains, and summer fog create conditions that support extremely tall evergreen forests. In North America, these forests are dominated toward the south by coast redwood (Sequoia sempervirens) and toward the north by Douglas-fir (Pseudotsuga spp.). These trees are typically 60–70 m tall and may grow to over 100 m. Ecologists do not understand why these sites are dominated by needle-leaved trees, but the fossil record shows that these plant communities are very old and that they are remnants of forests that were vastly more extensive during the Mesozoic era, as recently as 70 million years ago. In contrast to rain forests in the tropics, temperate rain forests typically support few species.

Temperate grassland/desert biome (climate zone VII)

In North America, grasslands develop within continental climate zones where rainfall ranges between 30 and 85 cm per year and winters are cold. The growing season increases from north to south from about 120 to 300 days. These grasslands are often called prairies. Extensive grasslands are also found in central Asia, where they are called steppes. Precipitation is infrequent, so organic detritus does not decompose rapidly, and the soils are rich in organic matter. Because of their low acidity, prairie soils, which belong to the mollisol group, are not heavily leached and tend to be rich in nutrients.

The vegetation is dominated by grasses, which grow to heights over 2 m in the moister parts of these grasslands and to less than 0.2 m in more arid regions. Forbs are also abundant. Fire is a dominant influence in these grasslands, particularly where the habitat dries out during the late summer. Most grassland species have fire-resistant underground stems, or rhizomes, from which shoots resprout, or they have fire-resistant seeds.

Where precipitation ranges between 25 and 50 cm per year, and winters are cold and summers are hot, grasslands grade into deserts. The temperate desert biome covers most of the Great Basin of the western United States. In the northern part of the region, sagebrush (Artemisia) is the dominant plant, whereas toward the south and on somewhat moister soils, widely spaced juniper and piñon trees predominate, forming open woodlands less than 10 m in stature with sparse coverings of grass. In these temperate deserts, evaporation and transpiration exceed precipitation during most of the year, so soils are dry and little water percolates through them to form streams and rivers. Calcium carbonate leached from the surface layers of the soil tends to accumulate at the depths to which water usually penetrates. Fires are infrequent in temperate deserts because the habitat produces little fuel. However, because of the low productivity of the plant community, grazing can exert strong pressure on the vegetation and may even favor the persistence of shrubs, which are not good forage. Indeed, many dry grass lands in the world have been converted into deserts by overgrazing.

Woodland/shrubland biome (climate zone IV)

The Mediterranean climate zone is found at 30°–40° north and south of the equator—and at somewhat higher latitudes in Europe—on the western sides of continental landmasses, where cold ocean currents and winds blowing from the continents dominate the climate. Mediterranean climates are found in southern Europe and southern California in the Northern Hemisphere and in central Chile, the Cape region of South Africa, and southwestern Australia in the Southern Hemisphere. Mediterranean climates are characterized by mild winter temperatures, winter rain, and summer drought. These climates support thick, evergreen, shrubby vegetation 1–3 m in height, with deep roots and drought-resistant foliage. The small, durable leaves of typical Mediterranean-climate plants have earned them the label of **sclerophyllous** ("hard-leaved") vegetation. Fires are frequent in the woodland/shrubland biome, and most plants have either fire-resistant seeds or root crowns that resprout soon after a fire.

Subtropical desert biome (climate zone III)

What people call "desert" varies tremendously. Many people refer to the dry areas of the Great Basin and of central Asia as deserts—the Gobi Desert is a name familiar to most of us. But the climates of those "deserts" fall within Walter's continental climate zone, characterized by low precipitation and cold winters. These areas are referred to as cold deserts. In contrast, subtropical deserts, often called hot deserts, develop at latitudes 20°–30° north and south of the equator, in areas with high atmospheric pressure associated with the descending air of the Hadley cells. Subtropical deserts have very sparse rainfall (less than 25 cm), high temperatures, and generally long growing seasons. Because of the low rainfall, the soils of subtropical deserts (aridosols) are shallow, virtually devoid of organic matter, and neutral in pH. Impermeable hardpans of calcium carbonate often develop at the limits of water penetration—at depths of a meter or less. Whereas sagebrush dominates the cold deserts of the Great Basin, creosote bush (Larrea tridentata) takes its place in the subtropical deserts of the Americas. Moister sites within this biome support a profusion of succulent cacti, shrubs, and small trees, such as mesquite (Prosopis) and paloverde (Cercidium microphyllum). Most subtropical deserts receive summer rainfall. After summer rains, many herbaceous plants sprout from dormant seeds, grow quickly, and reproduce before the soils dry out again. Many of the plants in subtropical deserts are not frost-tolerant. Species diversity is usually much higher than it is in temperate arid lands.

Boreal and polar climate zones have average temperatures below 5°C

At high latitudes, cold temperatures predominate. Precipitation is often very sparse because water evaporates slowly into the atmosphere at low temperatures, but soils are often saturated, and water availability is not an important limitation in high-latitude climate zones. Biological productivity during the short summer growing seasons is generally low, and cold temperatures slow the decomposition of organic matter and the release of nutrients in the soil. As a result, plants retain their foliage for many years, and the vegetation tends to be evergreen and highly adapted to cold winter temperatures.

Boreal forest biome (climate zone VIII)

Stretching in a broad belt centered at about 50°N in North America and about 60°N in Europe and Asia lies the boreal forest biome, often called taiga. The average annual temperature is below 5°C, and winters are severe. Annual precipitation generally ranges between 40 and 100 cm, and because evaporation is low, soils are moist throughout most of the growing season. The vegetation consists of dense, seemingly endless stands of 10–20 m tall evergreen needle-leaved trees, mostly spruces and firs. Because of the low temperatures, plant litter decomposes very slowly and accumulates at the soil surface, forming one of the largest reservoirs of organic carbon on earth. The needle litter produces high levels of organic acids, so the soils are acidic, strongly podsolized, and generally of low fertility. Growing seasons are rarely as much as 100 days and often half that. The vegetation is extremely frost-tolerant, as temperatures may reach –60°C during the winter. Species diversity is very low.

Tundra biome (climate zone IX)

To the north of the boreal forest, in the polar climate zone, lies the Arctic tundra, a treeless expanse underlain by permanently frozen soil, or permafrost. The soils thaw to a depth of 0.5–1 m during the brief summer growing season. Precipitation is generally less, and often much less, than 60 cm, but in low-lying areas where drainage is prevented by permafrost, soils may remain saturated with water throughout most of the growing season.

Soils tend to be acidic because of their high organic matter content, and they contain few nutrients. In this nutrient poor environment, plants hold their foliage for years. Most plants are dwarf, prostrate woody shrubs, which grow low to the ground to gain protection under the winter blanket of snow and ice.

Anything protruding above the surface of the snow is sheared off by blowing ice crystals. For most of the year, the tundra is an exceedingly harsh environment, but during the 24-hour-long summer days, the rush of biological activity in the tundra testifies to the remarkable adaptability of life. At high elevations within temperate latitudes, and even within the tropics, one finds vegetation resembling that of the Arctic tundra and even including some of the same species, or their close relatives. These areas of alpine tundra above the tree line occur most broadly in the Rocky Mountains of North America, the Alps of Europe, and especially on the Plateau of Tibet in central Asia.

In spite of their similarities, alpine and Arctic tundra have important points of dissimilarity as well. Areas of alpine tundra generally have warmer and longer growing seasons, higher precipitation, less severe winters, greater productivity, better-drained soils, and higher species diversity than Arctic tundra. Still, harsh winter conditions ultimately limit the growth of trees.

Climate zones within tropical latitudes have average temperatures exceeding 20°C

Within 20° of latitude from the equator, the temperature varies more throughout the day than average monthly temperatures vary throughout the year. Average temperatures at sea level generally exceed 20°C. Climates within tropical latitudes are distinguished by differences in the seasonal pattern of rainfall. These differences create a continuous gradient of vegetation from wet, aseasonal rain forest through seasonal forest, scrub, savanna, and desert. Frost is not a factor in tropical biomes, even at high elevations, and tropical plants and animals generally cannot tolerate freezing.

Tropical rain forest biome (climate zone I)

Climates where tropical rain forests develop (in Walter's equatorial climate zone) are always warm and receive at least 200 cm of precipitation throughout the year, with no less than 10 cm during any single month. These conditions prevail in three important regions within the tropics. First, the Amazon and Orinoco basins of South America, along with additional areas in Central America and along the Atlantic coast of Brazil, constitute the Neotropical rain forest. Second, the area from southernmost West Africa and extending eastward through the Congo River basin makes up the African rain forest (with an added area on the eastern side of the island of Madagascar). Third, the Indo-Malayan rain forest covers parts of Southeast Asia (Vietnam, Thailand, and the Malay Peninsula); the islands between Asia and Australia, including the Philippines, Borneo, and New Guinea; and the Queensland coast of Australia. The tropical rain forest climate often exhibits two peaks of rainfall centered on the equinoxes, corresponding to the periods when the intertropical convergence lies over the equator.

Rain forest soils are typically old and deeply weathered oxisols. Because they are relatively devoid of humus and clay, they take on the reddish color of aluminum and iron oxides and retain nutrients poorly. In spite of the low nutrient status of the soils, rain forest vegetation is dominated by a continuous canopy of tall evergreen trees rising to 30–40 m. Occasional emergent trees rise above the canopy to heights of 55 m or so. Because water stress on emergent trees is great due to their height and exposure, they are often deciduous, even in a mostly evergreen rain forest. Tropical rain forests typically have several understory layers beneath the canopy, containing smaller trees, shrubs, and herbs, but these are usually quite sparse because so little light penetrates the canopy. Climbing lianas, or woody vines, and epiphytes, plants that grow on the branches of other plants and are not rooted in soil (also called air plants), are prominent in the forest canopy itself. Species diversity is higher than anywhere else on earth.

Per unit of area, the biological productivity of tropical rain forests exceeds that of any other terrestrial biome, and their standing biomass exceeds that of all other biomes except temperate rain forests. Because of the continuously high temperatures and abundant moisture, plant litter decomposes quickly, and the vegetation immediately takes up the released nutrients. This rapid nutrient cycling supports the high productivity of the rain forest, but it also makes the rain forest ecosystem extremely vulnerable to disturbance. When tropical rain forests are cut and burned, many of the nutrients are carted off in logs or go up in smoke. The vulnerable soils erode rapidly and fill the streams with silt. In many cases, the environment degrades rapidly and the landscape becomes unproductive.

Tropical seasonal forest/savanna biome (climate zone II)

Within the tropics, but beyond 10° from the equator (in Walter's tropical climate zone), there is typically a pronounced dry season, corresponding to winter at higher latitudes. Seasonal forests in this climate zone have a preponderance of deciduous trees that shed their leaves during the season of water stress. Where the dry season is longer and more severe, the vegetation becomes shorter, and thorns develop to protect leaves from grazing. With progressive aridity, the vegetation grades from dry forest into thorn forest and finally into true desert in the rain shadows of mountain ranges or along coasts with cold ocean currents running alongside. As in more humid tropical environments, the soils tend to be strongly lateritic and nutrient poor. Savannas are grasslands with scattered trees. They are spread over large areas of the dry tropics, especially at moderate elevations in East Africa. Rainfall is typically 90–150 cm per year, but the driest three or four months bring less than 5 cm each. Fire and grazing undoubtedly play important roles in maintaining the character of the savanna biome, particularly in wetter regions, as grasses can persist better than other forms of vegetation under both influences. When grazing and fire are controlled within a savanna habitat, dry forest often begins to develop. Vast areas of African savanna owe their character to the influence of human activities, including burning, over many millennia.

AQUATIC ECOSYSTEMS AND THE CONCEPT OF BIOME

The biome concept must be modified for freshwater aquatic systems Terrestrial and aquatic ecologists have generated concepts and descriptive terms for ecological systems independently. The biome concept was developed for terrestrial ecosystems, where the growth form of the dominant vegetation reflects climatic conditions. In aquatic systems, however, depth, water temperature, flow rate, and oxygen and nutrient concentrations are the dominant physical factors, and the structural attributes of aquatic organisms do not differ much in relation to these factors. As a consequence, aquatic "biomes" do not exist in the sense in which the term is applied to terrestrial ecosystems. Indeed, defining aquatic biomes according to vegetation would be impossible, because the producers in many aquatic systems are single-celled algae, which do not form "vegetation" with a characteristic structure. As a result, aquatic systems have been classified primarily by such physical characteristics as salinity, water movement, and depth. The major kinds of aquatic environments are streams and rivers, lakes, wetlands, estuaries, and oceans, and each of these can be subdivided further with respect to many factors.

Flowing water: Streams and rivers

Streams form wherever precipitation exceeds evaporation and excess water drains from the land. Streams grow with distance as they join together to form rivers. Stream and river systems are often referred to as **lotic** systems, a term generally applied to flowing fresh waters. The continuous change in environments and ecosystems from the small streams at the headwaters of a river system to the mouth of the river is the basis for the river continuum concept. As one moves downstream, water flows more slowly and becomes warmer and richer in nutrients; ecosystems become more complex and generally more productive. Within small streams, ecologists distinguish areas of riffles, where water runs rapidly over a rocky substratum, and pools, which are deeper stretches of more slowly moving water. Water is well oxygenated in riffles, whereas pools tend to accumulate silt and organic matter.

Both areas tend to be unproductive because the nutrients needed for life are washed away in riffles, whereas the oxygen and sunlight needed for life are lacking in pools. In general, streams lack the richness and diversity of life seen in other aquatic systems. Toward the headwaters of rivers, where small streams are often shaded and nutrient poor, the productivity of algae and other photosynthetic organisms tends to be low. Streams are usually bordered by a riparian zone of terrestrial vegetation that is influenced by seasonal flooding and elevated water tables. Much of the food web of headwater ecosystems depends on leaves and other organic matter that falls or washes into streams from this surrounding vegetation. Such organic material that enters the aquatic system from the outside is termed **allochthonous**. The larger a river, the more of its organic material is homegrown, or autochthonous. As one moves down the **river continuum**, rivers become wider, slower moving, more heavily nutrient laden, and more exposed to direct sunlight.

The nutrients and sunlight support the growth of algae and plants within the river itself. However, rivers also become more heavily laden with sediments washed into them from the land and carried downstream. The high turbidity caused by suspended sediments in the lower reaches of silt-laden rivers can block light and reduce production. Fluvial systems, as rivers are sometimes called, are also distinguished by the fact that currents continuously move material, including animals, plants, and nutrients, downstream.

To maintain a fluvial system in a steady state, this downstream drift must be balanced by the upstream movement of animals, production in the upstream portions of the system, and input of allochthonous materials. All aquatic ecosystems interact with the terrestrial biomes that surround them. We have seen that streams receive runoff, groundwater, and organic matter from the surrounding land. A variety of organisms live their lives in both aquatic and terrestrial environments. Many frogs and salamanders, for example, have aquatic larval stages and terrestrial adult stages. Some terrestrial animals feed on organisms that grow in streams and lakes, effectively moving nutrients from aquatic to nearby terrestrial systems.

Conversely, many organisms with aquatic larval stages, such as mosquitoes, feed on terrestrial organisms. Thus, while aquatic and terrestrial biomes have recognizable borders, organisms readily cross these borders and the borders themselves move, extending onto and retreating from floodplains as rivers rise and fall. Lotic systems are extremely sensitive to any modification of their water flow. Several dams of all sizes interrupt stream flow in the India alone. These dams are built for flood control, to provide water for irrigation, or to generate electricity.

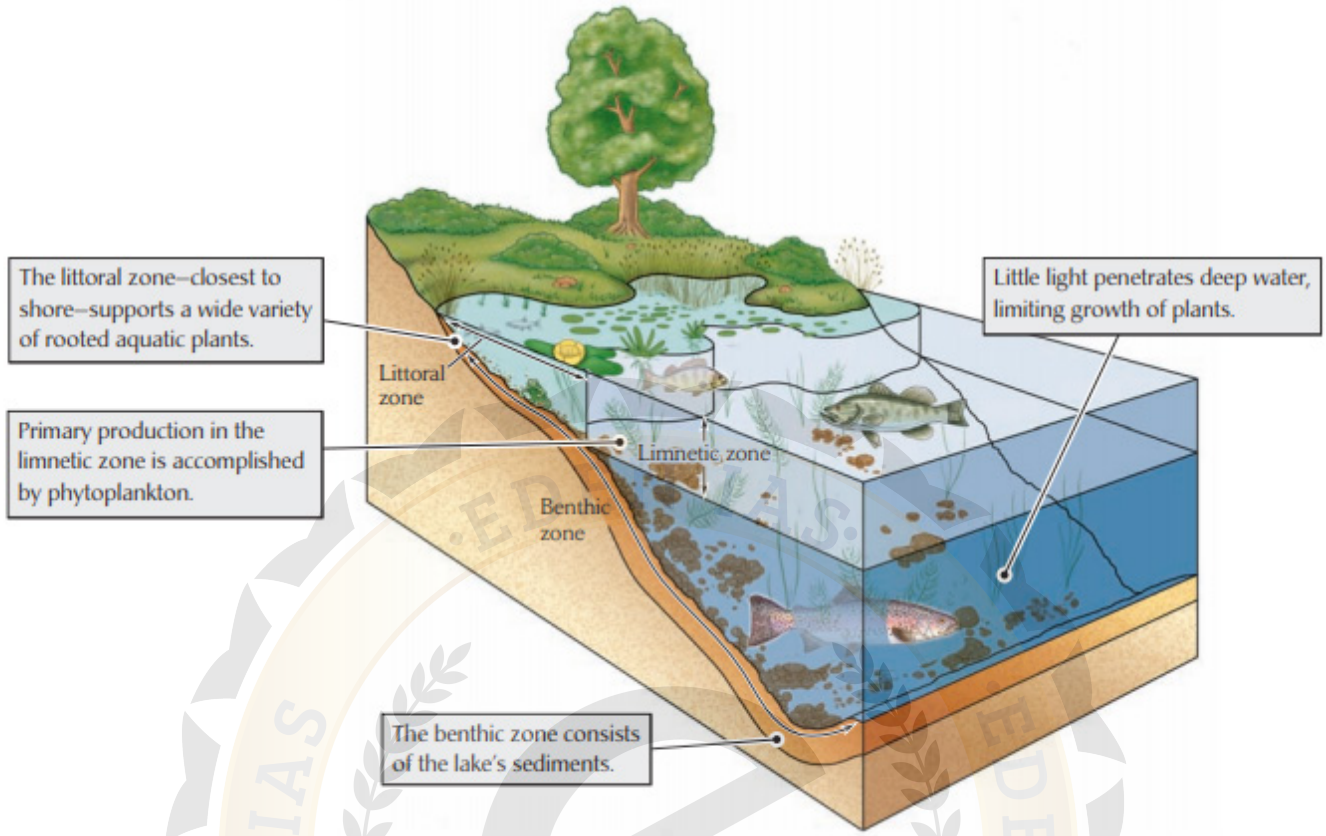
Dams alter rates of flow, water temperature, and sedimentation patterns. Typically, water behind dams becomes warmer, and bottom habitats become choked with silt, destroying habitat for fish and other aquatic organisms. Large dams used for hydroelectric power often release water downstream that has low concentrations of dissolved oxygen. Using dams for flood control changes the seasonal cycles of flooding necessary for maintaining many kinds of riparian habitats on floodplains. Dams also disrupt the natural movement of aquatic organisms upstream and downstream, fragmenting river systems and isolating populations. Thus, lotic systems are among the most vulnerable of all biomes to habitat modification.

Standing water: Lakes and ponds

Lakes and **ponds,** referred to as **lentic systems**, are distinguished by non-flowing water. Lakes and ponds can form in any kind of depression. They range in size from small, temporary rainwater pools a few centimeters deep to Lake Baikal, in Russia, which has a maximum depth of 1,740 m (about a mile) and contains about one-fifth of all the fresh water at the surface of the earth. Many lakes and ponds are formed by the retreat of glaciers, which leave behind gouged-out basins and blocks of ice buried in glacial deposits, which eventually melt. The Great Lakes of North America formed in glacial basins, overlain until 10,000 years ago by thick ice. Lakes are also formed in geologically active regions, such as the Great Rift Valley of Africa, where vertical shifting of blocks of the earth's crust creates basins within which water accumulates. Broad river valleys, such as those of the Mississippi and Amazon rivers, have oxbow lakes, which are broad bends of the former river cut off by shifts in the main channel.

An entire lake could be considered a biome, but it is usually subdivided into several ecological zones, each of which has distinct physical conditions. The **littoral zone** is the shallow zone around the edge of a lake or pond within which one finds rooted vegetation, such as water lilies and pickerelweed. The open water beyond the littoral zone is **the limnetic (or pelagic) zone**, where the producers are floating single-celled algae, or phytoplankton. **Lakes may also be subdivided vertically on the basis of light penetration and the formation of thermally stratified layers of water** (the **epilimnion** toward the surface and the **hypolimnion** at depth). The sediments at the bottoms of lakes and ponds constitute the **benthic zone**, which provides habitat for burrowing animals and microorganisms.

Lakes and ponds are not permanent. Small temporary ponds can dry out each year, often multiple times during a season. Most small temperate lakes that formed when glaciers retreated will gradually fill in with sediment until there is no open water. The formerly aquatic ecosystem will gradually change into a terrestrial ecosystem, first a wet meadow and later the natural terrestrial biome of the region.



Wetlands

Aquatic and terrestrial communities often come together in wetlands, which are areas of land consisting of soil that is saturated with water and supports vegetation specifically adapted to such conditions. Wetlands include swamps, marshes, and bogs when they derive from freshwater, and salt marshes and mangrove wetlands when they are associated with marine environments. Wetlands range in size from vernal pools formed in the aftermath of spring rains to vast areas of river deltas, such as the Okavango Swamp of Botswana, the Everglades of southern Florida, and the Pantanal of Brazil, Bolivia, and Paraguay—at 195,000 km2, the world's largest wetland. Most of the plants that grow in wetlands can tolerate low oxygen concentrations in the soil; indeed, many are specialized for these anoxic conditions and grow nowhere else. Wetlands also provide important habitat for a wide variety of animals, notably waterfowl and the larval stages of many species of fish and invertebrates characteristic of open waters. Wetlands protect coastal areas from the ravages of hurricanes and other storms. Wetland sediments immobilize potentially toxic or polluting substances dissolved in water and are thus natural water purifying plants. Unfortunately, wetlands also occupy space, and they have been cut, drained, and filled to obtain wood products, to develop new agricultural lands, and for ever-increasing urban and suburban sprawl.

Estuaries

Estuaries are found at the mouths of rivers, especially where the outflow is partially enclosed by landforms or barrier islands. Estuaries are unique because of their mix of fresh and salt water. In addition, they are abundantly supplied with nutrients and sediments carried downstream by rivers. The rapid exchange of nutrients between the sediments and the surface in the shallow waters of the estuary supports extremely high biological productivity. Because estuaries tend to be areas of sediment deposition, they are often edged by extensive tidal marshes at temperate latitudes and by mangrove wetlands in the tropics. Tidal marshes are among the most productive habitats on earth, owing to a combination of high nutrient levels and freedom from water stress. They contribute organic matter to estuarine ecosystems, which in turn support abundant populations of oysters, crabs, fish, and the animals that feed on them

HUMAN INPUTS INTO FRESH-WATER BIOMES

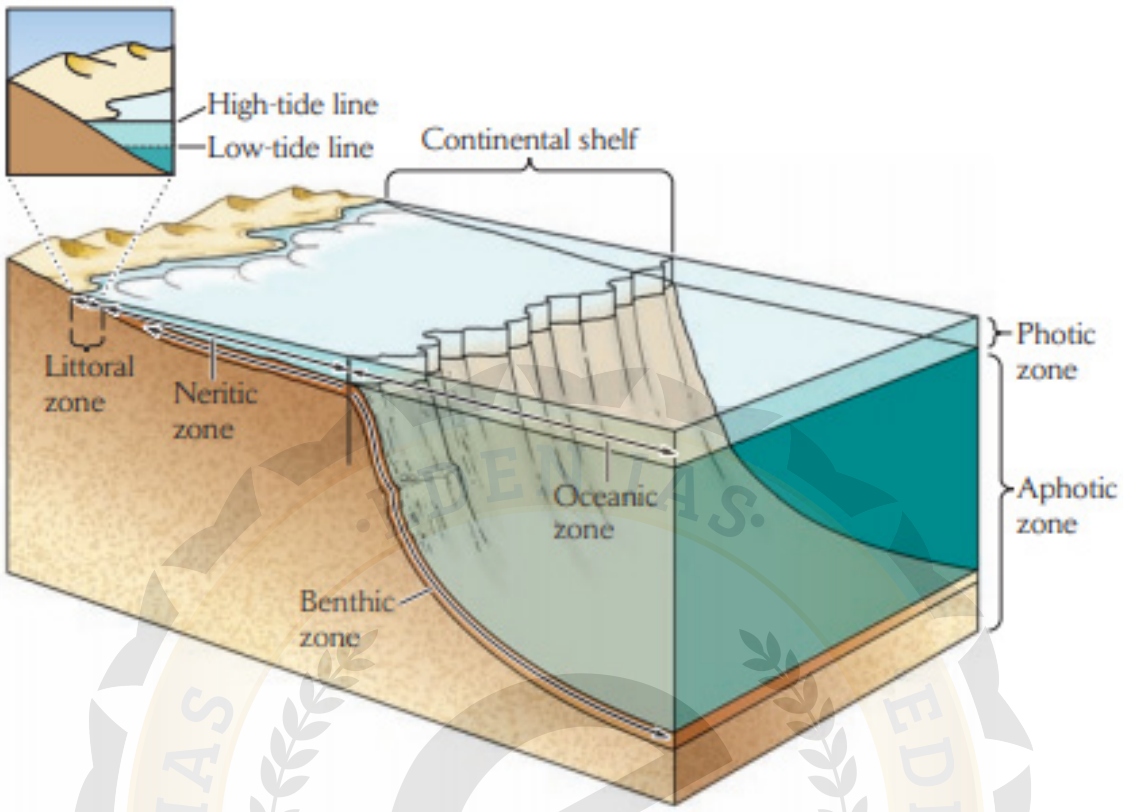
Freshwater biomes of all kinds are subject to a variety of inputs produced by human activities that can dramatically change their quality and ecological functioning. The most important of these are acid rain and eutrophication, which we shall discuss in more detail in later chapters. These inputs and their effects further demonstrate the intimate connections between terrestrial and aquatic biomes. Acid rain forms when various gases produced by the combustion of fossil fuels, particularly sulfur dioxide and nitrogen oxides dissolve in atmospheric moisture to form sulfuric and nitric acids. This acidified precipitation enters lakes and streams, where it can reduce the pH to as low as 4, well beyond the tolerance limits of many organisms. Acidified waters lose plant life and algae, and the low pH disrupts the normal reproduction of fish and other aquatic animals. In the most extreme case, the entire ecosystem can collapse.

Eutrophication is the addition of limiting nutrients, such as phosphorus, to aquatic ecosystems. These nutrients may come from runoff carrying sewage, industrial wastes, or fertilizers or animal wastes from agricultural lands. A sudden abundance of nutrients may not only increase production dramatically, but may also disrupt normal ecosystem functioning by favoring certain organisms over others. The abundant organic material stimulates the growth of exploding populations of decomposing bacteria, but the process of decomposition depletes waters of oxygen that other organisms need.

MARINE AQUATIC SYSTEMS: CLASSIFIED BY WATER DEPTH

Oceans cover the largest portion of the surface of the earth. Beneath the surface of the ocean lies an immensely complex realm harboring a great variety of physical conditions and ecological systems. Variation in marine environments comes from differences in temperature, salinity, depth (which influences light and pressure), currents, substrata, and at the edge of the oceans, tides. Many marine ecologists categorize marine ecological zones according to depth. The **littoral zone** (also called the intertidal zone) extends between the highest and lowest tidal water levels, and thus is exposed periodically to air. Ecological conditions within the littoral zone change rapidly as the tide flows in or out. A frequent consequence is the **sharp zonation** of organisms according to their ability to tolerate the stresses of terrestrial conditions, to which they are exposed to a varying extent depending on their position within the intertidal range. Beyond the range of the lowest tidal level, the **neritic zone** extends to depths of about 200 m, which correspond to the edge of the continental shelf. The neritic zone is generally a region of high productivity because the sunlit surface layers of water are close enough to the nutrients in the sediments below that strong waves can move them to the surface. Beyond the neritic zone, the seafloor drops rapidly to the great depths of the **oceanic zone**. Here, nutrients are sparse, and production is strictly limited. The seafloor beneath the oceanic zone constitutes the **benthic zone**. Both the neritic and the oceanic zones may be subdivided vertically into a superficial **photic zone**, in which there is sufficient light for photosynthesis, and an **aphotic zone** without light. Organisms in the aphotic zone depend mostly on organic material raining down from above.

Other systems of marine biome classification divide the oceans into biomes in different ways. One example is provided by the World Wildlife Fund's global list of 200 habitat types that are priorities for conservation. The World Wildlife Fund has singled out the following marine biomes as among the most productive and diverse on earth: polar, temperate shelves and seas, temperate upwelling, tropical upwelling, and tropical coral reefs. These biomes have traditionally provided most of the marine resources exploited by humans. Polar Regions, which contain large areas of shallow seas, and continental shelves at temperate latitudes, are highly productive because nutrients in seafloor sediments are not far below the surface waters, as indicated above. Upwelling zones are also highly productive because upwelling currents carry nutrients from the ocean depths to the sunlit surface waters.



Whereas the open ocean has been compared to a desert because of its low productivity, coral reefs are like tropical rain forests, both in the richness of their biological production and the diversity of their inhabitants. Reef-building corals are found in shallow waters of warm oceans, usually where water temperatures remain above 20°C year-round. Coral reefs often surround volcanic islands, where they are fed by nutrients eroding from the rich volcanic soil and by deep-water currents forced upward by the profile of the island. Corals are doubly productive because photosynthetic algae within their tissues generate the carbohydrate energy that fuels the corals' phenomenal rates of growth.

Moreover, the complexity of the structure built by the corals over time provides a wide variety of substrata and hiding places for algae and animals, making coral reefs among the most diverse biomes on earth. Unfortunately, rising sea surface temperatures in the tropics are killing the algal symbionts of corals over large areas—a phenomenon known as coral bleaching. The stability of these biomes is now at risk. Other marine biomes have physical conditions that foster unique forms of life and distinctive ecosystem properties. For example, the kelp forests that develop in shallow, fertile waters along continental coasts provide habitat for a rich variety of marine life.

Large areas of shallow polar seas are covered with pack ice that seals the air–water interface and increases the salinity of water as salts are excluded from ice. The result is a dim, salty environment without any wave disturbance. Hydrothermal vents are deep-sea environments dominated by the input of hot water laden with hydrogen sulfide, which provides the reducing power used by chemosynthetic bacteria to fuel high productivity in the otherwise sterile abyssal environment. The physical qualities that characterize each terrestrial and aquatic biome constitute the environments to which their inhabitants are adapted in form and function.

The close association between organisms and their environments over evolutionary time is the basis for ecological specialization and the resulting limits of the distributions of organisms and populations. Adaptations, however, reflect not only these physical factors in the environment, but also the many interactions of organisms with individuals of their own and other species.

UNIT-VI

[ENVIRONMENTAL DEGRADATION]

CAUSES OF ENVIRONMENTAL DEGRADATION

Environmental degradation is an umbrella concept which covers a variety of issues including pollution, biodiversity loss & animal extinction, deforestation & desertification, global warming, and a lot more. Environmental degradation is the deterioration of the environment through depletion of resources such as air, water and soil; the destruction of ecosystems and the extinction of wildlife. It is defined as any change or disturbance to the environment perceived to be deleterious or undesirable. **Environmental degradation is one of the ten threats officially cautioned by the High-level Panel on Threats, Challenges and Change of the United Nations.**

> **The United Nations International Strategy for Disaster Reduction defines environmental degradation as "The reduction of the capacity of the environment to meet social and ecological objectives, and needs".**

Environmental degradation is of many types. When natural habitats are destroyed or natural resources are depleted, the environment is degraded. Efforts to counteract this problem include environmental protection and environmental resources management. Environmental changes are based on many factors including:

- **Urbanization**
- **Population growth**
- **Economic growth**
- **Intensification of agriculture**
- **Increase in energy use**
- **Increase in transportation**

Environmental degradation is a process through which the natural environment is compromised in some way, reducing biological diversity and the general health of the environment. The primary cause of environmental degradation is human disturbance. The degree of the environmental impact varies with the cause, the habitat, and the plants and animals that inhabit it. There are a number of ways in which environmental degradation works. Classically, resources simply become depleted. Air, water, and soil are all resources which are vulnerable to depletion through overuse, as are natural resources like minerals and oil deposits. Habitat pressures which force animals into a small area can also contribute to resource depletion, as the animals consume a high volume of material in a small area. Pollution is another cause of environmental degradation. When the environment becomes polluted, it means that toxic substances have rendered it unhealthy. Pollution can come from a variety of sources, including vehicle emissions, agricultural runoff, accidental chemical release from factories, and poorly-managed harvesting of natural resources.

Many international organizations recognize environmental degradation as one of the major threats facing the planet, since humans have only been given one Earth to work with, and if the environment becomes irreparably compromised, it could mean the end of human existence. One of the major threat the planet faces today, environmental degradation, is bound to make life difficult for all the life forms, including

human beings, now or later. Studies by some of the eminent organizations reveal that the deterioration of environment is occurring at an alarming rate. In fact, the High Level Threat Panel of the United Nations has enlisted environmental degradation as one of the ten threats for us. This issue shares space with problems like poverty, terrorism and civil war in the list, and this itself highlights the fact that we are heading for a certain disaster. It is defined as a process wherein the natural environment of the planet is degenerated to such an extent, that the biodiversity and the general health of the planet is subjected to drastic reduction. In other words, this phenomenon can be defined as deterioration of the Earth's natural surroundings as a result of excessive exploitation of the available resources. These resources include water, air, flora, fauna, soil etc. Basically, the life on the planet is interwoven to such an extent that a decrease in a particular attribute triggers a domino effect on all the other attributes dependent on it. It is the destruction of ecosystems and the extinction of wildlife. It is defined as any change or disturbance to the environment perceived to be deleterious or undesirable.

Population

Population is an important source of development, yet it is a major source of environmental degradation when it exceeds the threshold limits of the support systems. Unless the relationship between the multiplying population and the life support system can be stabilized, development programmes, howsoever, innovative are not likely to yield desired results.

Population impacts on the environment primarily through the use of natural resources and production of wastes and is associated with environmental stresses like loss of biodiversity, air and water pollution and increased pressure on arable land.

India supports 17 per cent of the world population on just 2.4 per cent of world land area. Its current rate of population growth at 1.85 per cent continues to pose a persistent population challenge. In view of the linkages between population and environment, a vigorous drive for population control need hardly be over emphasized.

Poverty

Poverty is said to be both cause and effect of environmental degradation. The circular link between poverty and environment is an extremely complex phenomenon. Inequality may foster unsustainability because the poor, who rely on natural resources more than the rich, deplete natural resources faster as they have no real prospects of gaining access to other types of resources. Moreover, degraded environment can accelerate the process of impoverishment, again because the poor depend directly on natural assets. Although there has been a significant drop in the poverty ratio in the country, the absolute number of poor have, however, remained constant at around 320 million over the years. Acceleration in poverty alleviation is imperative to break this link between poverty and the environment.

Urbanization

Lack of opportunities for gainful employment in villages and the ecological stresses is leading to an ever increasing movement of poor families to towns. Mega cities are emerging and urban slums are expanding. There has been nearly a tenfold increase in urban population over 1901-2011. Such rapid and unplanned expansion of cities has resulted in degradation of urban environment. It has widened the gap between demand and supply of infrastructural services such as energy, housing, transport, communication, education, water supply and sewerage and recreational amenities, thus depleting the precious environmental resource base of the cities. The result is the growing trend in deterioration of air and water quality, generation of wastes, the proliferation of slums and undesirable land use changes, all of which contribute to urban poverty.

Economic Factors

To a large extent, environmental degradation is the result of market failure, that is, the non-existent or poorly functioning markets for environmental goods and services. In this context, environmental degradation is a particular case of consumption or production externalities reflected by divergence between private and social costs (or benefits). Lack of well defined property rights may be one of the reasons for such market failure. On the other hand, Market distortions created by price controls and subsidies may aggravate the achievement of environmental objectives.

The level and pattern of economic development also affect the nature of environmental problems. India's development objectives have consistently emphasized the promotion of policies and programmes for economic growth and social welfare.

The manufacturing technology adopted by most of the industries has placed a heavy load on environment especially through intensive resource and energy use, as is evident in natural resource depletion (fossil fuel, minerals, timber), water, air and land contamination, health hazards and degradation of natural eco-systems. With high proportion fossil fuel as the main source of industrial energy and major air polluting industries such as iron and steel, fertilizers and cement growing, industrial sources have contributed to a relatively high share in air pollution. Large quantities of industrial and hazardous wastes brought about by expansion of chemical based industry have compounded the wastes management problem with serious environmental health implications.

Transport activities have a wide variety of effects on the environment such as air pollution, noise from road traffic and oil spills from marine shipping. Transport infrastructure in India has expanded considerably in terms of network and services. Thus, road transport accounts for a major share of air pollution load in cities such as Delhi. Port and harbor projects mainly impact on sensitive coastal eco systems. Their construction affects hydrology, surface water quality, fisheries, coral reefs and mangroves to varying degrees.

Direct impacts of agricultural development on the environment arise from farming activities which contribute to soil erosion, land salination and loss of nutrients. The spread of green revolution has been accompanied by over exploitation of land and water resources, and use of fertilizers and pesticides have increased many fold. Shifting cultivation has also been an important cause of land degradation. Leaching from extensive use of pesticides and fertilizers is an important source of contamination of water bodies. Intensive agriculture and irrigation contribute to land degradation particularly salination, alkalization and water logging.

Institutional Factors

The Ministry of Environment & Forests (MOEF) in the Government is responsible for protection, conservation and development of environment. The Ministry works in close collaboration with other Ministries, State Governments, Pollution Control Boards and a number of scientific and technical institutions, universities, non-Governmental organizations etc.

Environment (Protection) Act, 1986 is the key legislation governing environment management. Other important legislations in the area include the Forest (Conservation) Act, 1980 and the Wildlife (Protection) Act, 1972. The weakness of the existing system lies in the enforcement capabilities of environmental institutions, both at the centre and the state.

There is no effective coordination amongst various Ministries/Institutions regarding integration of environmental concerns at the inception/planning stage of the project. Current policies are also fragmented across several Government agencies with differing policy mandates. Lack of trained personnel and comprehensive database delay many projects.

Most of the State Government institutions are relatively small suffering from inadequacy of technical staff and resources. Although overall quality of Environmental Impact Assessment

(EIA) studies and the effective implementation of the EIA process have improved over the years; institutional strengthening measures such as training of key professionals and staffing with proper technical persons are needed to make the EIA procedure a more effective instrument for environment protection and sustainable development.

Habitat Fragmentation

Habitat fragmentation carries long term environmental impacts some of which can destroy entire ecosystems. An ecosystem is a distinct unit and includes all the living and non-living elements that reside within it. Plants and animals are obvious members, but it will also include other components on which they rely on such as streams, lakes, and soils.

Habitats become fragmented when development breaks up solid stretches of land. Examples include roads which may cut through forests or even trails which wind through prairies. While it may not sound all bad on the surface, there are serious consequences.

Some wildlife species require large stretches of land in order to meet all of their needs for food, habitat, and other resources. These animals are called area sensitive. When the environment is fragmented, the large patches of habitat no longer exist. It becomes more difficult for the wildlife to get the resources they to survive, possibly becoming threatened or endangered. The environment suffers without the animals that play their role in the food web.

A more critical result is land disturbance. Many weedy plant species such as garlic mustard and purple loosestrife are both opportunistic and invasive. A breach in the habitat gives them an opportunity to take hold. These aggressive plants can take over an environment, displacing the native flora. The result is habitat with a single dominant plant which doesn't provide adequate food resources for all the wildlife. Entire ecosystems are threatened with extinction.

Some weeds are so invasive and aggressive that they are declared noxious by the federal or state governments to prevent them from destroying unspoiled areas. The cultivation or even the sale of noxious weeds is prohibited by law.

Soil erosion and desertification:

The development of the fertile top-soil takes centuries. But, it can be removed very easily due to human activities like over-cultivation, unrestricted grazing, deforestation and poor irrigation practices, resulting in arid patches of land. When large barren patches extend and meet over time, a desert is created. Internationally, it has been recognized that desertification is a major problem nowadays, particularly due to increased urbanization.

Water logging and soil salinity:

Irrigation without proper drainage of water leads to water logging in the soil. Besides affecting the crops, water logging draws salt to the surface of the soil. The salt then is deposited as a thin crust on the land surface or starts collecting at the roots of the plants. This increased salt content is inimical to the growth of crops and is extremely damaging to agriculture.

Water logging and soil salinity are some of the problems that have come in the wake of the Green Revolution. Inappropriate land use can lead to soil degradation. Bad farming techniques are often responsible for land degradation. Leaving fields bare, or ploughing them up and down the sides of a hill can cause severe soil erosion when it rains heavily as the soil has nothing keeping it in place. When the left over parts of crops and animal manure are ploughed back into the soil they serve to replenish and fertilize it. However, if the crops are cut to be fed to animals and the manure is burnt as a fuel, the soil will have no way of replenishing itself, and decreases in fertility.

Sometimes landowners make changes in the way they use the land in an attempt to make the land more productive, but often these changes damage the land and actually make it less productive.

TYPES OF ENVIRONMENTAL DEGRADATION

Soil erosion - Soil erosion is the gradual wearing away of soil by either physical breakdown or chemical solution which is then transported away by means of water, wind or ice to another location.

Soil erosion is the leading cause of damage to our soils, leaving them barren and ultimately less productive. It can take centuries to create just a few centimeters of soil and only a few moments to destroy the same few centimeters. Today the rate of erosion has been speeded up by human activities. Consequently making soil erosion an ever-increasing problem. Soil erosion results from the ways that people use the land. Practices such as tree felling cause deforestation, and can lead to soil erosion. The removed trees would usually guard the soil from rain and wind as their roots hold the soil in place. Additionally many land owners cut down trees to create space in which to plant crops and raise animals which eventually can lead to soil erosion.

Soil salinisation- This is a type of environmental degradation that is particularly common in naturally dry areas that undergo irrigation and do not allow for any fallow periods for the land to recover. Irrigation schemes are set up to provide a constant flow of water to dry lands so that crops can be grown. However when irrigation systems are badly designed the results can be disastrous. The irrigation causes the water-table level to rise bringing natural salts to the surface. The salts cause problems as they restrict the root activity of the plant and therefore slow down its growth. In areas with high rates of evaporation the salts become even more concentrated.

The final result is that the soils are too salty for plants to be able to grow in them and the degraded land has to be abandoned. Soils which have been affected by salinisation are very difficult and expensive to rehabilitate and often remain unused and abandoned.

Desertification - Desertification occurs when productive lands are turned into non-productive desert as a result of poor land-management. This generally occurs in semi-arid areas such as Namibia.

Deforestation - This is the permanent destruction of indigenous forests and woodlands which results in a loss of natural resources as well as a protective barrier for topsoil.

