USEFUL FOR IAS/PCS PRELIMINARY EXAM

मुख्यमंत्री अभ्युदय योजना

GENERAL STUDIES

Ecology

मुख्यमंत्री अभ्युदय योजना प्रकोष्ठ

उत्तर प्रदेश प्रशासन और प्रबंधन अकादमी

सेक्टर-D, अलीगंज, लखनऊ - 226024

यह अध्ययन-सामग्री मुख्यमंत्री अभ्युदय योजना प्रकोष्ठ (उत्तर प्रदेश प्रशासन और प्रबंधन अकादमी) द्वारा उत्तर प्रदेश सरकार की मुख्यमंत्री अभ्युदय योजना के अंतर्गत सिविल सेवा परीक्षा की तैयारी कर रहे प्रतियोगियों की सहायता के लिए तैयार कराई गई है।

इस पाठ्य-सामग्री को उत्तर प्रदेश प्रशासन एवं प्रबंधन अकादमी, लखनऊ में 65वें आधारभूत प्रशिक्षण कार्यक्रम के अंतर्गत प्रशिक्षण प्राप्त कर रहे प्रशिक्षु
(डिप्टी कलक्टर्स-UPPCS-2018) द्वारा प्रोजेक्ट
कार्य के रूप में तैयार किया गया है।

इस सामग्री की पूर्णत: शैक्षणिक और जन कल्याणकारी-उद्देश्यों के लिए तैयार किया गया है-इसका एक मात्र उद्देश्य प्रदेश के छात्र/छात्राओं का प्रतियोगी परीक्षाओं की तैयारी में मार्गदर्शन व सहयोग करना है।

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Ecology

- Ecology may be defined as the scientific study of the relationship of living organisms with each other and with their environment.'
- The term ecology was first coined in 1869 by Ernst Haeckel. It has been derived from two Greek words, 'Oikos', meaning home or estate, and 'logos' meaning study.
- The emphasis is on relationships between organisms and the components of the environment namely abiotic (non-living) and biotic (living).
- It deals with the ways in which organisms are molded by their environment, how they make use of environmental resources including energy flow and mineral cycling.

Environment

- Everything that surrounds or affects an organism during its lifetime is collectively known as its environment which comprises both living (biotic) and nonliving (abiotic) components.
- All organisms (from virus to man) are obligatorily dependent on the environment for food, energy, water, oxygen, shelter, and other needs.
- And we can say that this environment constitutes two components viz. abiotic and biotic components. These both are not static but are in flux and keep on changing continuously.
- Biotic components are living. Example plants, animals, parasites, decomposers, Man, etc.
- Abiotic components are non-living. Example energy, radiation, heat flow, water soil, air, etc.

Habitat

- Habitat is the physical environment in which an organism lives (address of an organism).
- Many habitats make up the environment.
- A single habitat may be common for more than one organism, which have similar requirements.

- For example, a single aquatic habitat may support a fish, frog, crab, phytoplankton and many others.

Abiotic Components (Nonliving):

Abiotic component can be grouped into the following three categories:

1. **Physical factors:** Sunlight, temperature, rainfall, humidity, and pressure. They sustain and limit the growth of organisms in an ecosystem.
2. **Inorganic substances:** Carbon dioxide, nitrogen, oxygen, phosphorus, sulfur, water, rock, soil, and other minerals.
3. **Organic compounds:** Carbohydrates, proteins, lipids, and humic substances. They are the building blocks of living systems and therefore, make a link between the biotic and abiotic components.

Biome

A biome is a large naturally occurring community of flora and fauna occupying a major habitat. E.g. Rainforest biome or tundra biome. Biomes are distinct from habitats because any biome can comprise a variety of habitats.

Types of Biome

1. Tundra

- Treeless low (less than 1 m) vegetation with short perennials, water frozen.
- Typical plants include sedges, lichens and mosses. Typical animals include snowy owls, musk ox and reindeer.
- Very cold, often dry climate, but with the permanently frozen ground creating saturated soils during summer months. Arctic Tundra is circumpolar (scanty Antarctic).

2. Boreal forest (taiga)

- Dense evergreen needle-leafed forest.
- Typical plants include white spruce, black spruce, and jack pine. Typical animals include moose, black bears and migrant birds.
- Cold winters with deep snow, but longer growing season than the tundra.

3. Temperate forest

- Dense forest with thin, broad, deciduous leaves; or rainforests typically dominated by conifers.
- Typical plants include maples, oaks. Typical animals include deer and squirrels.
- Freezing winters, warm, wet summers, and a longer growing season than the boreal forest.

4. Grasslands (steppe)

- Treeless vegetation less than 1 m high.
- Typical plants include grasses and woody plants predominate in steppes. Typical animals include horses, buffalo, and rhinoceros.

5. Desert

- Sparse drought-resistant vegetation, typically spiny and with tiny leaves and photosynthetic bark.
- Typical plants include cactuses and acacias.
- Typical animals include reptiles and ground-dwelling rodents

6. Tropical deciduous forest and savannah

- Thorny forest, woodlands, or scattered trees, many of which loose leaves during the dry season.
- Typical plants include acacias and grasses. Typical animals include giraffes and elephants.
- Warm frost-free winters, hot usually wet summers, and a pronounced dry season. Fire and grazing are important vegetation-forming processes.

7. Tropical rain forest

- Dense tall evergreen forest.
- Typical plants include strangler figs and tree ferns. Typical animals include snakes and birds.
- Mild frost-free winters and summers with year-round rain.

Biosphere

The biosphere includes all living organisms on earth, together with the dead organic matter produced by them. The biosphere represents a highly integrated and interacting zone comprising of the atmosphere (air), hydrosphere (water) and lithosphere (land).

Types of Ecosystems

Ecosystems are classified as follows:

1. Natural ecosystems
2. Manmade ecosystems

Natural ecosystems:

Totally dependent on solar radiation e.g. forests, grasslands, oceans, lakes, rivers, and deserts. They provide food, fuel, fodder, and medicines.

Ecosystems are dependent on solar radiation and energy subsidies (alternative sources) such as wind rain and tides. E.g. tropical rain forests, tidal estuaries, and coral reefs.

Man-made ecosystems:

- Dependent on solar energy. e.g.- agricultural fields and aquaculture ponds.
- Dependent on fossil fuel e.g. urban and industrial ecosystems.

Productivity of ecosystems

The rate of biomass production is called **productivity.** The portion of fixed energy, a trophic level passes on to the next trophic level is called **production.**

Productivity in ecosystems is of two kinds, i.e.

- Primary and
- Secondary.

Green plants fix solar energy and accumulate it in organic forms as chemical energy. As this is the first andthe basic form of energy storage, the rate at which

the energy accumulates in the green plants or producers is known as **primary productivity.**

Productivity is a rate function and is expressed in terms of dry matter produced or energy captured per unit area of land, per unit time.

It is more often expressed as energy in calories/cm2/yr or dry organic matter in g/m2/yr (g/m2 x 8.92 - lb/acre). Hence, the productivity of different ecosystems can be easily compared.

Primary productivity is measured in two ways:

- Gross Primary Productivity and
- Net Primary Productivity.

The total solar energy trapped in the food material by photosynthesis is referred to as **gross primary productivity (GPP).**

However, a good fraction of gross primary productivity is utilized in the respiration of green plants. The amount of energy-bound organic matter created per unit area and time that is left after respiration is **net primary productivity (NPP).**

Net productivity of energy - Gross productivity — Energy lost in respiration.

The rates at which the heterotrophic organisms re-synthesize the energy-yielding substances are called **secondary productivity.** Here, the net primary productivity (NPP) results in the accumulation of plant biomass, which serves the food of herbivores and decomposers.

It is notable that the primary producers have produced the food of consumers, and secondary productivity depicts only the utilization of this food for the production of consumer biomass.

Secondary productivity is the productivity of animals and saprobes in the ecosystem.