Bush Encroachment - Bush encroachment happens where woody vegetation gets so thick that it threatens farming lands. Bush encroachment happens because woody vegetation and grasses have different growth rates leading the woody vegetation to take over and dominate a piece of land. Before the introduction of domestic livestock, the balance between grasses and woody vegetation would have been kept in check by fires and game. This would have resulted in an African savannah dominated by grass with only a few scattered trees.

With the introduction of livestock the balance was upset. Most of the game was eliminated and selective grazers were brought in. Fire outbreaks have also been eliminated as far as possible due to human intervention. This means that grasses are heavily eaten but the trees which are usually controlled by fires, continue to grow. The result is a shift in the balance in favor of trees and woody vegetation.

Since the growth of grass is limited the soil is largely left bare making it especially susceptible to soil erosion by wind and water. The deposits of nutrients are therefore increasingly found only under trees and bushes, making it difficult for grasses to grow. Eventually the grasses cease to compete for water and die out.

As a consequence the land supports less and less livestock per hectare as the woody vegetation increases. It becomes more difficult for the cattle to move in or amongst the bushes in search for pastures. The majority of valuable nutrients and water in the soil are then taken up by the encroaching bush and the grasses cannot access them.

Loss of biodiversity - Loss of biodiversity is a reduction in the variety of plant and animal species.

In areas where environmental degradation has occurred there is often a loss of biodiversity as a result of the disruption to the ecosystem. However the loss of biodiversity itself can be considered a form of environmental degradation. The range of genetic make-up (plant and animal varieties) in a particular area can be considered to be a natural resource and is important in maintaining a healthy environment.

The biodiversity of an area can decrease as a result of pollution, poaching, expanding agriculture and urbanization. Sometimes there is a direct reduction in the number of a particular species which itself if being threatened, but more often it is as a result of a disruption in the ecosystem and food chain, which causes a domino effect, affecting a greater number of organisms.

IMPACT OF ENVIRONMENTAL DEGRADATION

Water pollution and water scarcity:-As per the estimation of UN, more than two million deaths and billions of illnesses a year are attributable to water pollution. Water scarcity compounds these health problems. Productivity is affected by the costs of providing safe water, by constraints on economic activity caused by water shortages, and by the adverse effects of water pollution and shortages on other environmental resources such as, declining fisheries and aquifer depletion leading to irreversible compaction.

Air pollution: - As per the estimation of UN, urban air pollution is responsible for 300,000-700,000 deaths annually and creates chronic health problems for many more people. Restrictions on vehicles and industrial activity during critical periods affect productivity, as does the effect of acid rain on forests and water bodies.

Solid and hazardous wastes: - Diseases are spread by uncollected garbage and blocked drains; the health risks from hazardous wastes are typically more localized, but often acute. Wastes affect productivity through the pollution of groundwater resources.

Soil degradation: - Depleted soils increase the risks of malnutrition for farmers. Productivity losses on tropical soils are estimated to be in the range of 0.5-1.5 per cent of GNP, while secondary productivity losses are due to siltation of reservoirs, transportation channels and other hydrologic investments.

Deforestation: - Death and disease can result from the localized flooding caused by deforestation. Loss of sustainable logging potential and of erosion prevention, watershed stability and carbon sequestration provided by forests are among the productivity impacts of deforestation.

Loss of biodiversity: - The extinction of plant and animal species will potentially affect the development of new drugs; it will reduce ecosystem adaptability and lead to the loss of genetic resources.

Atmospheric changes: - Ozone depletion is responsible for perhaps 300,000 additional cases of skin cancer a year and 1.7 million cases of cataracts. Global warming may lead to increase in the risk of climatic natural disasters. Productivity impacts may include sea-rise damage to coastal investments, regional changes in agricultural productivity and disruption of the marine food chain.

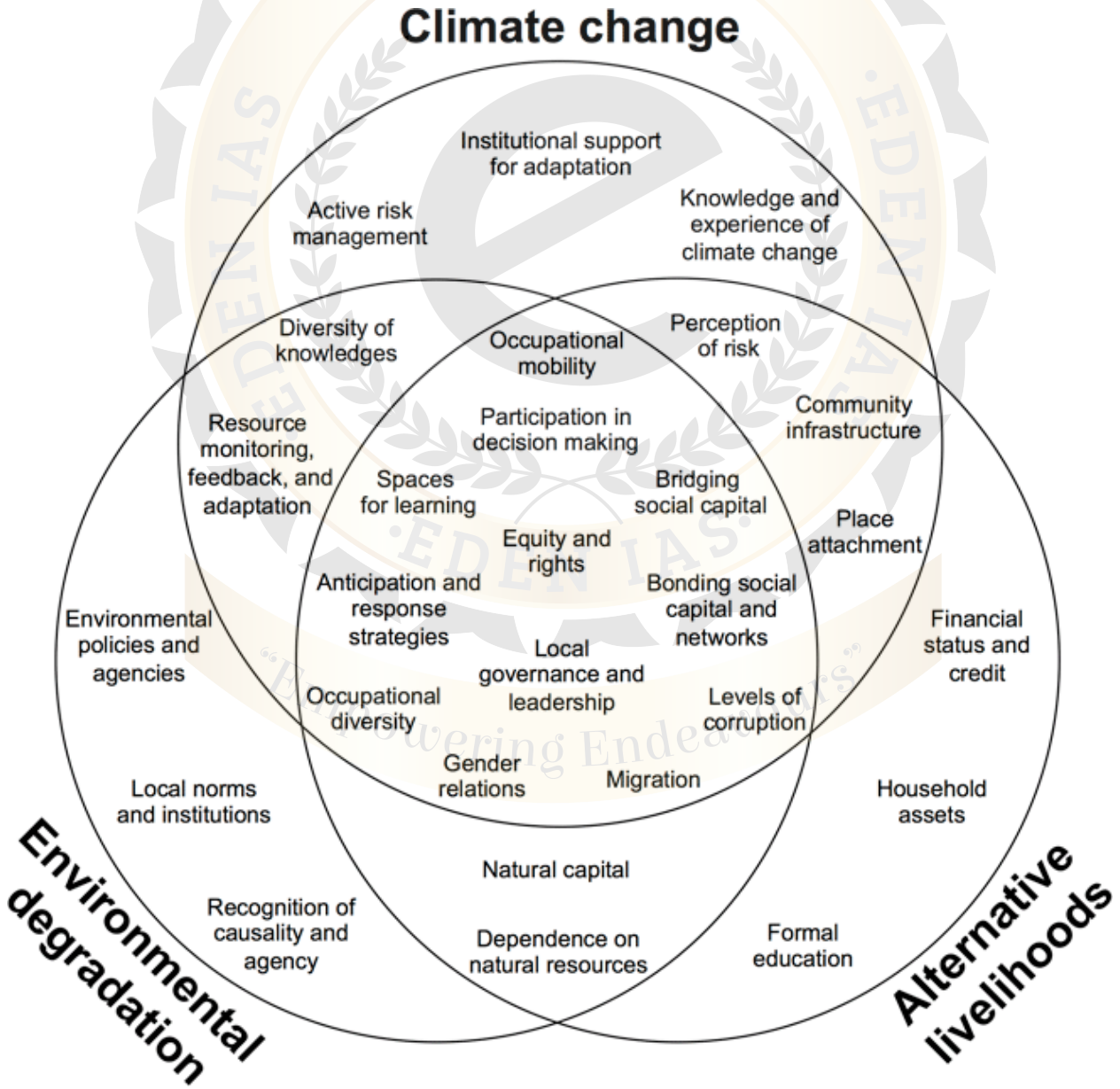
Poverty: - In many countries in Africa, crop harvests are falling as consumption increases. People are finding less nutritious food to eat. One argument held is that while fields in wealthier nations are used to grow crops for biofuel, poorer countries, especially those around the Equator, are vulnerable to weather changes, water shortages, and urbanization. All of these factors are increasing the health and lives of thousands. Some scientists and environmentalists are asking that non-food items and agriculture waste be used as alternative fuel for vehicles instead.

Aesthetic loss: - As humans dump waste products, use chemicals, and over fish in the oceans and seas, areas of beauty such as coral reefs are damaged. At times the destruction is so great that is cannot be reversed. We are killing our planet and the consequences are tremendous. One example of this lies within the coast lands of Thailand. Here marine and coastal resources at risk. Vast areas of mangrove wetlands have been lost. Coral reefs continue to suffer degradation, and the total fish available for catching is declining. Not only is the degradation causing marine and coastal resources to be lost, but this issue holds

large economic problems. When there are not enough fish to catch, fishermen are without income to support themselves and their families. In some coastal towns, the shores are eroding at a rate of one to five meters per year. This results in an annual loss of more than six billion baht ($150 million) in economic terms.

The impact of environmental disasters can be devastating on the social, economic, and environmental systems of a country or region as well as the global ecosystem. Environmental disasters do not recognize man-made borders, and threaten the legacy left to future generations of a clean and supportive environment. Because of the interdependency of earth ecosystems international co-operation is paramount to prevent, and when disaster strikes, respond to relieve quickly and effectively the effects of environmental disasters. Thus, Governments, International organizations and communities must work together – at all levels – to lessen the risks associated with environmental degradation and its contributing factors, such as climate change, and ensure that vulnerable people are prepared to survive and adapt. At the same time, companies, organizations and individuals must also ensure that their work is environmentally friendly and sustainable.

ENVIRONMENTAL DEGRADATION AND SOCIAL INTEGRATION



Contribution of components to community adaptive capacity to climate change, environmental degradation, and alternative livelihoods

Human societies everywhere are closely linked to their natural surroundings. Patterns of social integration influence natural resource utilization, and thus affect the condition of the physical environment, in a number of ways. The dynamics involved range from micro-level phenomena that collectively have a large impact on environmental conditions, to changing national and international social and economic structures.

Social changes affecting the performance of local level resource management systems include population growth, the spread of national and international markets, and changes in land tenure systems, particularly those that result in land concentration. These factors have undermined traditional mechanisms discouraging overexploitation of natural resources. In addition, inequitable social structures, including unequal control over resources on the basis of class or gender, have been implicated in environmental deterioration.

Environmental decline also impacts upon social structures. Social groups are affected differently: some may benefit from changes in price structures or in social relations that result from scarcities caused by environmental stress. More commonly, however, environmental decline adversely affects the health, well-being and livelihood opportunities of the individuals affected by pollution or natural resource depletion. Soil erosion, deforestation, the loss or depletion of animal and plant species limit the productive opportunities of vast numbers of people.

Individuals respond to environmental degradation in a variety of ways: they may adapt their customary production and consumption patterns to the new circumstances, search for alternative sources of income, migrate, or organize to undertake collective action to protect their livelihoods. Such individual responses, in the medium to long term, change social structures. When natural resource-dependent people intensify production, restrict or change consumption patterns, engage in new activities or migrate, they are changing their traditional societies, and participating in broader social transformations that will influence institutional change.

Policy responses to environmental degradation have taken three major forms: conservationism, "primary environmental care" and monetary cost-benefit approaches.

Each of these has proven effective in certain circumstances, but each also has its limitations. Conservation measures have often been able to halt or reverse environmental decline, especially in developed countries. In developing countries, however, the effectiveness of conservationism has been limited, while its human costs have not always been adequately recognized. "Primary environmental care" focuses on the needs of the individual resource user. This approach has been very effective in some areas, but requires an institutional capacity often lacking precisely where environmental degradation is most severe. The cost-benefit approach of mainstream environmental economics is also potentially useful, especially in industrialized countries. However, the reduction of environmental worth to monetary terms subsumes the livelihood concerns and the values of weaker social groups to those of stronger ones, and the environmental outcome is not necessarily positive.

The lesson derived from an examination of environmental degradation within the context of social integration is that it is essential to avoid fundamentalist policy approaches that isolate a single dimension of the social-environmental dynamic. The strengths and weaknesses of strategies to address environmental degradation- and the complementarities and contradictions between them- must be assessed in each context.

STEPS TO CHECK ENVIRONMENTAL DEGRADATION

At one point of time, the damage caused to the environment reaches a stage wherein the environment can't attain the required balance on its own. In such a situation, we humans need to step in, and ensure that the damage is curbed, and the balance is attained. Simple measures, such as conservation of electricity, use of alternative energy sources, avoiding the use of things that pollute the environment, soil

conservation etc., can help in saving the environment from the threat of degradation. Environmentalists, the world over, are trying their best to save our environment, and we need to do our bit to make sure that they succeed. The need of the hour is to identify the causes of environmental degradation, and eliminate them one by one.

We need to understand the fact that we are a part of the interwoven life system on the planet, and any problems, like environmental degradation and environmental pollution, are bound to affect us directly or indirectly. Though the disaster is not expected to happen tomorrow or a hundred years from now, that doesn't mean it will never happen at all. That being said, the onus is on us – the most intelligent species on the planet, to make sure that such problems are kept at bay.

There are ways which we can help to decrease degradation in our environment. Some of these include:

1) **Social Awareness**: - It is the need of the hour to spread social awareness about the dangers of pollution. It is also required how each individual can contribute to check this problem.

2) **Population Control**: - If environment is to be protected it is essential to check population growth.

3) **Strict Application of Environment Conservation Act**: - The Environment (Protection) Act was passed in 1986 in India. Its objective was to check deterioration in the quality of environment. This legislative measure should be strictly enforced.

4) **Control over Industrial and Agricultural Pollution**: - It is necessary for environmental protection that air and water pollution caused by industrial development should be controlled properly. To avoid agricultural pollution, use of pesticides and chemical fertilizers should be minimized.

5) **Afforestation Campaign**: - Extensive afforestation campaign should be launched in the interest of environment protection.

6) **Water Management**: - River waters should be made clean. Moreover, provision should be made to supply clean drinking water to the rural population.

7) **Management of Solid Waste**: - Planned management of solid waste is very essential. It is suggested that rural garbage be converted into compost.

8) **Dispose of Hazardous Waste**: - Make sure that hazardous waste is properly disposed of, not simply left around or placed with other garbage.

9) **Don't Dump Chemicals**: - Never pour toxic substances down the drain. Although water is cleaned, cities do not have the equipment to eliminate all toxic substances from the water supply.

10) **Other Steps**: - Purchase recycled products; Do not litter or throw waste into inappropriate places; Conserve water; Conserve energy; Join an awareness group; Talk with others about the impacts of environmental degradation.

The damage that we cause to the environment is currently not counted as a cost in economic and social terms. This lack of "environmental value" has allowed us to over-exploit "free" natural resources - which are, of course, not free.

It has also led to over-production of cheap goods with very short life spans which are liberally discarded into the environment after use, and then new cheap goods are purchased and discarded again, and this cycle goes on and on - affecting the planet's capacity to restore its environmental services in good time. We have to change this paradigm of our interaction with the environment. The nature doesn't owe us anything. It is not there for us to "control" and "manage" it either. We were born to live in harmony with it - indeed; we are a big part of it. And we certainly don't have the right to exploit and destroy it without thinking about the future generations of humans and animal who will be here after us.

ENVIRONMENT IMPACT ASSESSMENT (EIA)

Environmental Impact Assessment (EIA) is the formal process used to predict the environmental consequences (positive or negative) of a plan, policy, program, or project prior to the decision to move forward with the proposed action. Formal impact assessments may be governed by rules of administrative procedure regarding public participation and documentation of decision making, and may be subject to judicial review. An impact assessment may propose measures to adjust impacts to acceptable levels or to investigate new technological solutions.

U.K. Department of Environment defined EIA as **"The term environmental assessment describes the technique and process by which the information about the environmental effects of the project is collected both by the developer and other sources and taken into account by the planning authority informing their judgement whether the development should go ahead."**

The **International Association for Impact Assessment (IAIA)** defines an EIA as **"The process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made."**

EIAs commenced in the 1960s, as part of increasing environmental awareness. **The USA was the first country to enact legislation on EIA.** In the United States, EIAs obtained formal status in 1969, with enactment of the National Environmental Policy Act. This was the first time that EIA became the official tool to be used to protect the environment. The United Nations Conference on the Environment in Stockholm in 1972 and subsequent conventions formalized EIA (Ogola, 2007). EIAs have been used increasingly around the world. They have also been recognised in various international instruments.

Why is EIA conducted?

- To systematically examine both beneficial and adverse consequences of the proposal.
- To ensure that those consequences are taken into account during project design.
- To identify possible environmental effects of the proposal and means to mitigate them.
- To predict whether there will be significant adverse effects even after the mitigation.
- To lessen conflicts by promoting community participation and informing decision makers.

How is EIA done?

- **IDENTIFICATION** of the consequences of the proposal.
- **PREDICTION** of the extent of consequences.
- **EVALUATION** of the predicted consequences. (Significant or not)
- **MITIGATION** of the adverse consequences.
- **DOCUMENTATION** to inform decision makers what needs to be done.

Phases involved in the EIA Process

EIA involves the steps mentioned below. However, EIA process is cyclical with interaction between the various steps.

Identification: -The first step is to define a project and study all the likely activities involved in its process so as to understand the range and reach of the project. This helps in deciding the possible zones of environmental impacts

Screening: - Screening is done to see whether a project requires environmental clearance as per the statutory notifications. **Screening criteria are based upon:**

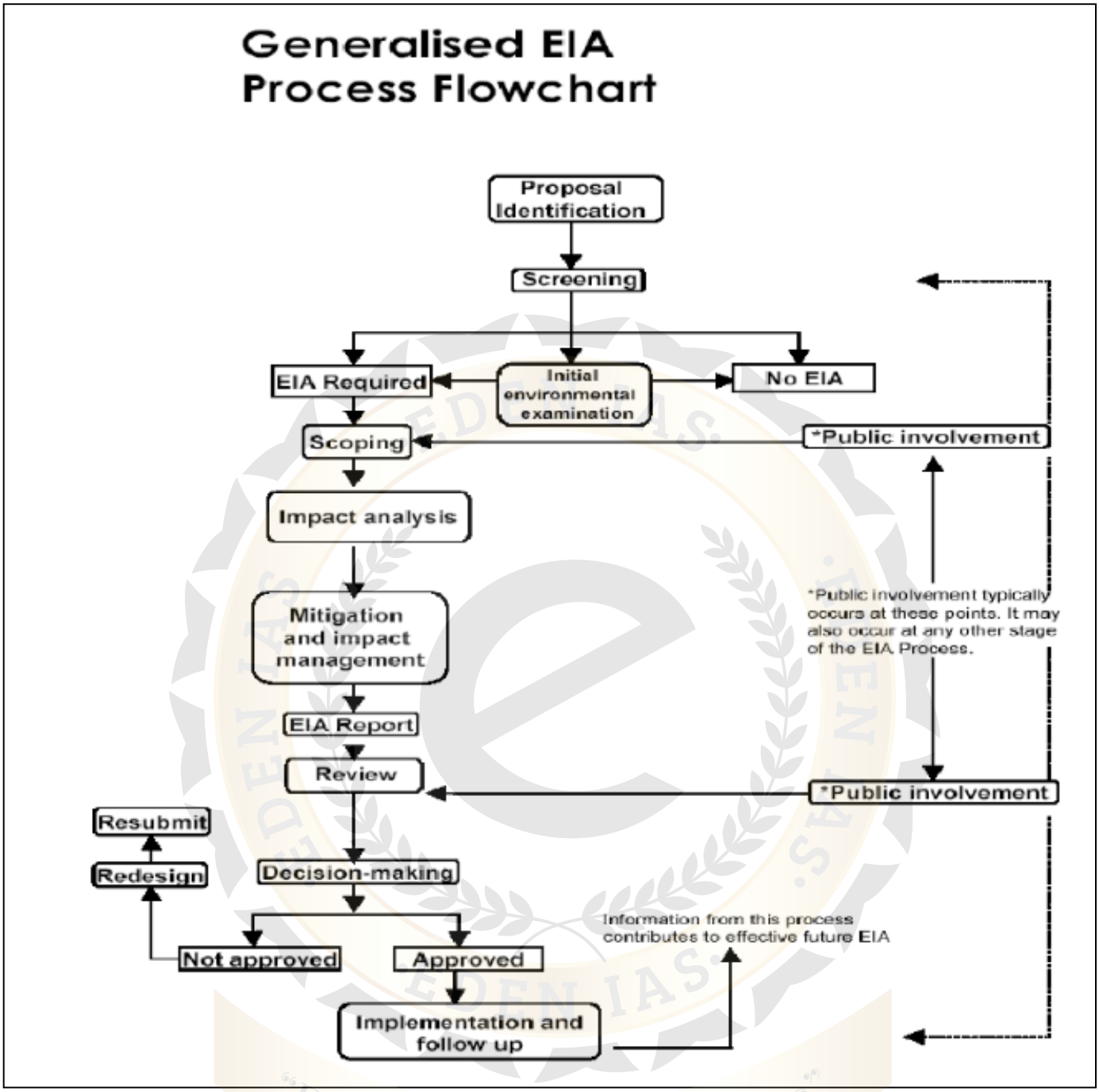
- Scales of investment
- Types of development
- Location of development

A project will have several ramifications biophysical or environmental, economic and social. Hence, it requires some degree of public participation. The law for EIA varies from country to country. If screening shows that a project necessitates EIA, it moves to the next stage.

Some projects may not require EIA. It is generally determined by the size of the project and is sometimes based on the site-specific information. The output of the screening process is a document known as "**Initial Environmental Examination or Evaluation (IEE)**", based on which the decision is taken whether an EIA is needed and if so, to what extent.

Scoping and Consideration of Alternatives: - Scoping is the procedure of identifying the key environmental issues and is possibly the most important step in an EIA. Scoping means the scope or range of the EIA report. It undertakes the project's effect on the air, water, soil, noise level, air quality and physical impact.

It identifies issues and concerns, decides the assessment methods, identifies affected parties and invites public participation for agreement on debatable issues. In which public participation involves interactions of all stakeholders including project beneficiaries, local people, private sectors, NGOs, scientists and other. It is on-going process and is likely to continue in the planning and design phases of the project. Scoping is important because it is possible to bring changes in the project in the early stages of the cycle of the project and it ensures the study of all possible important issues. In this stage there is an option for cancelling or revising the project. After crossing this stage, there is little opportunity for major changes to the project.



Impact Prediction: - Impact Prediction is a way of 'mapping' the environmental consequences of the significant aspects of the project and its alternatives. **There are two steps in impact analysis:**

(i) Identification:

Identification of the impacts would have been initiated in the scoping stage itself. These initial identifications may be confirmed and new ones are added as and when the investigations reveal.

(ii) Prediction of Impacts:

Predication of impacts is both qualitative and quantitative. The scale and severity of an impact is determined by whether it is reversible or irreversible. If the impact is reversible, then it may be taken as low impact. If the adverse impact cannot be reversed then the impact is said to be high.

Duration of the impact is equally important to understand. The chronological aspects of impacts, arising at different stages must be taken into account. **Thus, it may be categorized into:**

(i) Short-term (3-9 years)

(ii) Medium-term (10-20 years)

(iii) Long-term (beyond 20 years)

Mitigation: - This stage includes recommended actions that can offset the adverse impacts of the project. This is done with the idea of lessening the negative effects and improving the scope for project benefits. Mitigating measures may be:

(i) Preventive: public awareness programmes

(ii) Compensatory: to reduce potential reactions

(iii) Corrective: putting into place devices and installations

Reporting To Decision-Making Body: - The project authorities have to furnish the following documents for environmental appraisal of a development project.

1) **Detailed project report (DPR)**
2) **Filled in questionnaire**
3) **Environmental impact statement (EIS): EIS should provide the possible impact (positive and negative) of the project.**

Some of the issues to be included are:

- Impact on soil, water (hydrologic regime, ground water and surface water) and air quality
- Impact on land use, forests, agriculture, fisheries, tourism, recreation etc.
- Socio-economic impact including short and long-term impact on population
- Impact on health
- Impact on flora, fauna and wildlife, particularly endemic and endangered species, and
- Cost benefits analysis including the measures for environmental protection.

(iv) Environmental Management Plan (EMP):- It covers the following aspects:

1. Safeguards and control measures proposed to prevent or mitigate the adverse environmental impact

2. Plans for habitation of project outers

3. Contingency plans for dealing with accidents and disasters

4. Monitoring add feedback mechanisms on implementation of necessary safeguards.

(v) Human Exposure Assessment Location (HEAL): - The concept of Human Exposure Assessment Location (HEAL) was developed as a part of the health-related monitoring programme by WHO in cooperation with UNEP, and the project has three components, viz., air quality monitoring, water quality monitoring and food contamination monitoring on a global basis. In our country, Chembur and central Bombay city have been identified for such study of human exposure with reference to pollutants such as chlorinated pesticides (DDT and BHC), heavy metals (lead, cadmium) and air pollutants (nitrogen oxides).

Public Hearing: - After the completion of EIA report the law requires that the public must be informed and consulted on a proposed development after the completion of EIA report. Any one likely to be affected by the proposed project is entitled to have access to the executive summary of the EIA.

The affected person may include:

(i) Bonafide local residents;

(ii) Local associations;

(iii) Environmental groups active in the area

(iv) Any other person located at the project site/ sites of displacement

They are to be given an opportunity to make oral/written suggestions to the State Pollution Control Board as per Schedule IV of the act.

Review (EIA Report): - Once the final report is prepared, it may be reviewed based on the comments and inputs of stakeholders.

Decision-Making: - The final decision is based on the EIA to approve or reject the project. This is open to administrative or judicial review based on procedural aspects.

Post Project Monitoring & Environment Clearance Condition: - Once a project is approved, then it should function as per the conditions stipulated based on environmental clearance. These conditions have to be strictly monitored and implemented. Monitoring should be done during both construction and operation phases of a project. This is not only to ensure that the commitments made are complied with, but also to observe whether the predictions made in the EIA reports were correct or not.

Composition of the expert committees for EIA

The Committees will consist of experts in the following disciplines:

- Eco-system management
- Air/water pollution control
- Water resource management
- Flora/fauna conservation and management
- Land use planning
- Social Sciences/Rehabilitation
- Project appraisal
- Ecology
- Environmental Health
- Subject Area Specialists
- **Representatives of NGOs**/persons concerned with environmental issues
- The Chairman will be an outstanding and experienced ecologist or environmentalist or technical professional with wide managerial experience in the relevant development.

- The representative of Impact Assessment Agency will act as a Member-Secretary.
- Chairman and members will serve in their individual capacities except those specifically nominated as representatives.
- The membership of a committee **shall not exceed 15 members**.

Environmental Appraisal Procedure in India

- An Appraisal Committee constituted by the Ministry of Environment and Forests to first scrutinize a project based on the data presented by the project authorities.
- If necessary, the Ministry of Environment and Forests may also hold consultations with the investors and experts on specific issues as and when necessary.
- After considering all the facets of the project, environmental clearance is accorded subject to implementation of the stipulated environmental safeguards.
- In case of projects where the project proponents have submitted complete information, a decision is taken within **90 days**.
- The six regional offices of the Ministry functioning at **Shillong, Bhubaneshwar, Chandigarh, Bangalore, Lucknow** and **Bhopal** undertake monitoring of cleared projects.
- The primary objectives of this procedure is to ensure adequacy of the suggested safeguards and also to undertake mid-course corrections if required.
- Sometimes one or more natural resources become limiting resource in a given region and that restrict the scopes of development projects.

EIA of Coasts

- **Coastal Zone Management Plans** (CZMPs) are prepared by coastal states or Union Territories as per rules set by CRZ notification 1991.
- CZMPs are prepared based on identification and categorization of coastal areas for different activities and then submitted to the MoEF for approval.
- The ministry then forms a task force for examining their plans.

Environmental Clearance/Rejection Letter

Single window clearance

Environmental clearance and Forestry clearance

- When a project requires both environmental clearance as well as approval under the Forest (Conservation) Act, 1980, proposals for both are required to be given simultaneously to the concerned divisions of the Ministry.
- The processing is done simultaneously for clearance or rejection. If the project does not involve diversion of forestland, the case is processed only for environmental clearance.

Time frame

- Once all the requisite documents and data from the project authorities are received and public hearings (where required) have been held, assessment and evaluation of the project from the environ-

ment angle is completed within **90 days** and the decision of the ministry shall be conveyed within 30 days thereafter [**120 days for final decision**].

Post project monitoring

- Whenever a project is given environment clearance, a set of conditions are stipulated by the Appraisal Committee on a case to case basis, which have to be complied with by the project proponent.
- The project authorities are required to submit a half-yearly compliance report to the Ministry about the compliance of conditions stipulated.
- Cases of non-compliance of the recommendations and conditions by cleared projects/ units are brought to the notice of the Ministry, which may then initiate action against the project authorities.

The Main Participants of EIA

EIA applies to public and private sections. The six main players are:

1. **Those who propose the project**
2. **The environmental consultant who prepare EIA on behalf of project proponent.**
3. **Pollution Control Board (State or National).**
4. **Public has the right to express their opinion.**
5. **The Impact Assessment Agency.**
6. **Regional center of the Ministry of Environment and Forest.**

Salient Features of 2006 Amendment to EIA Notification

- Environment Impact Assessment Notification of 2006 has **decentralized** the environmental clearance projects by categorizing the developmental projects in two categories, i.e., Category A (national level appraisal) and Category B (state level appraisal).
- 'Category A' projects are appraised at national level by Impact Assessment Agency (IAA) and the Expert Appraisal Committee (EAC) and Category B projects are apprised at state level.
- State Level Environment Impact Assessment Authority (SEIAA) and State Level Expert Appraisal Committee (SEAC) are constituted to provide clearance to Category B process.

After 2006 Amendment the EIA cycle comprises of four stages

- **Screening**
- **Scoping**
- **Public hearing**
- **Appraisal**

- Category A projects require mandatory environmental clearance and thus they do not undergo the screening process.
- Category B projects undergoes screening process and they are classified into two types.

1. Category B, projects (Mandatory requires EIA).
2. Category B2 projects (Do not require EIA).

- Thus Category A projects and Category B, projects undergo the complete EIA process whereas Category B2 projects are excluded from complete EIA process.

Procedure for Public Hearing

Notice of Public Hearing

- Whoever applies for environmental clearance of projects, should request the concerned State Pollution Control Board to initiate a public hearing.
- The State Pollution Control Board issues a notice for environmental public hearing which will be published in at least two newspapers widely circulated in the region around the project, one of which will be in the vernacular language of the locality concerned.
- State Pollution Control Board mentions the date, time and place of public hearing.
- Suggestions, views, comments and objections of the public will be invited within thirty days from the date of publication of the notification.
- All persons including the residents, environmental groups and others located at the project site/sites of displacement/sites likely to be affected can participate in the public hearing. They can also make oral/written suggestions to the State Pollution Control Board.

Composition of public hearing panel

The composition of Public Hearing Panel may consist of the following, namely:

- Representative of State Pollution Control Board;
- District Collector or his nominee;
- Representative of State Government dealing with the subject;
- Representative of Department of the State Government dealing with Environment;
- Not more than three representatives of the local bodies such as Municipalities or panchayats;
- Not more than three senior citizens of the area nominated by the District Collector.

Shortcomings of Environmental Impact Assessment

Applicability

- There are several projects with significant environmental impacts that are exempted from the notification either because they are not listed in schedule I, or their investments are less than what is provided for in the notification.

Composition of expert committees and standards

- It is being found that the team formed for conducting EIA studies is lacking the expertise in various fields such as environmentalists, wild life experts, Anthropologists and Social Scientists (to study the social impact of the project).
- For example for the preparation of EIA report of the proposed oil exploration in coast of Orissa by the reliance group has been given to the life science Dept of Berhampur university which has no expertise on the study of turtles and its life cycle.

Public hearing

- Public comments are not taken into account at the early stage, which often leads to conflict at the later stage of project clearance.
- A number of projects with significant environmental and social impacts have been excluded from the mandatory public hearing process.
- The documents which the public are entitled to are seldom available on time.
- The data collectors do not pay respect to the indigenous knowledge of local people.

Quality of EIA

- One of the biggest concerns with the environmental clearance process is related to the quality of EIA report that are being carried out.
- The reports are generally incomplete and provided with false data.
- Many EIA report are based on single season data.
- The EIA document in itself is so bulky and technical, which makes it very difficult to decipher so as to aid in the decision making process.

Lack of Credibility

- It is the responsibility of the **project proponent** to commission the preparation of the EIA for its project.
- The EIA is actually *funded by an agency or individual whose primary interest is to procure clearance for the project proposed*.
- There is little chance that the final assessment presented is un biased, even if the consultant may provide an unbiased assessment that is critical of the proposed project.
- There are so many cases of fraudulent EIA studies where erroneous data has been used, same facts used for two totally different places etc.
- There is no accreditation of EIA consultants, therefore any such consultant with a track record of fraudulent cases cannot be held liable for discrepancies.
- It is hard to imagine any consultant after being paid lakh of rupees, preparing a report for the project proponents, indicating that the project is not viable.

Western Ghats Experts Ecology Panel (WGEEP)

The MoEF constituted the Western Ghats Experts Ecology Panel (WGEEP) in 2010 under the Chairmanship of **Prof. Madhav Gadgil**. The Panel submitted its report in 2011 but it was not made public immediately due to its stringent assessment of the condition of Western Ghats. The report suggested many radical changes are required to conserve Western Ghats. The recommendation if implemented would adversely affect mining mafia, sand mafia and local encroachers. Under pressure from various stakeholders, MoEF set up the High Level Working Group (HLWG) under the Chairmanship of **Dr. K. Kasturirangan** to study recommendations of WGEEP. The very constitution of the HLWG raised suspicions that this has been formed to dilute the recommendations of the WGEEP. The HLWG had indeed diluted many recommendations of WGEEP

Monitoring, compliance and institutional arrangements

- Often, and more so for strategic industries such as nuclear energy projected, the EMPs are kept **confidential** for political and administrative reasons.
- Details regarding the effectiveness and implementation of mitigation measures are often not provided.
- Emergency preparedness plans are not discussed in sufficient details and the information not disseminated to the communities.

Recommendations to improve EIA process

- **Independent** EIA Authority.
- Sector wide EIAs needed.
- Creation of a centralized baseline data bank.
- Dissemination of all information related to projects from notification to clearance to local communities and general public.

Applicability

- All those projects where there is likely to be a significant alternation of ecosystems need to go through the process of environmental clearance, without exception.
- No industrial developmental activity should be permitted in ecologically sensitive areas.

Public hearing

- Public hearings should be applicable to all hitherto exempt categories of projects which have environmental impacts.

Quality

- The focus of EIA needs to shift from utilization and exploitation of natural resources to conservation of natural resources.
- At present EIA reports are extremely weak when it comes to assessment of biological diversity of a project area and the consequent impacts on it. This gap needs to be plugged.
- All EIA reports should clearly state what are the adverse impacts that a proposed projects will have. This should be a separate chapter and not hidden within technical details.
- The sub components or subsidiary reports of EIA reports (e.g. Assessments of Biodiversity impacts done by a sub consultant) should be made publicly accessible as standalone reports with the EIA. This should be available on the websites of the MOEF.
- EIAs should be based on full studies carried out over at least one year. Single season data on environmental parameters like biodiversity, as is being done for several rapid assessments is not adequate to gain understanding of the full impact of the proposed project.
- It is critical that the preparation of an EIA is completely independent of the project proponent.

- State and central governments should maintain a list of credible, independent and competent agencies that can carry out EIAs. Similarly the EIA consultants, those are making false reports should be black listed.
- A national level accreditation to environment consultancy should be adopted

Grant of clearance

- The notification needs to make it clear that the provision for site clearance does not imply any commitment on the part of the impact Assessment agency to grant full environmental clearance.
- The prior informed consent of local communities and urban wards or residents association needs to be made mandatory before the grant of environmental clearance. The consent should be from the full general body.
- The language used for specifying conditions of clearance must be clear and specific.

Composition of expert committees

- The present executive committees should be replaced by expert's people from various stakeholder groups, who are reputed in environmental and other relevant fields.
- The process of selection of those committees should be open and transparent. The minutes, decisions and advice by these committee should be open to public.

Monitoring, compliance and institutional arrangements

- The EIA notification needs to build within it an automatic withdrawal of clearance if the conditions of clearance are being violated, and introduce more stringent punishment for noncompliance. At present the EIA notification limits itself to the stage when environmental clearance is granted.
- The MOEF should set up more regional offices with advisory Expert committees, each with smaller areas of jurisdiction, to effectively monitor the compliance of clearance conditions.

Redressal

- The composition of the NGT needs to be changed to include more judicials from the field of environment.
- Citizen should be able to access the authority for redressal of all violation of the EIA notification as well as issues relating to non-compliance.

Capacity building

- NGOs, civil society groups and local communities need to build their capacities to use the EIA notification towards better decision making on projects.

UNIT-VII

[ENVIRONMENTAL HAZARD]

ENVIRONMENTAL HAZARDS

An environmental hazard is a substance, a state or an event which has the potential to threaten the surrounding natural environment / or adversely affect people's health, including pollution and natural disasters such as storms and earthquakes.

Any single or combination of toxic chemical, biological, or physical agents in the environment, resulting from human activities or natural processes, that may impact the health of exposed subjects, including pollutants such as heavy metals, pesticides, biological contaminants, toxic waste, industrial and home chemicals

Disaster can be a natural or man-made phenomenon. Any distortion in the balanced equation between earth's resources, stock and ecology arising out of climatic changes, movement of the earth occurring inside and other natural process may lead to natural disaster like cyclone, floods, draughts, earthquakes, volcanoes, landslides, heat waves, and cold waves etc. Hazards arising out of man-made technological advancements, industrialisation and other developmental activities are coined as technological disasters like emission of deadly industrial pollutants, soil erosion and nuclear disaster etc.

IMPORTANT ENVIRONMENTAL HAZARDS

Drought

The literal meaning of drought is an extended period of dry weather which is especially injurious to crops. However, different disciplines have different perceptions about drought. Meteorologists define it as rainless or rain-deficit period. Agronomists consider drought as a condition of shortage of moisture for crop production. Economists view it as shortage of rainfall, which adversely affects agricultural production. A farmer considers drought as shortage of rainfall for critical operations and stages of crop growth.

Drought, if not managed properly and continues for more than two to three consecutive years, might lead to famine like situation. Drought adversely affects the economic and social life of the people. It aggravates poverty, water scarcity, famine, the internal displacement of people, migration and social breakdown. Further, reduction in crop production increases the prices of those commodities and also affects the relative prices.

At the household level, a large drop in production translates into huge reduction in farm employment and income. The drop in income, coupled with rapidly increasing food prices result in severe and widespread decline in purchasing power. This also leads to migration and people become environmental refugees. Moreover, low income and less food production leads to malnutrition among the children. This has enormous social costs and causes a huge drain of economic resources.

According to Prof. Amartya Sen, malnutrition and famine could occur on a massive scale despite considerable food availability. It is shortage in food grain production which leads to a prolonged fall in food grain intake that starvation on a massive scale leads to excessive rise in death rates.

Floods

Submergence of any land area due to excessive rain water is termed flood. Thus a flood is too much water in the wrong place whether it is an inundated city or a single street or field flood due to blocked drain. Among the trigger mechanisms are dam or levee failures; more rain than the landscape can dispose off; the torrential rains of hurricanes, tsunamis, ocean storm surges, rapid snow-melts; ice floes blocking a

river; and burst water mains. But most of the rapidly growing disasters are caused by humans, making their land more prone to floods, and themselves more vulnerable.

India is the most flood-affected country in the world after Bangladesh. The typical geo-climatic condition of the Indian sub-continent is responsible for this. For the coastal parts of India, it is not an unknown phenomenon. India accounts for one-fifth of global deaths due to floods.

Usually floods occur during June to September which is the rainy season for the country. During this period, severe depression of cyclonic storms, which originate in-the Bay of Bengal and sometimes in the Arabian Sea, increase the intensity of this disaster,

The Eastern and North-Eastern parts of India are the most affected regions in the country. States like Orissa, Bihar, U.P., West Bengal, Chhattisgarh, Assam and Gujarat are more prone to floods. Occurrence of floods in the major rivers in the Indo-Gangetic-Brahmaputra plains is an annual feature. On an average nearly one percent (more than a million housing units) of existing house stock are known to be damaged during the occurrence of these hazards every year, and thousands of crores of rupees are spent on relief and rehabilitation of the people by the Central and the State Governments on crisis relief, besides what the people and voluntary organisations have to spend on their own.

There are numerous instances of disasters caused by cloudburst floods and flash floods from landslides and debris flow, dam failures in the Indian Himalayas. On an average, at least one event is reported every year from some part of the Himalayas. Cloudbursts are common in the Higher Himalayas region and are mainly confined to narrow valleys.

On 14 August 1978, severe rains lashed the Himalayas causing landslides in their wake. As a result, 69 people died near Guptkashi. The entire village of Malpa along the Kali River was washed away. The death toll was 205 people including five dozen pilgrims returning from Mount Kailash and Lake Mansrover in Tibet.

Tsunami

Tsunami is a Japanese word, translated as Tsu meaning harbour and nami meaning wave. It is not just one wave; it is a train of waves generated in any large body of water by a disturbance of seismic volcanic or even cosmic origin. A tsunami is thus neither tidal nor just seismic event which an undersea landslide can generate. Tsunami waves travel at hundreds of kms per hour, reaching the coast several hours after the earthquake. Tsunamis can reach heights of up to 30 metres, as tall as a seven-floor building on approaching the coast. The force of Tsunamis is so enormous that large rocks weighing several towns along with boats and other debris are moved inland, destroying buildings.

The undersea earthquake that occurred under the Indian Ocean on December 26, 2004 produced tsunamis, devastating the shores of Indonesia, Sri Lanka, Thailand and India. The death toll was approximately 1, 60,000 in South Asia. Over more than 10,000 were killed in Southern India and the Andaman and Nicobar Islands. The Andaman and Nicobar Islands which continued to suffer from aftershocks of the quake accounted for 4000 deaths, most of them in the Nicobar area. Another 2,600 people were reported missing.

Cyclone

Cyclone is a sea storm, which is associated with speedy winds and heavy rainfall. Cyclone spreads from sea to land and affects the coastal areas. The speed of winds may vary from 180 km. to 400 km. per hour. A strip of 50 Km. width on the East Coast is liable to the occurrence of severe cyclones.

The West Coast is less severe in cyclone activity where during the same time period 20 cyclonic storms occurred on the coast of Gujarat and 13 on the rest of the West Coast. It may be mentioned that as many as 19 major cyclones occurred out of these, in which the life losses exceeded 10,000.

The Bay of Bengal and East Coast are prone to such cyclones. In the last two decades, Andhra Pradesh has been ravaged by two severe cyclonic storms in November 1977 and May 1990. Similarly, Orissa has also been devastated by a super cyclone in October, 1999 with a wind speed of 270-300 kms per hour accompanied by torrential rains continuously for three days.

Over seven lakh buildings were completed destroyed and 13 lakh partially damaged. The trail of destruction left behind a cyclonic storm in the regions would generally comprise of loss of human lives and livestock, a widespread destruction/damage to buildings, houses, rendering the occupants homeless and huge economic losses.

Earthquakes

An earthquake is a sudden motion of the earth caused by an abrupt release of slowly accumulating stress and is also a potent natural disaster. In other words, earthquakes occur due to sudden movements of earth's crust.

The magnitude of energy released by an earthquake is measured by the Richter scale, first devised by Charles F. Richter in 1935. Science has not succeeded in predicting the timing and place of earthquakes in advance despite decades of efforts. The reason lies probably in the time scale of the activity.

Geological activity can take place anywhere between a few thousand to a few hundred million years to complete. During the last 16 years, India has experienced quakes, ranging from very devastating ones to mere tremors. The one in Uttarkashi in the early 1990s was followed by the Latur quake. The Jabalpur quake in the Narmada valley in May 1977 was followed by the large scale tremors in Khandwa-Pandhana region. Hundreds of villagers fled from the region due to tremors and collapsed houses. For the last two years, the Koyna Valley has experienced earthquakes ranging from 6 to 7.5 on Richter scale.

Looking at the Kutch region, it has recorded a few major earthquakes in the last two centuries. The earthquake of 1819 in this region measuring approximately 7.8 created a natural bound of 90 Km lateral extent called Allabandhs'. An earthquake in 1903 near Anjar had 6 magnitudes while the one in 1956 in the same locality was of 6.1 magnitude and devastated Kutch. The historical record of seismicity in the Kutch region suggests that this region is seismically active.

In the morning of January 26, 2001 a massive earthquake struck Gujarat at Bhuj. The impact was so enormous that it left more than 20,000 dead in its wake and left ten times that number without food, shelter and other basic necessities. Recently, there was a severe earthquake in October 2005 in J&K which devastated large parts of Kashmir.

Large Dams and Earthquakes

The Narmada Valley Dam is located at the triple junction of the fault zone, thus making it seismologically very sensitive and geologically a disturbed area. The devastating Bhaj earthquake has brought to the fore the gravity of building large dams in quake-prone zones. Geologists and seismologists believe that both Narmada and Tehri dams could spell doom if an earthquake above 8 on Richter scale occurs. Besides, both these projects can even induce seismic activity and trigger earthquakes.

Scientists have warned that the Tehri dam might release elastic strain energy along the fault line between Nepal and Tibet. This might trigger an earthquake of as high as 8.9 Richter scale.

Earthquake experts underline that stress is building up along the active fault line in the Himalayan region and they predict an earthquake any time in the region. The Uttarkashi and Chamoli quakes occurred a few years back have already destroyed large chunks of ecology in the region. Earthquakes like Bhuj and Uttarkashi are pointers to the fact that we should not build big dams in areas which are ecologically and geologically fragile. If the Tehri Dam cracks due to a quake, Rishikesh would drown in 63 minutes and 17 minutes later, Hardwar would be inundated.

The large amount of water puts a heavy load on the earth's crust, especially in areas where it is thin and thereby induces seismicity. Earthquakes of shallow depths are possible by these mechanisms. Documented cases of reservoir induct seismicity have had a much longer time lag. For example, Aswan Dam in Egypt was affected after 17 years of post-impoundment. Cajuru in Brazil after 18 years. A strong earthquake (6.1 on the Richter scale) in 1997 focused attention on the seismic risks in the Narmada Valley. The event located close (20 to 40 km) to the Bargi Dam impounded in 1990, was associated with damages in Jabalpur.

PLASTIC-A MAJOR ENVIRONMENTAL HAZARD

The problem created by the use of plastics bags is primarily due to shortcomings in the waste management system. Indiscriminate chemical additives pose environmental problems including choking open drains, ground water contamination, etc.

What are Plastics?

Plastics are polymers i.e. large molecules consisting of repeating units called monomers. In the case of plastic bags, the repeating units are ethylene. When ethylene molecules are polymerized to form polyethylene, they form long chains of carbon atoms in which each carbon is also bonded to two hydrogen atoms.

What are plastic bags made of?

Plastic bags are made from one of the three basic types of polymers -polyethylene- High Density polyethylene (HDPE), Low Density Polyethylene (LDPE), or Linear Low-Density Polyethylene (LLDPE). Grocery bags are generally of HDPE, and bags from the dry cleaner are LDPE. The major difference between these materials is the degree of branching of the polymer chain. HDPE and LLDPE are composed of linear, unbranched chains, while LDPE chains are branched.

Are plastics harmful to health?

Plastics are not intrinsically toxic or harmful. But plastic carry bags are manufactured using organic and inorganic additives like colourants and pigments, plasticizers, antioxidants, stabilizers and metals.

Colourants and pigments are industrial azodyes which are used to give bright colour to plastic carry bags. Some of these are carcinogenic and likely to contaminate food stuffs, if packed in these carry bags. Heavy metals such as Cadmium contained in pigments can also reach out and prove to be a health hazard. Plasticizers are organic esters of low volatile nature. They can migrate to food stuffs as a result of leaching. Plasticizers are also carcinogenic. Antioxidants and Stabilizers are inorganic and organic chemicals to protect against thermal decomposition during manufacturing process.

Toxic metals like cadmium and lead when used in manufacturing of plastic bags also leach out and contaminate the food stuffs. Cadmium when absorbed in the low doses can cause vomiting and heart enlargement. Lead exposure in long term may cause degeneration of brain tissues.

Plastic bags if not disposed properly may find their way into the drainage system resulting into choking of drains, creating unhygienic environment and causing water borne diseases. Recycled /coloured plastic bags may contain certain chemicals, which can leach to the ground and contaminate soil and sub-soil water. Units not equipped with environmentally sound techniques for recycling may create environmen-

tal problems due to toxic fumes generated during reprocessing. Some of the plastic bags which contain leftover food or which get mixed up with other garbage are eaten by animals resulting in harmful effects. Because of the non-biodegradable and impervious nature of plastics, if disposed in the soil, they could arrest the recharging of ground water aquifers. Further, to improve the properties of plastic products and to inhibit degradation reactions, additives and plasticisers, fillers, flame retardants and pigments are generally used, these may have health impacts.

Strategies for Plastics Waste Management

Thin plastic bags have little value and their segregation is difficult. If the thickness of plastic bags is increased, it would make plastic bags expensive and check their usage. The plastic Manufacture Association and rag pickers could also be involved in the waste collection and disposal system.

Littering of Plastic carry bags, water bottles, plastic pouches have been a challenge for municipal solid waste management. In the country, 17 States / Union Territories have imposed complete ban on manufacture, stock, sale and use of plastic carrybags, through directions/notifications and executive orders. Further, use of plastic carry bags has been partially banned in some pilgrimage centres, tourist and historical places located in the States of Andhra Pradesh, Arunachal Pradesh, Assam, Goa, Gujarat, Karnataka, Odisha, Tamil Nadu, West Bengal, Uttar Pradesh and Uttarakhand.

The Government has notified Plastic Waste Management Rules, 2016, which, inter-alia, regulate manufacture, sale, distribution and use of plastic carry bags including carry bags of compostable plastic, and plastic sheets for packaging or wrapping applications. The use of carry bags made from conventional plastic with thickness less than 50 micron is prohibited. The use of plastic for packaging gutkha, tobacco and pan masala is also prohibited.
As per the provisions of Plastic Waste Management Rules, 2016, the generators of waste have been mandated to take steps to minimize generation of plastic waste, not to litter the plastic waste, ensure segregated storage of waste at source and handover segregated waste to local bodies or agencies authorised by the local bodies. The Rules also mandate the responsibilities of local bodies, gram panchayats, waste generators, retailers and street vendors to manage the plastic waste. The rules mandate the producers, importers and brand owners to work out modalities for waste collection system based on Extended Producer Responsibility. The Bureau of Indian Standards (BIS) has notified 10 standards on biodegradable plastics.

Alternatives to Plastic

The use of jute or cloth bag as alternatives to plastic paper bag should be popularized and prompted through fiscal incentives; however, it needs to be noted that paper bag involve cutting of trees and their use is limited. Ideally bio-degradable plastic bags alone should be used and research work is on to develop biodegradable plastics.

OZONE AND ENVIRONMENT

What is Ozone?

Ozone is a form of oxygen. But unlike oxygen, ozone is a poisonous gas. Each ozone molecule is made of three oxygen atoms, so its chemical formula is 0_3. Ozone is formed when ultraviolet radiation causes oxygen molecules (0_2) in the upper layers of the atmosphere to split apart. If a freed oxygen atom (O) bumps into an oxygen molecule (0_2), the three oxygen atoms re-form as ozone (0_3).

Good and bad ozone

In the stratosphere (the layer that is about 15 - 50 kms above the earth's surface), where ozone exists naturally, it prevents the sun's ultraviolet rays from reaching the earth and thereby protects life.

In the atmospheric layer closest to the earth's surface, due to pollution by vehicles, nitrogen oxides and Hydrocarbons levels increase. In the presence of sunlight, these chemicals form ozone. This ozone can cause health problems like coughing, throat irritation, aggravation of asthma, bronchitis etc. It can also damage crops. While ozone in the stratosphere benefits life on Earth by blocking ultraviolet radiation from the Sun, ozone in the lower atmosphere can trigger health problems.

What is ozone depletion?

Chlorofluorocarbons (CFCs) are the primary Ozone depleting chemicals. They are used as refrigerants in refrigerators, air conditioners etc. They contain Chlorine. **Ozone depletion process**

- **Step 1 : The CFCs generated as a result of human activities reach the ozone layer in the atmosphere**
- **Step 2 : The UV radiation from the sun breaks the CFCs and releases Chlorine**
- **Step 3: The Chlorine atoms break the ozone molecule and thereby facilitates ozone depletion.**

How ozone depletion affects us?

When the ozone layer gets depleted, the UV radiation of the sun striking the earth gets increased. This can cause genetic damage; skin cancer (melanoma and non-melanoma), premature aging of skin, cataracts and other eye damage and can also lead to immune system suppression. It can also have adverse effects on marine environment.

Preventive Measures

- Choose a cleaner commute — car pool, use public transportation, bike or walk when possible.
- Combine errands to reduce "cold starts" of your car and avoid extended idling.
- Use environmentally safe paints and cleaning products whenever possible.
- Some products that you use at your home or office are made with smog-forming chemicals that can evaporate into the air when you use them. Follow manufacturers' recommendations for use and properly seal cleaners, paints, and other chemicals to prevent evaporation into the air.
- Replace CFC's with HCFCs.

PRINCIPLES OF DISASTER MANAGEMENT

For disaster management, developing countries should follow the following three principles:

1. Be aware and prepare: - No country is immune from the harmful effects of extreme weather and disasters; and no country can afford to be complacent in preparing to face them. No country should forget the old maxim: An ounce of prevention is worth a pound of cure. One dollar invested in disaster management today can save about seven dollars tomorrow in relief and rehabilitation costs, besides saving millions of lives.

2. Strengthen resilience to disasters: - Countries should build "smarter and safer" disaster-resistant constructions in high-risk regions. To prevent huge loses of people and property in disaster-prone require large funds and new technologies. Toward this end, the U.N. has formed a new global partnership of governments, the World Bank, NGOs and civic groups. Besides, the World Bank's new Global Facility for Disaster Reduction and Recovery will provide funds to support the use of disaster-resilient technology, design and construction in 86 disaster-prone countries.

3. Prepare communities to face nature's hazards: - People must be prepared to face natural hazards. This requires a good warning and communication system and educating the people to take immediate measures to save themselves. Governments should have well-prepared evacuation plans, better land usage and environmental policies, public awareness campaigns, and emergency broadcasting systems to reduce disaster risk.

ENVIRONMENTAL HAZARDS IN INDIA

India is one of the most disaster prone countries with all sorts of hazards being visited in some parts of the country or the other every year. The natural hazards are related to climate, water and geological causes. Besides natural, the other hazards, as recognised by High Powered Committee on Disaster Management relate to chemical, Industrial, nuclear, biological and accidental disasters.

Over the last two decades the natural disasters have claimed over three million lives and adversely affected 800 million people worldwide with 90 percent of the victims being from developing countries. In India, there are a total of 593 districts, of which 199 are most disaster prone.

India has been affected by three major natural hazards, namely earthquakes, cyclones and floods from times immemorial. However, the listing of the major occurrence of these hazards is available only for the last about 200 years.

It is estimated that about 55 per cent of India's land area is vulnerable to seismic, 8 percent to cyclonic and 10 per cent to flood hazards. Out of that exposed to seismic, about 12 percent of the land area of the country is liable to severe earthquake intensities of MSK IX or more, about 18 percent liable to MSK VIII and about 25 percent MSK VII. Earthquakes of giant magnitudes 7.5 or more have occurred in Andaman islands, Kutch area of Gujarat, H.P, J- J& K, North Bihar and the North-Eastern States. Earthquake of magnitude up to 6.5 and MSK intensity VIII have occurred in the Peninsular India.

A strip of 50 km. on the East Coast is liable to the occurrence of severe cyclones where between 1737 and 2017, 270 cyclonic storms have occurred including 94 of the severe types. The West Coast is less severe in cyclone activity where during the same time period 20 cyclonic storms have occurred on the coast of Gujarat and 13 on the rest of the West Coast. It may be mentioned that as many as 19 major cyclones have occurred out of these, in which the life losses exceeded 10,000.

According to World Disaster Report, on an average 5000 people are killed and 59 million get affected and nearly one percent (more than a million housing units) of existing housing stock are known to be damaged during the occurrence of these hazards every year in India. Physical losses added to reconstruction and rehabilitation costs, deliver a body blow to the economy of the country. The memories of Gujarat, Latur and Kashmir earthquakes are still fresh in the minds of the people for heavy damages due to house collapses and heavy loss of human lives.

There are numerous instances of disasters caused by cloudburst, flash floods, landslides and debris flow from dam failures in the Indian Himalayas. On an average, at least one event is reported every year from some part of the Himalayas. Cloudbursts are common in the Higher Himalayas region and are mainly confined to narrow villages.

UNIT-VIII

[ENVIRONMENTAL POLLUTION]

ENVIRONMENTAL POLLUTION: SOURCES AND TYPES

What is Pollution

Pollution is the release of harmful environmental contaminants, or the substances so released. Generally the process needs to result from human activity to be regarded as pollution. Any human activity is liable to be regarded as pollution, if it results in negative effects later on.

Sources of pollution

- Serious pollution sources include chemical plants, oil refineries, nuclear waste dumps, regular garbage dumps, incinerators, PVC factories, car factories, plastics factories, and corporate animal farms creating huge amounts of animal waste.
- Some sources of pollution, such as nuclear power plants or oil tankers, can release very severe pollution when accidents occur.
- Some of the more common contaminants are chlorinated hydrocarbons (CFH), heavy metals like lead (in lead paint and until recently in gasoline), cadmium (in rechargeable batteries), chromium, zinc, arsenic and benzene.
- Pollution is often a serious side effect in natural disasters. For example hurricanes almost always involve sewage pollution, and petrochemical pollution from overturned boats, autos, or even damage from coastal refineries is common.

Types of pollution

Traditional forms of pollution include air pollution, water pollution, and radioactive contamination while a broader interpretation of the word has led to the ideas of ship pollution, light pollution, and noise pollution.

Sound Pollution- Noise, by definition, is unwanted sound. It is now increasingly understood that pollution from noise is an important component of air pollution. Noise travels through air and hence it is measured in ambient air quality level. Noise is measured in decibels. Experts believe that continuous noise levels in excess of 90 decibels can cause loss of hearing and irreversible changes in nervous systems. The World Health Organization (WHO) has fixed 45 decibels as the safe noise level for a city. Metropolitan areas in India usually register an average more than 90 decibels; Mumbai is rated the third noisiest city in the world, with New Delhi following closely. Noise not only causes irritation or annoyance but also constricts the arteries, and increases the flow of adrenaline and forces the heart to work faster. Continuous noise causes an increase in the cholesterol level resulting in permanent constriction of blood vessels, making one prone to heart attacks and strokes. Health experts are of the opinion that excessive noise can also lead to neurosis and nervous breakdown.

Waste and Water Pollution- When toxic substances enter lakes, streams, rivers, oceans, and other water bodies, they get dissolved or lie suspended in water or get deposited on the bed. This results in the pollution of water whereby the quality of the water deteriorates, affecting aquatic ecosystems. Pollutants can also seep down and affect the groundwater deposits. The effects of water pollution are not only devastating to people but also to animals, fish, and birds. Polluted water is unsuitable for drinking, recreation, agriculture, and industry. It diminishes the aesthetic quality of lakes and rivers.

Air Pollution- Air pollution is the contamination of air by the discharge of harmful substances. Air pollution can cause health problems and it can also damage the environment and property. It has caused thinning of the protective ozone layer of the atmosphere, which is leading to climate change.

Industries, vehicles, increase in the population, and urbanization are some of the major factors responsible for air pollution. Air pollution results from a variety of causes, not all of which are within human control. Dust storms in desert areas and smoke from forest fires and grass fires contribute to chemical and particulate pollution of the air.

Listed below are the major air pollutants and their sources

1) **Carbon monoxide (CO)** is a colourless, odourless gas that is produced by the incomplete burning of carbon-based fuels including petrol, diesel, and wood. It is also produced from the combustion of natural and synthetic products such as cigarettes. It lowers the amount of oxygen that enters our blood. It can slow our reflexes and make us confused and sleepy.

2) **Carbon dioxide (CO2)** is the principle greenhouse gas emitted as a result of human activities such as the burning of coal, oil, and natural gases.

3) **Chloroflorocarbons (CFC)** are gases that are released mainly from air-conditioning systems and refrigeration. When released into the air, CFCs rise to the stratosphere, where they come in contact with few other gases, which lead to a reduction of the ozone layer that protects the earth from the harmful ultraviolet rays of the sun.

4) **Lead** is present in petrol, diesel, lead batteries, paints, hair dye products, etc. Lead affects children in particular. It can cause nervous system damage and digestive problems and, in some cases, cause cancer.

5) **Ozone** occurs naturally in the upper layers of the atmosphere. This important gas shields the earth from the harmful ultraviolet rays of the sun. However, at the ground level, it is a pollutant with highly toxic effects. Vehicles and industries are the major source of ground-level ozone emissions. Ozone makes our eyes itch, burn, and water. It lowers our resistance to colds and pneumonia.

6) **Nitrogen oxide (NOx)** causes smog and acid rain. It is produced from burning fuels including petrol, diesel, and coal. Nitrogen oxides can make children susceptible to respiratory diseases in winters.

7) **Suspended particulate matter (SPM)** consists of solids in the air in the form of smoke, dust, and vapour that can remain suspended for extended periods and is also the main source of haze which reduces visibility. The finer of these particles, when breathed in can lodge in our lungs and cause lung damage and respiratory problems.

8) **Sulphur dioxide (SO_2)** is a gas produced from burning coal, mainly in thermal power plants. Some industrial processes, such as production of paper and smelting of metals, produce sulphur dioxide. It is a major contributor to smog and acid rain. Sulfur dioxide can lead to lung diseases.

9) **Chemical Pollution-**There are many different sources of chemical pollution, including:

- Domestic sewage
- Industrial discharges
- Seepage from waste sites
- Atmospheric fallout
- Domestic run-off
- Accidents and spills at sea
- Operational discharges from oil rigs
- Mining discharges and
- Agricultural run-off.

However, the chemicals that are probably of most concern for everyone are the persistent pollutants: those substances that enter marine food chains and are eventually passed along the chain to the marine top predators in increasing amounts. Persistent pollutants include pesticides, such as DDT, and industrial chemicals, most famously the PCBs.

ACID RAIN

"Acid rain" is a broad term referring to a mixture of wet and dry deposition (deposited material) from the atmosphere containing higher than normal amounts of nitric and sulfuric acids. The precursors, or chemical forerunners, of acid rain formation result from both natural sources, such as volcanoes and decaying vegetation, and man-made sources, primarily emissions of sulfur dioxide (SO_2) and nitrogen oxides (NOx) resulting from fossil fuel combustion. Acid rain occurs when these gases react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds. The result is a mild solution of sulfuric acid and nitric acid. When sulfur dioxide and nitrogen oxides are released from power plants and other sources, prevailing winds blow these compounds across state and national borders, sometimes over hundreds of miles.

Effects of Acid Rain

Acid rain causes acidification of lakes and streams and contributes to the damage of trees at high elevations (for example, red spruce trees above 2,000 feet) and many sensitive forest soils. In addition, acid rain accelerates the decay of building materials and paints, including irreplaceable buildings, statues, and sculptures that are part of our nation's cultural heritage. Prior to falling to the earth, sulfur dioxide (SO_2) and nitrogen oxide (NOx) gases and their particulate matter derivatives—sulfates and nitrates—contribute to visibility degradation and harm public health.

Preventive Measures

There are several ways to reduce acid rain—more properly called acid deposition—ranging from societal changes to individual action. It is critical that acid deposition be reduced, not only in India, but also throughout the world to preserve the integrity of natural habitats, as well as to reduce damage to man-made structures.

- Clean up smokestacks and exhaust pipes from time to time.
- Use alternate sources of energy.
- Limestone or lime (a naturally occurring basic compound) can be added to acidic lakes to "cancel out" the acidity.
- Buy vehicles with low NOx emissions, and properly maintain your vehicle.

THERMAL POLLUTION: CAUSES AND CONSEQUENCES

Thermal pollution is defined as sudden increase or decrease in temperature of a natural body of water which may be ocean, lake, river or pond by human influence. This normally occurs when a plant or facility takes in water from a natural resource and puts it back with an altered temperature. Usually, these facilities use it as a cooling method for their machinery or to help better produce their products.

An increase in the optimum water temperature by industrial process (steel factories, electric power houses and atomic power plants) may be called as "Thermal Pollution." Many industries generate their own power and use water to cool their generator.

This hot water is released into the system from where it was drawn, causing a warming trend of surface water. If the system is poorly flushed, a permanent increase in the temperature may result. However, if the water is released into the well flushed system, permanent increase in temperature does not occur.

Causes of Thermal Pollution

1. Water as Cooling Agent in Power, Manufacturing and Industrial plants: Production and Manufacturing plants are biggest source of thermal pollution. These plants draw water from nearby source to keep machines cool and then release back to the source with higher temperature. When heated water returns to the river or ocean, the water temperature rises sharply. When oxygen levels are altered in the water, this can also degrade the quality and longevity of life in wildlife that lives underwater. This process can also wipe away streamside vegetation, which constantly depends on constant levels of oxygen and temperature. By altering these natural environments, industries are essentially helping decrease the quality of life for these marines based life forms and can ultimately destroy habitats if they are not controlled and careful about their practices.

2. Soil Erosion: Soil erosion is another major factor that causes thermal pollution. Consistent soil erosion causes water bodies to rise, making them more exposed to sunlight. The high temperature could prove fatal for aquatic biomes as it may give rise to anaerobic conditions.

3. Deforestation: Trees and plants prevent sunlight from falling directly on lakes, ponds or rivers. When deforestation takes place, these water bodies are directly exposed to sunlight, thus absorbing more heat and raising its temperature. Deforestation is also a main cause of the higher concentrations of greenhouse gases i.e. global warming in the atmosphere.

4. Runoff from Paved Surfaces: Urban runoff discharged to surface waters from paved surfaces like roads and parking lots can make water warmer. During summer seasons, the pavement gets quite hot, which creates warm runoff that gets into the sewer systems and water bodies.

5. Natural Causes: Natural causes like volcanoes and geothermal activity under the oceans and seas can trigger warm lava to raise the temperature of water bodies. Lightening can also introduce massive amount of heat into the oceans. This means that the overall temperature of the water source will rise, having significant impacts on the environment.

Effects of Thermal Pollution

Among recognized scientists and scholars, there are generally two schools of thought when it comes to the effects of thermal pollution. Some lean on the side of the negatives of this pollution on marine ecosystems and how it is detrimental to positive environmental practices. However, some lean towards the side that without these industries operating the way they do, then some of the most basic parts of human life would be completely obsolete. Waste water would not be able to be properly maintained, we would have no industries that could produce the goods we need, and so on. The effects of thermal pollution on ecosystems, however, greatly outweigh the benefits that industries have by participating in the act.

1. Decrease in DO (Dissolved Oxygen) Levels: The warm temperature reduces the levels of DO (Dissolved Oxygen) in water. The warm water holds relatively less oxygen than cold water. The decrease in DO can create suffocation for plants and animals such as fish, amphibians and copepods, which may give rise to anaerobic conditions. Warmer water allows algae to flourish on surface of water and over the long term growing algae can decrease oxygen levels in the water.

2. Increase in Toxins: With the constant flow of high temperature discharge from industries, there is a huge increase in toxins that are being regurgitated into the natural body of water. These toxins may contain chemicals or radiation that may have harsh impact on the local ecology and make them susceptible to various diseases.

3. Loss of Biodiversity: A dent in the biological activity in the water may cause significant loss of biodiversity. Changes in the environment may cause certain species of organisms to shift their base to some other place while there could be significant number of species that may shift in because of warmer waters. Organisms that can adapt easily may have an advantage over organisms that are not used to the warmer temperatures.

4. Ecological Impact: A sudden thermal shock can result in mass killings of fish, insects, plants or amphibians. Hotter water may prove favorable for some species while it could be lethal for other species. Small water temperature increases the level of activity while higher temperature decreases the level of activity. Many aquatic species are sensitive to small temperature changes such as one degree Celsius that can cause significant changes in organism metabolism and other adverse cellular biology effects.

5. Affects Reproductive Systems: A significant halt in the reproduction of marine wildlife (although this may be true, reproduction can still occur between fish – but the likelihood of defects in newborns is significantly higher) can happen due to increasing temperatures as reproduction can happen within certain range of temperature. Excessive temperature can cause the release of immature eggs or can prevent normal development of certain eggs.

6. Increases Metabolic Rate: Thermal pollution increases the metabolic rate of organisms as increasing enzyme activity occurs that causes organisms to consume more food than what is normally required, if their environment were not changed. It disrupts the stability of food chain and alters the balance of species composition.

7. Migration: The warm water can also cause particular species of organisms to migrate to suitable environment that would cater to its requirements for survival. This can result in loss for those species that depend on them for their daily food as their food chain is interrupted.

CONTROLLING THERMAL POLLUTION

Control of thermal pollution is necessary as its detrimental effects on aquatic ecosystem may be detrimental in the future. Viable solutions to chronic thermal discharge into water bodies are as follows:

(1) Cooling Ponds:

Cooling ponds or reservoirs constitute the simplest method of controlling thermal discharges. Heated effluents on the surface of water in cooling ponds maximize dissipation of heat to the atmosphere and minimize the water area and volume. This is the simplest and cheapest method which cools the water to a considerable low temperature. However, the technique alone is less desirable and inefficient in terms of air-water contact.

(2) Cooling Towers:

Using water from water sources for cooling purposes, with subsequent return to the water body after passing through the condenser is termed as cooling process. In order to make the cooling process more effective, cooling towers are designed to control the temperature of water. In-fact, cooling towers are used to dissipate the recovered waste heat so as to eliminate the problems of thermal pollution.

(3) Artificial Lake:

Artificial lakes are man-made bodies of water which offer possible alternative to once through cooling. The heated effluents may be discharged into the lake at one end and the water for cooling purposes may be withdrawn from the other end. The heat is eventually dissipated through evaporation.

These lakes have to be rejuvenated continuously. A number of methods have been suggested and developed for converting the thermal effluents from power plants into useful heat resources for maximising the benefits.

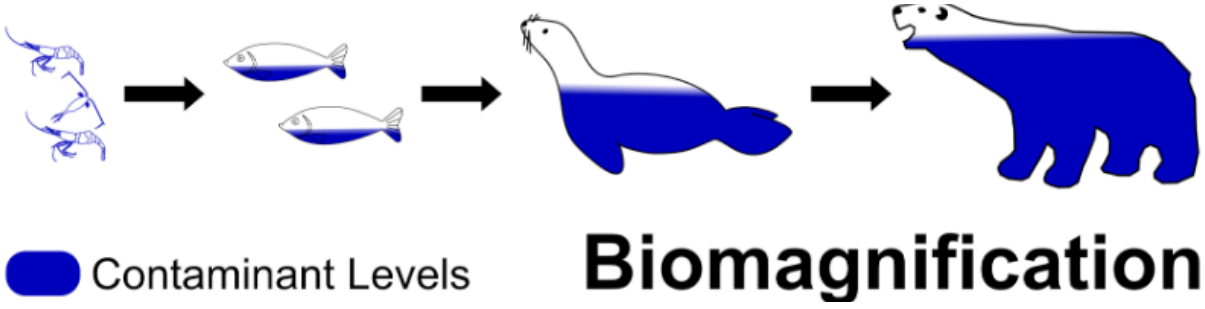
BIOACCUMULATION AND BIOMAGNIFICATION

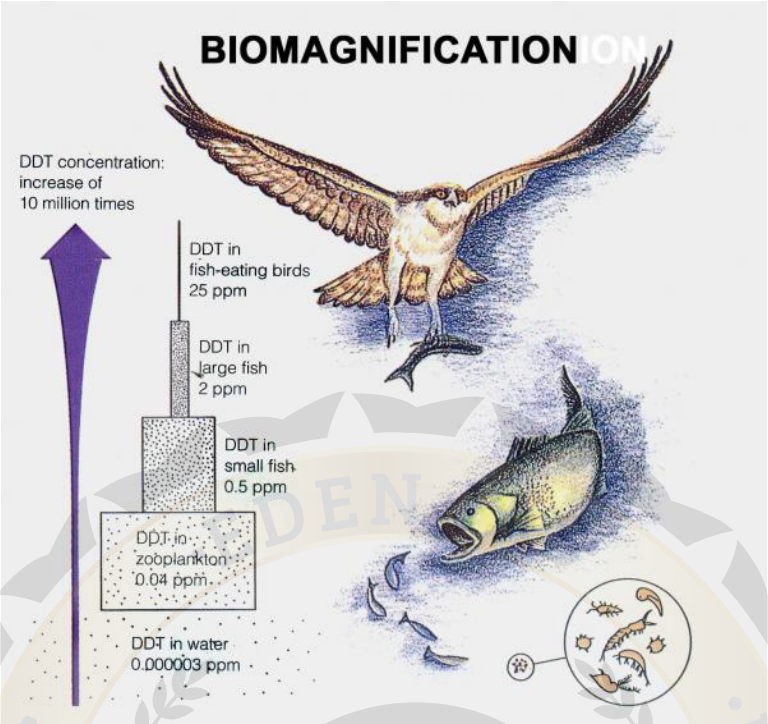
BIOACCUMULATION

It is a process by which certain toxic substances (such as heavy metals and polychlorinated biphenyls) accumulate and keep on accumulating in living organisms, posing a threat to health, life, and to the environment. Also called bioconcentration or biological concentration

BIOMAGNIFICATION

Biomagnification, also known as bioamplification or biological magnification, is the increasing concentration of a substance, such as a toxic chemical, in the tissues of tolerant organisms at successively higher levels in a food chain.

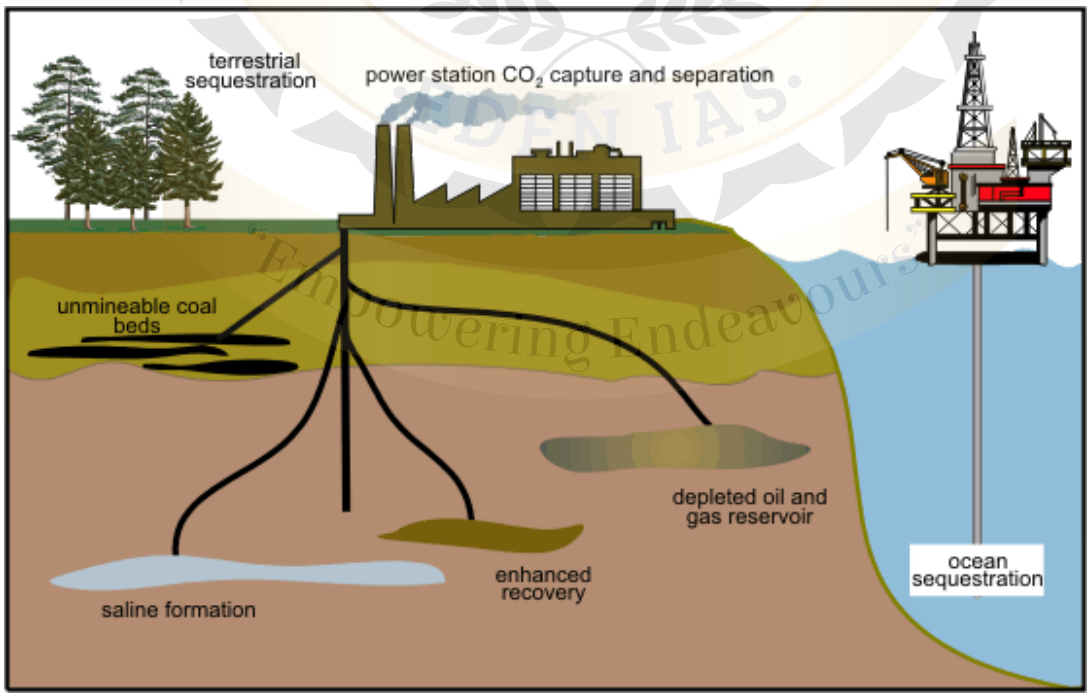




CARBON SEQUESTRATION

Carbon sequestration

Carbon sequestration is the process involved in carbon capture and the long-term storage of atmospheric carbon dioxide or other forms of carbon to mitigate or defer global warming



Usually the surface water is not contaminated with high fluoride, whereas ground water may be contaminated with high fluoride because the usual source of fluoride is fluoride rich rocks. When water percolates through rocks it leaches out the fluoride from these rocks. The rocks rich in fluoride are:

- CaF2 (Sedimentary rocks, lime stones, sand stones)
- Cryolite-Na3AlFP06 (Igneous, Granite)
- Fluorapatite.

Main sources of fluoride for human are Water, Food, Air, Medicament, Cosmetic etc. Although there are several sources of fluoride intake, it is roughly estimated that 60% of the total intake is through drinking water.

The fluoride of food items depends upon the fluoride contents of the soil and water used for irrigation, therefore the fluoride content of the food items may vary from place to place. Prolonged use of certain drugs has been associated with the chronic adverse effects of fluoride e.g. sodium fluoride for treatment of osteoporosis, Niflumic acid for the treatment of rheumatoid arthritis.

The use of fluorides in industry leads to occupational exposure e.g. inorganic fluoride compounds are used in the production of aluminium. Fluorides are also released during the manufacture and the use of phosphate fertilizers.

Water fluoridation is the controlled addition of fluoride to a public water supply to reduce tooth decay. Fluoridated water has fluoride at a level that is effective for preventing cavities, this can occur naturally or by adding fluoride.

Fluoridated water operates on tooth surfaces: in the mouth it creates low levels of fluoride in saliva, which reduces the rate at which tooth enamel demineralizes and increases the rate at which it remineralizes in the early stages of cavities.

The World Health Organization expert committee suggested a level of fluoride from 0.5 to 1.0 mg/L (milligrams per liter), depending on climate. Dental cavities remain a major public health concern in most countries, affecting 60-90% of school children and the vast majority of adults.

Water fluoridation prevents cavities in both children and adults, with studies estimating an 18-40% reduction in cavities when water fluoridation is used by children who already have access to toothpaste and other sources of fluoride.

Although water fluoridation can cause dental fluorosis, which can alter the appearance of developing teeth, most of this is mild and usually not considered to be of aesthetic or public-health concern. Fluoride's effects depend on the total daily intake of fluoride from all sources. Drinking water is typically the largest source of fluoride.

Fluorosis

Ingestion of excess fluoride, most commonly in drinking-water, can cause fluorosis which affects the teeth and bones. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems. Paradoxically, low levels of fluoride intake help to prevent dental caries. The control of drinking-water quality is therefore critical in preventing fluorosis.

Fluorosis is caused by excessive intake of fluoride. The dental effects of fluorosis develop much earlier than the skeletal effects in people exposed to large amounts of fluoride. Clinical dental fluorosis is characterized by staining and pitting of the teeth.

Chronic high-level exposure to fluoride can lead to skeletal fluorosis. In skeletal fluorosis, fluoride accumulates in the bone progressively over many years. The early symptoms of skeletal fluorosis include stiffness and pain in the joints. In severe cases, the bone structure may change and ligaments may calcify, with resulting impairment of muscles and pain. Acute high-level exposure to fluoride causes immediate effects of abdominal pain, excessive saliva, nausea and vomiting.

In India fluorosis is a serious national problem. The seriously affected areas are villages in Andhra Pradesh, Punjab, Haryana, Rajasthan, Uttar Pradesh, Tamil Nadu and Gujarat. The highest concentration, to date, has been reported from Rewari district of Haryana i.e., 48 mg/ L. An estimated 62 million people including 6 million children in India are affected by various types of fluorosis. Although it is difficult to assess exact extent of affected people as the monitoring of ground water of wells and hand pumps is not uniform i.e., all villages of the district are not monitored or samples are taken from some hand pumps in a particular locality ignoring others. As per WHO estimates about 10 to 25% of rural population of various states is at risk.

WHO has set the value of fluoride in drinking water at 1.5 mg/L. However, this guideline value of WHO is not a fixed one but is supposed to be adopted in consideration with the local conditions. Where alternative source of drinking water is not available, de-fluoridation of drinking water is the only remedy. It can be done with the help of bone charcoal. Nalgonda process developed and adopted by National Environmental Engineering Institute (NEERI) can be used at community and household level. The process uses aluminium sulphate to remove fluoride. The floes of aluminium hydroxide formed in the process takes a few hours to settle which may be discarded.

ARSENIC PROBLEM IN DRINKING WATER

Arsenic was a very rarely heard term in the water sector till a few decades back. However, in recent years, the number of areas reporting arsenic contamination has gone up drastically with over 20 countries from different parts of the world reporting arsenic contamination of groundwater. With the constantly increasing number of occurrences, especially in the South Asian region, it is now recognized as a major public health concern affecting a large number of people around the world.

In South Asia, arsenic contamination in groundwater in the Ganga- Brahmaputra fluvial plains in India and Padma-Meghna fluvial plains in Bangladesh has been found to have a huge impact on human health and its consequences have been reported as the world's biggest natural groundwater calamities. In India, West Bengal, Jharkhand, Bihar, Uttar Pradesh in the flood plains of the Ganga, Assam and Manipur in the flood plains of the Brahmaputra and Imphal rivers and Rajnandgaon village in Chhattisgarh state have been reported to be affected by arsenic contamination in groundwater.

What is arsenic?

Arsenic (As) is an odourless and tasteless metalloid widely distributed in the earth's crust. Elemental arsenic is a member of Group VA of the periodic table, with nitrogen, phosphorus, antimony and bismuth. It has an atomic number of 33 and an atomic mass of 74.91.

What are the forms of arsenic available in nature?

Arsenic and its compounds occur in crystalline, powder, amorphous or vitreous forms. It usually occurs in trace quantities in all rocks, soil, water and air. It is the 26th abundant element in the earth's crust.

Which form of arsenic is the most toxic?

Arsenite [As (III)] is most toxic form of arsenic and causes acute toxicity. Forms of arsenic such as As (III) and As (V) lead to chronic toxicity. Previously it was thought that methylated forms of arsenic [MMA (V), DMA (V)] were less toxic. However, current studies indicate that these two forms of arsenic are highly toxic.

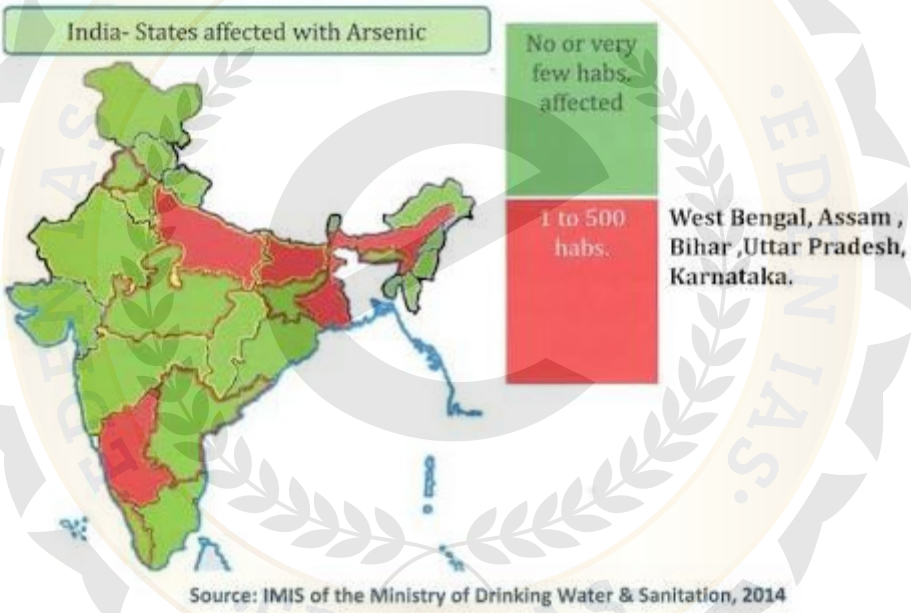
What are the different exposure sources of arsenic?

The exposure sources of arsenic in the environment include natural and anthropogenic sources:

- Natural – Leaching of ambient arsenic in groundwater from sediments containing arsenic bearing minerals; leaching and percolation of arsenic in soils.
- Anthropogenic – Agrochemicals, wood preservatives, industrial sources, mineral processing, acid mine drainage, burning of fossil fuels etc.

How does arsenic enter the human body?
Arsenic can get into the human body through drinking water as well as eating food that has been contaminated with arsenic

How does arsenic get into drinking water?
Because it occurs naturally in the environment and as a by-product of some agricultural and industrial activities, it can enter drinking water through the ground or as runoff into surface water sources.



How does arsenic become a part of the food cycle?
When agricultural fields are irrigated with arsenic contaminated groundwater, inorganic forms of arsenic get absorbed by the plants and hence arsenic enters the food cycle.

Is arsenic always harmful in food?
Arsenic present in inorganic forms as arsenite and arsenate is toxic. However, organic forms of arsenic like arsenobetaine, arsenocholine, arsenosugar, are non-toxic (these forms are mainly present in sea foods).

What happens to the arsenic that gets inside the human body?
Arsenic in drinking water is absorbed through the intestine into the bloodstream through which it reaches the various organs. The human body normally gets rid of smaller amounts of arsenic through urine. However, if there are large amounts of arsenic, the remaining arsenic accumulates inside the body and can lead to adverse health effects. However, the mechanisms underlying the adverse health effects by arsenic are not completely known. The level of accumulated arsenic can be known by investigating nail and hair samples.

What is Arsenicosis?
Arsenicosis is the medical word for arsenic poisoning, which occurs due to accumulation of large amounts of arsenic in the body. Arsenicosis leads to adverse health effects through inhibition of essential enzymes, which ultimately leads to death from multi-system organ failure.

What are the health effects of arsenic poisoning?
Arsenic causes or increases the risk of numerous illnesses. It leads to skin damage including keratosis and skin cancer, internal cancers such as that of the lung and bladder, and diseases of the vascular system. Other health problems, such as diabetes, cancers of the other organs and adverse reproductive outcomes have been observed, but the evidence is not yet conclusive, although it keeps increasing.

What is the accepted standard of arsenic concentration in drinking water?
The guideline value or maximum contaminant level (MCL) for arsenic in drinking water is 10 ppb (according to WHO) followed by most of the developed countries. In developing countries including India and Bangladesh, 50 ppb is considered as the accepted level for arsenic in drinking water.

How much exposure to arsenic contaminated water is expected to result in skin lesions?
Evidence from the field has indicated that people drinking arsenic contaminated water for a couple of years may show arsenical skin lesions. The risk has been found to be more among people who are exposed to water contaminated with arsenic above levels of 500 µg/l . However, studies also indicate that even when exposed to a similar risk, all individuals do not display symptoms of skin lesions. The exact reason for this is not yet known.