Environmental Factors Affecting Productivity in the Ecosystem:

1. Solar radiation and temperature.
2. Moisture, i.e., leaf water potential, soil moisture, fluctuation of precipitation, and transpiration.

3. Mineral nutrition, i.e., uptake of minerals from the soil, rhizosphere effects, fire effects, salinity, heavy metals, and nitrogen metabolism.
4. Biotic activities, i.e., grazing, above-ground herbivores, below ground herbivores, predators and parasites and diseases of primary producers.

Energy Flow through an Ecosystem – Trophic Levels

(Trophe - Nourishment)

- A trophic level is the representation of energy flow in an ecosystem.
- The trophic level of an organism is the position it occupies in a food chain.
- Trophic level interaction deals with how the members of an ecosystem are connected based on nutritional needs.

Trophic levels	
Autotrophs	Green plants (Producers)
Heterotrophs	Herbivore (Primary consumers)
Heterotrophs	Carnivores (Secondary consumers)
Heterotrophs	Carnivore (Tertiary consumers)
Heterotrophs	Top carnivores (Quaternary consumers)

- Energy flows through the trophic levels from producers to subsequent trophic levels is unidirectional.
- Energy level decreases from the first trophic level upwards due to loss of energy in the form of heat at each trophic level.

Food Chain

- Transfer of food energy from green plants (producers) through a series of organisms with repeated eating and being eaten link is called a food chain. E.g., Grasses → Grasshopper → Frog → Snake → Hawk/Eagle.
- A food chain starts with producers and ends with top carnivores.
- The trophic level of an organism is the position it occupies in a food chain.

- Types of Food Chains: 1) Grazing food chain and 2) Detritus food chain

Grazing food chain:

- The consumers, which start the food chain, utilising the plant or plant part as their food, constitute the grazing food chain.
- For example, in a terrestrial ecosystem, the grass is eaten by a caterpillar, which is eaten by lizard and lizard is eaten by a snake.

Detritus food chain:

- This type of food chain starts from organic matter of dead and decaying animals and plant bodies from the grazing food chain.
- Dead organic matter or detritus feeding organisms are called detrivores or decomposers.
- In an aquatic ecosystem, the grazing food chain 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 grazing food chain.
- Bacterial and fungal enzymes degrade detritus into simpler inorganic substances. This process is called catabolism.
- Humification and mineralisation occur during decomposition in the soil.
- Humification leads to accumulation of a dark-coloured amorphous (formless) substance called humus that is highly resistant to microbial action and undergoes decomposition at an extremely slow rate.
- Being colloidal in nature, humus serves as a reservoir of nutrients.
- The humus is further degraded by some microbes and release of inorganic nutrients occur by the process known as mineralisation.
- Warm and moist environment favour decomposition whereas low temperature and anaerobiosis inhibit decomposition resulting in a buildup of organic materials.

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 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 food producer forms the base of the pyramid and the top carnivore forms the tip. Other consumer trophic levels are in between.
- The ecological pyramids are of three categories:
  1. Pyramid of numbers,
  2. Pyramid of biomass, and
  3. 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 – upright

- In this pyramid, the number of individuals is decreased from lower level to higher trophic level.

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.

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. (In contrast, a pyramid of numbers for the aquatic ecosystem is upright)
- This is because the producers are tiny phytoplankton that grows and reproduces rapidly.
- Here, the pyramid of biomass has a small base, with the consumer biomass at any instant exceeding the producer biomass and the pyramid assumes an inverted shape.

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.
- Suppose an ecosystem receives 1000 calories of light energy in a given day. Most of the energy is not absorbed; some is reflected 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 calories of food energy. The deer use some of it for its metabolism and stores only 10 calories 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.

Ecological Efficiency

- 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 decreases at each subsequent trophic level is due to two reasons:
- At each trophic, a part of the available energy is lost in respiration or used up in metabolism.

- A part of the energy is lost at each transformation.

Limitations of Ecological Pyramids

- It does not consider the same species belonging to two or more trophic levels.
- It assumes a simple food chain, something that seldom 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.

Pollutants and Trophic Level

- Pollutants move through the various trophic levels in an ecosystem.
- Non-degradable pollutants (persistent pollutants), which cannot be broken down by detrivores, not only move through the various trophic levels but also remain in that tropic level for a very long duration.
- Chlorinated Hydrocarbons (Organochlorides) are the most damaging non-degradable pollutants that are long lasting.

Chlorinated Hydrocarbons (CHC):

CHCs are hydrocarbons in which one or more hydrogen atoms have been replaced by chlorine E.g. DDT (dichlorodiphenyltrichloroethane), endosulfan, chloroform, carbon tetrachloride, etc.

Effects of CHC

Dioxins (toxic by-products produced when organic matter is burned in the presence of chlorine in industrial or natural processes such as volcanic eruptions and forest fires), and some insecticides, such as DDT, are persistent organic pollutants.

It accumulates in food chains and causes eggshell thinning in certain bird species.

Movement of these pollutants involves two main processes:

1. Bioaccumulation
2. Biomagnification

1) Bioaccumulation:

- Bioaccumulation is the gradual accumulation of pollutants, chemicals (chronic poisoning) or other substances in an organism.
- Bioaccumulation occurs when the rate of loss of the substance from the body of the organism through catabolism (breakdown of complex molecules in living organisms), or excretion is lower than the rate of accumulation of the substance.

2) Biomagnification:

- Biomagnification refers to progressive bioaccumulation (increase in concentration) at each tropical level with the passage of time.
- In order for biomagnification to occur, the pollutant must have a long biological half-life (long-lived), must not be soluble in water but must be soluble in fats. E.g. DDT.
- If the pollutant is soluble in water, it will be excreted by the organism.

Biotic Interaction

The interaction that occurs among different individuals of the same species is called intraspecific interaction while the interaction among individuals of different species in a community is termed as interspecific interaction.

Interactions between organisms belonging to the same trophic level often involve competition. Individuals of the population may compete for food, space and mates. Interspecific relationships may be direct and close as between a lion and deer or indirect and remote as between an elephant and a beetle. This is because interactions between two species need not be through direct contact. Due to the connected nature of ecosystems, species may affect each other through intermediaries such as shared resources or common enemies. Specific terms are applied to interspecific interactions depending upon whether the interaction is beneficial, harmful or neutral to individuals of the species.

Biotic Interaction

S. No.	Type	Species 1	Species 2
1	Mutualism	+	+
2	Commensalism	+	0

3	Competition	–	–
4	Predation	+	–
5	Parasitism	+	–
6	Amensalism	–	0
7	Neutralism	0	0

(+) Benefited	(-) Harmed	(0) Neither benefited nor harmed

Types of Biotic Interactions

- **Amensalism**: This 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 are examples of amensalism.
  For example, the bread mould fungi Penicillium produces penicillin an antibiotic substance that inhibits the growth of a variety of bacteria. Penicillium benefits apparently by having greater availability of food when the competition because of the bacteria is removed.

- **Predation:** In this type of interaction predator captures, kills and eats an animal of another species called the prey. The predator naturally benefits from this relationship. While the prey is harmed. Predators like leopards, tigers and cheetahs use speed, teeth and claws to hunt and kill their prey.

- **Parasitism:** In this type of interaction, one species is harmed and the other benefits. Parasitism involves parasite usually a small size organism 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.

- **Competition:** This is an interaction between two populations in which both species are harmed to some extent. Competition occurs when two populations or species, both need a vital resource that is in short supply. The vital resource could be food, water, shelter, nesting site, mates or space. Such competition can be:
- Interspecific competition-occurring between individuals of two different species occurring in a habitat and intraspecific competition-occurs between individuals of the same species.
- Intraspecific competition occurs between members of the same species and so it is very intense.

- **Commensalism:** In this relationship one of the species benefits while the other is neither harmed nor benefited. Some species obtain the benefit of shelter or transport from another species.

- **Mutualism**: This is a close association between two species in which both the species benefit. For example, of protocooperation of the sea anemone, a cnidarian gets attached to the shell of hermit crabs for benefit of transport and obtaining new food while the anemone provides camouflage and protection utilizing its stinging cells to the hermit crab.