Can one use surface water and rainwater and dug well water as an arsenic free drinking water source? How?
These sources can be used for drinking after proper treatment against bacterial contamination and other toxins. Most of the dug wells are arsenic safe, but some of the dug wells could be contaminated with arsenic. Surface water is not usually contaminated with arsenic.

Does boiling remove arsenic from water?
No, arsenic cannot be removed by boiling as it is not a volatile substance. Rather, its concentration increases as water evaporates during boiling.

Is arsenicosis contagious?
No, it is not contagious.

How can one know if their tube well is arsenic contaminated?
Arsenic has no distinctive taste, colour and odour. After proper collection and preservation, the water sample has to be analyzed for arsenic from an authorized analytical laboratory. Certified field kits can also serve the purpose, but these kits are only indicative in nature and not conclusive.

What are the biomarkers of arsenic?
Hair, nails, urine and skin scales of the person consuming arsenic contaminated water.

Are results based on field kit analysis a reliable method to assess the presence of arsenic in water?
Field kit analysis results may be accepted as an indicative result and may be conclusively accepted only after verification with laboratory procedures of testing. In the past, it has been observed that field kit analysis results have often turned out to be inaccurate.

Can arsenic affect an unborn child?
Although there is no evidence that arsenic can harm pregnant women or their fetuses, studies in animals have shown that doses of arsenic that are large enough to cause illness in pregnant females may cause low birth weight, fetal malformations, or fetal death.

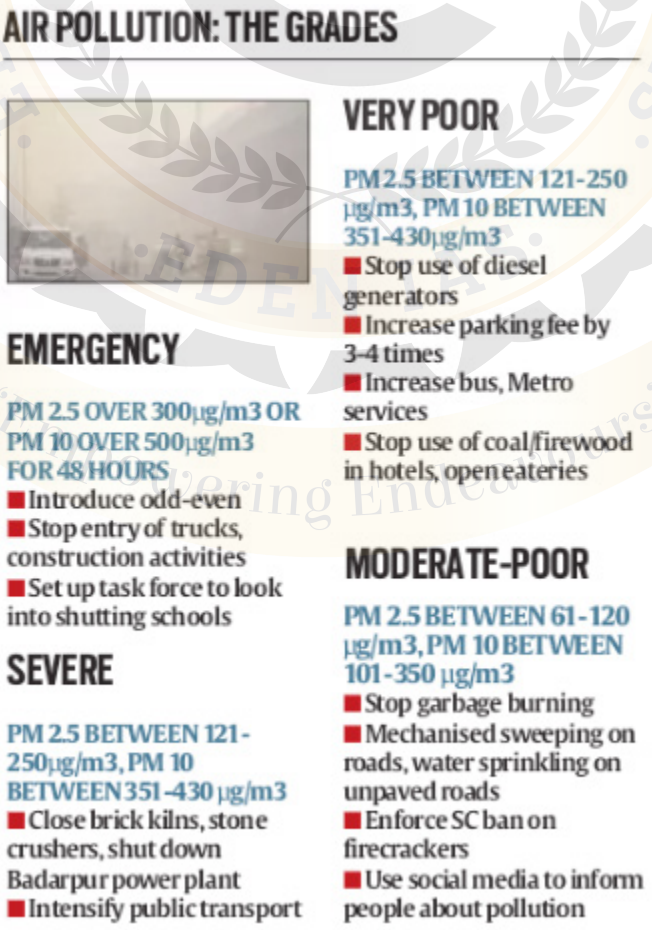
GRADED RESPONSE ACTION PLAN (GRAP)

A Graded Response Action Plan is a set of stratified actions that are taken once the pollution level reaches a certain specified limit. The Supreme Court had mandated the Environmental Pollution Control Authority (EPCA) to come up with such a plan. The Union Environment Ministry has recently announced this plan for Delhi and National Capital Region.

There are several limits specified under the plan. The limits are that of the pollution level or more specifically the concentration of Particulate Matter. When the concentration reaches a certain limit say, 100 micrograms per cubic metre of Particulate Matter, several steps to control pollution has to start, like water sprinkling on the roads, sweeping roads more often, etc.

When the pollutant concentration reaches a little higher level, there can be a ban imposed on firecrackers, and other fuel use, etc. It is the task of the Environmental Pollution Control Authority to find out the particulate matter levels in each state by the help of a task force. Then a proper scrutiny is done regarding the concentration levels. If it reaches the specified limit in any state, the Environmental Pollution Control Authority orders various departments to start functioning in order to control these levels. The various departments are given a set of various tasks beforehand.

These departments might include the transport department, public works department, etc. They are supposed to carry out these tasks so that the pollution level is controlled at an early stage. It is called a 'graded' plan because it does its function step by step. There are separate tasks for separate pollution concentration levels. In this way, gradually, pollution control is done. But it is not the role of any one specific department. It is a task of several departments coordinated together. The main objective of the plan is to avoid strict pollution control measures all of a sudden and respond to the problem gradually.



Key Facts

- Graded Response Action Plan defines the measures to taken based on air quality on the basis of PM 2.5 and PM 10 in the atmosphere.
- Based on the air quality the grades have been classified as Emergency, Severe, Very Poor and Moderate poor. It will be enforced by Environment Pollution Control Authority (EPCA).
- Under this plan emergency measures will be automatically enforced in NCR if level of PM2.5 breaches 300 micrograms per cubic metre (µgm/m3) and PM10 levels stay above 500 (µgm/m3) for two consecutive days.
- The plan recommends measures like odd-even car rationing scheme and ban on construction activities to combat air pollution.
- During 'very poor' air quality, it recommends banning diesel generators and parking fee increased by three to four times.
- It also lists a number of other measures such as closing brick kilns, stone crushers, hot mix plants and intensifying public transport services and increasing the frequency of mechanised cleaning and sprinkling of water on roads

For enforcement of the action plan, the Union Government has assigned the task of implementation of the Graded Response Action Plan to the EPCA (Environment Pollution Control Authority) in pursuance of sub-section (1) of section 3 of the Environment (Protection) Act, 1986 (29 of 1986).

The Delhi specific comprehensive action plan was prepared by the Central Pollution Control Board (CPCB) and was submitted to the Supreme Court in December 2016. The court had accepted the plan and asked the Union Government to notify it.

NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)

Ambient air quality refers to the condition or quality of air surrounding us in the outdoors. National Ambient Air Quality Standards are the standards for ambient air quality set by the Central Pollution Control Board (CPCB) that is applicable nationwide. The CPCB has been conferred this power by the Air (Prevention and Control of Pollution) Act, 1981.

Ambient Air Quality Standards in India

The Air (Prevention and Control of Pollution) Act 1981 was enacted by the Central Government with the objective of arresting the deterioration of air quality. The Air (Prevention and Control of Pollution) Act 1981 describes the main functions of the Central Pollution Control Board (CPCB) as follows:

- To advise the Central Government on any matter concerning the improvement of the quality the air and the prevention, control and abatement of air pollution.
- To plan and cause to be executed a nation-wide programme for the prevention, control and abatement of air pollution.
- To provide technical assistance and guidance to the State Pollution Control Board
- To carry out and sponsor investigations and research related to prevention, control and abatement of air pollution.
- To collect, compile and publish technical and statistical data related to air pollution; and
- To lay down and annul standards for the quality of air

The mandate provided to the CPCB under the Air (Prevention and Control of Pollution) Act empowers it to set standards for the quality of air

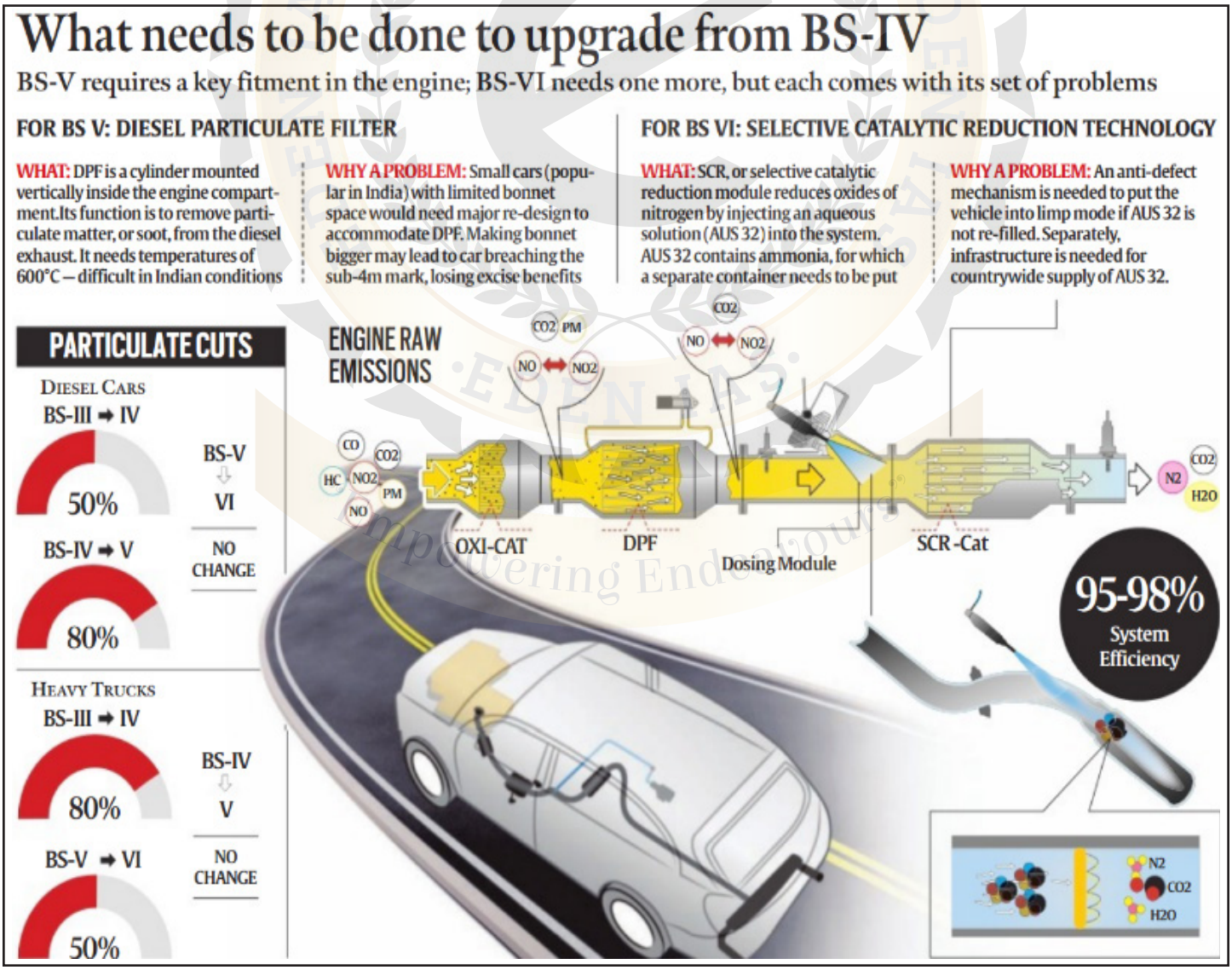
BS-NORMS

Bharat stage emission standards {BSES} are emission standards instituted by the Government of India to regulate the output of air pollutants from internal combustion engines and Spark-ignition engines equipment, including motor vehicles. The standards and the timeline for implementation are set by the Central Pollution Control Board under the Ministry of Environment & Forests and climate change.

The standards, based on European regulations were first introduced in 2000. Progressively stringent norms have been rolled out since then. All new vehicles manufactured after the implementation of the norms have to be compliant with the regulations. Since October 2010, Bharat Stage (BS) III norms have been enforced across the country. In 13 major cities, Bharat Stage IV emission norms have been in place since April 2010 and it has been enforced for entire country since April 2017. In 2016, the Indian government announced that the country would skip the BS-V norms altogether and adopt BS-VI norms by 2020. In its recent judgment, the Supreme Court has banned the sale and registration of motor vehicles conforming to the emission standard Bharat Stage-IV in the entire country from April 1, 2020.

Difference between BS-IV and the new BS-VI:

The major difference in standards between the existing BS-IV and the new BS-VI auto fuel norms is the presence of sulphur. The newly introduced fuel is estimated to reduce the amount of sulphur released by 80%, from 50 parts per million to 10 ppm. As per the analysts, the emission of NOx (nitrogen oxides) from diesel cars is also expected to reduce by nearly 70% and 25% from cars with petrol engines.



Why is it important to upgrade these norms?

Upgrading to stricter fuel standards helps tackle air pollution. Global automakers are betting big on India as vehicle penetration is still low here, when compared to developed countries. At the same time, cities such as Delhi are already being listed among those with the poorest air quality in the world. The national capital's recent odd-even car experiment and judicial activism against the registration of big diesel cars shows that governments can no longer afford to relax on this front.

With other developing countries such as China having already upgraded to the equivalent of Euro V emission norms a while ago, India has been lagging behind. The experience of countries such as China and Malaysia shows that poor air quality can be bad for business. Therefore, these reforms can put India ahead in the race for investments too.

CARCINOGENS

A carcinogen is any substance, radionuclide, or radiation that promotes carcinogenesis, the formation of cancer. This may be due to the ability to damage the genome or to the disruption of cellular metabolic processes. Several radioactive substances are considered carcinogens, but their carcinogenic activity is attributed to the radiation, for example gamma rays and alpha particles, which they emit. Common examples of non-radioactive carcinogens are inhaled asbestos, certain dioxins, and tobacco smoke. Although the public generally associates carcinogenicity with synthetic chemicals, it is equally likely to arise in both natural and synthetic substances. Carcinogens are not necessarily immediately toxic; thus, their effect can be insidious.

Cancer is any disease in which normal cells are damaged and do not undergo programmed cell death as fast as they divide via mitosis. Carcinogens may increase the risk of cancer by altering cellular metabolism or damaging DNA directly in cells, which interferes with biological processes, and induces the uncontrolled, malignant division, ultimately leading to the formation of tumors. Usually, severe DNA damage leads to programmed cell death, but if the programmed cell death pathway is damaged, then the cell cannot prevent itself from becoming a cancer cell.

Carcinogen	Associated cancer sites or types	Occupational uses or sources
Arsenic and its compounds	• Lung • Skin • Hemangiosarcoma	• Smelting byproduct • Component of: ○ Alloys ○ Electrical and semiconductor devices ○ Medications (e.g. melarsoprol) ○ Herbicides ○ Fungicides ○ Animal dips ○ Drinking water from contaminated aquifers.

Asbestos	• Lungs
	• Asbestosis
	• Gastrointestinal tract
	• Pleural Mesothelioma
	• Peritoneal Mesothelioma
		Not in widespread use, but found in:
		• Constructions
		  ○ Roofing papers
		  ○ Floor tiles
		• Fire-resistant textiles
		• Friction linings (brake pads) (only outside Europe)
		  ○ Replacement friction linings for automobiles still may contain asbestos

Benzene	• Leukemia • Hodgkin's lymphoma	• Light fuel oil • Former use as solvent and fumigant • Printing • Lithography • Paint • Rubber • Dry cleaning • Adhesives • Coatings • Detergents

Beryllium and its compounds	• Lung	• Missile fuel
		• Lightweight alloys
		  ○ Aerospace applications
		  ○ Nuclear reactors

Cadmium and its compounds	• Prostate	• Yellow pigments • Phosphors • Solders • Batteries • Metal paintings and coatings
Hexavalent chromium(VI) compounds	• Lung	• Paints • Pigments • Preservatives
IC engine exhaust gas	• Lung • Bladder	• Exhaust gas from engines

Ethylene oxide	• Leukemia	• Ripening agent for fruits and nuts • Rocket propellant • Fumigant for foodstuffs and textiles • Sterilant for hospital equipment
Nickel	• Nose • Lung	• Nickel plating • Ferrous alloys • Ceramics • Batteries • Stainless-steel welding by-product

Radon and its decay products	• Lung	• Uranium decay
		  ○ Quarries and mines
		  ○ Cellars and poorly ventilated places

Vinyl chloride	• Hemangiosarcoma • Liver	• Refrigerant • Production of polyvinyl chloride • Adhesive for plastics • Former use in pressurized containers
Shift work that involves circadian disruption	• Breast	
Involuntary smoking (Passive smoking)	• Lung	
Radium-226, Radium-224, Plutonium-238, Plutonium-239 and other alpha particle emitters with high atomic weight	• Bone (they are bone seekers) • Liver	• Nuclear fuel processing • Radium dial manufacturing

UNIT-IX

[WASTE MANAGEMENT]

SOLID WASTE MANAGEMENT

What is Solid Waste?

Solid waste is the unwanted or useless solid materials generated from human activities in residential, industrial or commercial areas. It may be categorised in three ways. According to its:

- Origin (domestic, industrial, commercial, construction or institutional)
- Contents (organic material, glass, metal, plastic paper etc)
- Hazard potential (toxic, non-toxin, flammable, radioactive, infectious etc).

Types of Solid Waste

It can be classified into different types depending on their source:

Municipal Solid Waste (MSW): It consists of household waste, construction and demolition debris (CnD), sanitation residue, and waste from streets, generated mainly from residential and commercial complexes. As per the MoEF it includes commercial and residential waste generated in municipal or notified areas in either solid or semi-solid form excluding industrial hazardous wastes but including treated bio-medical wastes;

Industrial Solid Waste (ISW): In a majority of cases it is termed as hazardous waste as they may contain toxic substances, are corrosive, highly inflammable, or react when exposed to certain things e.g. gases.

Biomedical waste or hospital waste: It is usually infectious waste that may include waste like sharps, soiled waste, disposables, anatomical waste, cultures, discarded medicines, chemical wastes, etc., usually in the form of disposable syringes, swabs, bandages, body fluids, human excreta, etc. These can be a serious threat to human health if not managed in a scientific and discriminate manner.

What is Solid Waste Management?

Solid waste management is a term that is used to refer to the process of collecting and treating solid wastes. It also offers solutions for recycling items that do not belong to garbage or trash. As long as people have been living in settlements and residential areas, garbage or solid waste has been an issue. Waste management is all about how solid waste can be changed and used as a valuable resource. Solid waste management should be embraced by each and every household including the business owners across the world. Industrialization has brought a lot of good things and bad things as well. One of the negative effects of industrialization is the creation of solid waste.

Various Sources of Solid Waste

Every day, tonnes of solid waste is disposed off at various landfill sites. This waste comes from homes, offices, industries and various other agricultural related activities. These landfill sites produce foul smell if waste is not stored and treated properly. It can pollute the surrounding air and can seriously affect the health of humans, wildlife and our environment. The following are major sources of solid waste:

Residential

Residences and homes where people live are some of the major sources of solid waste. Garbage from these places include food wastes, plastics, paper, glass, leather, cardboard, metals, yard wastes, ashes and special wastes like bulky household items like electronics, tires, batteries, old mattresses and used oil. Most homes have garbage bins where they can throw away their solid wastes in and later the bin is emptied by a garbage collecting firm or person for treatment.

Industrial

Industries are known to be one of the biggest contributors of solid waste. They include light and heavy manufacturing industries, construction sites, fabrication plants, canning plants, power and chemical plants. These industries produce solid waste in form of housekeeping wastes, food wastes, packaging wastes, ashes, construction and demolition materials, special wastes, medical wastes as well as other hazardous wastes.

Commercial

Commercial facilities and buildings are yet another source of solid waste today. Commercial buildings and facilities in this case refer to hotels, markets, restaurants, go downs, stores and office buildings. Some of the solid wastes generated from these places include plastics, food wastes, metals, paper, glass, wood, cardboard materials, special wastes and other hazardous wastes.

Institutional

The institutional centers like schools, colleges, prisons, military barracks and other government centers also produce solid waste. Some of the common solid wastes obtained from these places include glass, rubber waste, plastics, food wastes, wood, paper, metals, cardboard materials, electronics as well as various hazardous wastes.

Construction and Demolition Areas

Construction sites and demolition sites also contribute to the solid waste problem. Construction sites include new construction sites for buildings and roads, road repair sites, building renovation sites and building demolition sites. Some of the solid wastes produced in these places include steel materials, concrete, wood, plastics, rubber, copper wires, dirt and glass.

Municipal services

The urban centers also contribute immensely to the solid waste crisis in most countries today. Some of the solid waste brought about by the municipal services include, street cleaning, wastes from parks and beaches, wastewater treatment plants, landscaping wastes and wastes from recreational areas including sludge.

Treatment Plants and Sites

Heavy and light manufacturing plants also produce solid waste. They include refineries, power plants, processing plants, mineral extraction plants and chemicals plants. Among the wastes produced by these plants include, industrial process wastes, unwanted specification products, plastics, metal parts just to mention but a few.

Agriculture

Crop farms, orchards, dairies, vineyards and feedlots are also sources of solid wastes. Among the wastes they produce include agricultural wastes, spoiled food, pesticide containers and other hazardous materials.

Biomedical

This refers to hospitals and biomedical equipment and chemical manufacturing firms. In hospitals there are different types of solid wastes produced. Some of these solid wastes include syringes, bandages, used gloves, drugs, paper, plastics, food wastes and chemicals. All these require proper disposal or else they will cause a huge problem to the environment and the people in these facilities.

METHODS OF SOLID WASTE MANAGEMENT

Sanitary Land Filling:

In a sanitary landfill, garbage is spread out in thin layers, compacted and covered with clay or plastic foam. In the modern landfills the bottom is covered with an impermeable liner, usually several layers of clay, thick plastic and sand. The liner protects the ground water from being contaminated due to percolation of leachate.

Leachate from bottom is pumped and sent for treatment. When landfill is full it is covered with clay, sand, gravel and top soil to prevent seepage of water. Several wells are drilled near the landfill site to monitor if any leakage is contaminating ground water. Methane produced by anaerobic decomposition is collected and burnt to produce electricity or heat. Sanitary Landfills Site Selection:

- Should be above the water table, to minimize interaction with groundwater.
- Preferably located in clay or silt.
- Do not want to place in a rock quarry, as water can leech through the cracks inherent in rocks into a water fracture system.
- Do not want to locate in sand or gravel pits, as these have high leeching. Unfortunately, most of Long Island is sand or gravel, and many landfills are located in gravel pits, after they were no longer being used.
- Do not want to locate in a flood plain. Most garbage tends to be less dense than water, so if the area of the landfill floods, the garbage will float to the top and wash away downstream.

A large number of adverse impacts may occur from landfill operations. These impacts can vary:

- Fatal accidents (e.g., scavengers buried under waste piles).
- Infrastructure damage (e.g., damage to access roads by heavy vehicles).
- Pollution of the local environment (such as contamination of groundwater and/or aquifers by leakage and residual soil contamination during landfill usage, as well as after landfill closure).
- Off gassing of methane generated by decaying organic wastes (methane is a greenhouse gas many times more potent than carbon dioxide, and can itself be a danger to inhabitants of an area).
- Harbouring of disease vectors such as rats and flies, particularly from improperly operated landfills.

Incineration:

The term incinerates means to burn something until nothing is left but ashes. An incinerator is a unit or facility used to burn trash and other types of waste until it is reduced to ash. An incinerator is constructed of heavy, well-insulated materials, so that it does not give off extreme amounts of external heat.

The high levels of heat are kept inside the furnace or unit so that the waste is burned quickly and efficiently. If the heat were allowed to escape, the waste would not burn as completely or as rapidly. Incineration is a disposal method in which solid organic wastes are subjected to combustion so as to convert them into residue and gaseous products. This method is useful for disposal of residue of both solid waste management and solid residue from waste water management. This process reduces the volumes of solid waste to 20 to 30 per cent of the original volume.

Incineration and other high temperature waste treatment systems are sometimes described as "thermal treatment". Incinerators convert waste materials into heat, gas, steam and ash. Incineration is carried out both on a small scale by individuals and on a large scale by industry. It is used to dispose of solid, liquid and gaseous waste. It is recognized as a practical method of disposing of certain hazardous waste materials. Incineration is a controversial method of waste disposal, due to issues such as emission of gaseous pollutants.

Composting:

Due to shortage of space for landfill in bigger cities, the biodegradable yard waste (kept separate from the municipal waste) is allowed to degrade or decompose in a medium. A good quality nutrient rich and environmental friendly manure is formed which improves the soil conditions and fertility.

Organic matter constitutes 35%-40% of the municipal solid waste generated in India. This waste can be recycled by the method of composting, one of the oldest forms of disposal. It is the natural process of decomposition of organic waste that yields manure or compost, which is very rich in nutrients.

Composting is a biological process in which micro-organisms, mainly fungi and bacteria, convert degradable organic waste into humus like substance. This finished product, which looks like soil, is high in carbon and nitrogen and is an excellent medium for growing plants.

The process of composting ensures the waste that is produced in the kitchens is not carelessly thrown and left to rot. It recycles the nutrients and returns them to the soil as nutrients. Apart from being clean, cheap, and safe, composting can significantly reduce the amount of disposable garbage.

The organic fertilizer can be used instead of chemical fertilizers and is better specially when used for vegetables. It increases the soil's ability to hold water and makes the soil easier to cultivate. It helped the soil retain more of the plant nutrients.

Vermi-composting has become very popular in the last few years. In this method, worms are added to the compost. These help to break the waste and the added excreta of the worms makes the compost very rich in nutrients. In the activity section of this web site you can learn how to make a compost pit or a vermi-compost pit in your school or in the garden at home.

To make a compost pit, you have to select a cool, shaded corner of the garden or the school compound and dig a pit, which ideally should be 3 feet deep. This depth is convenient for aerobic composting as the compost has to be turned at regular intervals in this process.

Preferably the pit should be lined with granite or brick to prevent nitrite pollution of the subsoil water, which is known to be highly toxic. Each time organic matter is added to the pit it should be covered with a layer of dried leaves or a thin layer of soil which allows air to enter the pit thereby preventing bad odour. At the end of 45 days, the rich pure organic matter is ready to be used. Composting: some benefits

- Compost allows the soil to retain more plant nutrients over a longer period.
- It supplies part of the 16 essential elements needed by the plants.
- It helps reduce the adverse effects of excessive alkalinity, acidity, or the excessive use of chemical fertilizer.
- It makes soil easier to cultivate.
- It helps keep the soil cool in summer and warm in winter.
- It aids in preventing soil erosion by keeping the soil covered.
- It helps in controlling the growth of weeds in the garden.

Pyrolysis:

Pyrolysis is a form of incineration that chemically decomposes organic materials by heat in the absence of oxygen. Pyrolysis typically occurs under pressure and at operating temperatures above 430 °C (800 °F).

In practice, it is not possible to achieve a completely oxygen-free atmosphere. Because some oxygen is present in any pyrolysis system, a small amount of oxidation occurs. If volatile or semi-volatile materials are present in the waste, thermal desorption will also occur.

Organic materials are transformed into gases, small quantities of liquid, and a solid residue containing carbon and ash. The off-gases may also be treated in a secondary thermal oxidation unit. Particulate removal equipment is also required. Several types of pyrolysis units are available, including the rotary kiln, rotary hearth furnace, and fluidized bed furnace. These units are similar to incinerators except that they operate at lower temperatures and with less air supply.

Limitations and Concerns:

- The technology requires drying of soil prior to treatment.
- Limited performance data are available for systems treating hazardous wastes containing polychlorinated biphenyls (PCBs), dioxins, and other organics. There is concern that systems that destroy chlorinated organic molecules by heat have the potential to create products of incomplete combustion, including dioxins and furans. These compounds are extremely toxic in the parts per trillion ranges. The MSO process reportedly does not produce dioxins and furans.
- The molten salt is usually recycled in the reactor chamber. However, depending on the waste treated (especially inorganics) and the amount of ash, spent molten salt may be hazardous and require special care in disposal.
- Pyrolysis is not effective in either destroying or physically separating in organics from the contaminated medium. Volatile metals may be removed as a result of the higher temperatures associated with the process, but they are not destroyed. By-products containing heavy metals may require stabilization before final disposal.
- When the off-gases are cooled, liquids condense, producing an oil/tar residue and contaminated water. These oils and tars may be hazardous wastes, requiring proper treatment, storage, and disposal.

SOLID WASTE MANAGEMENT IN INDIA

Solid waste management

- **Centralised method**: This method involves collection of municipal waste from all over the local area and by means of land filling, dump outside the city/nagar panchayat limits. This process looks at door-to-door collection of solid waste by waste pickers who hand over to the collection team who then discard the collected waste in the landfill. The waste pickers are employees of the Municipal Corporation or Nagar Panchayat. The collection team is generally contracted out by a tendering process.

- **De-centralized method**: This is a model seen in a few places like Suryapet in Andhra Pradesh and Bangalore in Karnataka. The waste is collected ward-wise and is segregated at source into bio-degradable and non-biodegradable. The biodegradable waste is composted at a nearby facility by different methods of aerobic and anerobic composting. The non-biodegradable waste is further categorised into paper, plastic, metal and other waste and then further collected by recyclers for up-cycling or downcycling of products

Treatment methods for solid waste

- Thermal treatment: Incineration is the combustion of waste in the presence of oxygen, so that the waste is converted into carbon dioxide, water vapour and ash. Also labeled Waste to Energy (WtE) method, it is a means of recovering energy from the waste. It's advantages include waste volume reduction, cutback on transportation costs and reduction of greenhouse gas emissions. However, when garbage is burned, pollutants, such as mercury, lead, dioxins may be released into the atmosphere, and cause health issues.

- Pyrolysis and gasification: In this method, thermal processing is in complete absence of oxygen or with less amount of air.

- Biological treatment methods: This involves using micro-organisms to decompose the biodegradable components of waste. The 2 types of processes: Aerobic: This needs the presence of oxygen and includes windrow composting, aerated static pile composting & in-vessel composting, vermi-culture etc. Anaerobic digestion: Takes place in the absence of oxygen.

- Landfills and open dumping: Sanitary landfills: It is the controlled disposal of waste on land in such a way that contact between waste and the environment is significantly reduced and the waste is concentrated in a well defined area. Dumps are open areas where waste is dumped exposing it to natural elements, stray animals and birds. With the absence of any kind of monitoring and no leachate collection system, this leads to the contamination of both land and water resources.

Integrated Solid Waste Management (ISWM):

Recycling

Recycling is when waste is converted into something useful. It reduces the amount of waste that needs to be treated, the cost of its handling, its disposal to landfills and environmental impacts. It also reduces the amount of energy required to produce new products and thus helps conserve natural resources. Upcycling and downcycling are two common words used when it comes to recycling. Upcycling implies upgrading of a commodity by different processes of recycling. An example of upcycling is to make roads out of cheap plastic. Downcycling implies downgrading a commodity by different processes of recycling. An example of downcycling is breaking down of high quality plastics at high temperature into different lower quality plastics.

There are a large set of informal waste collectors in India. They are called local waste dealers or 'Kabadi-wallahs'. They collect and sort dry waste into aluminium, plastic, paper, glass, etc. Each waste has a price fixed in the waste market. In some cases, these local waste dealers have tie ups with waste pickers who supply to them the waste from nearby areas. In addition to the waste pickers, the dealers also collect dry waste from individuals, apartments and institutions.

Responsibility & stakeholders

Solid Waste Management is a state subject and it is the responsibility of the state government to ensure that appropriate solid waste management practices are introduced in all the cities and towns in the state. However, SWM is a municipal function and it is the urban local bodies (ULB) that are directly responsible for it. The ULBs are required to plan, design, operate, and maintain the SWM in their respective cities/ towns. India's 4378 municipalities spend a lot of money handling waste. Between 10% to 50% of the municipal budget is allocated for SWM and between 30% to 50% of the total staff are typically engaged in SWM. This critical service, if performed poorly, results in deterioration of health, sanitation and environmental degradation. Incorrect choice of technology, lack of public participation, financial constraints, institutional weakness, are factors that prevent a ULB from providing satisfactory service. The ULBs need both support and guide to manage the solid waste in a scientific and cost effective manner.The role of the Government is broadly to formulate policy guidelines and provide technical assistance to the states/cities whenever needed. It also assists the state governments and local bodies in human resource development and acts as an intermediary in mobilizing external assistance for implementation of solid waste management projects.

There are several NGOs, waste trade unions and experts who have become crucial stakeholders. A few well recognised people and organisations are: Chintan in Delhi, Swacha in Pune, Stree Mukti Sangathan in Mumbai, Solid Waste Management Round Table and Hasiru Dala in Bangalore.

Rules and regulations associated with SWM

Under the 74th Constitutional Amendment, Disposal and management of Municipal Solid Waste is one of the 18 functional domains of the Municipal Corporations and Nagar Panchayats. The various rules and regulations for solid waste management are:

1. The Bio-Medical Waste (Management And Handling) Rules, 1998
2. Municipal Solid Waste (Management And Handling) Rules 2000
3. The Plastic Waste (Management And Handling) Rules, 2011
4. E-Waste (Management And Handling) Rules, 2011

There are other court cases that find their importance in terms of Solid Waste Management in India:

1. Almitra Patel vs. Union of India
2. B.L Wadhera vs. Union of India.
3. Judgement of Karnataka High Court towards Mandatory Segregation at Source

Ragpickers/ manual scavenging

Waste Management also has several informal players such as ragpickers. They work in dump sites, garbage spots in local areas and trade in their collected waste with local dealers. These local dealers are called Kabadiwallahs. The large network of informal sector also aids in managing of waste effectively at

local levels as the Kabadiwallahs are connected to the formal group of recyclers who come and pick up the bulk quantity of waste. There is a National Body of Ragpickers in India. They are called the NSWAI- National Solid Waste Association of India. Formed on 25th January 1996, the association is also a member of the International Solid Waste Association (ISWA), and provides a forum for the exchange of information and expertise in the field of Solid Waste Management at the international level.

SOLID WASTE MANAGEMENT RULES, 2018

- The Rules are now applicable beyond Municipal areas and extend to urban agglomerations, census towns, notified industrial townships, areas under the control of Indian Railways, airports, airbase, Port and harbour, defence establishments, special economic zones, State and Central government organizations, places of pilgrims, religious & historical importance.
- The source segregation of waste has been mandated to channelize the waste to wealth by recovery, reuse and recycle.
- Responsibilities of Generators have been introduced to segregate waste in to three streams, Wet (Biodegradable), Dry (Plastic, Paper, metal, wood, etc.) and domestic hazardous wastes (diapers, napkins, empty containers of cleaning agents, mosquito repellents, etc.) and handover segregated wastes to authorized rag-pickers or waste collectors or local bodies.
- Integration of waste pickers/ rag pickers and waste dealers/ Kabadiwalas in the formal system should be done by State Governments, and Self Help Group, or any other group to be formed.
- No person should throw, burn, or bury the solid waste generated by him, on streets, open public spaces outside his premises, or in the drain, or water bodies.
- Generator will have to pay 'User Fee' to waste collector and for 'Spot Fine' for Littering and Non-segregation.
- Used sanitary waste like diapers, sanitary pads should be wrapped securely in pouches provided by manufacturers or brand owners of these products or in a suitable wrapping material and shall place the same in the bin meant for dry waste / non- bio-degradable waste.
- The concept of partnership in Swachh Bharat has been introduced. Bulk and institutional generators, market associations, event organizers and hotels and restaurants have been made directly responsible for segregation and sorting the waste and manage in partnership with local bodies.
- All hotels and restaurants should segregate biodegradable waste and set up a system of collection or follow the system of collection set up by local body to ensure that such food waste is utilized for composting /bio-methanation.
- All Resident Welfare and market Associations, Gated communities and institution with an area >5,000 sq. m should segregate waste at source- in to valuable dry waste like plastic, tin, glass, paper, etc. and handover recyclable material to either the authorized waste pickers or the authorized recyclers, or to the urban local body.
- The bio-degradable waste should be processed, treated and disposed of through composting or bio-methanation within the premises as far as possible. The residual waste shall be given to the waste collectors or agency as directed by the local authority.
- The bio-degradable waste should be processed, treated and disposed of through composting or bio-methanation within the premises as far as possible. The residual waste shall be given to the waste collectors or agency as directed by the local authority.
- New townships and Group Housing Societies have been made responsible to develop in-house waste handling, and processing arrangements for bio-degradable waste.

- Every street vendor should keep suitable containers for storage of waste generated during the course of his activity such as food waste, disposable plates, cups, cans, wrappers, coconut shells, leftover food, vegetables, fruits etc. and deposit such waste at waste storage depot or container or vehicle as notified by the local authority.
- The developers of Special Economic Zone, industrial estate, industrial park to earmark at least 5% of the total area of the plot or minimum 5 plots/ sheds for recovery and recycling facility.
- All manufacturers of disposable products such as tin, glass, plastics packaging etc. or brand owners who introduce such products in the market shall provide necessary financial assistance to local authorities for the establishment of waste management system.
- All such brand owners who sale or market their products in such packaging material which are non-biodegradable should put in place a system to collect back the packaging waste generated due to their production.
- Manufacturers or Brand Owners or marketing companies of sanitary napkins and diapers should explore the possibility of using all recyclable materials in their products or they shall provide a pouch or wrapper for disposal of each napkin or diapers along with the packet of their sanitary products.
- All such manufacturers, brand owners or marketing companies should educate the masses for wrapping and disposal of their products.
- All industrial units using fuel and located within 100 km from a solid waste based RDF plant shall make arrangements within six months from the date of notification of these rules to replace at least 5 % of their fuel requirement by RDF so produced.
- Non-recyclable waste having calorific value of 1500 K/cal/kg or more shall not be disposed of on landfills and shall only be utilized for generating energy either or through refuse derived fuel or by giving away as feed stock for preparing refuse derived fuel.
- High calorific wastes shall be used for co-processing in cement or thermal power plants.
- Construction and demolition waste should be stored, separately disposed off, as per the Construction and Demolition Waste Management Rules, 2016
- Horticulture waste and garden waste generated from his premises should be disposed as per the directions of local authority.
- An event, or gathering organiser of more than 100 persons at any licensed/ unlicensed place, should ensure segregation of waste at source and handing over of segregated waste to waste collector or agency, as specified by local authority.
- Special provision for management of solid waste in hilly areas:- Construction of landfill on the hill shall be avoided. A transfer station at a suitable enclosed location shall be setup to collect residual waste from the processing facility and inert waste. Suitable land shall be identified in the plain areas, down the hill, within 25 kilometers for setting up sanitary landfill. The residual waste from the transfer station shall be disposed off at this sanitary landfill.
- In case of non-availability of such land, efforts shall be made to set up regional sanitary landfill for the inert and residual waste.

E-WASTE MANAGEMENT IN INDIA

Electronic waste, or e-waste, is a term for electronic products that have become unwanted, obsolete, and have reached the end of their useful life. It refers to all items of electrical and electronic equipment (EEE) and its parts that have been discarded by its owner as waste without the intent of re-use.

What are E-wastes?

E-waste comprises of waste generated from used electronic devices and household appliances which are not fit for their original intended use and are destined for recovery, recycling or disposal. Such wastes encompasses wide range of electrical and electronic devices such as computers, hand held cellular phones, personal stereos, including large household appliances such as refrigerators, air conditioners etc. E-waste contain over 1000 different substances many of which are toxic and potentially hazardous to environment and human health, if these are not handled in an environmentally sound manner.

The last decade has seen a tremendous growth in the manufacturing and consumption of electronic and electrical equipment all over the world. As a consequence of this, combined with rapid product obsolescence, and lower costs, discarded electronic and electrical equipment or 'E-waste' is now the most rapidly growing waste problem in the world. Most companies today design their products for planned or perceived obsolescence. This is reinforced through marketing and retailing practices, and affordability and convenience have taken over from product durability as primary drivers.

Life –Cycle of E-wastes

Producers/manufacturers, retailers, consumers, traders, exporters, scrap dealers, disassemblers/dismantlers, smelters and recyclers are major stakeholders in e-waste supply chain.

E-waste is an emerging problem as well as a business opportunity of increasing significance, given the volumes of E-waste being generated and the content of both toxic and valuable materials in them. The fraction including iron, copper, aluminum, gold and other metals in E-waste is over 60%, while pollutants comprise 2.70%.

Therefore, recycling of E-waste is an important subject not only from the point of waste treatment but also from the recovery aspect of valuable materials. However the process of take-back and disposal of E-waste is very complex, which involves various kinds of products, many people and enterprises, extensive areas, and long time span (sometimes is even over ten years), it is a huge and complicated system.

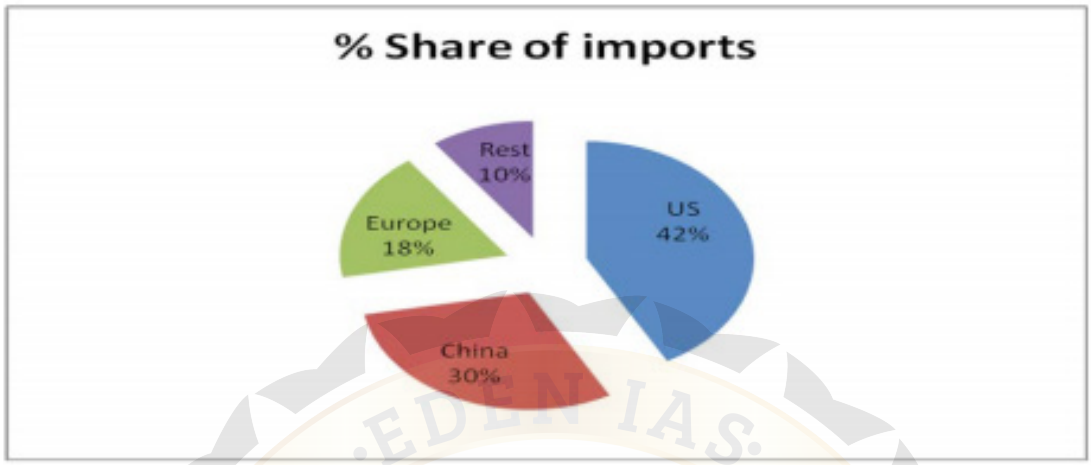
E-WASTE MANAGEMENT IN INDIA

India is the fifth biggest producer of e-waste in the world. In India E-waste collection, transportation, segregation, dismantling, recycling and disposal is done manually by untrained labors in informal sector. Due to low awareness and sensitization e-waste is thrown along with garbage which is collected and segregated by rag pickers. E-waste contains reusable and precious material. Rag pickers sell this E-waste to scrap dealers and run their livelihood. The scrap dealers supply the E-waste to recycling industries. The recyclers use old and hazardous technologies and equipment, to recycle/treat the e-waste. **India's produces nearly 12.5 lakh MTs of E-waste every year**.

India ranks 155 out of 178 nations in Environmental Performance Index. It also ranks poorly in various indicators like 127 in Health Hazards, 174 in Air Quality, 124 in Water and Sanitization

Environmentally Sound Management (ESM) of e-waste will also improve ranking of India in these areas.

India is being used as dumping ground of e-waste by many developed nations. Figure shows % share of e-waste imports in India from different countries.