- **Neutralism**: Neutralism describes the relationship between two species which do interact but do not affect each other. It is to describe interactions where the fitness of one species does not affect what so ever on that of others. True neutralism is extremely unlikely and impossible to prove.

- **Allelopathy:** refers to the chemical inhibition of one species by another. The "inhibitory" chemical is released into the environment where it affects the development and growth of neighboring plants.

Bio-geo Chemical Cycling or Nutrient Cycling

- Energy flow and nutrient circulation are the major functions of the ecosystem.
- Energy is lost as heat forever in terms of the usefulness of the system. On the other hand, nutrients of food matter never get used up. They can be recycled again and again indefinitely.
- Among the most important nutrient cycles are the carbon nutrient cycle and the nitrogen nutrient cycle.

- There are many other nutrient cycles that are important in ecology, including a large number of trace mineral nutrient cycles.
- Based on the replacement period, a nutrient cycle is referred to as Perfect or Imperfect cycle.
- A perfect nutrient cycle is one in which nutrients are replaced as fast as they are utilized.

Carbon Cycle

- Carbon is a minor constituent of the atmosphere as compared to oxygen and nitrogen.
- However, without carbon dioxide life could not exist because it is vital for the production of carbohydrates through photosynthesis by plants.
- It is the element that anchors all organic substances from coal and oil to DNA (deoxyribonucleic acid: the compound that carries genetic information).
- Carbon is present in the atmosphere, mainly in the form of carbon dioxide (CO_2).
- Carbon cycle involves a continuous exchange of carbon between the atmosphere and organisms.
- Carbon from the atmosphere moves to green plants by the process of photosynthesis, and then to animals.
- By process of respiration and decomposition of dead organic matter, it returns to the atmosphere. It is usually a short-term cycle.
- Some carbon also enters a long-term cycle. It accumulates as un-decomposed organic matter in the peaty layers of marshy soil or as insoluble carbonates in bottom sediments of aquatic systems, which take a long time to be released.
- In deep oceans, such carbon can remain buried for millions of years till geological movement may lift these rocks above sea level.
- These rocks may be exposed to erosion, releasing their carbon dioxide, carbonates and bicarbonates into streams and rivers.
- Fossil fuels such as coals, oil and natural gas etc. are organic compounds that were buried before they could be decomposed and were subsequently transformed by time and geological processes into fossil fuels. When they are burned the carbon stored in them is released back into the atmosphere as carbon dioxide.

Nitrogen Cycle

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

(a) Nitrogen fixation:

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

- **Atmospheric fixation:** Lightening, combustion and volcanic activity help in the fixation of nitrogen.
- **Industrial fixation:** At high temperature and high pressure, molecular nitrogen is broken into atomic nitrogen which then combines with hydrogen to form ammonia.
- **Bacterial fixation:**

(b) Nitrification:

In nitrification, a host of soil bacteria participate in turning ammonia into nitrate – the form of nitrogen that can be used by plants and animals. This requires two steps, performed by two different types of bacteria.

(c) Assimilation:

In assimilation, plants finally consume the nitrates made by soil bacteria and use them to make nucleotides, amino acids, and other vital chemicals for life.

(d) Ammonification:

Because there is so much nitrogen in the atmosphere, it may seem that the process could stop there but the atmosphere's supply is not infinite and keeping nitrogen inside plant and animal cells would eventually result in big changes to our soil, our atmosphere, and our ecosystems.

(e) Denitrification:

In the final step of the nitrogen cycle, anaerobic bacteria can turn nitrates back into nitrogen gas.

This process, like the process of turning nitrogen gas into ammonia, must happen in the absence of oxygen.

Water Cycle

Water is essential for life. No organism can survive without water. Precipitation (rain, snow, slush dew etc.) is the only source of water on the earth. Water received from the atmosphere on the earth returns back to the atmosphere as water vapor resulting from direct evaporation and through evapotranspiration the continuous movement of water in the biosphere is called water cycle (hydrological cycle).

The driving forces for the water cycle are 1) solar radiation 2) gravity. Evaporation and precipitation are the two main processes involved in the water cycle. These two processes alternate with each other Water from oceans, lakes, ponds, rivers and streams evaporates by the sun's heat energy. Plants also transpire huge amounts of water. Water remains in the vapor state in air and forms clouds that drift with the wind. Clouds meet with the cold air in the mountainous regions above the forests and condense to form rain precipitate, which comes down due to gravity.

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

Ecological Succession

- The process by which communities of plant and animal species in an area are replaced or changed into another over a period of time is known as ecological succession.
- Succession is a universal process of directional change in vegetation, on an ecological time scale.
- Succession occurs due to large scale changes or destruction (natural or manmade).
- The process involves a progressive series of changes with one community replacing another until a stable, mature, climax community develops.

Stages:

- The first plant to colonize an area is called the pioneer community.
- The final stage of succession is called the climax community.
- A climax community is stable, mature, more complex and long-lasting.
- The stage leading to the climax community is called successional stages or seres.
- Each transitional community that is formed and replaced during succession is called a stage in succession or a serel community.
- Succession is characterized by the following: increased productivity, the shift of nutrients from the reservoirs, increased diversity of organisms, and a gradual increase in the complexity of food webs.

Primary Succession

- Primary succession takes place an over where no community has existed previously.
- Such areas include rock outcrops, newly formed deltas and sand dunes, emerging volcano islands and lava flows, glacial moraines (muddy area exposed by a retreating glacier), etc.
- The pioneers over a few generations alter the habitat conditions by their growth and development.
- 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.
- The new conditions may be conducive to the establishment of additional organisms that may subsequently arrive at the site.
- As the community of organisms continues to develop, it becomes more diverse, and competition increases, but at the same time, new niche opportunities develop.
- 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 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.
- This abandoned land is first invaded by hardy species of grasses that can survive in bare, sun-baked soil.
- 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 land over a period becomes dominated by trees and is transformed into a forest.

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 is driven by the biotic components of an ecosystem.
- Allogenic succession is driven by the abiotic components (fire, flood) of the ecosystem.

Succession in Plants

- Succession that occurs on land (dry areas) where moisture content is low for e.g. on a bare rock is known as xerarch.
- Succession that takes place in a water body, like ponds or lake is called hydrarch.
- 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 mesophyte (plat needing only a moderate amount of water).

Succession in Water

- In primary succession in water, the pioneers are the small phytoplankton, and 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.
- Another important fact is to understand that all succession whether taking place in water or on land, proceeds to a similar climax community – the mesic.

Homeostasis in Ecosystem

- Homeostasis is the maintenance of stable equilibrium, especially through physiological (through bodily part functions. E.g. Cooling your body through sweating processes.
- Organisms try to maintain the constancy of its internal environment despite varying external environmental conditions that tend to upset their homeostasis.

1) Regulate

- Some organisms can maintain homeostasis by physiological (sometimes behavioural – migrating to tree shade) means which ensures constant body temperature, constant osmotic concentration, etc.
- All birds and mammals and a very few lower vertebrate and invertebrate species are indeed capable of such regulation (thermoregulation and osmoregulation).
- The 'success' of mammals is largely due to their ability to maintain constant body temperature and thrive whether they live in Antarctica or the Sahara Desert.
- Plants, on the other hand, do not have such mechanisms to maintain internal temperatures.

2) Conform

- An overwhelming majority of animals and nearly all plants cannot maintain a constant internal environment. Their body temperature changes with the ambient temperature.
- In aquatic animals, the osmotic concentration of the body fluids changes with that of the ambient water osmotic concentration. These animals and plants are simply conformers.
- In ecology, the term homeostasis applies to the tendency for a biological system to resist changes.
- Ecosystems are capable of maintaining their state of equilibrium.