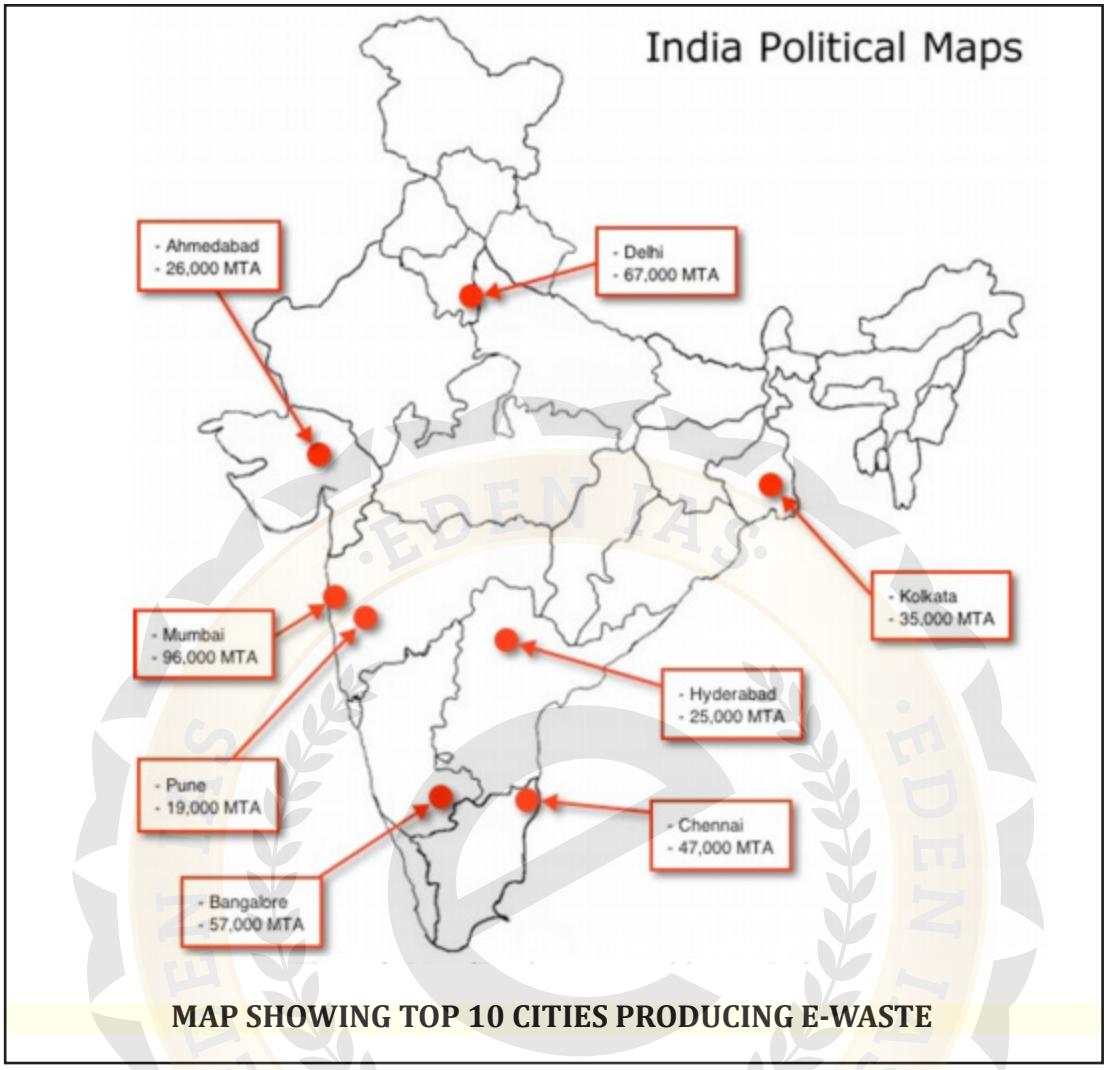


Percentage share of e-waste imports

Looking at the country-wise share in India's e-waste imports, US has a maximum share of around 42%, China at around 30% followed by Europe at around 18% and rest 10% is from other countries like Taiwan, South Korea, Japan etc. 10 States/UT contribute to 70% of the total e-waste generated in the country. While 65 cities generate more than 60% of the total e-waste in India.

Top ten e waste producing states in India

State	E waste MT
Maharashtra	20270.59
Tamil Nadu	13486.24
Andhra Pradesh	12780.33
Uttar Pradesh	10381.11
West Bengal	10059.36
Delhi	9729.15
Karnataka	9118.74
Gujarat	8994.33
Madhya Pradesh	7800.62
Punjab	6958.46



MAP SHOWING TOP 10 CITIES PRODUCING E-WASTE

E-waste HAZARD

E-waste is not hazardous per se. However, the hazardous constituents present in the e-waste render it hazardous when such wastes are dismantled and processed, since it is only at this stage that they pose hazard to health and environment. Electronics and electrical equipment seem efficient and environmentally- friendly, but there are hidden dangers associated with them once these become e-waste. The harmful materials contained in electronics products, coupled with the fast rate at which we're replacing outdated units, pose a real danger to human health if electronics products are not properly processed prior to disposal. Electronics products like computers and cell phones contain a lot of different toxins. For example, cathode ray tubes (CRTs) of computer monitors contain heavy metals such as lead, barium and cadmium, which can be very harmful to health if they enter the water system. These materials can cause damage to the human nervous and respiratory systems. Flame-retardant plastics, used in electronics casings, release particles that damage human endocrine functions. These are the types of things that can happen when unprocessed e-waste is put directly in landfill.

E waste toxins affecting body parts

COMPONENTS	CONSTITUENTS	AFFECTED BODY PARTS
Printed circuit boards	Lead and cadmium	Nervous system and kidney
Mother boards	Beryllium	Lung and skin
CRT Cathode ray tubes	Lead oxide , barium & cadmium	Heart, liver and muscles
Switches and flat screen monitors	Mercury	Brain and skin
Computer	Cadmium	Kidney, liver
Cable insulating	PVC Polyvinyl chloride	Immune system
Plastic housing	Bromine	Endocrine system

Issues related to E-waste in India

1. Volume of E-waste generated
India stands fifth in e-waste generation producing around 1.7 lakhs metric tonnes per annum

2. Involvement of Child Labor
In India, about 4.5 lakh child laborers in the age group of 10-14 are observed to be engaged in various E-waste activities and that too without adequate protection and safeguards in various yards and recycling workshops. So, there is a urgent need to bring out effective legislation to prevent entry of child labor into E-waste market- its collection, segregation and distribution.

3. Ineffective Legislation
There is absence of any public information on most SPCBs/PCC websites. 15 of the 35 PCBs/PCC do not have any information related to E-waste on their websites, their key public interface point. Even the basic E-waste Rules and guidelines have not been uploaded. In absence of any information on their website, specially on details of recyclers and collectors of E-waste, citizens and institutional generators of E- waste are totally at a loss to deal with their waste and do not know how to fulfill their responsibility. So, there is failure in successful implementation of E-waste Management and Handling Rules, 2012.

4. Lack of infrastructure
There is huge gap between present recycling and collection facilities and quantum of E-waste that is being generated. No collection and take back mechanisms are in place. There is lack of recycling facilities.

5. Health hazards
E-waste contains over 1,000 toxic materials, which contaminate soil and ground water. Exposure can cause headache, irritability, nausea, vomiting, and eye pain. Recyclers may suffer liver, kidney and neurological disorders. Due to lack of awareness, they are risking their health and the environment as well.

6. Lack of incentive schemes
No clear guidelines are there for the unorganized sector to handle E-waste. Also no incentives are mentioned to lure people engaged to adopt formal path for handling E-waste. Working conditions in the informal recycling sector are only slightly worse than in the formal sector. No incentive schemes for producers who are doing something to handle e-waste.

7. Poor awareness and sensitization
Limited reach out and awareness regarding disposal, after determining end of useful life. Also Only 2% of individuals think of the impact on environment while disposing off their old electrical and electronic equipment.

8. E-waste imports
Cross-border flow of waste equipment into India- 80 percent of E-waste in developed countries meant for recycling is sent to developing countries such as India, China, Ghana and Nigeria.

9. Reluctance of authorities' involved
Lack of coordination between various authorities responsible for E-waste management and disposal including the non-involvement of municipalities.

10. Security implications
End of life computers often contains sensitive personal information and bank account details which, if not deleted leave opportunity for fraud.

11. Lack of research

Government must encourage research into the development and standards of hazardous waste management, environmental monitoring and the regulation of hazardous waste-disposal.

High cost of setting up recycling facility

In addition, to the above the advanced technology recycling projects (including metallurgy and refining of non ferrous metals) are at further economic disadvantage compared to basic process activities and are in general not economically viable. The formal recycling companies in India except some are only limited to pre-processing of the e-waste material, where the crushed e-waste with precious metals is sent to smelting refineries outside India. Formal sector in India still has a long way to go in adopting state - of-art technologies for e-waste recycling due to problems in sourcing e-waste and partly due to difficulty in making it profitable with high end investment in such superior and costly technologies.

E-waste policy and regulation

The Policy shall address all issues ranging from production and trade to final disposal, including technology transfers for the recycling of electronic waste. Clear regulatory instruments, adequate to control both legal and illegal exports and imports of e-wastes and ensuring their environmentally sound management should be in place. There is also a need to address the loop holes in the prevailing legal frame work to ensure that e-wastes from developed countries are not reaching the country for disposal. The Port and the Custom authorities need to monitor these aspects. The regulations should prohibit the disposal of e-wastes in municipal landfills and encourage owners and generators of e-wastes to properly recycle the wastes. Manufactures of products must be made financially, physically and legally responsible for their products.

Proposed Solutions to the Problem of e waste

- Domestic legal framework to address these gaps in import of E Waste
- Need to address safe disposal of domestic waste.
- Tie recycling in with take-back product
- The Framework should address the issue of E waste imports for reuse and recycling.
- Attract investment in this sector
- Link up activities of informal sector with formal sector
- Provide for appropriate framework for processes
- Promote adequate ESM technologies for recycling
- Incorporate precautionary principles and polluter pays
- Insist on domestic processing
- Then make sure the company you select has capacity to handle every type of E-Scrap.
- Promote recycling units to ease process and to encourage generators to have proper e-waste disposal
- Impart training to generators on e-waste handling
- Awareness program on recycling

- Fix duties and responsibilities to recyclers
- Tax incentives for scrap dealers
- Reward and reprimand schemes for performance and non-compliance of e-waste management

Solid waste management, which is already a mammoth task in India, is becoming more complicated by the invasion of e-waste, particularly computer waste. There exists an urgent need for a detailed assessment of the current and future scenario including quantification, characteristics, existing disposal practices, environmental impacts etc. Institutional infrastructures, including e-waste collection, transportation, treatment, storage, recovery and disposal, need to be established, at national and/or regional levels for the environmentally sound management of e-wastes. Establishment of e-waste collection, exchange and recycling centres should be encouraged in partnership with private entrepreneurs and manufacturers. Model facilities employing environmentally sound technologies and methods for recycling and recovery are to be established. Criteria are to be developed for recovery and disposal of E Wastes. Policy level interventions should include development of e-waste regulation, control of import and export of e-wastes and facilitation in development of infrastructure. An effective take-back program providing incentives for producers to design products that are less wasteful, contain fewer toxic components, and are easier to disassemble, reuse, and recycle may help in reducing the wastes. It should set targets for collection and reuse/recycling, impose reporting requirements and include enforcement mechanisms and deposit/refund schemes to encourage consumers to return electronic devices for collection and reuse/recycling. End-of life management should be made a priority in the design of new electronic products.

E-WASTE (MANAGEMENT) RULES, 2016

E-Waste (Management) Rules, 2016 - What's New?

- Manufacturer, dealer, refurbisher and Producer Responsibility Organization (PRO) have been introduced as additional stakeholders in the rules.
- The applicability of the rules has been extended to components, consumables, spares and parts of EEE in addition to equipment as listed in Schedule I.
- Compact Fluorescent Lamp (CFL) and other mercury containing lamp brought under the purview of rules.

- Collection mechanism based approach has been adopted to include collection centre, collection point, take back system etc for collection of e - waste by Producers under Extended Producer Responsibility (EPR).
- Option has been given for setting up of PRO , e - waste exchange , e - retailer, Deposit Refund Scheme as additional channel for implementation of EPR by Producers to ensure efficient channelization of e - waste.
- Provision for Pan India EPR Authorization by CPCB has been introduced replacing the state wise EPR authorization.
- Collection and channelisation of e - waste in Extended Producer Responsibility - Authorisation shall be i n line with the targets prescribed in Schedule III of the Rules. The phase wise Collection Target for e - waste, which can be either in number or Weight shall be 30% of the quantity of waste generation as indicated in EPR Plan during first two year of implementation of rules followed by 40% during third and fourth years, 50% during fifth and sixth years and 70% during seventh year onwards.
- Deposit Refund Scheme has been introduced as an additional economic instrument wherein the producer charges an additional amount as a deposit at the time of sale of the electrical and electronic equipment and returns it to the consumer along with interest when the end - of - life electrical and electronic equipment is returned.
- The e - waste exchange as an option has been provided in the rules as an independent market instrument offering assistance or independent electronic systems offering services for sale and purchase of e - waste generated from end - of - life electrical and electronic equipment between agencies or organizations authorised under these rules.
- The manufacturer is also now responsible to collect e - waste generated during the manufacture of any electrical and electronic equipment and channelise it for recycling or disposal and seek authorization from SPCB.
- The dealer, if has been given the responsibility of collection on behalf of the producer, need to collect the e - waste by providing the consumer a box and channelize it to Producer.
- Dealer or retailer or e - retailer shall refund the amount as per take back system or De posit Refund Scheme of the producer to the depositor of e - waste.
- Refurbisher need collect e - waste generated during the process of refurbishing and channelise the waste to authorised dismantler or recycler through its collection centre and seek one time authorization from SPCB.
- The roles of the State Government has been also introduced in the Rules in order to ensure safety, health and skill development of the workers involved in the dismantling and recycling operations.
- Department of Industry in State o r any other government agency authorised in this regard by the State Government is to ensure earmarking or allocation of industrial space or shed for e - waste dismantling and recycling in the existing and upcoming industrial park, estate and industrial clusters.
- Department of Labour in the State or any other government agency authorised in this regard by the State Government need to ensure recognition and registration of workers involved in dismantling and recycling; assist formation of groups of such workers to facilitate setting up dismantling facilities; undertake industrial skill development activities for the workers involved in dismantling and recycling; and undertake annual monitoring and to ensure safety & health of workers involved in dismantling and recycling.

- State Government to prepare integrated plan for effective implementation of these provisions, and to submit annual report to Ministry of Environment, Forest and Climate Change.
- The transportation of e - waste shall be carried out as per the manifest system whereby the transporter shall be required to carry a document (three copies) prepared by the sender, giving the details.
- Liability for damages caused to the environment or third party due to improper management of e - waste including provision for levying financial penalty for violation of provisions of the Rules has also been introduced.
- Urban Local Bodies (Municipal Committee/Council/Corporation) has been assign the duty to collect and channelized the orphan products to authorized dismantler or recycler.

E-WASTE (MANAGEMENT) AMENDMENT RULES, 2018

The amendment in rules has been done with the objective of channelizing the E-waste generated in the country towards authorized dismantlers and recyclers in order to formalize the e-waste recycling sector. The collection targets under the provision of Extended Producer Responsibility (EPR) in the Rules have been revised and targets have been introduced for new producers who have started their sales operations recently.

Some of the salient features of the E-waste (Management) Amendment Rules, 2018 are as follows:

- The e-waste collection targets under EPR have been revised and will be applicable from 1 October 2017. The phase-wise collection targets for e-waste in weight shall be 10% of the quantity of waste generation as indicated in the EPR Plan during 2017-18, with a 10% increase every year until 2023. After 2023 onwards, the target has been made 70% of the quantity of waste generation as indicated in the EPR Plan.
- The quantity of e-waste collected by producers from the 1 October 2016 to 30 September 2017 shall be accounted for in the revised EPR targets until March 2018.
- Separate e-waste collection targets have been drafted for new producers, i.e. those producers whose number of years of sales operation is less than the average lives of their products. The average lives of the products will be as per the guidelines issued by CPCB from time to time.
- Producer Responsibility Organizations (PROs) shall apply to the Central Pollution Control board (CPCB) for registration to undertake activities prescribed in the Rules.
- Under the Reduction of Hazardous Substances (RoHS) provisions, cost for sampling and testing shall be borne by the government for conducting the RoHS test. If the product does not comply with RoHS provisions, then the cost of the test will be borne by the Producers.

BIO-MEDICAL WASTE MANAGEMENT

All human activities produce waste. We all know that such waste may be dangerous and needs safe disposal. Industrial waste, sewage and agricultural waste pollute water, soil and air. It can also be dangerous to human beings and environment. Similarly, hospitals and other health care facilities generate lots of waste which can transmit infections, particularly HIV, Hepatitis B & C and Tetanus, to the people who handle it or come in contact with it.

India generates around three million tonnes of medical wastes every year and the amount is expected to grow at eight per cent annually.

Types of Bio-medical waste

Bio-medical waste means "any solid and/or liquid waste including its container and any intermediate product, which is generated during the diagnosis, treatment or immunization of human beings or animals or research activities pertaining thereto or in the production or testing of biological or in health camps.

Biomedical waste poses hazard due to two principal reasons – the first is infectivity and other toxicity.

Bio Medical waste consists of

- Human anatomical waste like tissues, organs and body parts
- Animal wastes generated during research from veterinary hospitals
- Microbiology and biotechnology wastes
- Waste sharps like hypodermic needles, syringes, scalpels and broken glass
- Discarded medicines and cytotoxic drugs
- Soiled waste such as dressing, bandages, plaster casts, material contaminated with blood, tubes and catheters
- Liquid waste from any of the infected areas
- Incineration ash and other chemical wastes

The biomedical waste (BMW) management requires its categorisation as a first step. The BMW Rules classify the BMW into following categories.

CATEGORY	TYPE OF WASTE	TYPE OF BAG OR CONTAINER TO BE USED	TREATMENT AND DISPOSAL OPTION
Yellow	Human tissues, organs, body parts and fetus below the viability period (as per the Medical Termination of Pregnancy Act 1971, amended from time to time).	Yellow coloured non-chlorinated plastic bags	Incineration or Plasma Pyrolysis or deep burial *
	Animal Anatomical Waste : Experimental animal carcasses, body parts, organs, tissues, including the waste generated from animals used in experiments or testing in veterinary hospitals or colleges or animal houses.		
	Soiled Waste: Items contaminated with blood, body fluids like dressings, plaster casts, cotton swabs and bags containing residual or discarded blood and blood components.		Incineration or Plasma Pyrolysis or deep burial * In absence of above facilities, autoclaving or micro-waving/ hydroclaving followed by shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent for energy recovery.
	Expired or Discarded Medicines: Pharmaceutical waste like antibiotics, cytotoxic drugs including all items contaminated with cytotoxic drugs along with glass or plastic ampoules, vials etc.	Yellow coloured non-chlorinated plastic bags or containers	Expired cytotoxic drugs and items contaminated with cytotoxic drugs to be returned back to the manufacturer or supplier for incineration at temperature >1200 0 C or to common bio - medical waste treatment facility or hazardous waste treatment, storage and disposal facility for incineration at >1200 0 C Or Encapsulation or Plasma Pyrolysis at >1200 0 C All other discarded medicines shall be either sent back to manufacturer or disposed by incineration.

	Chemical Waste: Chemicals used in production of biological and used or discarded disinfectants.	Yellow coloured containers or non-chlorinated plastic bags	Disposed of by incineration or Plasma Pyrolysis or Encapsulation in hazardous waste treatment, storage and disposal facility.
	Chemical Liquid Waste : Liquid waste generated due to use of chemicals in production of biological and used or discarded disinfectants, Silver X - ray film developing liquid, discarded Formalin, infected secretions, aspirated body fluids , liquid from laboratories an d floor washings, cleaning, house - keeping and disinfecting activities etc.	Separate collection system leading to effluent treatment system	After resource recovery, the chemical liquid waste shall be pre - treated before mixing with other wastewater. The combined discharge shall conform to the discharge norms given in Schedule - III.
	Discarded linen, mattresses, beddings contaminated with blood or body fluid.	Non-chlorinated yellow plastic bags or suitable packing material	Non - chlorinated chemical disinfection followed by incineration or Plazma Pyrolysis or for energy recovery. In absence of above facilities, shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent for energy recovery or incineration or Plazma Pyrolysis.
	Microbiology, Biotechnology and other clinical laboratory waste: Blood bags, Laboratory cultures, stocks or specimens of micro - organisms, live or attenuated vaccines, human and animal cell cultures used in research, industrial laboratories, production of biological, residual toxins, dishes and devices used for cultures.	Autoclave safe plastic bags or containers	Pre - treat to sterilize with non - chlorinated chemicals on - site as per National AIDS Control Organisation or World Health Organisation guidelines thereafter for Incineration.
Red	Contaminated Waste (Recyclable) Wastes generated from disposable items such as tubing, bottles, intravenous tubes and sets, catheters, urine bags, syringes (without needles and fixed needle syringes) and vaccutainers with their needles cut) and gloves.	Red coloured non-chlorinated plastic bags or containers	Autoclaving or micro - wawing/ hydroclaving followed by shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent to registered or authorized recyclers or for energy recovery or plastics to diesel or fuel oil or for road making, whichever is possible. Plastic waste should not be sent to landfill sites.

White (Translu-cent)	**Waste sharps including Metals:** Needles, syringes with fixed needles, needles from needle tip cutter or burner, scalpels, blades, or any other contaminated sharp object that may cause puncture and cuts. This includes both used, discarded and contaminat-ed metal sharps	Puncture proof, Leak proof, tamper proof containers	Autoclaving or Dry Heat Sterilization followed by shredding or mutilation or encapsulation in metal con-tainer or cement concrete; combination of shredding cum autoclaving; and sent for final disposal to iron foundries (having consent to operate from the State Pollution Control Board s or Pollution Control Commit-tee s) or sanitary landfill or designated concrete waste sharp pit.
Blue	**Glassware:** Broken or discarded and contaminated glass including medicine vials and ampoules except those con-taminated with cytotoxic wastes Metallic Body Implants	Cardboard boxes with blue colored marking	Disinfection (by soaking the washed glass waste after cleaning with detergent and Sodium Hypochlorite treatment) or through auto-claving or microwaving or hydroclaving and then sent for recycling.

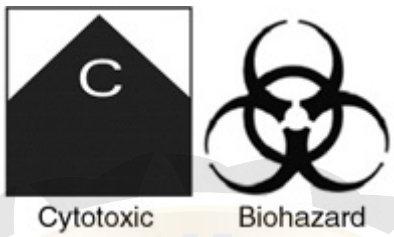
Segregation

Segregation refers to the basic separation of different categories of waste generated at source and there-by reducing the risks as well as cost of handling and disposal. Segregation is the most crucial step in bio-medical waste management. Effective segregation alone can ensure effective bio-medical waste man-agement.

How does segregation help?

- Segregation reduces the amount of waste needs special handling and treatment
- Effective segregation process prevents the mixture of medical waste like sharps with the gener-al municipal waste.
- Prevents illegally reuse of certain components of medical waste like used syringes, needles and other plastics.
- Provides an opportunity for recycling certain components of medical waste like plastics after prop-er and thorough disinfection.
- Recycled plastic material can be used for non-food grade applications.
- Of the general waste, the biodegradable waste can be composted within the hospital premises and can be used for gardening purposes.

- Recycling is a good environmental practice, which can also double as a revenue generating activity.
- Reduces the cost of treatment and disposal (80 per cent of a hospital's waste is general waste, which does not require special treatment, provided it is not contaminated with other infectious waste)



Proper labelling of bins

The bins and bags should carry the biohazard symbol indicating the nature of waste to the patients and public.

Collection

The collection of biomedical waste involves use of different types of container from various sources of biomedical wastes like Operation Theatre, laboratory, wards, kitchen, corridor etc. The containers/ bins should be placed in such a way that 100 % collection is achieved. Sharps must always be kept in puncture-proof containers to avoid injuries and infection to the workers handling them.

Storage

Once collection occurs then biomedical waste is stored in a proper place. Segregated wastes of different categories need to be collected in identifiable containers. The duration of storage should not exceed for 8-10 hrs in big hospitals (more than 250 bedded) and 24 hrs in nursing homes. Each container may be clearly labelled to show the ward or room where it is kept. The reason for this labelling is that it may be necessary to trace the waste back to its source. Besides this, storage area should be marked with a caution sign.

Transportation

The waste should be transported for treatment either in trolleys or in covered wheelbarrow. Manual loading should be avoided as far as for as possible. The bags / Container containing BMWs should be tied/ lidded before transportation. Before transporting the bag containing BMWs, it should be accompanied with a signed document by Nurse/ Doctor mentioning date, shift, quantity and destination.

Special vehicles must be used so as to prevent access to, and direct contact with, the waste by the transportation operators, the scavengers and the public. The transport containers should be properly enclosed. The effects of traffic accidents should be considered in the design, and the driver must be trained in the procedures he must follow in case of an accidental spillage. It should also be possible to wash the interior of the containers thoroughly.

Personnel safety devices

The use of protective gears should be made mandatory for all the personnel handling waste.

Gloves: Heavy-duty rubber gloves should be used for waste handling by the waste retrievers. This should be bright yellow in colour. After handling the waste, the gloves should be washed twice. The gloves should be washed after every use with carbolic soap and a disinfectant. The size should fit the operator.

Aprons, gowns, suits or other apparels: Apparel is worn to prevent contamination of clothing and protect skin. It could be made of cloth or impermeable material such as plastic. People working in incinerator chambers should have gowns or suits made of non-inflammable material.

Masks: Various types of masks, goggles, and face shields are worn alone or in combination, to provide a protective barrier. It is mandatory for personnel working in the incinerator chamber to wear a mask covering both nose and mouth, preferably a gas mask with filters.

Boots: Leg coverings, boots or shoe-covers provide greater protection to the skin when splashes or large quantities of infected waste have to be handled. The boots should be rubber-soled and anti-skid type. They should cover the leg up to the ankle.

Cleaning devices

Brooms: The broom shall be a minimum of 1.2 m long, such that the worker need not stoop to sweep. The diameter of the broom should be convenient to handle. The brush of the broom shall be soft or hard depending on the type of flooring.

Dustpans: The dustpans should be used to collect the dust from the sweeping operations. They may be either of plastic or enamelled metal. They should be free of ribs and should have smooth contours, to prevent dust from sticking to the surface. They should be washed with disinfectants and dried before every use.

Mops: Mops with long handles must be used for swabbing the floor. They shall be of either the cloth or the rubber variety. The mop has to be replaced depending on the wear and tear. The mechanical-screw type of mop is convenient for squeezing out the water.

Vacuum cleaners: Domestic vacuum cleaners or industrial vacuum cleaners can be used depending on the size of the rooms.

Storage devices

Dustbins:

It is very important to assess the quantity of waste generated at each point. Dustbins should be of such capacity that they do not overflow between each cycle of waste collection. Dustbins should be cleaned after every cycle of clearance of waste with disinfectants. Dustbins can be lined with plastic bags, which are chlorine-free, and colour coded as per the law.

Handling devices

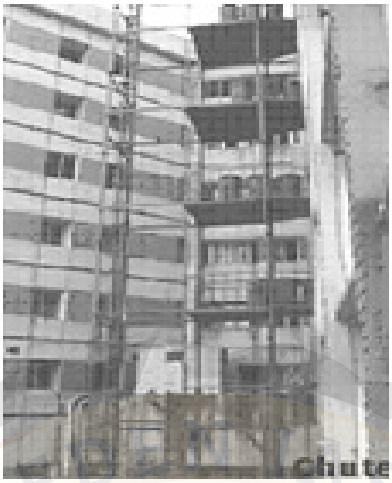
Trolleys

The use of trolleys will facilitate the removal of infectious waste at the source itself, instead of adding a new category of waste.

Wheelbarrows:

Wheelbarrows are used to transfer the waste from the point source to the collection centres. There are two types of wheelbarrow – covered and open. Wheelbarrows are made of steel and provided with two wheels and a handle. Care should be taken not to directly dump waste into it. Only packed waste (in plastic bags) should be carried. Care should also be taken not to allow liquid waste from spilling into the wheelbarrow, as it will corrode. These are ideal for transferring debris within the institution. Wheelbarrows also come in various sizes depending on the utility.

Chutes:



Chutes are vertical conduits provided for easy transportation of refuse vertically in case of institutions with more than two floors. Chutes should be fabricated from stainless steel. It should have a self-closing lid. These chutes should be fumigated everyday with formaldehyde vapours. The contaminated linen (contaminated with blood and or other body fluids) from each floor should be bundled in soiled linen or in plastic bags before ejecting into the chute. Alternately, elevators with mechanical winches or electrical winches can be provided to bring down waste containers from each floor. Chutes are necessary to avoid horizontal transport of waste thereby minimizing the routing of the waste within the premises and hence reducing the risk of secondary contamination.

BIO-MEDICAL (WASTE MANAGEMENT) RULES, 2016

Salient features of BMW Management Rules, 2016

- The ambit of the rules has been expanded to include vaccination camps, blood donation camps, surgical camps or any other healthcare activity;
- Phase-out the use of chlorinated plastic bags, gloves and blood bags within two years;
- Pre-treatment of the laboratory waste, microbiological waste, blood samples and blood bags through disinfection orsterilisation on-site in the manner as prescribed by WHO or NACO;
- Provide training to all its health care workers and immunise all health workers regularly;
- Establish a Bar-Code System for bags or containers containing bio-medical waste for disposal;
- Report major accidents; (g) Existing incinerators to achieve the standards for retention time in secondary chamber and Dioxin and Furans within two years;
- Bio-medical waste has been classified in to 4 categories instead 10 to improve the segregation of waste at source;
- Procedure to get authorisation simplified. Automatic authorisation for bedded hospitals. The validity of authorization synchronised with validity of consent orders for Bedded HCFs. One time Authorisation for Non-bedded HCFs;
- The new rules prescribe more stringent standards for incinerator to reduce the emission of pollutants in environment;
- Inclusion of emissions limits for Dioxin and furans;

- State Government to provide land for setting up common bio-medical waste treatment and disposal facility;
- No occupier shall establish on-site treatment and disposal facility, if a service of `common bio-medical waste treatment facility is available at a distance of seventy-five kilometer.
- Operator of a common bio-medical waste treatment and disposal facility to ensure the timely collection of bio-medical waste from the HCFs and assist the HCFs in conduct of training.

BIO-MEDICAL (WASTE MANAGEMENT) AMENDMENT RULES, 2018

Bio-Medical Waste Management Rules, 2016 Rules have been amended to improve compliance and strengthen the implementation of environmentally sound management of biomedical waste in India.

The amended rules stipulate that generators of bio-medical waste such as hospitals, nursing homes, clinics, and dispensaries etc will not use chlorinated plastic bags and gloves beyond March 27, 2019 in medical applications to save the environment. Blood bags have been exempted for phase-out, as per the amended BMW rules, 2018.

Salient features of Bio-Medical Waste Management (Amendment) Rules, 2018 are as follows:

1) Bio-medical waste generators including hospitals, nursing homes, clinics, dispensaries, veterinary institutions, animal houses, pathological laboratories, blood banks, health care facilities, and clinical establishments will have to phase out chlorinated plastic bags (excluding blood bags) and gloves by March 27, 2019.

2) All healthcare facilities shall make available the annual report on its website within a period of two years from the date of publication of the Bio-Medical Waste Management (Amendment) Rules, 2018.

3) Operators of common bio-medical waste treatment and disposal facilities shall establish bar coding and global positioning system for handling of bio-medical waste in accordance with guidelines issued by the Central Pollution Control Board by March 27, 2019.

4) The State Pollution Control Boards/ Pollution Control Committees have to compile, review and analyze the information received and send this information to the Central Pollution Control Board in a new Form (Form IV A), which seeks detailed information regarding district-wise bio-medical waste generation, information on Health Care Facilities having captive treatment facilities, information on common bio-medical waste treatment and disposal facilities.

5) Every occupier, i.e. a person having administrative control over the institution and the premises generating biomedical waste shall pre-treat the laboratory waste, microbiological waste, blood samples, and blood bags through disinfection or sterilization on-site in the manner as prescribed by the World Health Organization (WHO) or guidelines on safe management of wastes from health care activities and WHO Blue Book 2014 and then sent to the Common bio-medical waste treatment facility for final disposal.

PLASTIC WASTE MANAGEMENT

Plastic has multiple uses and the physical and chemical properties lead to commercial success. However, the indiscriminate disposal of plastic has become a major threat to the environment. In particular, the plastic carry bags are the biggest contributors of littered waste and every year, millions of plastic bags end up in to the environment vis-a-vis soil, water bodies, water courses, etc and it takes an average of one thousand years to decompose completely. Therefore, to address the issue of scientific plastic waste management, the Plastic Waste (Management and Handling) Rules, 2011 were notified in 2011, which included plastic waste management. The Government has notified the Plastic Waste Management Rules, 2016, in suppression of the earlier Plastic Waste (Management and Handling) Rules, 2011.

Aim

The Plastic Waste Management Rules, 2016 aim to:

- Increase minimum thickness of plastic carry bags from 40 to 50 microns and stipulate minimum thickness of 50 micron for plastic sheets also to facilitate collection and recycle of plastic waste
- Expand the jurisdiction of applicability from the municipal area to rural areas, because plastic has reached rural areas also
- To bring in the responsibilities of producers and generators, both in plastic waste management system and to introduce collect back system of plastic waste by the producers/brand owners, as per extended producers responsibility
- To introduce collection of plastic waste management fee through pre-registration of the producers, importers of plastic carry bags/multilayered packaging and vendors selling the same for establishing the waste management system
- To promote use of plastic waste for road construction as per Indian Road Congress guidelines or energy recovery, or waste to oil etc. for gainful utilization of waste and also address the waste disposal issue; to entrust more responsibility on waste generators, namely payment of user charge as prescribed by local authority, collection and handing over of waste by the institutional generator, event organizers.
- An eco-friendly product, which is a complete substitute of the plastic in all uses, has not been found till date. In the absence of a suitable alternative, it is impractical and undesirable to impose a blanket ban on the use of plastic all over the country. The real challenge is to improve plastic waste management systems.

What's new in Plastic Waste Management Rules, 2016

- Rural areas have been brought in ambit of these Rules since plastic has reached to rural areas also. Responsibility for implementation of the rules is given to Gram Panchayat.

- First time, responsibility of waste generators is being introduced. Individual and bulk generators like offices, commercial establishments, industries are to segregate the plastic waste at source, handover segregated waste, pay user fee as per bye-laws of the local bodies.
- Plastic products are left littered after the public events (marriage functions, religious gatherings, public meetings etc) held in open spaces. First time, persons organising such events have been made responsible for management of waste generated from these events.
- Use of plastic sheet for packaging, wrapping the commodity except those plastic sheet's thickness, which will impair the functionality of the product are brought under the ambit of these rules. A large number of commodities are being packed/wrapped in to plastic sheets and thereafter such sheets are left for littered. Provisions have been introduced to ensure their collection and channelization to authorised recycling facilities.
- Extended Producer Responsibility: Earlier, EPR was left to the discretion of the local bodies. First time, the producers (i.e persons engaged in manufacture, or import of carry bags, multi-layered packaging and sheets or like and the persons using these for packaging or wrapping their products) and brand owners have been made responsible for collecting waste generated from their products. They have to approach local bodies for formulation of plan/system for the plastic waste management within the prescribed timeframe.
- State Pollution Control Board (SPCBs) will not grant/renew registration of plastic bags, or multi-layered packaging unless the producer proposes the action plan endorsed by the concerned State Development Department.
- Producers to keep a record of their vendors to whom they have supplied raw materials for manufacturing carry bags, plastic sheets, and multi-layered packaging. This is to curb manufacturing of these products in unorganised sector.
- The entry points of plastic bags/plastic sheets/multi-layered packaging in to commodity supply chain are primarily the retailers and street vendors. They have been assigned the responsibility of not to provide the commodities in plastic bags/plastic sheets/multi-layered packaging which do not conform to these rules. Otherwise, they will have to pay the fine.
- Plastic carry bag will be available only with shopkeepers/street vendors pre-registered with local bodies on payment of certain registration fee. The amount collected as registration fee by local bodies is to be used for waste management.
- Central Pollution Control Board (CPCB) has been mandated to formulate the guidelines for thermoset plastic (plastic difficult to recycle). In the earlier Rules, there was no specific provision for such type of plastic.
- Manufacturing and use of non-recyclable multi-layered plastic to be phased in two years.

Plastic Waste Management (Amendment) Rules 2018

The Ministry of Environment, Forest and Climate Change has notified the Plastic Waste Management (Amendment) Rules 2018 on March 27, 2018.

- The amended Rules lay down that the phasing out of Multilayered Plastic (MLP) is now applicable to MLP, which are "non-recyclable, or non-energy recoverable, or with no alternate use."
- The amended Rules also prescribe a central registration system for the registration of the producer/importer/brand owner.
- The Rules also lay down that any mechanism for the registration should be automated and should take into account ease of doing business for producers, recyclers and manufacturers.
- The centralised registration system will be evolved by Central Pollution Control Board (CPCB) for the registration of the producer/importer/brand owner.

While a national registry has been prescribed for producers with presence in more than two states, a state-level registration has been prescribed for smaller producers/brand owners operating within one or two states.

UNIT-X

[ENVIRONMENTAL EDUCATION]

Environmental education enables learners to develop a structure of knowledge about the world and seek knowledge that they can use and develop throughout their lives. Environmental education empowers learners by enabling them to participate in a sustainable future. Thus the foundation for a lifelong learning is laid by environmental education.

MEANING OF ENVIRONMENTAL EDUCATION

Environment is derived from the French word "Environner", which means encircle or surrounding. Environment is a complex of many variables, which surrounds man as well as the living organisms. Environmental education describe the interrelationships among organisms, the environment and all the factors, which influence life on earth, including atmospheric conditions, food chains, the water cycle, etc. It is a basic science about our earth and its daily activities, and therefore, this science is important for everyone.

SCOPE OF ENVIRONMENTAL EDUCATION

Environmental education discipline has multiple and multilevel scopes. This study is important and necessary not only for children but also for everyone. The scopes are summarized as follows:

- The study creates awareness among the people to know about various renewable and nonrenewable resources of the region. The endowment or potential, patterns of utilization and the balance of various resources available for future use in the state of a country are analysed in the study.
- It provides the knowledge about ecological systems and cause and effect relationships.
- It provides necessary information about biodiversity richness and the potential dangers to the species of plants, animals and microorganisms in the environment.
- The study enables one to understand the causes and consequences due to natural and induced disasters (flood, earthquake, landslide, cyclones etc.,) and pollutions and measures to minimize the effects.
- It enables one to evaluate alternative responses to environmental issues before deciding an alternative course of action.
- The study enables environmentally literate citizens (by knowing the environmental acts, rights, rules, legislations, etc.) to make appropriate judgments and decisions for the protection and improvement of the earth.
- The study exposes the problems of over population, health, hygiene, etc. and the role of arts, science and technology in eliminating/ minimizing the evils from the society.
- The study tries to identify and develop appropriate and indigenous eco-friendly skills and technologies to various environmental issues.
- It teaches the citizens the need for sustainable utilization of resources as these resources are inherited from our ancestors to the younger generation without deteriorating their quality.
- The study enables theoretical knowledge into practice and the multiple uses of environment.

IMPORTANCE OF ENVIRONMENTAL EDUCATION

Environmental study is based upon a comprehensive view of various environmental systems. It aims to make the citizens competent to do scientific work and to find out practical solutions to current environmental problems. The citizens acquire the ability to analyze the environmental parameters like the aquatic, terrestrial and atmospheric systems and their interactions with the biosphere. Need of Environmental Education arises due to the following reasons

1. World population is increasing at an alarming rate especially in developing countries.
2. The natural resources endowment in the earth is limited.
3. The methods and techniques of exploiting natural resources are advanced.
4. The resources are over-exploited and there is no foresight of leaving the resources to the future generations.
5. The unplanned exploitation of natural resources lead to pollution of all types and at all levels.
6. The pollution and degraded environment seriously affect the health of all living things on earth, including man.
7. The people should take a combined responsibility for the deteriorating environment and begin to take appropriate actions to save the earth.
8. Education and training are needed to save the biodiversity and species extinction. 9. The urban area, coupled with industries, is major sources of pollution.
9. The number and area extinct under protected area should be increased so that the wild life is protected at least in these sites.
10. The study enables the people to understand the complexities of the environment and need for the people to adapt appropriate activities and pursue sustainable development, which are harmonious with the environment.
11. The study motivates students to get involved in community action, and to participate in various environment and management projects.
12. It is a high time to reorient educational systems and curricula towards these needs.
13. Environmental education takes a multidisciplinary approach to the study of human interactions with the natural environment.
14. Environmental study is a key instrument for bringing about the changes in the knowledge, values, behaviors and lifestyles required to achieve sustainability and stability within and among countries.

Environmental education deals with every issue that affects an organism. It is essentially a multidisciplinary approach that brings about an appreciation of our natural world and human impacts on its integrity. It is an applied science as it seeks practical answers to making human civilization sustainable on the earth's finite resources.

The rationales for environmental education arise as a result of the following

- Environment is the basis of all life and therefore deserves proper care and management.
- If the environment is threatened on a continuous basis, numerous problems which would constitute a danger to human existence could arise.
- The environment is part of our cultural heritage which should be handed down to prosperity.
- Some resources of the environment are not easily replaceable and should be managed on a sustainable basis, to prevent the extinction of certain components of the environment such as plants and animals.
- There is need to enhance the sanity and aesthetic quality of our environment in order to promote healthy living.
- The environment is part of nature and needs to be preserved for its own sake.

GUIDING PRINCIPLES OF ENVIRONMENTAL EDUCATION

1. Consider the environment in its totality, natural and built technological and social structures (economic, political, technological, cultural, historical, moral and aesthetic).
2. Environmental education should be a continuous life saving process (beginning at the pre-school level continuing through all formal and non-formal stages).
3. Environmental education should be interdisciplinary in its approach.
4. Examine major environmental issues from local, national and international point of view.
5. Environmental education should focus on current and potential environmental situations.
6. Promote the values and necessity of local, national and international cooperation in the prevention and solution to environmental problems.
7. Explicitly consider environmental aspects of plan for development and growth.
8. Enhance the position of learners in making decision concerning their environment and accept responsibility.
9. Enable learners to discover symptoms and real and potential causes of environmental problems.
10. Enhance the learners' ability to develop critical thinking and problem solving skills.
11. Utilize different learning environment and approaches to learn/teach about different forms of the environment with emphasis on first hand information.

Constraints in implementing Environmental Education

1. Rigid Specialization.
2. Complexity of inter-disciplinary value of Environmental education.
3. High pupil - teacher ratio for organizing pupil participation programs.
4. Paucity of qualified trained environmental educator.
5. Lack of proper resources in terms of equipment, supplementary materials and reference materials.
6. Tendency to resist changes.

UNIT-XI

[DEFORESTATION]

CAUSES OF DEFORESTATION AND FOREST DEGRADATION

Deforestation is the removal of a forest or stand of trees where the land is thereafter converted to a non-forest use. Examples of deforestation include conversion of forestland to farms, ranches, or urban use. The most concentrated deforestation occurs in tropical rainforests. About 30% of Earth's land surface is covered by forests.

Causes of deforestation and forest degradation

There are various reasons for deforestation, some of which are mentioned below:

Agricultural expansion

A combination of forces is responsible for deforestation and the biggest among them is agricultural expansion. Forests are being cleared on an alarming rate due to rising global demand of food grain and the commodities like soybeans and palm oil. Since the beginning of agriculture, there has been a mass reduction in the forests worldwide for agricultural expansion. As per an estimate, over 40% of the forests have already been cleaned worldwide to obtain land to meet the demands for agriculture and wood. Agricultural expansion has left the world much devoid of its original forests. Forest areas are eliminated for raising commercial crops such as plantation for palm oil. In simple terms, deforestation takes place because forest land is not financially viable.