- They can regulate their own species structure and functional processes.
- This capacity of the ecosystem of self-regulation is known as homeostasis.
- For example, in a pond ecosystem, if the population of zooplankton increases, they consume a large number of the phytoplankton and as a result, food would become scarce for zooplankton.
- When the number of zooplanktons is reduced because of starvation, the phytoplankton population start increasing.
- After some time, the population size of zooplankton also increases, and this process continues at all the trophic levels of the food chain.
- Note that in a homeostatic system, negative feedback mechanism induced by the limiting resource (here its scarcity of food) is responsible for maintaining stability in an ecosystem.
- However, the homeostatic capacity of ecosystems is not unlimited as well as not everything in an ecosystem is always well regulated.

Deforestation

It is a very broad term, which consists of cutting of trees including repeated lopping, felling, and removal of forest litter, browsing, grazing and trampling of seedlings. It can also be defined as the removal or damage of vegetation in a forest to the extent that it no longer supports its natural flora and fauna.

The rapid rate of deforestation in the tropics is a key driving force in the yearly increase of flood disasters.

Deforestation refers to the loss of tree cover; land that is permanently converted from forest to non-forest uses such as agricultural pasture, desert, and human settlement.

Causes of Deforestation

The most common reason for deforestation is cutting of wood for fuel, lumber, and paper. Another important cause relates to the clearing of forest land for agriculture, including conversion to cropland and pasture.

The main causes of deforestation are:

Agriculture

- Expanding agriculture is one of the most important causes of deforestation. Man has always modified the natural ecosystems in such a way that environment becomes more favorable for crop growth whether using traditional or modern methods of agriculture.
- As demands for agricultural products rise, more and more land is brought under cultivation, and for that more forests are cleared, grasslands and even marshes, and lands under water are reclaimed.
- Thus, there is much more ecological destruction than gain in terms of crop yield. The forest soil after clearing is unable to support farming for long periods due to exhaustion of nutrients. Once the soils become unfit for cultivation, the area suffers from soil erosion and degradation.

Shifting cultivation

- Hunting and gathering have been the main form of sustenance practiced in the earlier periods of human history. Shifting cultivation or Jhoom farming is a 12000-year old practice and a step towards the transition from food collection to food production.
- It is also known as the slash-and-burn method of farming. Annually about 5 lakhs ha (hectares) of the forest is cleared for this type of farming. In this type of cultivation, there is limited use of tools with a not very high level of mechanization.
- However, this method of cultivation causes extreme deforestation, as, after 2-3 years of tilling, the land is left to the mercy of nature to recover.
- This type of cultivation was always meant to fulfill local needs or onsite demands to meet the requirements of the cultivating villagers. Even today, shifting cultivation is practiced in the states of Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Andaman, and the Nicobar Islands.

Demand for firewood

- Firewood has been used as a source of energy for cooking, heating, etc. Almost 44% of the total global wood produced fulfills the fuel requirements of the world. A close look at the pattern of utilization of wood produced will show that the developed countries utilize 16% of their share for fuel requirements. India consumes nearly 135-170 Mt (Million tonnes) of firewood annually and 10-15 ha of forest cover is being stripped off to meet the minimum fuel needs of urban and rural poor.

Wood for industry and commercial use

- Wood, the versatile forest produce, is used for several industrial purposes, such as making crates, packing cases, furniture, matchboxes, wooden boxes, paper and pulp, plywood, etc. 1.24 lakh ha of forest have been cut for various industrial uses.
- Unrestricted exploitation of timber, as well as other wood products for commercial purposes, is the main cause of forest degradation. The paper industry accounts for about 2% of the country's annual consumption of wood and 51% of this requirement is met by bamboo wood. This has led to the depletion of bamboo stocks in most of peninsular India.
- For example, the apple industry in the Himalayan region has led to the destruction of fir and other tree species, for making wooden boxes used for

transporting apples. Similarly, plywood crates were used for packing particularly tea and other produce.

Urbanization and developmental projects

- Often urbanization and developmental activities lead to deforestation. The process of deforestation begins with the building of infrastructure in the form of roads, railway lines, the building of dams, townships, electric supply, etc. Thermal power plants, mining for coal, metal ores, and minerals are also important causes of deforestation.

Effects of Deforestation

Climate Imbalance

- Deforestation also affects the climate in more than one way. Trees release water vapor in the air, which is compromised with the lack of trees. Trees also provide the required shade that keeps the soil moist.
- This leads to the imbalance in the atmospheric temperature further making conditions for the ecology difficult. Flora and fauna across the world are accustomed to their habitat. This haphazard clearance of forests has forced several of these animals to shift from their native environment. Due to this several species are finding it difficult to survive or adapt to new habitats.

Increase in Global Warming

- Trees play a major role in controlling global warming. The trees utilize the greenhouse gases, restoring the balance in the atmosphere. With constant deforestation the ratio of greenhouse gases in the atmosphere has increased, adding to our global warming woes.

Soil Erosion

- Also due to the shade of trees the soil remains moist. With the clearance of tree cover, the soil is directly exposed to the sun, making it dry.

Floods

- When it rains, trees absorb and store a large amount of water with the help of their roots. When they are cut down, the flow of water is disrupted and leads to floods in some areas and droughts in others.

Wildlife Extinction

- Due to the massive felling down of trees, various species of animals are lost. They lose their habitat and forced to move to a new location. Some of them are even pushed to extinction. Our world has lost so many species of plants and animals in the last couple of decades.

Strategies to Reduce Deforestation

- Reduce population growth and increasing per capita incomes
- Reducing emissions from deforestation and forest degradation (REDD and REDD+)
- Increase the area and standard of management of protected areas
- Increase the area of forest permanently reserved for timber production
- Increase the perceived and actual value of forests
- Promote sustainable management
- Encouraging substitutes
- Increase area of forest plantation
- Strengthen government and non-government institutions and policies
- Participatory forest management and rights

Aquatic Ecosystems

- Aquatic ecosystems refer to plant and animal communities occurring in water bodies.
- Aquatic ecosystems are classified into two subgroups: 1) Freshwater ecosystems, such as rivers, lakes and ponds; 2) Marine ecosystems, such as oceans, estuary and mangroves.
- Aquatic ecosystems are classified on the basis of salinity into the following types:
- Freshwater ecosystems: water on land which is continuously cycling and has low salt content (always less than 5 ppt) is known as fresh water.
- Marine ecosystems: the water bodies containing salt concentration equal to or above that of seawater (i.e., 35 ppt or above). E.g. shallow seas and open ocean.

Aquatic Organisms

The aquatic organisms are classified on the basis of their zone of occurrence.

- **Neuston:** These organisms live at the air-water interface, e.g. floating plants.
- **Periphyton:** These are organisms which remain attached to stems and leaves of rooted plants or substances emerging above the bottom mud such as sessile algae.
- **Plankton:** Microscopic floating organisms such as algae, diatoms, protozoans and larval forms are called plankton. This group includes both microscopic plants like algae (phytoplankton) and animals like crustaceans and protozoans (zooplankton). The locomotory power of the planktons is limited so that their distribution is controlled, largely, by currents in the aquatic ecosystems.
- **Nekton:** This group contains powerful swimmers that can overcome the water currents.
- **Benthos:** The benthic organisms are those found living at the bottom of the water mass.

Factors Limiting the Productivity of Aquatic Habitats

- Sunlight and oxygen are the most important limiting factors of the aquatic ecosystems.

Sunlight

- Sunlight penetration rapidly diminishes as it passes down the column of water.
- The depth to which light penetrates a lake determines the extent of plant distribution.
- Suspended particulate matters such as clay, silt, phytoplankton, etc. make the water turbid.
- Turbidity limits the extent of light penetration and photosynthetic activity in a significant way.
- Based on light penetration and plant distribution they are classified as photic and aphotic zones.

Photic zone

- Photic (or "euphotic") zone is the portion that extends from the lake surface down to where the light level is 1% of that at the surface. The depth of this zone depends on the transparency of water.
- Photosynthetic activity is confined to the photic zone.
- Both photosynthesis and respiration activity takes place.

Aphotic zone

- The lower layers of the aquatic ecosystems, where light penetration and plant growth are restricted forms the aphotic zone (profundal zone). Only respiration activity takes place in this zone.
- The aphotic zone extends from the end of the photic zones to bottom of the lake.

Dissolved oxygen

- In freshwater the average concentration of dissolved oxygen is 10 parts per million by weight.
- This is 150 times lower than the concentration of oxygen in an equivalent volume of air.
- Oxygen enters the aquatic ecosystem through the air-water interface and by the photosynthetic activities of aquatic plants.
- Dissolved oxygen escapes the water body through the air-water interface and respiration of organisms (fish, decomposers, zooplankton, etc.).

- The amount of dissolved oxygen retained in water is also influenced by temperature.
- Oxygen is less soluble in warm water. Warm water also enhances decomposer activity. Therefore, increasing the temperature of a water body increases the rate at which oxygen is depleted from the water.
- When the dissolved oxygen level falls below 3-5 ppm, many aquatic organisms are likely to die.

Temperature

- Since water temperatures are less subject to change, the aquatic organisms have narrow temperature tolerance limit.
- As a result, even small changes in water temperature are a great threat to the survival of aquatic organisms when compared to the changes in air temperatures in the terrestrial organisms.

Wetland Ecosystem

What is wetland

The Convention uses a broad definition of wetlands. It includes all lakes and rivers, underground aquifers, swamps and marshes, wet grasslands, peatland, oases, estuaries, deltas and tidal flats, mangroves and other coastal areas, coral reefs, and all human-made sites such as fish ponds, rice paddies, reservoirs and salt pans.

- Wetlands are areas of marsh or peatland with water that is static or flowing, fresh, brackish or saline, including areas of marine water the depth of which at low tide does not exceed 6 m.
- Wetlands are transition zones (ecotone) between terrestrial and aquatic ecosystems.
- E.g. Mangroves, lake littorals (marginal areas between highest and lowest water level of the lakes), floodplains (areas lying adjacent to the river channels beyond the natural levees and periodically flooded during high discharge in the river) and other marshy or swampy areas.
- These habitats experience periodic flooding from adjacent deepwater habitats and therefore supports plants and animals specifically adapted to such shallow flooding or waterlogging.
- Waterlogged soil adapted plant life (hydrophytes), and hydric soils (not enough O_2) are the chief characteristics of wetlands.
- India has over 27,000 wetlands, of which 23,000+ are inland wetlands, and around 4000 are coastal wetlands.
- Wetlands occupy 18.4% of the country's area of which 70% are under paddy cultivation.
- Natural wetlands in India range from high altitude wetlands in the Himalayas; flood plains of the major river systems; saline and temporary wetlands of the arid and semi-arid regions; coastal wetlands such as lagoons, backwaters, estuaries, mangroves, swamps and coral reefs, and so on.

Importance of Wetlands

- Wetlands are indispensable for the countless benefits or "ecosystem services" that they provide humanity, ranging from freshwater supply, food and building

materials, and biodiversity, to flood control, groundwater recharge, and climate change mitigation.

- Wetlands are habitat to aquatic flora and fauna, numerous species of native and migratory birds.
- Wetlands are an important resource for sustainable tourism.
- They carry out water purification, filtration of sediments and nutrients from surface water.
- They help in nutrients recycling, groundwater recharging and stabilisation of local climate.
- Play an important role in flood mitigation by controlling the rate of runoff.
- Buffer (act as a riparian buffer) shorelines against erosion and pollutants.

Reasons for depletion

- Excessive pollutants (Industrial effluents, domestic waste, agricultural runoff etc.) are dumped into wetlands beyond the recycling capacity.
- Habitat destruction and deforestation create ecological imbalance by altering the population of wetland species.
- Conversion of wetlands for agriculture and encroachment by public and mafia.
- Removal of sand from beds near seas makes the wetland vulnerable to wave action and tidal bore.

Mitigation

- Demarcation of wetlands using the latest technology, proper enforcement of laws and stringent punishments for violators.
- Preventing unsustainable aquaculture and cultivation of shellfish.
- Treating industrial effluents and water from farmlands before discharging into wetlands.
- Utilizing wetlands on a sustainable basis by giving enough time for natural regeneration.
- Artificial regeneration for a quick recovery.
- Afforestation, weed control, preventing invasive species is the key to wetland conservation.
- Preventive measures to stop the introduction of exotic invasive species like water hyacinth.

- Soil conservation measures & afforestation.
- Preventing grazing in peripherals of wetlands.
- Wildlife conservation, sustainable tourism, eco-tourism and sensitizing local populace.
- Eutrophication abatement by processing nutrient rich discharge into the water body.
- Involving the local population in the conservation of wetlands.

Ramsar Convention on Wetlands

- International treaty for "the conservation and sustainable use of wetlands".
- It is also known as the Convention on Wetlands.
- It is named after the city of Ramsar in Iran.
- The Convention was signed on 2nd of February 1971.
- The 2nd of February each year is World Wetlands Day.
- Number of parties to the convention (COP) is170.
- At the centre of the Ramsar philosophy is the "wise use" of wetlands.
- Wise use: maintenance of ecological character within the context of sustainable development.

COP

- COP is the policy-making organ of the Convention which adopts decisions (Resolutions and Recommendations) to administer the work of the Convention.
- Every three years, representatives of the Contracting Parties meet as the Conference of the Contracting Parties (COP)
- COP12 was held in Punta del Este, Uruguay in 2015. COP13 took place in Dubai, United Arab Emirates, in 2018.

Under the Convention, the Contracting Parties commit to:

- Work towards the wise use of all their wetlands;
- Designate suitable wetlands for the List of Wetlands of International Importance (the "Ramsar List") and ensure their effective management;

- Cooperate internationally on Trans boundary wetlands, shared wetland systems and shared species.

Ramsar Site

- At the time of joining the Convention, each Contracting Party undertakes to designate at least one wetland site for inclusion in the List of Wetlands of International Importance.
- The inclusion of a "Ramsar Site" in the List embodies the government's commitment to take the steps necessary to ensure that its ecological character is maintained.
- There are over 2,300 Ramsar Sites on the territories of 170 Ramsar Contracting Parties across the world.
- The countries with the most Sites are the United Kingdom with 170 and Mexico with 142.
- Bolivia has the largest area under Ramsar protection.

Transboundary Ramsar Sites

- Contracting Parties are designating their new and existing Ramsar Sites as Transboundary Ramsar Sites.
- These are ecologically coherent, shared wetlands extending across national borders, which are managed collaboratively.

The Montreux Record

- The Montreux Record 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.

International Organization Partners

- The Ramsar Convention works closely with six organisations known as International Organization Partners (IOPs). These are:

1. Birdlife International
2. International Union for Conservation of Nature (IUCN)
3. International Water Management Institute (IWMI)

4. Wetlands International
5. WWF
6. International Wildfowl & Wetlands Trust (WWT)

Other Partners

- Convention on Biological Diversity (CBD)
- Convention to Combat Desertification (UNCCD),
- Convention on the Conservation of Migratory Species of Wild Animals
- Convention on Migratory Species (CMS),
- World Heritage Convention (WHC) and
- Convention on International Trade in Endangered Species (CITES).
- Project funding is done by various groups like multilateral development banks, bilateral donors, UN agencies such as UNEP, UNDP, Non-governmental organisations etc.

Criteria for Identification of Wetlands under Ramsar Convention

If a wetland

- contains a representative, rare, or unique example of a natural or near-natural wetland type.
- supports vulnerable, endangered, or critically endangered species; or threatened ecological communities.
- supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
- supports plant and/or animal species at a critical stage in their life cycles or provides refuge during adverse conditions.
- regularly supports 20,000 or more water birds.
- regularly supports 1% of the individuals in a population of one species or subspecies of water birds.
- supports a significant proportion of indigenous fish subspecies
- is an important source of food for fishes, spawning ground, nursery and/or migration path.
- is an important source of food and water resource, increased possibilities for recreation and eco-tourism, etc.