Due to this trend, there has been widespread destruction of Savannah grasslands as the Savannah vegetation has been cleaned and the wide area has been converted into agricultural land. The grasslands and trees of temperate tropical regions (e.g. the prairies of North America, and the steppes of Russia) have been cleaned. Forests have been cleared on a large scale and converted into gardens, agricultural lands. Likewise, forest areas have been destroyed in a big way to expand the agricultural land to eradicate the hunger of the rapidly growing population in the monsoon areas of south and south-east Asia.

Increasing Urbanization and Industrialization

For the purpose of development work the cutting of trees has been going on for years. Increased urbanization is one of the major causes of deforestation. To meet residential and industrial requirements, such as for the development of housing on a mass scale besides, construction of roads, mineral exploitation and industrial expansion, forests are being cleared on a large scale.

The road expansions also leads to illegal logging, where the people take benefits of doubt and slash down trees without obtaining permission from authorities.

Growth in Population

Deforestation is taking place at a faster rate to cater to explosive growth in population. Due to rapid increase in human population in developing countries, it has become necessary that the vast areas of forests should be cleaned and farmed so that the needs of the growing population can be met. Demand for timber is increasing day by day. As a result, there is a steady increase in tree cutting. Equatorial mangrove forests are being eliminated by 20 million hectares annually. More and more collection of wood for fodder and burning wood by the rural masses in developing and undeveloped countries also leads to depletion of forests.

Diverse Human Needs

Tree and forests have been burnt or cut for centuries to meet various human needs: to obtain wood for fuel, to build houses, boats, match boxes, furniture etc and the requirement of wood for use in many works. Since the beginning of this century, deforestation has occurred at such a fast pace that many environmental problems have arisen. The greedy man has forgotten that the vast destruction of forests would endanger his own existence.

Livestock Ranching and Logging

Forests in major parts of the world have already been cleared for livestock ranching, or cattle farming. Cattle ranchers have burned huge tracts of rainforests converting them into pastures for the cattle. They clear vast swaths of forest lands for cattle grazing. Later when the land prices increase, they sell the land and make profit. This kind of deforestation is very common in developing countries.

Forests have decayed due to grazing of animals in the normal density forests of hot and subtropical and dry and semi-arid regions. It is known that in the developing and undeveloped countries of these areas, milch animals feed on bushes, and plants, scattered on the ground and in open forests. They also trample upon the land with their hooves so that plants do not bloom there. In most countries, large herds of sheep have completely wiped out the grass. Logging is another major driver of deforestation. Some greedy people are indulging in activities leading to deforestation to earn money from wood. Illegal logging operations which are very common in developing countries also destroy the livelihood of the people who depend on forests.

Changes of Forests into Pastures

Forests have been converted into pastures for livestock for widespread expansion and development of dairy farming in temperate regions of the world, particularly in North and South America and Africa.

Multipurpose River-Valley Projects

During the implementation of multipurpose river valley projects, vast forest areas are lost, because in the large reservoirs built behind the dams, the extensive area covered with forest is submerged in water, due to which not only the natural forest wealth but the ecological balance of that area is also disturbed.

Jhum (Shifting) Cultivation

Jhum Agriculture is one of the major reasons for the decay and destruction of forests in the mountainous areas of southern and south-eastern Asia. Under this practice of agriculture, the land is cleaned by burning forests on hillsides. When the productivity of that land decreases, farmers shift to another place, burning the jungle again.

Mining Operations

The people are cutting forests for oil and coal mining operations as well. Large-scale mining operations, result into major deforestation through clearing of forests. The construction of roads into the forests for such purposes is also responsible for deforestation.

Paper Production

Paper is made from pulp of trees. Rising consumption of paper and cutting down trees for manufacturing paper throughout the world has already attracted major attention of the environmentalists. In the past four decades, the use of paper has gone up by 400%. It takes twelve to seventeen full-grown trees to make one ton of good quality paper.

For Fuel

Extensive deforestation takes place due to requirement of wood for fuel.

Due to Corruption

Forest contractors and forest mafia resort to massive cutting of forests for their ulterior motives. To earn more money, they do large-scale cutting of trees and smuggle the wood.

Lack of Awareness

Deforestation takes place as people, by and large, lack adequate knowledge about the need to conserve forests.

Other causes

Natural Causes of Deforestation are global warming, landslides, earthquakes, hail, strong winds, hurricanes, lighting etc. also lead to loss of forest cover, apart from fires that erupt in the forests.

VARIOUS EFFECTS OF DEFORESTATION

Floods and Droughts: Soil erosion increases the soil flows, due to which the specific cycle of flood and drought is started. Cutting forests on mountain slopes obstructs the flow of rivers towards the plains, which have an impact on their water efficiency, so that the water rapidly comes downwards. Deforestation leads to land erosion arises because the trees play an important role in maintaining the surface of the mountains and cause natural barriers to the rapidly rising rain water. Consequently the water level of the rivers increases suddenly, causing floods.

Loss of Soil Fertility: When the fuel becomes inadequate, the cow dung and the vegetable residue are used like fuels to make food. Because of this, every part of the plant is gradually used and nothing goes back in the soil. After some time the drift of this nutrition influences the productivity of the soil, it causes degradation of soil-fertility. With the elimination of forests, the fertile soil above the ground flows through rain water to those places where it is not used.

Air Pollution: There are grave consequences for forest destruction. Its biggest disadvantage is in the form of air pollution. The air where there is lack of trees gets polluted. And the problem of air pollution is the highest in the cities. There people suffer from many diseases, especially breathing problems such as asthma.

Extinction of species: Due to the destruction of forests, wildlife is disappearing. Many species have disappeared (such as Asiatic cheetah, Namdapha flying squirrel, Himalayan wolf, Elvira rat, Andaman shrew, Jenkins' shrew, Nicobar shrew, etc) and many are on the verge of extinction.

Global Warming: Deforestation has a direct impact on the natural climate change, thereby increasing the global temperature. With the decreasing area of forests, the rain is also becoming irregular. This contributes to 'global warming', which has direct impact on humans.

Spread of deserts: Due to continuous decrease in the area of forests, and the erosion of the land, the desert is spreading on a big scale.

Depletion in Water Resources: Today, the water of rivers is becoming shallow, less deep and polluted because of the indiscriminate harvest of trees and plants on their shores, exits and mountains. Due to this there is insufficient rainfall, the water source is getting contaminated, and the environment is also becoming polluted and fatal.

Ill-Effects of Industrialisation: Trees and plants prevent the environment from being polluted by pre-

venting those toxic gases from dissolving in the atmosphere, and preventing the particles of ash and sand etc. from rising too. Nowadays, there is a flood of industries in the cities, even towns and villages. The smoke emanating from them fills the environment with different types of toxic gases.

Damage to ozone layer: The normal environment of the Earth as a result of deforestation has become polluted. It is posing grave danger to the ozone layer, which is necessary for the overall defence of the Earth. Imagine that bad day (may it never come), when the ozone layer disappears.

Endangering Tribals: Forest is essential for the survival of tribals or Adivasis. The thinking of modern society has made life an object of profit, but for the tribals, the jungle is a complete lifestyle. It is the means of their livelihood. Their approach is very important in forest conservation, which is neither being implemented nor is it being recognized. They have been protecting the forest from the time of their forefathers. Adivasis take as much as they need from the forest, and in exchange, they give something to them. They have deep respect towards the forest. The ways and the rules of the tribals in the use of the forest are inherently sustainable as forest conservation is in their blood.

It is noteworthy that the forest is not only the economic base of the tribals, but they also use wild herbs in the treatment of their diseases. 'Baiga tribals' of Mandla and Dindori districts are considered to have the best knowledge of herbs and herbal remedies throughout the country. *Baiga* tribals use barks of trees during maternity (delivery). Before removing the bark, they offer rice, pulses to the tree. Then they worship the tree with incense and chant mantras in the praise of the tree god. After that, they pluck out with their sickle only that much bark that is used as the medicine. According to these knowledgeable tribals, only a little bark is removed in this way. They believe that if bark is removed without any rules, then people will start using it arbitrarily.

Unavailability of herbal medicines: Today the mountains and forests have become deserted due to the loss of tree cover. With this, getting medicinal flora has become rare. Because of lack of tree plantation, this precious natural property is eroding fast. This is spoiling the balance of life and environment. Mountain cliffs are getting deserted by breaking of stones and the rainfall is decreasing in the nearby areas.

Homeless Animals: Due to endless deforestation, destitute animals are taking shelter in villages. As a result, incidents of wild animals entering villages and towns of the country are happening quite frequently, posing a grave danger to human life.

CONSERVATION OF FORESTS

Some of the steps we can take to conserve our forest resources are as follows:

1. Regulated and Planned Cutting of Trees:

One of the main reasons of deforestation is commercial felling of trees. According to an estimate, about 1,600 million cubic metres of wood have been used for various purposes in the world. Although trees are considered as perennial resource, when exploited on a very large scale, their revival cannot be possible.

Therefore, cutting should be regulated by adopting methods like:

(i) Clear cutting,

(ii) Selective cutting, and

(iii) Shelter wood cutting.

The clear cutting method is useful for those areas where the same types of trees are available over a large area. In that case, trees of same age group can be cut down in a selected area and then marked for replantation. In selective cutting only mature trees are selected for cutting. This process is to be followed in rotation.

The time gap between these cuttings is helpful in re-growth of trees. In regulated cutting only one-tenth of the forest area is selected for use and rotational system is always followed for their protection. The forest can be managed in such a way that a timber crop may be harvested indefinitely year after year without being depleted. This technique is called the 'sustained yield' method adopted by many countries.

2. Control over Forest Fire:

Destruction or loss of forest by fire is fairly common; because trees are highly exposed to fire and once started it becomes difficult to control. Sometimes, the fire starts by natural process, i.e., by lightning or by friction between trees during speedy winds, while in most cases it is also by man either intentionally or unintentionally.

In order to save forests from fire, it is necessary to adopt latest techniques of fire fighting. Some of the fire suppression techniques are to develop three metre wide fire lanes around the periphery of the fire, back fires, arrangement of water spray, fire retardant chemicals should be sprayed from back tank and if possible by helicopters. There must be trained staff of fire fighters to control the fire.

3. Reforestation and Afforestation:

The sustained yield concept dictates that whenever timber is removed, either by block cutting or by selective cutting, the denuded area must be reforested. This may be done by natural or artificial methods. Similarly, any forested land, which has been destroyed by fire or mining activities, should be reforested. In rugged terrain aerial seeding is the method of choice.

Besides all this, fresh afforestation programmes should be started. New plantations will not only increase the forest cover but also help in making up the eco-balance. For afforestation, selection of trees should be done according to local geographical conditions and care must be taken during initial growth of the trees.

4. Check over Forest Clearance for Agricultural and Habitation Purposes:

Most of the present-day agricultural land was once forested and then cleared for the use of agriculture. But now it has reached the stage where further clearance will be dangerous for the entire ecosystem. There are tribals in some parts of Asia, Africa and South America, where shifting cultivation is still a part of their system of land procurement.

5. Protection of Forests:

The existing forests should be protected. Apart from commercial cutting, unorganised grazing is also one of the reasons. There are several forest diseases resulting from parasitic fungi, rusts, mistletoes, viruses and nematodes which cause the destruction of trees. The forests should be protected either by use of chemical spray, antibiotics or by development of disease resistant strains of trees.

6. Proper Utilisation of Forest and Forests Products:

Generally, trees are cut for logs and the rest, including stump, limbs, branches and foliage, etc., is left out as worthless debris. Further waste occurs at the saw mills. There is thus need to utilise this waste material. Today, several uses have been developed and products like waterproof glues, boar r etc., can be obtained.

Similarly, forests can be used or developed as tourist centres. By using them as tourist centres the country can earn substantial foreign exchange. This practice has been adopted by many countries, both developed and developing. The concepts of 'national park' and 'game sanctuary' have now become popular and every country has developed its unique forest area as a 'national park'.

7. Role of Government in Forest Conservation:

Although the government of every country is very particular about conservation of its forest resources and has several rules and laws for the protection of forests but, they are not implement in an effective manner.

Both national and provincial governments can take some steps in this direction, such as:

- Pass acts for the conservation of forests,
- Survey of the forest resources,
- Categorization of forest areas and proper delimitation of reserved forest areas,
- Find out the areas where reforestation can be done,
- Regulate the commercial use of forest products,
- Protect forest from fire, mining and other natural calamities,
- Develop national parks,
- Encourage forests developmental activities like social forestry, agro-forestry, etc., and
- Prepare master plans, both for long-term and short-term period, etc.

8. Forest Management:

Management of forest resources is the key to all conservation efforts. In forest management, the following aspects should be taken into consideration:

1) Survey of forest,
2) Categorisation of forest,
3) Economic use of forest,
4) Administrative setting for forest management,
5) Training programmes for persons engaged in forest conservation activities,
6) Use of forest land as tourist centers,
7) Social and agro-forestry,
8) Development of new techniques for the conservation of forests,
9) Research for efficient use and conservation of forest, and
10) Policy decisions and their proper implementation.

SOCIAL FORESTRY

Social forestry means the management and protection of forest and afforestation of barren and deforested lands with the purpose of helping environmental, social and rural development. The term, Social Forestry, was first used in India in 1977 by The National Commission on Agriculture, Government of India. It was then that India embarked upon a social forestry project with the aim of taking the pressure off currently existing forests by planting trees on all unused and fallow lands.

Objectives of Social Forestry

1. Increasing Forest Area and Restoring Ecological Balance

(i) Moisture conservation—trees take water from the lower soil strata and bring it to the upper layers through long tap root system and, also, trees check evaporation of water;

(ii) Soil conservation—trees help in checking erosion by wind and water;

(iii) Natural habitat conservation—trees provide habitat to many birds and animals, some of which are agro-friendly.

2. Meeting Basic Rural Needs:

Social forestry satisfies the basic rural needs referred to as 'five Fs'—food, fuel, fodder, fertiliser (green manure) and fibre. The large-scale depletion of easily accessible forests has resulted in acute scarcity of fuel-wood and fodder. What is disturbing is that the deficit in fuel wood is met by using cow-dung cakes, thus wasting a rich and cheap source of manure. Trees also supply the raw material for various small and village industries through small timber and minor forest produce.

3. Ensuring Better Land Use:

Social forestry helps achieve a balanced and viable land use by checking soil erosion, facilitating reclamation of marginal lands, checking water logging and by bringing about monolithic integration of forestry, agriculture and animal husbandry.

4. Generation of Employment:

Social forestry operations have the potential of improving the employment situation in rural areas especially during the lean agricultural season. This helps in stabilising incomes of weaker sections of Society.

5. Controlling Pollution:

Trees are known to absorb harmful gases and release oxygen. This way they help reduce air pollution especially in urban areas.

AGRO FORESTRY

Agroforestry is the management and integration of trees, crops and/or livestock on the same plot of land and can be an integral component of productive agriculture. It may include existing native forests and forests established by landholders. It is a flexible concept, involving both small and large-sized land holdings

Scientifically speaking, agroforestry is derived from ecology and is one of the three principal land-use sciences, the other two being agriculture and forestry. Agroforestry differs from the latter two principals by placing an emphasis on integration of and interactions among a combination of elements rather than just focusing on each element individually.

Agroforestry has a lot in common with intercropping (the practice of planting two or more crops on the same plot) with both practices placing an emphasis on interaction between different plant species. Generally speaking, both agroforestry and intercropping can result in higher overall yields and reduced operational costs.

The Benefits of Agroforestry

Over the past two decades, a number of studies have been carried out analysing the viability of agroforestry. The combined research has highlighted that agroforestry can reap substantial benefits both economically and environmentally, producing more output and proving to be more sustainable than forestry or agricultural monocultures. Agroforestry systems have already been adopted in many parts of the

Agroforestry Systems can include the following benefits

1. They can control runoff and soil erosion, thereby reducing losses of water, soil material, organic matter and nutrients.
2. They can maintain soil organic matter and biological activity at levels satisfactory for soil fertility. This depends on an adequate proportion of trees in the system- normally at least 20% crown cover of trees to maintain organic matter over systems as a whole.
3. They can maintain more favourable soil physical properties than agriculture, through organic matter maintenance and the effects of tree roots.
4. They can lead to more closed nutrient cycling than agriculture and hence to more efficient use of nutrients. This is true to an impressive degree for forest garden/farming systems.
5. They can check the development of soil toxicities, or reduce exiting toxicities-both soil acidification and salinization can be checked and trees can be employed in the reclamation of polluted soils.
6. They utilize solar energy more efficiently than monocultural systems different height plants, leaf shapes and alignments all contribute.
7. They can lead to reduced insect pests and associated diseases.
8. They can be employed to reclaim eroded and degraded land.
9. Agro forestry can augment soil water availability to land use systems. In dry regions, though, competition between trees and crops is a major problem.
10. Nitrogen-fixing trees and shrubs can substantially increase nitrogen inputs to agro forestry systems.
11. Trees can probably increase nutrient inputs to agro forestry systems by retrieval from lower soil horizons and weathering rock.
12. The decomposition of tree and pruning can substantially contribute to maintenance of soil fertility. The addition of high-quality tree prunings leads to large increase in crop yields.
13. The release of nutrients from the decomposition of tree residues can be synchronized with the requirements for nutrient uptake of associated crops. While different trees and crops will all have different requirement, and there will always be some imbalance, the addition of high quality prunings to the soil at the time of crop planting usually leads to a good degree of synchrony between nutrient release and demand.
14. In the maintenance of soil fertility under agro forestry, the role of roots is at least as important as that of above-ground biomass.
15. Agro forestry can provide a more diverse farm economy and stimulate the whole rural economy, leading to more stable farms and communities. Economics risks are reduced when systems produce multiple products.

UNIT-XII

[ENVIRONMENTAL INSTITUTIONS]

POLLUTION CONTROL BOARD

The main function of the Pollution Control Board is to improve the quality of air, promote cleanliness of water bodies and to prevent pollution.

If may also perform the following functions:

- Advise the Government on prevention and control of pollution.
- Carry out and encourage investigations and research relating to pollution problems.
- Plan and organize training programmes for persons involved in prevention and control of pollution.
- Organize through mass media, a comprehensive programme regarding pollution and control.
- Collect, compile and publish technical and statistical data, manuals, codes and guides.
- Establish or recognize laboratories for analyzing pollution parameters.
- Advise the Government regarding the suitability of any site for the location of industry.
- Issue environmental no objection certificate to start an industry.
- Inspect and review sewage or industrial effluent treatment plants and to grant consent.
- Prescribe effluent quality standards and the quality of receiving waters resulting from the discharge of effluents.
- Evolve economical and reliable methods of treatment, utilization, and disposal of sewage and industrial effluent with regard to soil, climate and water resources of the region under consideration.
- Inspect air pollution control areas to assess the quality of air and to take steps for prevention of pollution.
- Lay down standards for the quality of air and emission of air pollutants into the atmosphere, to frame rules and regulations to improve the quality of environment.
- Regulate and control noise producing and generating sources.
- Monitor the compliance of the standards regarding ground water, ambient air, leachate quality, compost quality and incineration standards.
- Close down a defaulting industrial plant or withdraw its supply of power or water.

(1) Constitution of Central Board:

Central Board shall consist of the following members:

(a) A full time Chairman (to be nominated by the Central Government) having knowledge or practical experience in matters related to environmental protection or having knowledge and experience in administration of institutions dealing with aforesaid matters.

(b) Not more than five officials nominated by the Central Government.

(c) Not more than five persons nominated by the Central Government from amongst the members of State Boards.

(d) Not more than three non-officials nominated by the government to represent interests of agriculture, fishery, agriculture-trade etc.

(e) Two persons nominated by the government to represent the companies or corporations owned by the Central Government.

(f) One full time Member-Secretary (to be appointed by the Central Govt.) having knowledge and experience of scientific engineering or management aspects of pollution control.

(2) Constitution of State Boards:

State Pollution Control Board may be constituted having the same constitution as the Central Board.

(3) Constitution of Committees:

A board may constitute as many committees as necessary. The members of a committee shall be paid such fees and allowances for attending to any other work of the Board.

(4) Constitution of Joint Boards:

Under agreement between two or more contiguous States, Joint Boards may be constituted for those states, by the Central or State Governments.

(5) Terms and Service Conditions of the Members of the Board:

(a) Terms and service conditions of the Member Secretary and Chairman shall be as prescribed by the Government.

(b) Rest of the members shall hold office for a term of three years.

(c) A member shall be eligible for renomination.

(d) Central or State Government may remove a member of the Central or State Board at any time by giving him reasonable notice and opportunity.

(e) The Chairman may resign by addressing his resignation to the government and a member may resign by addressing his resignation to the Chairman.

NATIONAL GREEN TRIBUNAL (NGT)

The NGT was established on October 18, 2010 under the National Green Tribunal Act 2010, passed by the Central Government. The stated objective of the Central Government was to provide a specialized forum for effective and speedy disposal of cases pertaining to environment protection, conservation of forests and for seeking compensation for damages caused to people or property due to violation of environmental laws or conditions specified while granting permissions.

Structure

Following the enactment of the said law, the Principal Bench of the NGT has been established in the National Capital – New Delhi, with regional benches in Pune (Western Zone Bench), Bhopal (Central Zone Bench), Chennai (Southern Bench) and Kolkata (Eastern Bench). Each Bench has a specified geographical jurisdiction covering several States in a region. There is also a mechanism for circuit benches. For example, the Southern Zone bench, which is based in Chennai, can decide to have sittings in other places like Bangalore or Hyderabad.

The Chairperson of the NGT is a retired Judge of the Supreme Court, Head Quartered in Delhi. Other Judicial members are retired Judges of High Courts. Each bench of the NGT will comprise of at least one Judicial Member and one Expert Member. Expert members should have a professional qualification and a minimum of 15 years experience in the field of environment/forest conservation and related subjects.

Powers

The NGT has the power to hear all civil cases relating to environmental issues and questions that are linked to the implementation of laws listed in Schedule I of the NGT Act. These include the following:

1. The Water (Prevention and Control of Pollution) Act, 1974;
2. The Water (Prevention and Control of Pollution) Cess Act, 1977;
3. The Forest (Conservation) Act, 1980;
4. The Air (Prevention and Control of Pollution) Act, 1981;
5. The Environment (Protection) Act, 1986;
6. The Public Liability Insurance Act, 1991;
7. The Biological Diversity Act, 2002.

This means that any violations pertaining only to these laws, or any order / decision taken by the Government under these laws can be challenged before the NGT. Importantly, the NGT has not been vested with powers to hear any matter relating to the Wildlife (Protection) Act, 1972, the Indian Forest Act, 1927 and various laws enacted by States relating to forests, tree preservation etc. Therefore, specific and substantial issues related to these laws cannot be raised before the NGT. You will have to approach the State High Court or the Supreme Court through a Writ Petition (PIL) or file an Original Suit before an appropriate Civil Judge of the taluk where the project that you intend to challenge is located.

Procedure for filing an Application or Appeal

The NGT follows a very simple procedure to file an application seeking compensation for environmental damage or an appeal against an order or decision of the Government. The official language of the NGT is English.

Principles of Justice adopted by NGT

The NGT is not bound by the procedure laid down under the Code of Civil Procedure, 1908, but shall be guided by principles of natural justice. Further, NGT is also not bound by the rules of evidence as enshrined in the Indian Evidence Act, 1872. Thus, it will be relatively easier (as opposed to approaching a court) for conservation groups to present facts and issues before the NGT, including pointing out technical flaws in a project, or proposing alternatives that could minimize environmental damage but which have not been considered.

While passing Orders/decisions/awards, the NGT will apply the principles of sustainable development, the precautionary principle and the polluter pays principles.

However, it must be noted that if the NGT holds that a claim is false, it can impose costs including lost benefits due to any interim injunction.

Review and Appeal

Under Rule 22 of the NGT Rules, there is a provision for seeking a Review of a decision or Order of the NGT. If this fails, an NGT Order can be challenged before the Supreme Court within ninety days.

Criticism of National Green Tribunal

As soon as the NGT came into action after October 2010 it got stuck in number of controversies. The first criticism it faces is that it lacks judicial independence from the government. The rules of the NGT act allowed the bureaucrats to be appointed to the tribunal while holding their post in the government. This is problematic in the sense that a government official will never rule against the government because he is also a part of government and faces various kinds of pressure to not to rule against the central government.

The concept of Tribunals is in itself problematic as they are funded by the parent ministry and hence it exercises control over the tribunal and its decisions. The need for experts in the tribunal is also problematic concept because the NGT has to decide the question of law and does not have to do fact finding. The expert knowledge is not needed in granting compensation or awarding punishment. For this there needs to be a knowledge of law. The Indian evidence act provides specifically for the statement of expert witness in cases where some special knowledge is required than what is the need for appointing experts in the tribunal itself.

The tribunal also faces a lack of resources for its proper functioning. The NGT was operating from a guest house earlier. Also the members of the tribunal were not given houses and were living in government guest house. The funds were decreased further without taking into consideration the fact that NGT is already suffering from lack of adequate funding. The law commission report on the environmental courts suggested that one such court should be established in every state. But the NGT has only 5 benches. This has created problem for common citizens asking for justice as it is difficult to approach a court which is in different state and far from their home. The establishment of NGT also took away the right of civil courts to admit cases regarding environmental issues. So it is now compulsory to file the case before the NGT in these cases. Now even a PIL cannot be filed in the High Court of the state for environmental issues as all environmental litigation shall be dealt only by the five benches of NGT. There is a need for environmental tribunal on district bases but present system is not even providing it on state basis.

FOREST SURVEY OF INDIA

Forest Survey of India (FSI), founded in June 1981 and headquartered at Dehradun in Uttarakhand, is a Government of India Ministry of Environment, Forest and Climate Change organisation for conducting forest surveys, studies and research to periodically monitor the changing situation of land and forest resources and present the data for national planning, conservation and sustainable management of environmental protection as well for the implementation of social forestry projects

The main objective of PISFR was to ascertain the availability of raw material for establishment of wood based industries in selected areas of the country. In its report in 1976, the National Commission on Agriculture (NCA) recommended for the creation of a National Forest Survey Organization for a regular, periodic and comprehensive forest resources survey of the country leading to creation of FSI. After a critical review of activities undertaken by FSI, Government of India redefined the mandate of FSI in 1986 in order to make it more relevant to the rapidly changing needs and aspirations of the country.

OBJECTIVES

- To prepare State of Forest Report biennially, providing assessment of latest forest cover in the country and monitoring changes in these.
- To conduct inventory in forest and non-forest areas and develop database on forest tree resources.

- To prepare thematic maps on 1:50,000 scale, using aerial photographs.
- To function as a nodal agency for collection, compilation, storage and dissemination of spatial database on forest resources.
- To conduct training of forestry personnel in application of technologies related to resources survey, remote sensing, GIS, etc.
- To strengthen research & development infrastructure in FSI and to conduct research on applied forest survey techniques.
- To support State/UT Forest Departments (SFD) in forest resources survey, mapping and inventory.
- To undertake forestry related special studies/consultancies and custom made training courses for SFD's and other organisations on project basis.

MAJOR ACTIVITIES

- Forest Cover Assessment
- Inventory of Forest areas.
- Inventory of Trees Outside Forests (Rural & Urban).
- Inventory data processing.
- Methodology Design.
- Training and Extension.
- Projects and Consultancies.

GENETIC ENGINEERING APPRAISAL COMMITTEE (GEAC)

The Genetic Engineering Appraisal Committee (GEAC) was constituted under the Ministry of Environment, Forest and Climate Change (MoEFCC) as the apex body under the 'Rules for Manufacture, Use, Import, Export and Storage of Hazardous Microorganisms/Genetically Engineered Organisms or Cells 1989' in accordance with the Environment Protection Act, 1986.

It is the organization engaged in the appraisal of activities that involve the large-scale usage of hazardous microorganisms and recombinants in industrial production as well as research from an environmental point of view.

- Its mandate is to ensure that only safe and environmentally harmless activities are done.
- The organization also appraises proposals related to the release of genetically engineered organisms and products into the environment, including experimental field trials.
- The ministry's Special Secretary/Additional Secretary is the Chairman of the GEAC.
- It is co-chaired by a representative of the Department of Biotechnology.
- Currently, the GEAC has twenty-four members and meets once every month to carry out its prescribed activities.

Genetic Engineering Appraisal Committee Functions:

The following are the core functions of the Genetic Engineering Appraisal Committee:

- To appraise activities involving the large-scale use of hazardous microorganisms and recombinants in research and industrial production from the environmental angle.

- To appraise proposals relating to release of genetically engineered organisms and products into the environment including experimental field trials.
- The committee or any persons authorized by it has powers to take punitive action under the Environment Protection Act.

Genetically Engineered Organisms (GMOs):

- India is one of the earliest countries to establish a biosafety system for regulation of GMOs.
- The Genetic Engineering Appraisal Committee (GEAC) is also responsible for giving technical approval of proposals relating to the release of GMOs and products including experimental field trials.
- However, Environment Minister gives final approval for GMOs.

INSTITUTIONAL FRAMEWORK FOR WILDLIFE CONSERVATION IN INDIA

To be an effective conservationist, it is important to understand which institutions control land in India and what laws govern the protection of forests and wildlife. Before any conservation interventions can be attempted in any landscape, the legal status of the land must first be ascertained so that one can engage with the correct authorities or agencies.

Institutional Framework

The institutions that control land use through land ownership include:

- State Forest Departments and associated Forest Development Corporations.
- State Government institutions such as the Public Works, Electricity, Irrigation and Revenue Departments.
- Central Government institutions like Railways, Ports Authority and Indian defense forces.
- Private plantation companies (tea, coffee, rubber, cardamom) and individual landowners.

Responsibilities:

Wildlife conservation in India is the responsibility of both the Federal (Central) and State Governments. It is therefore included in what is known as the 'concurrent list' in the Constitution. Both the Union and State Governments can pass laws relating to forest and wildlife conservation. However, federal legislation has dominance over state legislation.

Constitutional imperatives:

State: Article 48A of the Constitution of India mandates that the state shall endeavor to protect and improve the environment and safeguard the forests and wildlife of the country.

Citizen: Article 51 A (g) of the Constitution states that it shall be the *fundamental duty* of every citizen to protect and improve the natural environment including forests and Wildlife.

Federal (Central) Government Institutions dealing with wildlife conservation:

The **Ministry of Environment and Forests** (MoEF), based in New Delhi, is the authority vested with the task of:

- Formulating legislation

- Formulating policy
- Other statutory functions under various environmental, forest and wildlife laws including granting environmental and forest clearances.

A Directorate of Wildlife Preservation in the MoEF oversees all matters concerning wildlife. The Directorate is headed by the Additional Director General of Forests (ADG), a senior officer of the Indian Forest Service (IFS).

Division of responsibilities:

- Federal Government has the mandate to legislate and evolve policy guidelines.
- State Governments have exclusive administrative control over forest areas, and are responsible for the implementation of laws and policies.
- In general, the MoEF has limited direct power over state governments, except notably through the Forest Conservation Act and Wildlife Protection Act.

Policies:

The MoEF has formulated the following important policies:

- National Forest Policy in 1988
- The National Conservation Strategy and Policy Statement on Environment and Development in 1992
- The National Wildlife Action Plan 2002- 2016.

In addition to legislation and policy, the MoEF performs **several statutory functions** to enforce provisions of the Forest (Conservation) Act, 1980, the Wildlife (Protection) Act, 1972 and the Environment (Protection) Act, 1986. Some of these important functions include:

- Approval (or otherwise) of proposals from state governments to divert forest lands for non-forestry activities.
- Approval of working plans that enable commercial logging by State Forest Departments.
- Environmental clearance based on Impact Assessments for establishing industries.

With a view to ensuring focus on conservation of flagship species (Eg. tiger, lion, elephant, snow leopard), the MoEF has launched special conservation projects such as Project Tiger and Project Elephant.

The **National Tiger Conservation Authority** (NTCA), a statutory body, was set up in 2006 to conserve and manage Tiger Reserves in conjunction with State Governments.

A **National Biodiversity Authority** is functioning since 2003 to regulate access to, and use of, biodiversity and to advise the Central Government.

(A Statutory Body/Committee is one that is formed on the basis of a law. For example, the NTCA is a Statutory Body created under the Wildlife (Protection) Act. The Forest Advisory Committee (FAC) is a Statutory Body created under the Forest Conservation Act. Statutory Bodies and Committees have sweeping powers to enforce the provisions of the Act under which they were created).

Some Federal Government institutions that fall under the purview of the MoEF:

- The Wildlife Institute of India (WII),
- Indian Council of Forestry Research and Education (IFCRE)
- Botanical Survey of India (BSI),
- Zoological Survey of India (ZSI),
- Forest Survey of India (FSI)
- Indira Gandhi National Forest Academy (IGNFA).

These institutions are primarily involved in research, training and documentation activities. The **IGNFA** in Dehradun is where probationers undergo training to become Forest Officers.

Independent federal government institutions that are empowered to prevent and/or investigate forest and wildlife offences include:

- The Wildlife Crime Control Bureau (WCCB)
- The Indian Coast Guard
- Central Police organizations like the Border Security Force, Indo- Tibetan Border Police and Railway Police Force.
- Customs Bureau
- Central Bureau of Investigation (CBI)

NATIONAL BOARD FOR WILDLIFE

- It is a "Statutory Organization" constituted under the Wildlife Protection Act, 1972.
- Its role is "advisory" in nature and advises the Central Government on framing policies and measures for conservation of wildlife in the country.
- Primary function of the Board is to promote the conservation and development of wildlife and forests.
- It has power to review all wildlife-related matters and approve projects in and around national parks and sanctuaries.
- No alternation of boundaries in national parks and wildlife sanctuaries can be done without approval of the NBWL.
- **Composition:** The NBWL is chaired by the Prime Minister. It has 47 members including the Prime Minister. Among these, 19 members are ex-officio members. Other members include three Members of Parliament (two from Lok Sabha and one from Rajya Sabha), five NGOs and 10 eminent ecologists, conservationists and environmentalists.

TRADITIONAL KNOWLEDGE DIGITAL LIBRARY

CSIR and the Department of AYUSH (now Ministry) developed the Traditional Knowledge Digital Library (TKDL).

- The Traditional Knowledge Digital Library (TKDL) is an Indian digital knowledge repository of the traditional knowledge, especially about medicinal plants and formulations used in Indian systems of medicine.
- Set up in 2001, as a collaboration between the Council of Scientific and Industrial Research (CSIR) and the MINISTRY OF AYUSH.
- Objective of the library is to protect the ancient and traditional knowledge of the country from exploitation through biopiracy and unethical patents, by documenting it electronically and classifying it as per international patent classification systems.
- Apart from that, the non-patent database serves to foster modern research based on traditional knowledge, as it simplifies access to this vast knowledge of remedies or practices.

The TKDL contains documentation of publicly available traditional knowledge (TK) that:

- relates to Ayurveda, Unani, Siddha and Yoga
- is in digitized format
- is available in five languages: English, German, French, Japanese and Spanish.

The TKDL:

- seeks to prevent the granting of patents for products developed utilizing TK where there has been little, if any, inventive step
- intends to act as a bridge between information recorded in ancient Sanskrit and patent examiners (with its database containing information in a language and format understandable to patent examiners)
- facilitates access to information not easily available to patent examiners, thereby minimizing the possibility that patents could be granted for "inventions" involving only minor or insignificant modifications.

UNEP

The United Nations Environment Programme (UNEP), an agency of the United Nations, coordinates the organization's environmental activities and assists developing countries in implementing environmentally sound policies and practices. It was founded by Maurice Strong, its first director, as a result of the United Nations Conference on the Human Environment (Stockholm Conference) in June 1972 and has overall responsibility for environmental problems among United Nations agencies; however, international talks on specialized issues, such as addressing climate change or combating desertification, are overseen by other UN organizations, like the Bonn-based Secretariat of the United Nations Framework Convention on Climate Change and the United Nations Convention to Combat Desertification. UNEP's activities cover a wide range of issues regarding the atmosphere, marine and terrestrial ecosystems, environmental governance and green economy. It has played a significant role in developing international environmental conventions, promoting environmental science and information and illustrating the way those can be implemented in conjunction with policy, working on the development and implementation of policy with national governments, regional institutions in conjunction with environmental non-governmental organizations (NGOs). UNEP has also been active in funding and implementing environment related development projects.

The United Nations Environment Assembly is UNEP's governing body. Created in June 2012 to replace the Governing Council, it currently has 193 members and meets every two years

Structure

UNEP's structure includes seven substantive Divisions:

- Early Warning and Assessment (DEWA)
- Environmental Policy Implementation (DEPI)
- Technology, Industry and Economics (DTIE)
- Regional Cooperation (DRC)
- Environmental Law and Conventions (DELC)
- Communications and Public Information (DCPI)
- Global Environment Facility Coordination (DGEF)

Activities

UNEP's main activities are related to:

- climate change
  - including the Territorial Approach to Climate Change (TACC)
- disasters and conflicts
  - Disasters and Conflicts UNEP has endeavored to lighten the influence of emergencies or natural disasters on human health and to prepare for future disasters. It contributes to the reduction of the origin of disasters by controlling the balance of ecosystems and actively support Sendai Framework for Disaster Risk Reduction which aims to reduce the risk of disasters (DRR). As well as preventing natural disasters, the UNEP supports countries such as to make laws or policies which protect the countries from getting serious damage by disasters. Since 1999 it has helped 40 countries to recover from the effect of disasters.
- ecosystem management
- environmental governance
- environment under review
  - UNEP provides information and data on the global environment to stakeholders including governments, non-governmental organizations and the public for them to engage in realizing the Sustainable Development Goals. The information which UNEP shares is based on the latest science and is collected in a proper way. This makes policy makers find reliable information effectively. Through this The Environment Outlook and the Sustainable Development Goals Indicators stakeholders can have access to information easily. In addition, the UN environment Live Platform and Online Access to Research in Environment (OARE) provide transparent information collected by UNEP.
- harmful substances
- resource efficiency

Notable achievements

- UNEP has registered several successes, such as the 1987 Montreal Protocol for limiting emissions of gases blamed for thinning the planet›s protective ozone layer, and the 2012 Minamata Convention, a treaty to limit toxic mercury.

- UNEP has sponsored the development of solar loan programmes, with attractive return rates, to buffer the initial deployment costs and entice consumers to consider and purchase solar PV systems. The most famous example is the solar loan programme sponsored by UN Environment helped 100,000 people finance solar power systems in India. Success in India's solar programme has led to similar projects in other parts of the developing world, including Tunisia, Morocco, Indonesia and Mexico.

- UNEP sponsors the Marshlands project in the Middle East. In 2001, UN Environment alerted about the destruction of the Marshlands when it released satellite images showing that 90 percent of the Marshlands had been lost. The UN Environment "support for Environmental Management of the Iraqi Marshland" began in August 2004, to manage the Marshland area in an environmentally sound manner.

- UN Environment has a programme for young people known as Tunza. Within this programme are other projects like the AEO for Youth

UNDP

The United Nations Development Programme (UNDP) is the United Nations' global development network. It advocates for change and connects countries to knowledge, experience and resources to help people build a better life for themselves. It provides expert advice, training and grants support to developing countries, with increasing emphasis on assistance to the least developed countries. It promotes technical and investment cooperation among nations.

Headquartered in New York City, the status of UNDP is that of an executive board within the United Nations General Assembly. The UNDP Administrator is the third highest-ranking official of the United Nations after the United Nations Secretary-General and Deputy Secretary-General

The UNDP is funded entirely by voluntary contributions from UN member states. It works internationally to help countries achieve the Sustainable Development Goals (SDGs). UNDP was one of the main UN agencies involved in the development of the Post-2015 Development Agenda.

Functions

UNDP's offices and staff are on the ground in 170 countries and territories, working with governments and local communities to help them find solutions to global and national development challenges.

UNDP links and coordinates global and national efforts to achieve the goals and national development priorities laid out by host countries. UNDP focuses primarily on five developmental challenges:

Democratic governance

UNDP supports national democratic transitions by providing policy advice and technical support, improving institutional and individual capacity within countries, educating populations about and advocating for democratic reforms, promoting negotiation and dialogue, and sharing successful experiences from other countries and locations. UNDP also supports existing democratic institutions by increasing dialogue, enhancing national debate, and facilitating consensus on national governance programmes.

Poverty reduction

UNDP helps countries develop strategies to combat poverty by expanding access to economic opportunities and resources, linking poverty programmes with countries' larger goals and policies, and ensuring a greater voice for the poor. It also works at the macro level to reform trade, encourage debt relief and foreign investment, and ensure the poorest of the poor benefit from globalisation.

On the ground, UNDP sponsors developmental pilot projects, promotes the role of women in development, and coordinates efforts between governments, NGOs, and outside donors. In this way, UNDP works with local leaders and governments to provide opportunities for impoverished people to create businesses and improve their economic condition.

The UNDP International Policy Centre for Inclusive Growth (IPC-IG) in Brasília, Brazil expands the capacities of developing countries to design, implement and evaluate socially inclusive development projects. IPC-IG is a global forum for South-South policy dialogue and learning, having worked with more than 7,000 officials from more than 50 countries.

A 2013 evaluation of the UNDP's poverty reduction efforts states that the UNDP has effectively supported national efforts to reduce poverty, by helping governments make policy changes that benefit the poor.[15] Nevertheless, the same evaluation also states there is a strong need for better measurement and monitoring of the impacts of the UNDP›s work. The UNDP's Strategic Plan 2014-2017 incorporates the recommendations of this poverty evaluation.

Crisis prevention and recovery

UNDP works to reduce the risk of armed conflicts or disasters, and promote early recovery after crisis have occurred. UNDP works through its country offices to support local government in needs assessment, capacity development, coordinated planning, and policy and standard setting.

Examples of UNDP risk reduction programmes include efforts to control small arms proliferation, strategies to reduce the impact of natural disasters, and programmes to encourage use of diplomacy and prevent violence. Recovery programmes include disarmament, demobilization and reintegration of ex-combatants, demining efforts, programmes to reintegrate displaced persons, restoration of basic services, and transitional justice systems for countries recovering from warfare.

Environment and energy

As the poor are disproportionately affected by environmental degradation and lack of access to clean, affordable water, sanitation and energy services, UNDP seeks to address environmental issues in order to improve developing countries' abilities to develop sustainably, increase human development and reduce poverty. UNDP works with countries to strengthen their capacity to address global environmental issues by providing innovative policy advice and linking partners through environmentally sensitive development projects that help poor people build sustainable livelihoods.

UNDP's environmental strategy focuses on effective water governance including access to water supply and sanitation, access to sustainable energy services, Sustainable land management to combat desertification and land degradation, conservation and sustainable use of biodiversity, and policies to control emissions of harmful pollutants and ozone-depleting substances. UNDP's Equator Initiative office biennially offers the Equator Prize to recognize outstanding indigenous community efforts to reduce poverty through the conservation and sustainable use of biodiversity, and thus making local contributions to achieving the Millennium Development Goals (MDGs).

In 2012 the Biodiversity Finance Initiative (BIOFIN) was established. BIOFIN brings 30 countries together to develop and implement evidence-based finance plans to safeguards biodiversity. BIOFIN has developed an innovative and adaptable methodology to guide countries to analyse the policy and institutional context for biodiversity finance; measure the current biodiversity expenditures; assess future financial needs; and identify the most suitable finance solutions to achieve national biodiversity targets.