Mangroves

- Mangroves represent a characteristic littoral (near the seashore) forest ecosystem.
- These are mostly evergreen forests that grow in sheltered low lying coasts, estuaries, mudflats, tidal creeks backwaters (coastal waters held back on land), marshes and lagoons of tropical and subtropical regions.
- Mangroves grow below the high water level of spring tides.
- The best locations are where abundant silt is brought down by rivers or on the backshore of accreting sandy beaches.
- Mangroves are highly productive ecosystems, and the trees may vary in height from 8 to 20 m. They protect the shoreline from the effect of cyclones and tsunamis.
- They are breeding and spawning ground for many commercially important fishes.
- Mangroves are salt tolerant trees, also called halophytes, and are adapted harsh coastal conditions.
- Mangrove vegetation facilitates more water loss. Leaves are thick and contain salt-secreting glands. Some block absorption of salt at their roots itself.
- Mangroves occur worldwide in the tropics and subtropics, mainly between latitudes 25° N and 25° S.
- Mangroves occur in a variety of configurations. Some species (e.g. Rhizophora) send arching prop roots down into the water.
- While other (e.g. Avicennia) send vertical “Pneumatophores” or air roots up from the mud.
- Adventitious roots which emerged from the main trunk of a tree above ground level are called stilt roots.
- Mangroves exhibit Viviparity mode of reproduction. i.e. seeds germinate in the tree itself (before falling to the ground).
- This is an adaptive mechanism to overcome the problem of germination in saline water.

Mangroves in India

- The mangroves of Sundarbans are the largest single block of tidal halophytic mangroves of the world.
- This mangrove forest is famous for the Royal Bengal Tiger and crocodiles.
- Mangrove areas here are being cleared for agricultural use.
- The mangroves of Bhitarkanika (Orissa), which is the second largest in the Indian sub-continent, harbour high concentration of typical mangrove species and high genetic diversity.
- Mangrove swamps occur in profusion in the intertidal mudflats on both side of the creeks in the Godavari-Krishna deltaic regions of Andhra Pradesh.
- Mangroves are of scrubby type with stunted growth, forming narrow, discontinuous patches on soft clayey mud.
- On the Andaman & Nicobar Islands, the small tidal estuaries and the lagoons support a dense and diverse undisturbed mangrove flora.

Importance of Mangroves

- Mangrove plants have (additional) special roots such as prop roots, pneumatophores which help to impede water flow and thereby enhance the deposition of sediment in areas (where it is already occurring), stabilise the coastal shores, provide a breeding ground for fishes.
- Mangroves moderate monsoonal tidal floods and reduce inundation of coastal lowlands.
- They prevent coastal soil erosion.
- They protect coastal lands from tsunami, hurricanes and floods.
- Mangrove supports numerous florae, avifauna and wildlife.
- Provide a safe and favourable environment for breeding, spawning, rearing of several fishes.
- They supply woods, firewood, medicinal plants and edible plants to local people.
- They provide numerous employment opportunities to local communities and augments their livelihood.

Threats

- They are destroyed for conversion of the area for agricultural purpose, fuel, fodder and, salinisation, mining, oil spills, aquacultural (shrimp farming), use of chemical pesticides & fertilisers, industrial purposes.

Pollution

It is any undesirable change in physical, chemical or biological characteristics of air, land, water or soil. Agents that bring about such an undesirable change are called as pollutants. Pollution is often classed as point source or nonpoint source pollution. A point source is a single, identifiable source of pollution, such as a pipe or a drain. Non-point sources of pollution are often termed 'diffuse' pollution and refer to those inputs and impacts which occur over a wide area and are not easily attributed to a single source.

Air pollution

Air pollution is the introduction of particulates, biological molecules, or other harmful materials into Earth's atmosphere, causing damage, diseases and death to living organisms. Air pollutants can be either gases or aerosols (particles or liquid droplets suspended in the air). They change the natural composition of the atmosphere and can cause damage to natural water bodies and the land. Air pollution has both natural and human sources:

Natural air pollution

- Dust from natural sources, usually large areas of land with little or no vegetation
- Methane, emitted by various sources.
- Radon gas from radioactive decay within the Earth's crust.
- Smoke and carbon monoxide from wildfires
- Vegetation, in some regions, emits environmentally significant amounts of Volatile organic compounds (VOCs) on warmer days.

Anthropogenic sources

- Stationary sources include smoke stacks of power plants, factories and waste incinerators, as well as furnaces and other types of fuel-burning heating devices.
- Mobile sources include motor vehicles, marine vessels, and aircraft.
- Fumes from paint, hair spray, varnish, aerosol sprays and other solvents
- Waste deposition in landfills, which generate methane. Methane is also an asphyxiant and may displace oxygen in an enclosed space.

- Military resources, such as nuclear weapons, toxic gases, germ warfare and rocketry
- Particulate matter from mining activities.

Types of Pollutants

1. Primary Pollutants:

These are emitted directly into the air from sources at the Earth's surface. Examples are greenhouse gasses.

2. Secondary Pollutants:

The regional gases can also react chemically in the atmosphere to form other compounds, which are known as secondary pollutants. One of the main results of secondary pollution is photochemical smog.

Negative Effects of Air Pollution

Global negative effects of air pollution include the enhanced greenhouse effect and the ozone hole. Smog and acid rain are the best known local effects and smog, in particular, affects people living in urban areas.

Humans: It is detrimental to human health causing major respiratory disorders. Hay fever, asthma and bronchitis are caused due to air pollution. Sulphur dioxide is responsible for cough, spasm of larynx and reddening of the eye due to irritation of membranes in the eye.

Animals: Air contaminated with ozone causes pulmonary changes, oedema and haemorrhage in dogs, cats, and rabbits. Animals feeding on fluoride compound containing fodder may suffer from fluorosis.

Materials and atmosphere: Increase in carbon dioxide concentration increases the temperature of the earth. Depletion of ozone layer due to fluorocarbon of aerosol causes the exposure of U. V. radiation, which is lethal.

Smog: The word "smog" is the combination of the words smoke and fog.

Acid Rain

Clean rain is slightly acidic naturally but when the pH of rain falls below 5.6, we call it acid rain. Emissions of the two air pollutants, nitrogen oxides (NOx) and sulphur dioxide (SO2) are the main reasons for acid rain formation. Nitrogen oxides (NOx - NO + NO2) and sulphur dioxide (SO2) are emitted during fossil

fuel combustion and then undergo reactions with water in the air to form the nitric acid (HNO3) and the sulphuric acid (H2SO4) found in acid rain.

Types of Acid Deposition

Wet Deposition

- If the acid chemicals in the air are blown into areas where the weather is wet, the acids can fall to the ground in the form of rain, snow, fog, or mist.
- As this acidic water flows over and through the ground, it affects a variety of plants and animals.

Dry Deposition

- In areas where the weather is dry, the acid chemicals may become incorporated into dust or smoke and fall to the ground through dry deposition, sticking to the ground, buildings, vegetation, cars, etc.
- Dry deposited gases and particles can be washed from these surfaces by rainstorms, through runoff. This runoff water makes the resulting mixture more acidic.
- About half of the acidity in the atmosphere falls back to earth through dry deposition.

Chemistry of Acid Rain

Six basic steps are involved in the formation of acid rain:

1. The atmosphere receives oxides of sulphur and nitrogen from natural and human-made sources.
2. Some of these oxides fall back directly to the ground as dry deposition, either close to the place of origin or some distance away.
3. Sunlight stimulates the formation of photo-oxidants (such as ozone) in the atmosphere.
4. These photo-oxidants interact with the oxides of sulphur and nitrogen and other gases (like NH_3) to produce H_2SO_4 (sulphuric acid) and HNO_3 (nitric acid) by oxidation.
5. Acid rain containing ions of sulfate, nitrate, ammonium and hydrogen falls as wet deposition.

Harmful effects of acid rain

Effects on humans

- Bad smells, reduced visibility; irritation of the skin, eyes and the respiratory tract.
- Some direct effects include chronic bronchitis, pulmonary emphysema and cancer.

Effects on soil

- The exchange between hydrogen ions and the nutrient cations like potassium and magnesium in the soil cause leaching of the nutrients, making the soil infertile.
- An increase in ammonia in the soil due to a decrease in other nutrients decrease the rate of decomposition. The nitrate level of the soil is also found to decrease.
- The impact of acid rain on soil is less in India; because Indian soils are mostly alkaline, with good buffering ability.

Effects on aquatic life

- Eggs or sperms of fish, frogs and other aquatic organisms are sensitive to pH changes.
- Acid rain kills their gametes affecting the life cycles and productivity (ecosystem imbalances).
- Acidic lake waters may kill microbes and turn them unproductive.
- Acid rain can make metals bound on soils to be released into the aquatic environment.

Effect on terrestrial life

- Acid rain damage cuticle of plant leaves and reduces photosynthesis.
- Other indirect effects of acid rain on wildlife are loss or alteration of food and habitat resources.

Effects on microorganisms

- pH determines the proliferation of any microbial species.

- Most blue-green bacteria prefer an alkaline environment.
- So, microbial species in the soil and water shift from bacteria-bound to fungi-bound.
- This causes a delay in the decomposition of soil organic material.

Effect on buildings, monuments and materials

- Limestone and marble are destroyed by acid rain. Smoke and soot cover such objects. They slowly dissolve/flake away from the surfaces because of acid fumes in the air.
- Many buildings/monuments such as Taj Mahal in Agra have suffered from acid rain (Marble Cancer).

Acid Rain Areas

- They are concentrated in the industrialised belt of the northern hemisphere.
- In India, the first report of acid rain came from Bombay in 1974.
- Instances of acid rain are being reported from metropolitan cities.

Acid Rain Control

- Use of low sulphur fuel or natural gas or washed coal (chemical washing of pulverised coal) in thermal plants can reduce incidences of acid rain.
- Buffering: the practice of adding a neutralising agent to the acidified water to increase the pH. Usually, lime in the form of calcium oxide and calcium carbonate is used.

Ocean Acidification

- Ocean acidification has been called the "evil twin of global warming" and "the other CO_2 problem".
- Ocean acidification is the ongoing decrease in the pH of the Earth's oceans, caused by the uptake of carbon dioxide (CO_2) from the atmosphere.
- An estimated 30–40% of the carbon dioxide from human activity released into the atmosphere dissolves into oceans, rivers and lakes.
- To achieve chemical equilibrium, some of it reacts with the water to form carbonic acid.

- Some of these extra carbonic acid molecules react with a water molecule to give a bicarbonate ion and a hydronium ion, thus increasing ocean acidity (H+ ion concentration).
- Checking CO and CO_2 emissions and controlling pollution are the only means to reduce ocean acidification.

Other contributors

- Eutrophication leads to large plankton blooms, and when these blooms collapse and sink to the sea bed the subsequent respiration of bacteria decomposing the algae leads to a decrease in seawater oxygen and an increase in CO_2 (a decline in pH).

Effects of Ocean Acidification

- Oceans are an important reservoir for CO_2, absorbing a significant quantity of it (one-third) produced by anthropogenic activities and effectively buffering climate change.
- The uptake of atmospheric carbon dioxide is occurring at a rate exceeding the natural buffering capacity of the oceans.
- Increasing acidity depresses metabolic rates and immune responses in some organisms.
- Seawater absorbs CO_2 to produce carbonic acid, bicarbonate and carbonate ions.
- However, the increase in atmospheric CO_2 levels lead to a decrease in pH level, an increase in the concentration of carbonic acid and bicarbonate ions, causing a decrease in the concentration of carbonate ions.
- The decrease in the amount of carbonate ions available makes it more difficult for marine calcifying organisms, such as coral (calcareous corals) and some plankton (calcareous plankton), to form biogenic calcium carbonate.
- Commercial fisheries are threatened because acidification harms calcifying organisms which form the base of the Arctic food webs.
- Increasing acidity accentuates coral bleaching as corals are very sensitive to changes in water composition.

Impact of Ocean Acidification on Cloud Formation

- The majority of sulphur in the atmosphere is emitted from the ocean, often in the form of dimethylsulfide (DMS) produced by phytoplankton.

- Some of DMS produced by phytoplankton enters the atmosphere and reacts to make sulphuric acid, which clumps into aerosols, or microscopic airborne particles.
- Aerosols seed the formation of clouds, which help cool the Earth by reflecting sunlight.
- But, in acidified ocean water, phytoplankton produces less DMS.
- This reduction of sulphur may lead to decreased cloud formation, raising global temperatures.

Water Pollution

- Water pollution is the addition/presence of undesirable substances to/in water such as organic, inorganic, biological, radiological, heat, which degrades the quality of water so that it becomes unfit for use'.
- Natural sources of pollution of water are soil erosion, leaching of minerals from rocks (due to natural solubility and solubility triggered by acid rain) and decaying of organic matter.

Point and non-point sources of pollution

- Pollutants are discharged from a specific location such as a drain pipe represents point source pollution.
- Non-point sources include discharge of pollutants from diffused sources such as runoff from agricultural fields, grazing lands, construction sites, abandoned mines and pits, etc.

Causes of Water Pollution

Sewage Water

- Sewage water includes discharges from houses and other establishments.
- The sewage contains human and animal excreta, food residues, cleaning agents, detergents, etc.
- Domestic and hospital sewage contain many undesirable pathogenic microorganisms.

Industrial Wastes

- Discharge of wastewater from industries like petroleum, paper manufacturing, metal extraction and processing, chemical manufacturing, etc., that often contain toxic substances, notably, heavy metals (defined as elements with density > 5 g/cm^3 such as mercury, cadmium, copper, lead, arsenic) and a variety of organic compounds.

Agricultural sources

- Agricultural runoff contains dissolved salts such as nitrates, phosphates, ammonia and other nutrients, and toxic metal ions and organic compounds.
- Fertilizers contain major plant nutrients such as nitrogen, phosphorus and potassium.
- Excess fertilisers may reach the groundwater by leaching or may be mixed with surface water.
- Pesticides include insecticides, fungicides, herbicides, etc. They contain a wide range of chemicals such as chlorinated hydrocarbons (CHCs. E.g. DDT, Endosulfan etc.), organophosphates, metallic salts, carbonates, etc.
- Many of the pesticides are non-degradable, and their residues have a long life.
- Wastes from poultry farms, piggeries and slaughterhouses etc. reach the water though runoff.

Thermal and Radiation Waste

- Power plants – thermal and nuclear, chemical and other industries use a lot of water for cooling purposes, and the used hot water is discharged into rivers, streams or oceans.
- Discharge of hot water may increase the temperature of the receiving water by 10 to 15 °C above the ambient water temperature. This is thermal pollution.
- Increase in water temperature decreases dissolved oxygen in the water.
- Unlike terrestrial organisms, aquatic organisms are adapted to a uniform steady temperature of the environment. A sudden rise in temperature kills fishes and other aquatic animals.
- One of the best methods of reducing thermal pollution is to store the hot water in cooling ponds, allow the water to cool before releasing into any receiving water body

- Nuclear accidents near water bodies or during natural calamities like tsunami and earthquakes pose the risk of radiation leakage (radiation exposure) into water bodies. E.g. Fukushima Daiichi nuclear disaster.
- Radiation exposure causes mutations in the DNA of marine organisms. If those mutations are not repaired, the cell may turn cancerous.
- Radioactive iodine tends to be absorbed by the thyroid gland and can cause thyroid cancer.