HIV/AIDS

HIV/AIDS is a big issue in today's society and UNDP works to help countries prevent further spreading and reduce its impact, convening The Global Commission on HIV and the Law which reported in 2012.

WORLD WIDE FUND FOR NATURE (WWF)

The World Wide Fund for Nature (WWF) is an international non-governmental organization founded in 1961, working in the field of the wilderness preservation, and the reduction of human impact on the environment. It was formerly named the World Wildlife Fund, which remains its official name in Canada and the United States.

WWF is the world's largest conservation organization with over five million supporters worldwide, working in more than 100 countries, supporting around 1,300 conservation and environmental projects. They have invested over $1 billion in more than 12,000 conservation initiatives since 1995. WWF is a foundation with 55% of funding from individuals and bequests, 19% from government sources (such as the World Bank, DFID, USAID) and 8% from corporations in 2014

WWF aims to "stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature." The Living Planet Report is published every two years by WWF since 1998; it is based on a Living Planet Index and ecological footprint calculation. In addition, WWF has launched several notable worldwide campaigns including **Earth Hour** and **Debt-for-Nature Swap**, and its current work is organized around these six areas: **food, climate, freshwater, wildlife, forests, and oceans**.

Policies of the WWF are made by board members elected for three-year terms. An Executive Team guides and develops WWF's strategy. There is also a National Council which stands as an advisory group to the board and a team of scientists and experts in conservation who research for WWF.

National and international law plays an important role in determining how habitats and resources are managed and used. Laws and regulations become one of the organization's global priorities.

BIRDLIFE INTERNATIONAL

- BirdLife International (formerly the International Council for Bird Preservation) is a global partnership of conservation organisations that strives to conserve birds, their habitats, and global biodiversity, working with people towards sustainability in the use of natural resources. It is the world's largest partnership of conservation organisations.
- BirdLife International's priorities include preventing extinction of bird species, identifying and safeguarding important sites for birds, maintaining and restoring key bird habitats, and empowering conservationists worldwide.
- BirdLife International is the official Red List authority for birds, for the International Union for Conservation of Nature.
- Its global office is in UK with 6 regional offices – Africa, the Americas, Asia, Europe and Central Asia, the Middle East and the Pacific.
- It publishes a quarterly magazine, World Birdwatch, which contains recent news and authoritative articles about birds, their habitats, and their conservation around the world.
- It is the official Red List authority for birds, for the International Union for Conservation of Nature.
- It also published important bird areas (IBA) inventory.

What are Key Biodiversity Areas (KBAs)?

Key Biodiversity Areas (KBAs) are sites contributing significantly to the global persistence of biodiversity. They are identified using a standard set of criteria applicable to plants, animals and ecosystems.

What are Important Bird and Biodiversity Areas (IBAs) and what is their relationship with KBAs?

Since the late 1970s, the BirdLife Partnership has been working collectively to identify, document and protect all places on earth of greatest significance for the conservation of the world's birds. As a result, over 12,000 Important Bird and Biodiversity Areas (IBAs) have been identified. All of these sites are also KBAs for birds at the global or regional level.

Since birds have been shown to be effective indicators of wider biodiversity, many IBAs are likely to be also KBAs for other animal and plant species.

UNIT-XIII

[INTERNATIONAL EFFORTS & CONVENTIONS]

Environmental awareness among the public and policy makers has been growing since the 1960s. Research has demonstrated the importance of the environment to human health and well-being. On account of the growing awareness of the environmental crisis today assigned top priority in national and international agenda. In order to develop environmental awareness and to deal with regional and global environmental changes, many international efforts have been initiated. The international efforts like Stockholm conference, the Nairobi conference, the RIO summit, and the Kyoto conference are discussed here.

THE STOCKHOLM CONFERENCE

The Conference in Stockholm was the first time that attention was drawn to the need to preserve natural habitats to produce a sustained improvement in living conditions for all, and the need for international cooperation to achieve this. The emphasis was on solving environmental problems, but without ignoring social, economic and developmental policy factors. United Nations Environmental agency organized a World Conference on Environment at Stockholm, the capital of Sweden from 5th to 16th June 1972. It was attended by high level representatives of 114 nations and many environmentalists and nature lovers and was presided by Maurice Strong.

It was called the "**International Conference on Human Environment, 1972**". The Indian delegation led by Prime Minister Indira Gandhi while addressing this conference, drew the attention of the world community to our environmental problems. India, along with other developing countries felt that the environmental problems are more due to lack of development rather than excessive development. In that conference 150 action plans, 109 other suggestions and 26 principles were approved for promoting the improvement of environment and protection of the delicate environmental balance.

That same year, the Club of Rome published its report on "**The Limits to Growth**", which attracted enormous attention in the climate of the Stockholm Conference and the oil crisis of the early 1970s.The Stockholm Declaration that was adopted at the conference was formulated jointly by industrialized and developing countries. It contains principles of environmental protection and development, as well as practical recommendations for their implementation. It may be regarded as one of the foundation stones of the international policy that would come to be known as "sustainable development". The Conference led in the same year to the establishment of **the UN Environmental Programme (UNEP)**, based in Nairobi, Kenya. A global monitoring system, 'Earthwatch', was also set up and has since been integrated into the UNEP.

Highlights of the Stockholm Declaration

- Human rights must be asserted.
- Natural resources must be safeguarded
- The Earth's capacity to produce renewable resources must be maintained
- Wildlife must be safeguarded
- Non-renewable resources must be shared and not exhausted
- Pollution must not exceed the environment's capacity to clean itself
- Damaging oceanic pollution must be prevented
- Development is needed to improve the environment
- Developing countries therefore need assistance

- Developing countries need reasonable prices for exports to carry out environmental management
- Environment policy must not hamper development
- Developing countries need money to develop environmental safeguards
- Integrated development planning is needed
- Rational planning should resolve conflicts between environment and development
- Human settlements must be planned to eliminate environmental problems
- Governments should plan their own appropriate population policies
- National institutions must plan development of states' natural resources
- Science and technology must be used to improve the environment
- Environmental education is essential
- Environmental research must be promoted, particularly in developing countries
- States may exploit their resources as they wish but must not endanger others
- Compensation is due to states thus endangered
- Each nation must establish its own standards
- There must be cooperation on international issues
- International organisations should help to improve the environment
- Weapons of mass destruction must be eliminated

Salient Recommendations of the Stockholm Conference

The salient recommendations of the Stockholm conference are as follows:

(i) All possible steps should be taken by States to prevent pollution of the seas by substances that are causing hazards to human health, living resources and marine life.

(ii) Introduction of the concept of Sustainable Development, which was given a definite shape in 1987 by the World Commission on Environment and Development in its report, entitled "Our Common Future".

(iii) Man can transform his environment in countless ways on an unprecedented scale. The protec tion and improvement of the human environment promotes the well being of people and economic development throughout the world; it is the urgent desire of the people of the whole world the duty of all governments.

(iv) Resources should be made available to preserve and improve the environment.

(v) The task of planning, managing or controlling the environmental resources for improving the qual ity of environment must be entrusted to appropriate national institutions.

(vi) Scientific research and development in the context of environmental problems must be promoted in all countries, especially in developing countries.

(vii) In accordance with the provisions of the United Nations Charter and Principles of Internation al Law, States have sovereign rights to exploit their own resources pursuant to their environmental problems.

(viii) International matters concerning the protection and improvement of the environment should be handled in a cooperative spirit by all countries through multinational or bilateral agreements or treaties.

The conference helped to evoke environmental consciousness all over the world. Many nations started enacting laws to protect environment. In fact, the rising environmental awareness resulting in the formation of many environmental organizations and groups all over the world and all the environmental protection laws, protocols and covenants are the aftermath of the Stockholm Conference.

The conference declared that June 5 to be observed as the World Environment Day every year.

BRUNDTLAND COMMISSION

In 1983, the World Commission on Environment and Development (WCED) convened by the United Nations was created to address growing concern about the consequences of the accelerating deterioration of the human environment and the natural resources. The outcome of the work by the WCED was the report 'Our Common Future'. The report was quickly named the Brundtland Report in recognition of the chairman of the WCED, Gro Harlem Brundtland. The report was published in 1987 and was the first to focus on global sustainability. It addressed governments, businesses and, above all, people whose welfare should be a key element for environmental and development policies. It provided a comprehensive overview of the major global environmental crisis and suggestions on how to solve these problems.

The Brundtland report placed environmental issues firmly on the political agenda with the aim to discuss environment and development as a single and identical issue. The report gathered different issues related to environmental problems and launched a comprehensive gateway to sustainability, which included social, economic, political-institutional and environmental criteria. The concept of sustainability created by the WCED has since been used and also redeveloped in the ongoing work with sustainability within different spheres. The Brundtland Report, however, has been criticised for toning down the social dimension of sustainability by organizations who have worked to maintain the original holistic idea. Among these are The Wuppertal Institute who further processed the Brundtland report. The Brundtland Report and the concept of sustainability can be seen as an attempt to create awareness of the disturbing relations between human society and the natural environment, focusing on institutional, economic, ecological and social aspects. Sustainability is, however, not a clear cut homogeneous concept. It is a complex concept, which there is in praxis no consensus about, apart from the overall and quite broad principles.

Today, the term is very commonly used but in effect the concept of sustainability is actively re-designed for the specific purpose at any given time and context. Nevertheless, the birth of the Brundtland report sustainability concept has influenced environmental laws and planning in a wide range of countries. The publication of Our Common Future and the work of the World Commission on Environment and Development laid the groundwork for the convening of the Rio Declaration created at the 1992 Earth Summit, the adaptation of Agenda 21 and the establishment of the UN Commission on Sustainable Development.

RIO CONFERENCE

The United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit, took place in Rio de Janeiro, Brazil, from June 2-14, 1992. It was held twenty years after the United Nations Conference on the Human Environment took place in Stockholm, Sweden. Government officials from 178 countries and between 20,000 and 30,000 individuals from governments, non-governmental organizations, and the media participated in this event to discuss solutions for global problems such as poverty, war, and the growing gap between industrialized and developing countries. The central focus was the question of how to relieve the global environmental system through the introduction to the paradigm of sustainable development. This concept emphasizes that economic and social progress depends critically on the preservation of the natural resource base with effective measures to prevent environmental degradation.

Rio Declaration at the earth charter

The Rio Declaration on Environment and Development is a set of 27 legally nonbinding principles designed to commit governments to ensure environmental protection and responsible development and intended to be an Environmental Bill of Rights, defining the rights of people to development, and their responsibilities to safeguard the common environment. It established the "Precautionary principle" and the principle of "common but differentiated responsibilities". The Declaration recognizes that the only way to have long-term social and economic progress is to link it with environmental protection and to establish equitable global partnerships between governments and key actors of civil society and the business sector.

The Declaration includes many progressive approaches such as the polluter pays principle (the polluter bears the costs of pollution) and the precautionary principle (carry out environmental assessments to identify adverse impacts and eliminate any potential harms from a project before it is started). It advocates that today's development shall not undermine the resource base of future generations and that developed countries bear a special responsibility due to the pressure their societies place on the global environment and the technologies and financial resources they command. Strong environmental policies are inevitable but should not be used as an unjustifiable means of restricting international trade and shutting off the Northern markets for Southern countries. However, nations shall eradicate unsustainable patterns of production and consumption.

The earlier title "Earth Charter" was later appropriately downgraded as its contents were watered down and negotiated away. Effectively, its 27 principles are almost all weaker than the equivalent document signed in Stockholm 20 years earlier. The original idea of establishing an Earth Charter has not been forgotten but taken forward by the independent NGO body, the Earth Charter Initiative. In order to evolve a common and concerted approach towards environmental problems raised at the Rio Summit, pre-summit deliberations were held at Kualalampur and Nairobi. It was evident from such discussions that battle lines have been drawn between rich nations of the north and the impoverished nations of the south. The major six basic issues on which the divide was conspicuous are as follows:

1. Greenhouse Gas Emission: The rich nations of the north wanted 20% reduction in emission of greenhouse gases like CO2, by the year 2005. They also wanted a major shift from the use of coal and wood for energy. The poor developing and underdeveloped countries blamed, the developed countries for large scale emissions of CO2 and CHn over the past 50 years and hence wanted the latter to make drastic reductions by them would adversely affect their development.

2. Forests: The rich countries considered forests in terms of timber, paper and CO2 links and wanted a legally binding convention that severely restricts the felling of trees especially in tropical rain forests which are rich in biodiversity. But the poorer countries see the forest as community resources in terms of fodder and fuel wood. The moves of the rich would impinge on national sovereignty. The poor nations wanted the north to compensate for conservation and share the profits if the biodiversity is used for research.

3. Population: The developed countries think that poverty and population growth are the main reasons for deforestation and water pollution. They want severe steps to control them. The developing countries blame the rich for over consumption. They feel that over-exploitation of resources to feed the industrial development of the west is the major cause of deforestation.

4. Technology Transfer: North believes that the technology of development is to be treated as a commercial proposition and those who want it should pay for it. Since most of the pollution is caused by the industrially advanced countries, the South wants the use of technology for cleaning up the pollutants and for improving energy efficiency to be transferred free.

5. Finance: The rich does not want to give any mandatory contribution and wants the UN institutions such as the Global Environmental Facility (GEF) or the World Bank to distribute the aid. The South wants firm commitment on aid for environmental actions as the common environment is brutally exploited by the industrialized north.

6. Degradation: The developed countries admit that the degradation of environment is due to rapid rate of industrialization, but do not want to pay for it. The developing countries strongly believe that the north is responsible for all the muck in the past and, therefore, should pay for the cleaning up process. The main stumbling blocks at the Earth Summit were the sharp differences between the U.S. and the third world countries on the issue of owning the responsibility and agreeing to pay for the cleaning-up. The U.S. President declared at the Summit that though he would not sign the bio-diversity treaty, the U.S. will continue to support the cause. The Earth Summit finally ended on June 14, 1992, after adopting the Rio Declaration and Agenda 21. The latter is considered to be a blue print for sustainable development. The Agenda 21 document covered a wide variety of conservation issues and management of resources for development so that the future needs for resources were taken care of. The atmosphere, land resources, forests, mountains, sustainable agriculture and rural development, drought, biological diversity, seas and oceans, freshwater and waste management were among the subjects that were covered with.

Principles of Rio Conference

The Rio Declaration is a framework document which is made up of 27 principles; not legally binding similar to the Stockholm declaration adopted 20 years ago. These Principles are as follows:

Principle 1: Human beings, being at the centre of concerns for sustainable development, are entitled to a healthy and productive life in harmony with nature.

Principle 2: States have the sovereign right to exploit their own resources with their own environmental and developmental policies. They have the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states or of areas beyond the limits of national jurisdiction.

Principle 3: The right to development must be fulfilled so as to equitably meet development

Principle 4: In order to achieve sustainable development, environmental protection should constitute an integral part of the development process and cannot be considered in isolation from it.

Principle 5: All states and all people should get involved in eradicating poverty as an indispensable requirement for sustainable development, in order to decrease the disparities in standards of living and betterment the needs of the majority of the people of the world.

Principle 6: The special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, should be given special priority. International actions on environment and development should address the interests and needs of all countries.

Principle 7: States should co-operate to conserve, protect and restore the health and integrity of the earth's eco system. The developed countries acknowledge the responsibility that they bear in the pursuit of sustainable development in view of the pressures their societies place on the environment and of the technologies and financial resources they command.

Principle 8: To achieve sustainable development and a higher quality of life for all people, states should reduce and eliminate sustainable patterns of production and consumption and promote appropriate demographic policies.

Principle 9: States should co-operate to strengthen endogenous capacity-building for sustainable development by improving scientific understanding through exchange of scientific and technological knowledge, and by enhancing the development, adoption, diffusion and transfer of technologies, including new and innovative technologies.

Principle 10: Environmental issues are best handled with the participation of all concerned citizen, at the relevant level. At the national level, each individual should have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States should facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, should be provided.

Principle 11: States should enact effective environmental legislation. Environmental standards, management objectives and priorities should reflect the environmental and developmental context to which they apply. Standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular, developing countries.

Principle 12: States should co-operate to promote a supportive and open international economic system that would lead to economic growth and sustainable development in all countries, to better address the problems of environmental degradation. Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade. Unilateral actions to deal with environmental challenges outside the jurisdiction of the importing country should be avoided. Environmental measures addressing transboundary or global environmental problems should, as far as possible, be based on an international consensus.

Principle 13: States should develop national laws regarding liability and compensation for the victims of population and other environmental damage. States should also cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction.

Principle 14: States should effectively co-operate to discourage or prevent the relocation and transfer to other states of any activities and substances that cause severe environmental degradation or are found to be harmful to human health.

Principle 15: In order to protect the environment, the precautionary approach should be widely applied by states. Where there are treats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing cost effective measures to prevent environmental degradation.

Principle 16: National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter-should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.

Principle 17: Environmental impact assessment, as a national instrument, should be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to decision of a competent national authority.

Principle 18: States should immediately notify other states of any natural disasters or other emergencies that are likely to produce sudden harmful effects on the environment of those states. Every effort should be made by the international community to help states so afflicted.

Principle 19: States should provide prior and timely notification and relevant information to potentially affected states on activities that may have a significant adverse transboundary environmental effect and should consult with those states at an early stage and in good faith.

Principle 20: Women have a vital role in environmental management and development. Their full participation is, therefore essential to achieve sustainable development.

Principle 21: The creativity, ideals and courage of the youth should be mobilized to forge a global partnership in order to achieve sustainable development and ensure a better future for all.

Principle 22: Indigenous people and their communities, and other local communities, have a vital role in environmental management and development because of their knowledge and traditional practices. States should recognize and duly support their identity, culture and interest and enable their effective participation in the achievement of sustainable development.

Principle 23: The environment and natural resources of people under oppression, and domination and occupation should be protected.

Principle 24: Warfare is inherently destructive of sustainable development. States should, therefore, respect international law providing protection for the environment in times of armed conflict and co-operate in its further development, as necessary.

Principle 25: Peace, development and environmental protection are interdependent and indivisible.

Principle 26: States should resolve all their environmental disputes peacefully and by appropriate means in accordance with the Charter of the United Nations.

Principle 27: States and people should co-operate in good faith and in a spirit of partnership in the fulfillment of the principles embodied in this Declaration and in the further development of international law in the field of sustainable development.

Major Achievements of Rio Summit

The major achievements of the Earth Summit can be found in the following documents:

- **The Rio Declaration of Environment and Development**: This document contains a series of principles that define the rights and responsibilities of States in this area.
- **Agenda 21:** This document is a comprehensive blueprint for global actions to effect the transition to sustainable development.
- **Forest Principles**: This document features a set of principles to support the sustainable management or forests worldwide.
- **Two Legally Binding Conventions:** These are the Convention on Climate Change and the Convention on Biodiversity, which are aimed at preventing global climate change and the eradication or biologically diverse species. These conventions were signed by the representatives of more than 150 countries.

United Nations
Framework Convention on
Climate Change

United Nations Framework Convention on Climate Change (UNFCCC)

1) It is the first internationally accepted "multilateral and legal instrument" on climate change.
2) It originated from the United Nations' Conference on Environment and Development (UNCED), which was held in June 1992 in Rio de Janerio (Brazil).
3) There are, at present, 195 parties to the convention; India is a willful partner in the UNFCCC.
4) The aim of this convention was to limit the growth in average global temperature and consequent climate change.
5) The UNFCCC function through a secretariat, located in the German city of Bonn, at the head of the secretariat is the Executive Secretary.

6) The main task of the secretariat is to support intergovernmental climate change negotiations, particularly the Conference of Parties (CoP).

7) The Conference of the Parties (COP) held together with the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP), held annually and hosted alternately by the regional groups.

8) It is the largest annual United Nations conference, attended by up to 10,000 people(approx)from all over the world. Plans for the COP and CMP, as well as other arrangements for the intergovernmental process are developed in consultation with Parties each year

9) All the negotiations on Climate change, including both adaptation and mitigation, are guided by the principles and objectives set out by the UNFCCC.

10) Five years after its formation the UNFCCC adopted the Koyoto Protocol in Dec, 1997.

Koyoto Protocol

1) The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change, which commits its Parties to reduce Green House Gases (GHG) emissions, in other words it commits them to binding emission reduction targets.

2) It is a protocol and hence is to be distinguished from a Convention. While a convention encourages the parties to do something, a protocol commits them to do so.

3) The Kyoto Protocol was adopted in Kyoto, Japan, on 11 December 1997 and entered into force on 16 February 2005.

4) The detailed rules for the implementation of the Protocol were adopted at COP 7 in Marrakesh, Morocco, in 2001, and are referred to as the "Marrakesh Accords." Its first commitment period started in 2008 and ended in 2012.

5) At the heart of the Koyoto Protocol is the principle of-**"Common but Differentiated Responsibility"**

6) Recognizing that developed countries are principally responsible for the current high levels of GHG emissions in the atmosphere as a result of more than 150 years of industrial activity, the Protocol places a heavier burden on developed nations under the principle of "common but differentiated responsibilities."

7) During the first commitment period, 37 industrialized countries and the European Community committed to reduce GHG emissions under the Koyoto Protocol.

8) In the first commitment period ,the target was an average five percent reduction in GHGs emissions compared to 1990 levels over the Five year period i.e. from 2008-2012.

9) In Doha, Qatar, on 8 December 2012, the **"Doha Amendment to the Kyoto Protocol"** was adopted.

10) During the second commitment period, Parties committed to reduce GHG emissions by at least 18 percent below 1990 levels in the eight-year period from 2013 to 2020; however, the composition of Parties in the second commitment period is different from the first.

Koyoto Mechanisms

Under the Protocol, countries must meet their targets primarily through national measures. However, the Protocol also offers them an additional means to meet their targets by way of three market-based mechanisms.

The Kyoto mechanisms are:

- **International Emissions Trading**
- **Clean Development Mechanism (CDM)**
- **Joint implementation (JI)**

International Emissions Trading

1. Parties with commitments under the Kyoto Protocol (Annex B Parties) have accepted targets for limiting or reducing emissions.

2. These targets are expressed as levels of allowed emissions, or "assigned amounts," over the 2008-2012 commitment period.

3. The allowed emissions are divided into "assigned amount units" (AAUs).

Emissions trading, under the Kyoto Protocol, allow countries that have emission units to spare - emissions permitted to them but not "used" - to sell this excess capacity to countries that are over their targets.

Thus, a new commodity was created in the form of emission reductions or removals. Since carbon dioxide is the principal greenhouse gas, people speak simply of trading in carbon. Carbon is now tracked and traded like any other commodity. This is known as the "carbon market" and the trading as "Carbon Trading."

Clean Development Mechanisms

The Clean Development Mechanism (CDM), defined in Article 12 of the Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO2, which can be counted towards meeting Kyoto targets.

eg:-A CDM project activity might involve, for example, a rural electrification project using solar panels or the installation of more energy-efficient boilers.

Note:-

1. Annex B countries are those countries which have quantified obligations under the Koyoto Protocol

2. Most of the CDM projects are implemented now in growing emerging economies like India, China, Brazil, South Africa etc.

Joint Implementation

1. The mechanism known as "joint implementation," defined in the Kyoto Protocol, allows a country with an emission reduction or limitation commitment under the Kyoto Protocol (Annex B Party) to earn emission reduction units (ERUs) from an emission-reduction or emission removal project in another Annex B Party, each equivalent to one tonne of CO2, which can be counted towards meeting its Kyoto target.

2. Joint implementation offers Parties a flexible and cost-efficient means of fulfilling a part of their Kyoto commitments, while the host Party benefits from foreign investment and technology transfer.

Annex-A

Greenhouse gases

1. Carbon dioxide (C02)

2. Methane (CH4)

3. Nitrous oxide (N20)

4. Hydrofluorocarbons (HFCs)

5. Perfluorocarbons (PFCs)

6. Sulphur hexafluoride (SF6)

Annex B

Party [Quantified emission limitation or reduction commitment (percentage of base year or period)]

1. Australia 108

2. Austria 92

3. Belgium 92

4. Bulgaria* 92

5. Canada 94

6. Croatia* 95

7. Czech Republic* 92

8. Denmark 92

9. Estonia* 92

10. European Community 92

11. Finland 92

12. France 92

13. Germany 92

14. Greece 92

15. Hungary* 94

16. Iceland 110

17. Ireland 92

18. Italy 92

19. Japan 94

20. Latvia* 92

21. Liechtenstein 92

22. Lithuania* 92

23. Luxembourg 92

24. Monaco 92

25. Netherlands 92

26. New Zealand 100

27. Norway 101

28. Poland* 94

29. Portugal 92

30. Romania* 92

31. Russian Federation* 100

32. Slovakia* 92

33. Slovenia* 92

34. Spain 92

35. Sweden 92

36. Switzerland 92

37. Ukraine* 100

38. United Kingdom of Great Britain and Northern Ireland 92

39. United States of America 93

*** Countries that are undergoing the process of transition to a market economy.**

The Convention divides countries into three main groups according to differing commitments:

Annex I Parties include the industrialized countries that were members of the OECD (Organisation for Economic Co-operation and Development) in 1992, plus countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States.

Annex II Parties consist of the OECD members of Annex I, but not the EIT Parties. They are required to provide financial resources to enable developing countries to undertake emissions reduction activities under the Convention and to help them adapt to adverse effects of climate change. In addition, they have to "take all practicable steps" to promote the development and transfer of environmentally friendly technologies to EIT Parties and developing countries. Funding provided by Annex II Parties is channelled mostly through the Convention's financial mechanism.

Non-Annex I Parties are mostly developing countries. Certain groups of developing countries are recognized by the Convention as being especially vulnerable to the adverse impacts of climate change, including countries with low-lying coastal areas and those prone to desertification and drought. Others (such as countries that rely heavily on income from fossil fuel production and commerce) feel more vulnerable to the potential economic impacts of climate change response measures. The Convention emphasizes activities that promise to answer the special needs and concerns of these vulnerable countries, such as investment, insurance and technology transfer.

The **49 Parties** classified as **least developed countries (LDCs)** by the United Nations are given special consideration under the Convention on account of their limited capacity to respond to climate change and adapt to its adverse effects. Parties are urged to take full account of the special situation of LDCs when considering funding and technology-transfer activities.

Inter-Governmental Panel on Climate Change (IPCC)

1. The Intergovernmental Panel on Climate Change (IPCC) is the international body for assessing the science related to climate change.

2. The IPCC was set up in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) to provide policymakers regular assessments on climate change, its impacts and future risks, and options for adaptation and mitigation.

3. IPCC is open to all member countries of the UN and WMO. There are at present 195 members of the IPCC. The Secretariat of IPCC is supported by United Nations Environment Program (UNEP) and is located in Geneva.

4. IPCC assessments provide a scientific basis for governments at all levels to develop climate related policies, and they underlie negotiations at the UN Climate Conference – the United Nations Framework Convention on Climate Change (UNFCCC).

5. The assessments are policy-relevant but not policy-prescriptive: they may present projections of future climate change based on different scenarios and the risks that climate change poses and discuss the implications of response options, but they do not tell policymakers what actions to take.

6. The Panel, made up of representatives of the member states, meets in Plenary Sessions to take major decisions.

7. The IPCC Bureau, elected by member governments, provides guidance to the Panel on the scientific and technical aspects of the Panel's work and advises the Panel on related management and strategic issues.

8. The authors producing the reports are currently grouped in three working groups –

- **Working Group I: The Physical Science Basis**
- **Working Group II: Impacts, Adaptation and Vulnerability;**
- **Working Group III: Mitigation of Climate Change – and the Task Force on National Greenhouse Gas Inventories (TFI).**

9. IPCC Assessment Reports cover the full scientific, technical and socio-economic assessment of climate change, generally in four parts – one for each of the Working Groups plus a Synthesis Report.

10. Special Reports are assessments of a specific issue. Methodology Reports provide practical guidelines for the preparation of greenhouse gas inventories under the UNFCCC.

Note:-

a) The IPCC is administered in accordance to UNEP, WMO and UN rules and procedures, including codes of conduct and ethical principles (as outlined in UN Ethics, WMO Ethics Function, Staff Regulations etc. Thousands of scientists from all over the world contribute to the work of IPCC on a voluntary basis.

b) National Greenhouse gas inventories provides the methods for estimating national green house gas emissions to, and removals from the atmosphere

Different Stages of an IPCC report

1. "**Approval"** is the process used for IPCC Summaries for Policymakers (SPMs).

Approval signifies that the material has been subject to detailed, line-by-line discussion, leading to agreement among the participating IPCC member countries, in consultation with the scientists responsible for drafting the report. This process strengthens the SPM by ensuring that SPM statements are as direct,

clear and unambiguous as possible in summarizing the material contained in the corresponding Working Group Assessment Report or Special Report. Participation of assessment authors ensures that any changes to the SPM are consistent with the underlying report and are scientifically robust.

2. "**Adoption"** is the process used for IPCC Synthesis Reports. Adoption is a section-by-section discussion leading to agreement among participating governments in consultation with the authors. This process ensures that the Synthesis Report effectively integrates material from the underlying Working Group Assessment Reports and Special Reports. The SPM of a Synthesis Report is approved line by line, as described above.

3. "**Acceptance"** is the process used for the full underlying report in a Working Group Assessment Report or a Special Report after its SPM has been approved. Acceptance by governments signifies that the Technical Summary and chapters of the underlying report present a comprehensive, objective and balanced view of the subject matter. Acceptance does not involve line-by-line discussion and consultation between the scientists and the governments. Changes (other than grammatical or minor editorial changes) after acceptance are limited to those necessary to ensure consistency with the Summary for Policymakers, and are identified in writing after SPM approval.

Note:-Assessment Reports and Special Reports are approved and accepted by the responsible Working Group, with the government representatives to the Panel coming together in a Plenary Session of the Working Group.

Special Climate Change Fund

1. The Special Climate Change Fund (SCCF), was established under the UNFCCC in 2001.

2. Its purpose is to finance projects relating to adaptation, technology transfer, capacity building, waste management and economic diversification.

3. The Global Environment facility (GEF) is entrusted with the task of operating the SCCF.

Least Developed Countries Fund

1. The Least Developed Countries Fund (LDCF) was established to support a work programme to assist Least Developed Country Parties (LDCs) carry out, inter alia, the preparation and implementation of national adaptation programmes of action (NAPAs).

2. The Global Environment Facility (GEF), as an operating entity of the Financial Mechanism of the Convention, has been entrusted to operate this Fund

Finance Mechanism for Climate Change

The financial resources that have been made available to non-annex I parties to the UNFCCC consist of the following three modules

A) National Communication Module

1. The National Communications Module of the Finance Portal for Climate Change captures information communicated by Annex II Parties on the provision of financial resources related to the implementation of the Convention through their national communications

2. The data presented in this module is extracted from submitted national communications documents and every effort is being made to ensure accuracy and consistency to the extent possible

Note:-Annex II Parties consist of the OECD members of Annex I, but not the EIT Parties

B) Fast Start Finance

1. During the Conference of the Parties (COP15) held in December 2009 in Copenhagen developed countries pledged to provide new and additional resources, including forestry and investments, approaching USD 30 billion for the period 2010 - 2012 and with balanced allocation between mitigation and adaptation. This collective commitment has come to be known as 'fast-start finance'

2. Following up on this pledge, the Conference of the Parties in Cancun, in December 2010, took note of this collective commitment by developed country Parties and reaffirmed that funding for adaptation will be prioritized for the most vulnerable developing countries, such as the least developed countries, small island developing States and Africa.

3. Further, the COP invited developed country Parties to submit information on the resources provided to achieve this goal, including ways in which developing country Parties access these resources

4. At COP 17 Parties welcomed the Fast-start Finance provided by developed countries as part of their collective commitment to provide new and additional resources approaching USD 30 billion for the period 2010–2012, and noted the information provided by developed country Parties on the fast-start finance they have provided and urged them to continue to enhance the transparency of their reporting on the fulfillment of their fast-start finance commitments.

5. At COP 18, Parties acknowledged the delivery of Fast-start Finance by developed country Parties to fulfil their collective Fast-start Finance commitment, and invited developed country Parties to expedite its full disbursement.

C) Funds Managed by the GEF Module

1.The Global Environment Facility (GEF) was established in 1991 and provides funding to developing countries and countries with economies in transition for projects related to the focal areas of biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants

2. The funding comes in the form of grants and concessional funding and covers the incremental or additional costs associated with transforming a project with national benefits into one with global environmental benefits.

3. In addition, the Facility administers two funds under the Convention: Least Developed Countries Fund (LDCF) and Special Climate Change Fund (SCCF).

REDD AND REDD+

1. The idea of REDD (Reducing emissions from deforestation and Forest Degradation) in developing countries was first introduced into the COP agenda at its eleventh session in Montreal (December 2005)

2.It is a global endeavour to create an incentive for developing countries to protect better manage, and save their forest resources, thus contributing to the global fight against Climate change.

3.Reducing Emissions from Deforestation and Forest Degradation (REDD) is an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development.

4. REDD+ stands for countries' efforts to reduce emissions from deforestation and forest degradation, and foster conservation, sustainable management of forests, and enhancement of forest carbon stocks.

5. REDD+ argues that for ensuring sustainable development there should be efforts for livelihood improvement, biodiversity conservation and Food security.

INDIA's Position on REDD and REDD+

1.India believes that REDD and REDD+ must be treated as two sides of the same coin in other words India strongly proclaim that reduction in Deforestation and forest degradation must go hand in hand with conservation efforts and improvements in forest resources including Biodiversity.

2.India's stand was finally accepted by all in the 13th CoP meeting at Bali when elements of conservation, sustainable management of forests and enhancement of forest stocks were added to the then existing text of Reducing Emissions from Deforestation and Forest Degradation as part of **Bali Action Plan**

3. India has presented her own **Green India Mission** programme under its National Action Plan on Climate Change (NACC)

Note:-Unlike afforestation and reforestation activities, which generally cause small annual changes in carbon stocks over long periods of time, stemming deforestation causes large changes in carbon stocks over a short period of time. Most emissions from deforestation take place rapidly, whereas carbon removal from the atmosphere through afforestation and reforestation activities is a slow process.

United Nations Convention on Environment and Development (UNCED)

1.The United Nations Conference on Environment and Development (UNCED), also known as the Rio de Janeiro **Earth Summit** , **Rio Summit**, **Rio Conference** and **ECO92**, was a major United Nations conference held in Rio de Janeiro from 3 to 14 June 1992.

2. In 2012, the United Nations Conference on Sustainable Development was also held in Rio, and is also commonly called Rio+20 or Rio Earth Summit 2012. It was held from 13 to 22 June.

3. The issues addressed included:

a) Systematic scrutiny of patterns of production — particularly the production of toxic components, such as lead in gasoline, or poisonous waste including radioactive chemicals

b) Alternative sources of energy to replace the use of fossil fuels which delegates linked to global climate change

c) New reliance on public transportation systems in order to reduce vehicle emissions, congestion in cities and the health problems caused by polluted air and smoke

d) The growing usage and limited supply of water

4. An important achievement of the summit was an agreement on the **Climate Change Convention which in turn led to the Kyoto Protocol.**

5. Another agreement was to "not to carry out any activities on the lands of indigenous peoples that would cause environmental degradation or that would be culturally inappropriate".

6. Three important legally binding agreements (Rio Convention) were opened for signature:

(i) **Convention on Biological Diversity**

(ii) **Framework Convention on Climate Change (UNFCCC)**

(iii) **United Nations Convention to Combat Desertification**

7. The Earth Summit resulted in the following documents:

(i) **Rio Declaration on Environment and Development**

(ii) **Agenda 21**

(iii) **Forest Principles**

Rio Declaration on Environment and Development

The Rio Declaration on Environment and Development, often shortened to Rio Declaration, was a short document produced at the 1992 United Nations "Conference on Environment and Development" (UNCED), informally known as the Earth Summit, and signed by over 170 countries. The Rio Declaration consisted of 27 principles intended to guide countries in future sustainable development.

Note:-The 27 principles are already discussed earlier (refer previous sections)

Agenda 21

Agenda 21 is a non-binding, voluntarily implemented action plan of the United Nations with regard to sustainable development. It is a product of the Earth Summit (UN Conference on Environment and Development) held in Rio de Janeiro, Brazil, in 1992. It is an action agenda for the UN, other multilateral organizations, and individual governments around the world that can be executed at local, national, and global levels. The "21" in Agenda 21 refers to the 21st Century. It has been affirmed and had a few modifications at subsequent UN conferences.

Forest Principles

The Forest Principles (also Rio Forest Principles) is the informal name given to the Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests (1992), a document produced at the United Nations Conference on Environment and Development (UNCED), informally known as the Earth Summit. It is a non-legally binding document that makes several recommendations for conservation and sustainable development forestry. At the Earth Summit, the negotiation of the document was complicated by demands by developing nations in the Group of 77 for increased foreign aid in order to pay for the setting aside of forest reserves. Developed nations resisted those demands, and the final document was a compromise.

Note:-The Commission on Sustainable Development (CSD) was created to monitor and report on implementation of the Earth Summit agreements. 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. This special session of the UN General Assembly took stock of how well countries, international organizations and sectors of civil society have responded to the challenge of the Earth Summit.

Rio+5 Conference, New York, 1997

1. The Rio+5 Conference was the first comprehensive status review of work to implement the UNCED's agreements. This Conference aimed to revive and strengthen commitment to sustainable development, ascertain failures and identify the reasons in each case, recognize achievements, set priorities and determine problems that had not been addressed sufficiently in Rio.

2. The Conference concluded that little progress had been made. For example, social injustice and poverty, as well as greenhouse gases, the release of toxic substances into the atmosphere and solid waste had continued to rise since 1992.

3. The meeting adopted two programmes:

The **Programme of Work of the Commission for 1998-2002** and the **Programme for the Further Implementation of Agenda 21,** an action plan for the following five years.

Rio+10 Conference, Johannesburg, 2002

1. The United Nations World Summit on Sustainable Development (WSSD), also known as Earth Summit II or Rio +10, took place in Johannesburg, South Africa, it was held 10 years after the Earth Summit.

2. The Johannesburg Declaration was a principal outcome of the Summit. It was a renewed commitment to fully implement the agenda 21 and other agreements of the Earth Summit, alongside the achievement of Millennium Development Goals.

Millennium Development Goals

The Millennium Development Goals (MDGs) are the eight international development goals that were established following the Millennium Summit of the United Nations in 2000, following the adoption of the United Nations Millennium Declaration.

All United Nations member states at the time , and at least 23 international organizations, committed to help achieve the following Millennium Development Goals by 2015:

1) To eradicate extreme poverty and hunger
2) To achieve universal primary education
3) To promote gender equality and empower women
4) To reduce child mortality
5) To improve maternal health
6) To combat HIV/AIDS, malaria, and other diseases
7) To ensure environmental sustainability
8) To develop a global partnership for development

Rio+20 Conference, Rio de Janerio, 2012

1.The United Nations Conference on Sustainable Development (UNCSD), also known as Rio 2012, Rio+20, or Earth Summit 2012 was the third international conference on sustainable development aimed at reconciling the economic and environmental goals of the global community. Hosted by Brazil in Rio de Janeiro from 13 to 22 June 2012, Rio+20 was a 20-year follow-up to the 1992 Earth Summit / United Nations Conference on Environment and Development (UNCED) held in the same city, and the 10th anniversary of the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg.

2. The conference had three objectives:

i) Securing renewed political commitment for sustainable development

ii) Assessing the progress and implementation gaps in meeting previous commitments.

iii) Addressing new and emerging challenges.

3. The primary result of the conference was the nonbinding document, "The Future We Want."It was a renewed political commitment for sustainable development and the promotion of a sustainable future. The document largely reaffirms previous action plans like Agenda 21.

4. "The text proposed the development of Sustainable Development Goals (SDGs), a set of measurable targets aimed at promoting sustainable development globally. It is thought that the SDGs will pick up where the Millennium Development Goals leave off."

Sustainable Development Goals

The Sustainable Development Goals (SDGs), officially known as transforming our world: the 2030 Agenda for Sustainable Development are an intergovernmental set of aspiration for ensuring sustainable development. The SDGs are a set of 17 goals with 169 targets covering a broad range of sustainable development issues.

Following the negotiations, a final document was adopted at the UN Sustainable Development Summit September 25–27, 2015 in New York, USA. The title of the agenda is **Transforming our world: the 2030 Agenda for Sustainable Development**

The 17 SGDs are as follows:-

1) End poverty in all its forms everywhere
2) End hunger, achieve food security and improved nutrition and promote sustainable agriculture
3) Ensure healthy lives and promote well-being for all at all ages
4) Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
5) Achieve gender equality and empower all women and girls
6) Ensure availability and sustainable management of water and sanitation for all
7) Ensure access to affordable, reliable, sustainable and modern energy for all
8) Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
9) Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
10) Reduce inequality within and among countries
11) Make cities and human settlements inclusive, safe, resilient and sustainable
12) Ensure sustainable consumption and production patterns
13) Take urgent action to combat climate change and its impacts.
14) Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15) Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
16) Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
17) Strengthen the means of implementation and revitalize the global partnership for sustainable development

Convention on Biodiversity (CBD)

1. The Convention on Biological Diversity (CBD), known informally as the Biodiversity Convention, is a multilateral treaty. The Convention was opened for signature at the Earth Summit in Rio de Janeiro on 5 June 1992 and entered into force on 29 December 1993.The Convention has three main goals:

a) The conservation of biological diversity

b) The sustainable use of the components of biological diversity

c) The fair and equitable sharing of the benefits arising out of the utilization of genetic resources

2. In other words, its objective is to develop national strategies for the conservation and sustainable use of biological diversity. It is often seen as the key document regarding sustainable development.

3. The convention acknowledges that substantial investments are required to conserve biodiversity. However it argues that such investments shall bring significant environmental, economic and social benefits.

4. The convention recognized for the first time in international law that the conservation of biological diversity is “a common concern of humankind” and is an integral part of the development process. The agreement covers all ecosystems, species, and genetic resources. It links traditional conservation efforts to the economic goal of using biological resources sustainably. It sets principles for the fair and equitable sharing of the benefits arising from the use of genetic resources, notably those destined for commercial use. It also covers the rapidly expanding field of biotechnology through its Cartagena Protocol on Biosafety, addressing technology development and transfer, benefit-sharing and biosafety issues.

5. **Importantly, the Convention is legally binding; countries that join it (‘Parties’) are obliged to implement its provisions.**

6. The convention reminds decision-makers that natural resources are not infinite and sets out a philosophy of sustainable use. While past conservation efforts were aimed at protecting particular species and habitats, the Convention recognizes that ecosystems, species and genes must be used for the benefit of humans. However, this should be done in a way and at a rate that does not lead to the long-term decline of biological diversity.

7. International bodies established by the convention

a)Conference of the parties: The convention's governing body is the Conference of the parties (COP), consisting of all governments (and regional economic integration organizations) that have ratified the treaty. This ultimate authority reviews progress under the Convention, identifies new priorities, and sets work plans for members. The COP can also make amendments to the Convention, create expert advisory bodies, review progress reports by member nations, and collaborate with other international organizations and agreements.

The Conference of the Parties uses expertise and support from several other bodies that are established by the Convention. In addition to committees or mechanisms established on an ad hoc basis, two main organs are:

i) The CBD Secretariat, based in Montreal, operates under the United Nations Environment Programme. Its main functions are to organize meetings, draft documents, assist member governments in the implementation of the programme of work, coordinate with other international organizations, and collect and disseminate information.

ii) The Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA). The SBSTTA is a committee composed of experts from member governments competent in relevant fields. It plays a key role in making recommendations to the COP on scientific and technical issues.

Cartagena Protocol

1.The Cartagena Protocol on Biosafety to the Convention on Biological Diversity is an international agreement which aims to ensure the safe handling, transport and use of living modified organisms (LMOs) resulting from modern biotechnology that may have adverse effects on biological diversity, taking also into account risks to human health. It was adopted on 29 January 2000 and entered into force on 11 September 2003.

2. The Biosafety Protocol makes clear that products from new technologies must be based on the precautionary principle and allow developing nations to balance public health against economic benefits. It will for example let countries ban imports of a genetically modified organism if they feel there is not enough scientific evidence the product is safe and requires exporters to label shipments containing genetically modified commodities such as corn or cotton.

3. The protocol defines a 'living modified organism' as any living organism that possesses a novel combination of genetic material obtained through the use of modern biotechnology and 'living organism' means any biological entity capable of transferring or replicating genetic material, including sterile organisms, viruses and viroids.

Overall the term 'living modified organisms' is equivalent to genetically modified organism – the Protocol did not make any distinction between these terms and did not use the term 'genetically modified organism.'

4. There are two main sets of procedures, one for LMOs intended for direct introduction into the environment, known as the **Advanced Informed Agreement (AIA)** procedure, and another for **LMOs intended**

for direct use as food or feed, or for processing (LMOs-FFP).

5. Procedures for moving LMOs across borders

Advance Informed Agreement

The "Advance Informed Agreement" (AIA) procedure applies to the first intentional transboundary movement of LMOs for intentional introduction into the environment of the Party of import.

It includes four components: notification by the Party of export or the exporter, acknowledgment of receipt of notification by the Party of import, the decision procedure, and opportunity for review of decisions.

The purpose of this procedure is to ensure that importing countries have both the opportunity and the capacity to assess risks that may be associated with the LMO before agreeing to its import.

The Party of import must indicate the reasons on which its decisions are based (unless consent is unconditional). A Party of import may, at any time, in light of new scientific information, review and change a decision. A Party of export or a notifier may also request the Party of import to review its decisions.

However, the Protocol's AIA procedure does not apply to certain categories of LMOs:

i) LMOs in transit;

ii) LMOs destined for contained use;

iii) LMOs intended for direct use as food or feed or for processing

While the Protocol's AIA procedure does not apply to certain categories of LMOs, Parties have the right to regulate the importation on the basis of domestic legislation. There are also allowances in the Protocol to declare certain LMOs exempt from application of the AIA procedure.

LMOs intended for food or feed, or for processing

LMOs intended for direct use as food or feed, or processing (LMOs-FFP) represent a large category of agricultural commodities. The Protocol, instead of using the AIA procedure, establishes a more simplified procedure for the transboundary movement of LMOs-FFP.

Under this procedure, A Party must inform other Parties through the Biosafety Clearing-House, within 15 days, of its decision regarding domestic use of LMOs that may be subject to transboundary movement.

Decisions by the Party of import on whether or not to accept the import of LMOs-FFP are taken under its domestic regulatory framework that is consistent with the objective of the Protocol.

A developing country Party or a Party with an economy in transition may, in the absence of a domestic regulatory framework, declare through the Biosafety Clearing-House that its decisions on the first import of LMOs-FFP will be taken in accordance with risk assessment as set out in the Protocol and time frame for decision-making.

6. Biosafety Clearing-House

The Protocol established a Biosafety Clearing-House (BCH), in order to facilitate the exchange of scientific, technical, environmental and legal information on, and experience with, living modified organisms; and to assist Parties to implement the Protocol

Nagoya-Kuala Lampur Supplementary Protocol

1. The Cartagena Protocol is reinforced by the Nagoya-Kuala Lampur Supplementary Protocol on liability and redressal.

2. This protocol specifies response measures to be taken in the event of damage to biodiversity resulting from LMOs.

3. The Competent authority under the supplementary protocol must require the person in control of the LMO (i.e. the Operator) to take the response measures or it may implement such measures itself and recover any costs incurred from the operator.

Nagoya Protocol

1. **What is the Nagoya Protocol and what is its objective?**

The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (ABS) to the Convention on Biological Diversity is a supplementary agreement to the Convention on Biological Diversity. It provides a transparent legal framework for the effective implementation of one of the three objectives of the CBD: the fair and equitable sharing of benefits arising out of the utilization of genetic resources.

The Nagoya Protocol on ABS was adopted on 29 October 2010 in Nagoya, Japan and entered into force on 12 October 2014, 90 days after the deposit of the fiftieth instrument of ratification. Its objective is the fair and equitable sharing of benefits arising from the utilization of genetic resources, thereby contributing to the conservation and sustainable use of biodiversity.

2. **Why is the Nagoya Protocol important?**

The Nagoya Protocol will create greater legal certainty and transparency for both providers and users of genetic resources by: Establishing more predictable conditions for access to genetic resources.

Helping to ensure benefit-sharing when genetic resources leave the country providing the genetic resources

By helping to ensure benefit-sharing, the Nagoya Protocol creates incentives to conserve and sustainably use genetic resources, and therefore enhances the contribution of biodiversity to development and human well-being.

3. **What does the Nagoya Protocol cover?**

The Nagoya Protocol applies to genetic resources that are covered by the CBD, and to the benefits arising from their utilization. The Nagoya Protocol also covers traditional knowledge (TK) associated with genetic resources that are covered by the CBD and the benefits arising from its utilization.

4. **What are the core obligations of the Nagoya Protocol with respect to genetic resources?**

The Nagoya Protocol sets out core obligations for its contracting Parties to take measures in relation to access to genetic resources, benefit-sharing and compliance.

i) Access obligations

Domestic-level access measures are to:

- Create legal certainty, clarity and transparency
- Provide fair and non-arbitrary rules and procedures

- Establish clear rules and procedures for prior informed consent and mutually agreed terms
- Provide for issuance of a permit or equivalent when access is granted
- Create conditions to promote and encourage research contributing to biodiversity conservation and sustainable use
- Pay due regard to cases of present or imminent emergencies that threaten human, animal or plant health
- Consider the importance of genetic resources for food and agriculture for food security

ii) Benefit-sharing obligations

Domestic-level benefit-sharing measures are to provide for the fair and equitable sharing of benefits arising from the utilization of genetic resources with the contracting party providing genetic resources. Utilization includes research and development on the genetic or biochemical composition of genetic resources, as well as subsequent applications and commercialization. Sharing is subject to mutually agreed terms. Benefits may be monetary or non-monetary such as royalties and the sharing of research results.

Iii) Compliance obligations

Specific obligations to support compliance with the domestic legislation or regulatory requirements of the contracting party providing genetic resources, and contractual obligations reflected in mutually agreed terms, are a significant innovation of the Nagoya Protocol. Contracting Parties are to:

- Take measures providing that genetic resources utilized within their jurisdiction have been accessed in accordance with prior informed consent, and that mutually agreed terms have been established, as required by another contracting party
- Cooperate in cases of alleged violation of another contracting party's requirements
- Encourage contractual provisions on dispute resolution in mutually agreed terms
- Ensure an opportunity is available to seek recourse under their legal systems when disputes arise from mutually agreed terms
- Take measures regarding access to justice
- Take measures to monitor the utilization of genetic resources after they leave a country including by designating effective checkpoints at any stage of the value-chain: research, development, innovation, pre-commercialization or commercialization

5. **How does the Nagoya Protocol address traditional knowledge associated with genetic resources and genetic resources held by indigenous and local communities?**

The Nagoya Protocol addresses traditional knowledge associated with genetic resources with provisions on access, benefit-sharing and compliance. It also addresses genetic resources where indigenous and local communities have the established right to grant access to them. Contracting Parties are to take measures to ensure these communities' prior informed consent, and fair and equitable benefit-sharing, keeping in mind community laws and procedures as well as customary use and exchange.

6. Tools and mechanisms to assist implementation

The Nagoya Protocol's success will require effective implementation at the domestic level. A range of tools and mechanisms provided by the Nagoya Protocol will assist contracting Parties including:

- Establishing national focal points (NFPs) and competent national authorities (CNAs) to serve as contact points for information grant access or cooperate on issues of compliance

- An Access and Benefit-sharing Clearing-House to share information, such as domestic regulatory ABS requirements or information on NFPs and CNAs
- Capacity-building to support key aspects of implementation. Based on a country's self-assessment of national needs and priorities, this can include capacity to
    - Develop domestic ABS legislation to implement the Nagoya Protocol
    - Negotiate MAT
    - Develop in-country research capability and institutions
    - Awareness-raising
    - -Technology Transfer
- Targeted financial support for capacity-building and development initiatives through the Nagoya Protocol's financial mechanism, the Global Environment Facility (GEF)

7. Criticism

Many scientists have voiced concern over the protocol, fearing the increased red tape may hamper disease prevention and conservation efforts, and that the threat of possible imprisonment of scientists will have a chilling effect on research. Non-commercial biodiversity researchers and institutions such as natural history museums fear maintaining biological reference collections and exchanging material between institutions will become difficult.

Ramsar Convention on Wetlands

1. 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.

2. There are presently 162 Contracting Parties to the Convention, with 2,040 wetland sites, totaling 193 million hectares, designated for inclusion in the Ramsar List of Wetlands of International Importance

3. Convention's mission**:-"The conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world"**.

4.The Convention uses a broad definition of the types of wetlands covered in its mission, including swamps and marshes, lakes and rivers, wet grasslands and peat lands, oases, estuaries, deltas and tidal flats, near-shore marine areas, mangroves and coral reefs, and human-made sites such as fish ponds, rice paddies, reservoirs, and salt pans.

5. **Why Wetlands?**

- Wetlands provide fundamental ecological services and are regulators of water regimes and sources of biodiversity at all levels - species, genetic and ecosystem.
- Wetlands constitute a resource of great economic, scientific, cultural, and recreational value for the community.

- Wetlands play a vital role in climate change adaptation and mitigation.
- Progressive encroachment on, and loss of, wetlands cause serious and sometimes irreparable environmental damage to the provision of ecosystem services.
- Wetlands should be restored and rehabilitated, whenever possible. Wetlands should be conserved by ensuring their wise use.

6. **Wise use of Wetlands**

Wise use of wetlands is defined as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development". Wise use therefore has at its heart the conservation and sustainable use of wetlands and their resources, for the benefit of humankind.

7. Under the 3 pillars of the Convention, the Parties have committed themselves to:

i) Work towards the wise use of all their wetlands through national land-use planning, appropriate policies and legislation, management actions, and public education;

ii) Designate suitable wetlands for the List of Wetlands of International Importance and ensure their effective management; and

iii) Cooperate internationally concerning transboundary wetlands, shared wetland systems, shared species, and development projects that may affect wetlands.

8. HOW DOES THE CONVENTION WORK?

- The Conference of the Contracting Parties (COP) meets every 3 years and promotes policies and guidelines to further the application of the Convention.
- The Standing Committee, made up of Parties representing the 6 Ramsar regions of the world, meets annually to guide the Convention between meetings of the COP.
- The Scientific and Technical Review Panel provides guidance on key issues for the Convention.
- The Ramsar Secretariat manages the day-to-day activities of the Convention.
- The MedWet Initiative, with its Secretariat in Athens, provides a model for regional wetland cooperation now being emulated by regional initiatives under the Convention in many parts of the world.
- Nationally, each Contracting Party designates an Administrative Authority as its focal point for implementation of the Convention.
- Countries are encouraged to establish National Wetland Committees, involving all government sectors dealing with water resources, development planning, protected areas, biodiversity, tourism, education, development assistance, etc. Participation by NGOs and civil society is also encouraged.
- Ramsar sites facing problems in maintaining their ecological character can be placed by the country concerned on a special list, the Montreux Record, and technical assistance to help solve the problems can be provided.
- Eligible countries can apply to a Ramsar Small Grants Fund and Wetlands for the Future Fund for financial assistance to implement wetland conservation and wise use projects.

Montreux Record

Montreux Record under the Convention is a register of wetland sites on the List of Wetlands of International Importance where changes in ecological character have occurred, are occurring, or are likely to occur as a result of technological developments, pollution or other human interference. It is maintained as part of the Ramsar List. The Montreux Record was established by Recommendation 4.8 of the Conference of the Contracting Parties (1990). Resolution 5.4 of the Conference (1993) determined that the Montreux Record should be employed to identify priority sites for positive national and international conservation attention. Sites may be added to and removed from the Record only with the approval of the Contracting Parties in which they lie. As of September 2007, 59 Ramsar sites are present in the Montreux Record 23 sites which had been listed on the Montreux Record have since been removed from it

World Wetland Day

World Wetlands Day which is celebrated each year on 2 February marks the date of the adoption of the Convention on Wetlands on 2 February 1971, in the Iranian city of Ramsar on the shores of the Caspian Sea. World Wetlands Day was celebrated for the first time on February 2, 1997, on the 16th anniversary of the Ramsar Convention. Each year since 1997, government agencies, non-governmental organizations, and groups of citizens at all levels of the community have taken advantage of the opportunity to undertake actions aimed at raising public awareness of wetland values and benefits in general and the Ramsar Convention in particular.

Convention on International Trade in Endangered Species (CITES)

1. CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora, also known as the Washington Convention) is a multilateral treaty to protect endangered plants and animals. It was drafted as a result of a resolution adopted in 1963 at a meeting of members of the International Union for Conservation of Nature (IUCN).

2. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten the survival of the species in the wild, and it accords varying degrees of protection to more than 35,000 species of animals and plants.

3. CITES is an international agreement to which States (countries) adhere voluntarily. States that have agreed to be bound by the Convention ('joined' CITES) are known as Parties. Although CITES is legally binding on the Parties – in other words they have to implement the Convention – it does not take the place of national laws. Rather it provides a framework to be respected by each Party, which has to adopt its own domestic legislation to ensure that CITES, is implemented at the national level.

4. CITES is administered through the United Nations Environment Programme (UNEP).The Secretariat located in Geneva oversees its implementation.

5. Species for which trade is controlled under CITES are listed in three appendices.

i) Appendix I: - It includes species threatened with Extinction and provides the greatest level of Protection, including restrictions on commercial trade.

ii) Appendix II: - It includes species that although currently not threatened with extinction, may become so without trade controls.

iii) Appendix III: - It includes species for which a country has asked other parties to help in controlling international trade.

Convention on the Conservation of Migratory Species (CMS)

1.The Convention on the Conservation of Migratory Species of Wild Animals - more commonly abbreviated to just the Convention on Migratory Species (CMS) or the Bonn Convention-aims to conserve terrestrial, marine and avian migratory species throughout their range.

2. It is an intergovernmental treaty, concluded under the aegis of the United Nations Environment Programme, concerned with the conservation of wildlife and habitats on a global scale.

3. The Convention was signed in 1979 in Bad Godesberg, a suburb of Bonn (hence the name), and entered into force in 1983.

4. The CMS is the only global and UN-based intergovernmental organization established exclusively for the conservation and management of terrestrial, aquatic and avian migratory species throughout their range.

5. CMS and its daughter agreements determine policy and provide further guidance on specific issues through their Strategic Plans, Action Plans, resolutions, decisions and guidelines.

6. The CMS Family covers a great diversity of migratory species. The Appendices of CMS include many mammals, including land mammals, marine mammals and bats; birds; fish; reptiles and one insect

7. Two Appendices

Appendix I – Threatened Migratory Species

Migratory species threatened with extinction are listed on Appendix I of the Convention, with relevant provisions outlined in Article III, paragraphs 4 and 5. Parties that are Range States to Appendix I species are obliged to afford them strict protection. CMS Parties strive towards strictly protecting these animals, conserving or restoring the places where they live, mitigating obstacles to migration and controlling other factors that might endanger them. Besides establishing obligations for each State joining the Convention, CMS promotes concerted action among the Range States of many of these species.

Appendix II – Migratory Species requiring international cooperation

Migratory species that need or would significantly benefit from international co-operation are listed in Appendix II of the Convention. These species, either individually or by taxonomic group, are the basis for establishing instruments – regional or global – under CMS. For this reason, the Convention encourages the Range States to conclude global or regional Agreements.

International Union for Conservation of Nature and Natural Resources (IUCN)

1. The International Union for Conservation of Nature and Natural Resources (IUCN) is an international organization working in the field of nature conservation and sustainable use of natural resources. IUCN was established in 1948. It was previously called the International Union for Protection of Nature.

2. It is involved in data gathering and analysis, research, field projects, advocacy, lobbying and education.

3. IUCN's mission is to "influence, encourage and assist societies throughout the world to conserve nature and to ensure that any use of natural resources is equitable and ecologically sustainable."

4. Over the past decades, IUCN has widened its focus beyond conservation ecology and now incorporates issues related to gender equality, poverty alleviation and sustainable business in its projects.

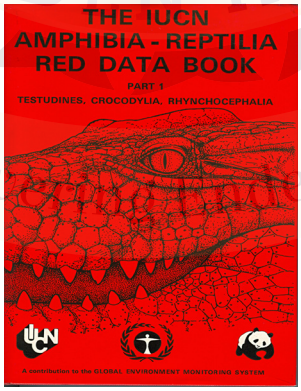
5. Unlike other international NGOs, IUCN does not itself aim to mobilize the public in support of nature conservation. It tries to influence the actions of governments, business and other stakeholders by providing information and advice, and through lobbying and partnerships.

6. The organization is best known to the wider public for compiling and publishing the IUCN Red List of Threatened Species, which assesses the conservation status of species worldwide.

7. IUCN has a membership of over 1200 governmental and non-governmental organizations. Some 11,000 scientists and experts participate in the work of IUCN commissions on a voluntary basis. It employs approximately 1000 full-time staff in more than 60 countries. Its headquarters are in Gland, Switzerland.

8. IUCN has observer and consultative status at the United Nations, and plays a role in the implementation of several international conventions on nature conservation and biodiversity. It was involved in establishing the World Wide Fund for Nature and the World Conservation Monitoring Centre.

9. In the past, IUCN has been criticized for placing the interests of nature over those of indigenous peoples. In recent years, its closer relations with the business sector have caused controversy.



IUCN Red Data Book

1. The IUCN Red List of Threatened Species (also known as the IUCN Red List or Red Data List), founded in 1964, is the world's most comprehensive inventory of the global conservation status of biological species. The International Union for the Conservation of Nature (IUCN) is the world's main authority on the conservation status of species.

2. The IUCN Red List is set upon precise criteria to evaluate the extinction risk of thousands of species and subspecies. These criteria are relevant to all species and all regions of the world.

3. The aim is to convey the urgency of conservation issues to the public and policy makers, as well as help the international community to try to reduce species extinction.

4. According to IUCN (1996), the formally stated goals of the Red List are

(i) To provide scientifically based information on the status of species and subspecies at a global level.

(ii) To draw attention to the magnitude and importance of threatened biodiversity

(iii) To influence national and international policy and decision-making

(iv) To provide information to guide actions to conserve biological diversity.

5. Species are classified by the IUCN Red List into nine groups, set through criteria such as rate of decline, population size, area of geographic distribution, and degree of population and distribution fragmentation.

- **Extinct (EX**) – No known individuals remaining.
- **Extinct in the wild (EW)** – Known only to survive in captivity, or as a naturalized population outside its historic range.
- **Critically endangered (CR)** – Extremely high risk of extinction in the wild.
- **Endangered (EN)** – High risk of extinction in the wild.
- **Vulnerable (VU)** – High risk of endangerment in the wild.
- **Near threatened (NT**) – Likely to become endangered in the near future.
- **Least concern (LC**) – Lowest risk. Does not qualify for a more at-risk category. Widespread and abundant taxa are included in this category.
- **Data deficient (DD)** – Not enough data to make an assessment of its risk of extinction.
- **Not evaluated (NE)** – Has not yet been evaluated against the criteria.

When discussing the IUCN Red List, the official term "threatened" is a grouping of three categories: Critically Endangered, Endangered, and Vulnerable.

6."Lower Risk" category which contained three subcategories:

- Conservation Dependent
- Near Threatened
- Least Concern

7. **Possibly extinct**

The tag of "possibly extinct" (PE) is used by Birdlife International, the Red List Authority for birds for the IUCN Red List. Birdlife International has recommended PE become an official tag for Critically Endangered species, and this has now been adopted, along with a "Possibly Extinct in the Wild" tag for species with populations surviving in captivity but likely to be extinct in the wild.

THE MONTREAL PROTOCOL

1. The Montreal Protocol on Substances that Deplete the Ozone Layer (a protocol to the Vienna Convention for the Protection of the Ozone Layer) is an international treaty designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion.

2. As a result of the international agreement, the ozone hole in Antarctica is slowly recovering. Climate projections indicate that the ozone layer will return to 1980 levels between 2050 and 2070.

3. It is perhaps the single most successful international agreement till date. It has been ratified by 197 parties, which includes 196 states and the European Union making it the first universally ratified treaties in United Nations history.

4. Chlorofluorocarbons (CFCs) Phase-out Management Plan

The stated purpose of the treaty is that the signatory states

"Recognizing that worldwide emissions of certain substances can significantly deplete and otherwise modify the ozone layer in a manner that is likely to result in adverse effects on human health and the environment. Determined to protect the ozone layer by taking precautionary measures to control equitably total global emissions of substances that deplete it with the ultimate objective of their elimination on the basis of developments in scientific knowledge. Acknowledging that special provision is required to meet the needs of developing countries"

5. Hydrochlorofluorocarbons (HCFCs) Phase-out Management Plan (HPMP)

Under the Montreal Protocol on Substances that Deplete the Ozone Layer, especially Executive Committee (ExCom) 53/37 and ExCom 54/39, Parties to this Protocol agreed to set year 2013 as the time to freeze the consumption and production of HCFCs.

The HCFCs are transitional CFCs replacements, used as refrigerants, solvents, blowing agents for plastic foam manufacture, and fire extinguishers. In terms of Ozone Depleting Potential (ODP), in comparison to CFCs that have ODP 0.6 – 1.0, these HCFCs have lower ODPs (0.01 – 0.5). In terms of Global Warming Potential (GWP), in comparison to CFCs that have GWP 4,680 – 10,720, HCFCs have lower GWPs (76 – 2,270).

6. Hydrofluorocarbons (HFCs)

Produced mostly in developed countries, hydro fluorocarbons (HFCs) replaced CFCs and HCFCs. HFCs pose no harm to the ozone layer because, unlike CFCs and HCFCs, they do not contain chlorine. But it has been established that HFCs are not innocuous either. They are greenhouse gases, with a high global warming potential (GWP), comparable to that of CFCs and HCFCs.

Note:-The Montreal Protocol does not currently address HFCs, but these substances figure in the basket of six greenhouse gases under the Kyoto Protocol. Developed countries following the Kyoto Protocol report their HFC emission data to UNFCCC; parties to the Montreal Protocol have no such obligation.

Rotterdam Convention

1. The Rotterdam Convention (formally, the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade) is a multilateral treaty to promote shared responsibilities in relation to importation of hazardous chemicals.

2. The convention promotes open exchange of information and calls on exporters of hazardous chemicals to use proper labeling, include directions on safe handling, and inform purchasers of any known restrictions or bans.

3. Signatory nations can decide whether to allow or ban the importation of chemicals listed in the treaty, and exporting countries are obliged to make sure that producers within their jurisdiction comply.

The Stockholm Convention on PoPs

What are Persistent Organic Pollutants (POPs)?

Persistent Organic Pollutants (POPs) are chemical substances that persist in the environment, bio-accumulate through the food web, and pose a risk of causing adverse effects to human health and the environment. With the evidence of long-range transport of these substances to regions where they have never been used or produced and the consequent threats they pose to the environment of the whole globe, the international community has now, at several occasions, called for urgent global actions to reduce and eliminate releases of these chemicals, because they are in a nutshell:

- Highly toxic to humans and the environment
- Persistent in the environment, resisting bio-degradation
- Taken up and bio-accumulated in terrestrial and aquatic ecosystems
- Capable of long-range, transboundary atmospheric transport and deposition

In nature these substances affect plant and animal development and growth. They can cause reduced reproductive success, birth defects, behavioral changes and death. They are suspected human carcinogens and disrupt the immune and endocrine systems.

1. The Stockholm Convention is a global treaty to protect human health and the environment from persistent organic pollutants (POPs).

2. 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.

3. POPs circulate globally and can cause damage wherever they travel. In implementing the Convention, Governments will take measures to eliminate or reduce the release of POPs into the environment.

4. The Stockholm Convention focuses on eliminating or reducing releases of 12 POPs, the so-called “Dirty Dozen”

5. The Stockholm Convention is perhaps best understood as having five essential aims:

- Eliminate dangerous POPs, starting with the 12 worst
- Support the transition to safer alternatives
- Target additional POPs for action
- Cleanup old stockpiles and equipment containing POPs
- Work together for a POPs-free future

The Global Environmental Facility (GEF) is the designated interim financial mechanism for the Stockholm Convention.

6. The Dirty Dozen includes

Aldrin

A pesticide applied to soils to kill termites, grasshoppers, corn rootworm, and other insect pests, aldrin can also kill birds, fish, and humans. In one incident, aldrin-treated rice is believed to have killed hundreds of shorebirds, waterfowl, and passerines along the Texas Gulf Coast when these birds either ate

animals that had eaten the rice or ate the rice themselves. In humans, the fatal dose for an adult male is estimated to be about five grams. Humans are mostly exposed to aldrin through dairy products and animal meats. Studies in India indicate that the average daily intake of aldrin and its byproduct dieldrin is about 19 micrograms per person.

Chlordane

Used extensively to control termites and as a broad-spectrum insecticide on a range of agricultural crops, chlordane remains in the soil for a long time and has a reported half-life of one year. The lethal effects of chlordane on fish and birds vary according to the species, but tests have shown that it can kill mallard ducks, bobwhite quail, and pink shrimp. Chlordane may affect the human immune system and is classified as a possible human carcinogen. It is believed that human exposure occurs mainly through the air, and chlordane has been detected in the indoor air of residences in the US and Japan.

DDT

DDT was widely used during World War II to protect soldiers and civilians from malaria, typhus, and other diseases spread by insects. After the war, DDT continued to be used to control disease, and it was sprayed on a variety of agricultural crops, especially cotton. DDT continues to be applied against mosquitoes in several countries to control malaria. Its stability, its persistence (as much as 50% can remain in the soil 10-15 years after application), and its widespread use have meant that DDT residues can be found everywhere; residual DDT has even been detected in the Arctic. Perhaps the best known toxic effect of DDT is egg-shell thinning among birds, especially birds of prey. Its impact on bird populations led to bans in many countries during the 1970s. Although its use had been banned in many countries, it has been detected in food from all over the world. Although residues in domestic animals have declined steadily over the last two decades, food-borne DDT remains the greatest source of exposure for the general population. The short-term acute effects of DDT on humans are limited, but long-term exposures have been associated with chronic health effects. DDT has been detected in breast milk, raising serious concerns about infant health.

Dieldrin

Used principally to control termites and textile pests, dieldrin has also been used to control insect-borne diseases and insects living in agricultural soils. Its half-life in soil is approximately five years. The pesticide aldrin rapidly converts to dieldrin, so concentrations of dieldrin in the environment are higher than dieldrin use alone would indicate. Dieldrin is highly toxic to fish and other aquatic animals, particularly frogs, whose embryos can develop spinal deformities after exposure to low levels. Dieldrin residues have been found in air, water, soil, fish, birds, and mammals, including humans. Food represents the primary source of exposure to the general population. For example, dieldrin was the second most common pesticide detected in a US survey of pasteurized milk.

Endrin

This insecticide is sprayed on the leaves of crops such as cotton and grains. It is also used to control rodents such as mice and voles. Animals can metabolize endrin, so it does not accumulate in their fatty tissue to the extent that structurally similar chemicals do. It has a long half-life, however, persisting in the soil for up to 12 years. In addition, endrin is highly toxic to fish. When exposed to high levels of endrin in the water, sheepshead minnows hatched early and died by the ninth day of their exposure. The primary route of exposure for the general human population is through food, although current dietary intake estimates are below the limits deemed safe by world health authorities.

Heptachlor

Primarily used to kill soil insects and termites, heptachlor has also been used more widely to kill cotton insects, grasshoppers, other crop pests, and malaria-carrying mosquitoes. It is believed to be responsible for the decline of several wild bird populations, including Canadian Geese and American Kestrels in the

Columbia River basin in the US. The geese died after eating seeds treated with levels of heptachlor lower than the usage levels recommended by the manufacturer, indicating that even responsible use of heptachlor may kill wildlife. Laboratory tests have also shown high doses of heptachlor to be fatal to mink, rats, and rabbits, with lower doses causing adverse behavioral changes and reduced reproductive success.

Heptachlor is classified as a possible human carcinogen. Food is the major source of exposure for humans, and residues have been detected in the blood of cattle from the US and from Australia.

Hexachlorobenzene (HCB)

First introduced in 1945 to treat seeds, HCB kills fungi that affect food crops. It was widely used to control wheat bunt. It is also a byproduct of the manufacture of certain industrial chemicals and exists as an impurity in several pesticide formulations.

When people in eastern Turkey ate HCB-treated seed grain between 1954 and 1959, they developed a variety of symptoms, including photosensitive skin lesions, colic, and debilitation; several thousand developed a metabolic disorder called porphyria turcica, and 14% died. Mothers also passed HCB to their infants through the placenta and through breast milk. In high doses, HCB is lethal to some animals and, at lower levels, adversely affects their reproductive success. HCB has been found in food of all types. A study of Spanish meat found HCB present in all samples. In India, the estimated average daily intake of HCB is 0.13 micrograms per kilogram of body weight.

Mirex

This insecticide is used mainly to combat fire ants, and it has been used against other types of ants and termites. It has also been used as a fire retardant in plastics, rubber, and electrical goods. Direct exposure to mirex does not appear to cause injury to humans, but studies on laboratory animals have caused it to be classified as a possible human carcinogen. In studies mirex proved toxic to several plant species and to fish and crustaceans. It is considered to be one of the most stable and persistent pesticides, with a half life of up to 10 years. The main route of human exposure to mirex is through food, particularly meat, fish, and wild game.

Toxaphene

This insecticide is used on cotton, cereal grains, fruits, nuts, and vegetables. It has also been used to control ticks and mites in livestock. Toxaphene was the most widely used pesticide in the US in 1975. Up to 50% of a toxaphene release can persist in the soil for up to 12 years.

For humans, the most likely source of toxaphene exposure is food. While the toxicity to humans of direct exposure is not high, toxaphene has been listed as a possible human carcinogen due to its effects on laboratory animals. It is highly toxic to fish; brook trout exposed to toxaphene for 90 days experienced a 46% reduction in weight and reduced egg viability, and long-term exposure to levels of 0.5 micrograms per liter of water reduced egg viability to zero.

Polychlorinated biphenyls (PCB)

These compounds are used in industry as heat exchange fluids, in electric transformers and capacitors, and as additives in paint, carbonless copy paper, and plastics. Of the 209 different types of PCBs, 13 exhibit a dioxin-like toxicity. Their persistence in the environment corresponds to the degree of chlorination, and half-lives can vary from 10 days to one-and-a-half years.

PCBs are toxic to fish, killing them at higher doses and causing spawning failures at lower doses. Research also links PCBs to reproductive failure and suppression of the immune system in various wild animals, such as seals and mink.

Large numbers of people have been exposed to PCBs through food contamination. Consumption of PCB-contaminated rice oil in Japan in 1968 and in Taiwan in 1979 caused pigmentation of nails and

mucous membranes and swelling of the eyelids, along with fatigue, nausea, and vomiting. Due to the persistence of PCBs in their mothers' bodies, children born up to seven years after the Taiwan incident showed developmental delays and behavioral problems. Similarly, children of mothers who ate large amounts of contaminated fish from Lake Michigan showed poorer short-term memory function. PCBs also suppress the human immune system and are listed as probable human carcinogens.

Polychlorinated dibenzo-p-dioxins (PCDD)

These chemicals are produced unintentionally due to incomplete combustion, as well during the manufacture of pesticides and other chlorinated substances. They are emitted mostly from the burning of hospital waste, municipal waste, and hazardous waste, and also from automobile emissions, peat, coal, and wood. There are 75 different dioxins, of which seven are considered to be of concern. One type of dioxin was found to be present in the soil 10 - 12 years after the first exposure.

Dioxins have been associated with a number of adverse effects in humans, including immune and enzyme disorders and chloracne, and they are classified as possible human carcinogens. Laboratory animals given dioxins suffered a variety of effects, including an increase in birth defects and stillbirths. Fish exposed to these substances died shortly after the exposure ended. Food (particularly from animals) is the major source of exposure for humans.

Polychlorinated dibenzofurans (PCDF)

These compounds are produced unintentionally from many of the same processes that produce dioxins, and also during the production of PCBs. They have been detected in emissions from waste incinerators and automobiles. Furans are structurally similar to dioxins and share many of their toxic effects. There are 135 different types, and their toxicity varies. Furans persist in the environment for long periods, and are classified as possible human carcinogens. Food, particularly animal products, is the major source of exposure for humans. Furans have also been detected in breast-fed infants.

Basel Convention

1. The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal was adopted on 22 March 1989 by the Conference of Plenipotentiaries in Basel, Switzerland, in response to a public outcry following the discovery, in the 1980s, in Africa and other parts of the developing world of deposits of toxic wastes imported from abroad.

2. The overarching objective of the Basel Convention is to protect human health and the environment against the adverse effects of hazardous wastes. Its scope of application covers a wide range of wastes defined as "hazardous wastes" based on their origin and/or composition and their characteristics, as well as two types of wastes defined as "other wastes" - household waste and incinerator ash.

3. The provisions of the Convention center around the following principal aims:

i)The reduction of hazardous waste generation and the promotion of environmentally sound management of hazardous wastes, wherever the place of disposal;

ii)The restriction of transboundary movements of hazardous wastes except where it is perceived to be in accordance with the principles of environmentally sound management; and

Iii)A regulatory system applying to cases where transboundary movements are permissible.

4. The Convention also provides for the establishment of regional or sub-regional centres for training and technology transfers regarding the management of hazardous wastes and other wastes and the minimization of their generation to cater to the specific needs of different regions and sub regions. Fourteen such centres have been established. They carry out training and capacity building activities in the regions.

United Nations Convention to Combat Desertification (UNCCD)

1. Desertification, along with climate change and the loss of biodiversity were identified as the greatest challenges to sustainable development during the 1992 Rio Earth Summit. Established in 1994, UNCCD is the sole legally binding international agreement linking environment and development to sustainable land management.

2. The Convention addresses specifically the arid, semi-arid and dry sub-humid areas, known as the dry-lands, where some of the most vulnerable ecosystems and peoples can be found.

3. In the 10-Year Strategy of the UNCCD (2008-2018) that was adopted in 2007, Parties to the Convention further specified their goals: "to forge a global partnership to reverse and prevent desertification/land degradation and to mitigate the effects of drought in affected areas in order to support poverty reduction and environmental sustainability".

4. The Convention's 195 parties work together to improve the living conditions for people in drylands, to maintain and restore land and soil productivity, and to mitigate the effects of drought.

5. The UNCCD is particularly committed to a bottom-up approach, encouraging the participation of local people in combating desertification and land degradation.

6. The UNCCD secretariat facilitates cooperation between developed and developing countries, particularly around knowledge and technology transfer for sustainable land management.

Note:-As the dynamics of land, climate and biodiversity are intimately connected, the UNCCD collaborates closely with the other two Rio Conventions; the Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC), to meet these complex challenges with an integrated approach and the best possible use of natural resources.

ENVIRONMENTAL LEGISLATIONS IN INDIA

In India, there are a number of laws which deal with various aspects of environment protection regulation, conduct of environmentally harmful activities and provide for remedies in case of their breach. Some of them are "general" having an "indirect" bearing on environment protection, while others are "special" (viz. Water, Air and Environmental Acts, Forest Act, etc.) being "directly" concerned with environment protection. General legislation comprises of Indian Penal Code, 1860; Code of Criminal Procedure, 1973; Code of Civil Procedure, 1908; and, specific sector legislations having a bearing on the environmental aspects viz. The Factories Act, 1948,

The Mines Act, 1952, The Industries (Development and Regulation) Act, 1951, The Insecticides Act, 1968, The Atomic Energy Act, 1962, The Motor Vehicles Act, 1939 and 1988, The Delhi Municipal Corporation Act, 1957, etc. Under Indian law, for instance, the remedies for a public nuisance are (i) a criminal prosecution for the offence of causing a public nuisance (Indian Penal Code 1860, Sec. 268), (ii) a criminal proceeding before a Magistrate for removing a public nuisance (Criminal Procedure Code 1973, Sections. 133-44), and (iii) a civil action by Advocate General or by two or more members of the public with the permission of the court, for a declaration, an injunction or both (Civil Procedure Code 1908, Section. 91).

The remedy under the civil law is not often used; however this provision is a reservoir for class action against environmental violations. Traditionally, the interpretation of the Indian Penal Code has been viewed as a conservative attempt at enforcement. This is because punishment and fines have been characterized as meager. The law of public nuisance contained in Sec. 133, Cr. P.C. has been used in a number of cases for the purpose of protection of the environment. In 1987, shortly after the Bhopal gas tragedy and the Supreme Court's ruling in the Shriram Gas Leak Case2, the 1987 amendment to the Factories Act introduced special provisions on hazardous industrial activities.

The amendment empowers the States to appoint "site appraisal committees" to advice on the initial location of factories using hazardous processes. The occupier of every hazardous unit must disclose to her workers the Factory Inspector the local authority and the general public in the vicinity of all particulars regarding health hazards at the factory, and the preventive measures taken. The regulation of nuclear energy and radioactive substances in India is governed by the Atomic Energy Act of 1962, and the Radiation Protection Rules of 1971.

Under the Act, the Central Government is required to prevent radiation hazards, guarantee public safety and the safety of workers handling radioactive substances, and ensure the disposal of radioactive wastes. The control of air pollution resulting from the vehicular emissions which contributes for about 65-70 per cent of the pollution load in India was taken care of by the Motor Vehicles Act, 1939. The Act empowered the State Government to make rules inter-alia regarding the emission of smoke, visible vapour, sparks, ashes, girt or oil.

The 1939 Act has now been repealed by the Motor Vehicles Act, 1988. Section 110 of the new Act empowers the Central Government to make rules regulating the construction equipment and maintenance of motor vehicles and trailers. In the Constitution of India it is clearly stated that it is the duty of the state 'to protect and improve the environment and to safeguard the forests and wildlife of the country'. It imposes a duty on every citizen 'to protect and improve the natural environment including forests, lakes, rivers and wildlife'. Reference to the environment has also been made in the Directive Principles of State Policy as well as the Fundamental Rights. 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. The constitutional provisions are backed by a number of laws – acts, rules and notifications. The Environment Protection Act of 1986(EPA) came into force soon after the Bhopal Gas Tragedy and is considered an umbrella legislation as it fills many gaps in the existing laws. Thereafter a large number of laws came into existence as the problems began arising e.g. Handling and Management of Hazardous Waste Rules in 1989. Following is a list of the environmental legislations that have come into effect.

1986 – The Environment (Protection) Act authorizes the central government to protect and improve environmental quality, control and reduce pollution from all sources, and prohibit or restrict the setting and /or operation of any industrial facility on environmental grounds.

1986 – The Environment (Protection) Rules lays down procedures for setting standards of emission or discharge of environmental pollutants.

1989 – Hazardous waste (Management and Handling) Rules objective is to control generation, collection, treatment, import, storage and handling of hazardous waste.

1989 – The Manufacture, Storage and Import of Hazardous Chemical Rules defines the terms used in this context, and sets up an Authority to inspect, once a year, the industrial activity connected with hazardous chemicals and isolated storage facilities.

1989 – The Manufacture, Use, Import, Export and Storage of hazardous Micro-organisms/ Genetically Engineered Organisms or Cells Rules were introduced with a view to protect the environment, nature and health, in connection with the application of gene technology and micro organisms.

1991 – The Public Liability Insurance Act and Rules and Amendment, 1992 was drawn up to provide for public liability insurance for the purpose of providing immediate relief to the persons affected by accident while handling any hazardous substance.

1995 – National environmental Tribunal Act has been created to award compensation for damages to persons, property and the environment arising from any activity involving hazardous substances.

1997 – The National Environment Appellate Authority Act has been created to hear appeals with respect to restrictions of areas in which classes of industries etc are carried out or prescribed subject to certain safeguards under the EPA (Environment Protection Act).

1998 – Biomedical waste (Management and Handling) Rules is a legal binding on the health care institutions to streamline the process of proper handling of hospital waste such as segregation, disposal, collection and treatment.

Forest and wildlife

1927 – Indian Forest Act and Amendment 1984 is one of the many surviving colonial statutes. It was enacted to 'consolidate the law related to forest, the transit of forest produce and the duty leviable on timber and other forest produce.

1972 – Wildlife Protection Act, Rules 1973 and Amendment 1991 provides for the protection of birds and animals and for all matters that are connected to it whether it be their habitat or the waterhole or the forest that sustain them.

1980 – The Forest (Conservation) Act and Rules 1981 provides for the protection of and the conservation of the forests.

Water

1882 – The Easement Act allows private rights to use a resource i.e. groundwater, by viewing it as an attachment to the land. It also states that all surface water belongs to the state and is a state property.

1897– Indian Fisheries Act establishes two sets of penal offences whereby the government can sue any person who uses dynamite or other explosive substance in any way (whether coastal or inland) with intent to catch or destroy any fish or poisons fish in order to kill.

1956 – The River Boards Act enables the states to enroll the Central Government in setting up an Advisory River Board to resolve issues in interstate cooperation.

1970 – Merchant Shipping Act aims to deal with waste arising from ships along the coastal areas within a specified radius.

1974 – The Water (Prevention and Control of Pollution) Act establishes an institutional structure for preventing and abating water pollution. It establishes standards for water quality and effluent. Polluting industries must seek permission to discharge waste into effluent bodies. The Pollution Control Board (CPCB) was constituted under this act.

1977 – The Water (Prevention and Control of Pollution) Cess Act provides for the levy and collection of cess or a fees on water consuming industries and local authorities.

1978 – The Water (Prevention and Control of Pollution) Cess Rules contains the standard definitions and indicate the kind of and location of meters that every consumer of water is required to affix.

1991 – Coastal Regulation Zone Notification puts regulations on various activities, including construction, are regulated. It gives some protection to the backwaters and estuaries.

Air

1948 – Factories Act and Amendment in 1987 was the first to express concern for the working environment of the workers. The amendment of 1987 has sharpened its environmental focus and expanded its application to hazardous processes.

1981 – Air (Prevention and Control of Pollution) Act provides for the control and abatement of air pollution. It entrusts the power of enforcing this act to the Central Pollution Control Board.

1982 – Air (Prevention and Control of Pollution) Rules defines the procedures of the meetings of the Boards and the powers entrusted on them.

1982 – Atomic Energy Act deals with the radioactive waste.

1987 – Air (Prevention and Control of Pollution) Amendment Act empowers the central and state pollution boards to meet with grave emergencies of air pollution.

1988 – Motor Vehicles Act states that all hazardous waste is to be properly packaged, labeled and transported.

Note: - For the international treaties and conventions students should rely more on current affairs as this section is very dynamic

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Ecology is the scientific study of processes influencing the distribution and abundance of organisms, the interactions among organisms and the interactions between organisms and the transformation and flux of energy and matter .This book is an effort by Team EDEN IAS to introduce the concepts of ecology to young and enthusiastic minds who harbor the dream of becoming a Civil Servant