Effects of Water Pollution

On Human Health

- Consumption of arsenic polluted water leads to accumulation of arsenic in the body parts like blood, nails and hairs causing skin lesions, rough skin, dry and thickening of the skin and ultimately skin cancer.
- Mercury compounds in wastewater are converted by bacterial action into extremely toxic methyl mercury, which can cause numbness of limbs, lips and tongue, deafness, blurring of vision and mental derangement.
- Pollution of water bodies by mercury causes Minamata (neurological syndrome) disease in humans.
- The compounds of lead cause anaemia, headache, loss of muscle power and bluish line around the gum.
- Water contaminated with cadmium can cause itai itai disease also called ouch-ouch disease (a painful disease of bones and joints) and cancer of lungs and liver.

On the Environment

- Presence of large amounts of nutrients in water results in algal bloom (excessive growth of planktonic algae. This leads to ageing of lakes.
- A few toxic substances, often present in industrial wastewaters, can undergo biological magnification (Biomagnification) in the aquatic food chain. This phenomenon is well-known for mercury and DDT.
- High concentrations of DDT disturb calcium metabolism in birds, which causes thinning of eggshell and their premature breaking, eventually causing a decline in bird populations.

On Aquatic Ecosystem

- Polluted water reduces Dissolved Oxygen (DO) content, thereby, eliminates sensitive organisms like plankton, molluscs and fish etc.
- However, a few tolerant species like Tubifex (annelid worm) and some insect larvae may survive in highly polluted water with low DO content. Such species are recognized as indicator species for polluted water.
- Biocides, polychlorinated biphenyls (PCBs) and heavy metals directly eliminate sensitive aquatic organisms.
- Hot waters discharged from industries, when added to water bodies, lowers its DO content.

Eutrophication

- Lakes receive their water from surface runoff and along with its various chemical substances and minerals.
- Over periods spanning millennia, ageing occurs as the lakes accumulate mineral and organic matter and gradually, get filled up.
- The nutrient-enrichment of the lakes promotes the growth of algae, aquatic plants and various fauna. This process is known as natural eutrophication.
- Similar nutrient enrichment of lakes at an accelerated rate is caused by human activities and the consequent ageing phenomenon is known as cultural eutrophication.

Soil Pollution

- Soil pollution is defined as the 'addition of substances to the soil, which adversely affects physical, chemical and biological properties of soil and reduces its productivity.
- It is a build-up of persistent toxic compounds, chemicals, salts, radioactive materials, or disease-causing agents in the soil which have adverse effects on plant growth, human and animal health.

Causes and Sources of Soil Pollution

Plastic bags

- They accumulate in soil and prevents germination of seeds. They stay in the soil for centuries without decomposing (non-biodegradable).

- Burning of plastic in garbage dumps release highly toxic and poisonous gases like carbon monoxide, carbon dioxide, phosgene, dioxins and other poisonous chlorinated compounds.
- Toxic solid residue left after burning remains in the soil. The harmful gases enter soils through chemical cycles.

Industrial sources

- They include fly ash, metallic residues, mercury, lead, copper, zinc, cadmium, cyanides, chromates, acids, alkalies, organic substances, nuclear wastes
- A large number of industrial chemicals, dyes, acids, etc. find their way into the soil.

Pesticides and fertilisers

- Chlorohydrocarbons (CHCs) like DDT, endosulfan, heptachlor accumulate in soil and cause biomagnification. Some of these pesticides like DDT and endosulfan are banned by most of the countries.
- Excessive use of chemical fertilisers reduces the population of soil-borne organisms and the crumb structure of the soil, productivity of the soil and increases salt content of the soil.

Other pollutants

- Many air pollutants (acid rain) and water pollutants ultimately become part of the soil, and the soil also receives some toxic chemicals during weathering of certain rocks.
- Radioactive elements from mining and nuclear power plants, find their way into the water and then into the soil.

Effects of soil pollution

- Reduced soil fertility due to increase in alkalinity, salinity or pH.
- Reduced nitrogen fixation due to the reduced number of nitrogen fixers.
- Increased erosion due to loss of forests and other vegetation.
- Runoff due to deforestation cause loss of soil and nutrients.
- Deposition of silt in tanks and reservoirs due to soil erosion.
- Health effects are similar to the effects of water pollution.

- Ecological imbalance.

Solid Wastes

- Solid wastes or municipal solid wastes generally comprise paper, food wastes, plastics, glass, metals, rubber, leather, textile, etc.
- Open-burning reduces the volume of the wastes, although it is generally not burnt to completion and open dumps often serve as the breeding ground for rats and flies.
- Sanitary landfills were adopted as the substitute for open-burning dumps. In a sanitary landfill, wastes are dumped in a depression or trench after compaction and covered with dirt every day.
- Landfills are also not much of a solution since the amount of garbage generation especially in the metros has increased so much that these sites are getting filled too.
- Also, there is a danger of seepage of chemicals, etc. from these landfills polluting the underground water resources.

Effects of Plastic Waste

- Conventional plastics, right from their manufacture to their disposal are a major problem to the environment.
- The land gets littered by plastic bag garbage and becomes ugly and unhygienic.
- Conventional plastics have been associated with reproductive problems in both humans and wildlife.
- Dioxin (highly carcinogenic and toxic) by-product of the manufacturing process is one of the chemicals believed to be passed on through breast milk to the nursing infant.
- Burning of plastics, especially PVC releases dioxin and also furan into the atmosphere.
- Plastic bags can also contaminate foodstuffs due to leaching of toxic dyes and transfer of pathogens.
- Careless disposal of plastic bags chokes drains, blocks the porosity of the soil and causes problems for groundwater recharge.
- Plastic disturbs the soil microbe activity. The terrestrial and aquatic animals misunderstand plastic garbage as food items, swallow them and die.

- Plastic bags deteriorate soil fertility as it forms part of manure and remains in the soil for years.

Industrial solid waste

- Thermal power plants producing coal ash/fly ash;
- The integrated iron and steel mills producing blast furnace slag;
- Non-ferrous industries like aluminium, copper and zinc producing red mud and tailings;
- Sugar industries generating press mud;
- Pulp and paper industries producing lime mud;
- Fertilizer and allied industries producing gypsum;

Plastic waste in road construction

- Polyblend is a fine powder of recycled and modified plastic waste.
- This mixture is mixed with the bitumen that is used to lay roads.
- Blends of Polyblend and bitumen, when used to lay roads, enhanced the bitumen's water repellent properties, and helped to increase road life by a factor of three.

Issues with treatment and disposal of solid waste

Open dumps

- Open dumps refer to uncovered areas that are used to dump solid waste of all kinds.
- The waste is untreated, uncovered, and not segregated. It is the breeding ground for flies, rats, and other insects that spread disease.
- The rainwater runoff from these dumps contaminates nearby land and water thereby spreading disease.

Landfills

- It is a pit that is dug in the ground. The garbage is dumped, and the pit is covered with soil every day thus preventing the breeding of flies and rats.

- After the landfill is full, the area is covered with a thick layer of mud, and the site can thereafter be developed as a parking lot or a park.
- All types of waste are dumped in landfills, and when water seeps through them it gets contaminated and in turn, pollutes the surrounding area.
- This contamination of groundwater and soil through landfills is known as leaching.

Incineration plants

- The process of burning waste in large furnaces at high temperature is known as incineration.
- In these plants, the recyclable material is segregated, and the rest of the material is burnt.
- Burning garbage is not a clean process as it produces tonnes of toxic ash and pollutes the air and water.
- At present, incineration is kept as the last resort and is used mainly for treating infectious waste.

Composting

- Composting is a biological process in which micro-organisms, mainly fungi and bacteria, decompose degradable organic waste into humus-like substance in the presence of oxygen.
- This finished product, which looks like soil, is high in carbon and nitrogen and is an excellent medium for growing plants.
- It increases the soil's ability to hold water and makes the soil easier to cultivate. It helps the soil retain more plant nutrients.

Vermiculture

- It is also known as earthworm farming. In this method, Earthworms are added to the compost.
- These worms break the waste, and the added excreta of the worms makes the compost very rich in nutrients.

Waste Minimization Circles (WMC)

- WMC helps Small and Medium Industrial Clusters in waste minimisation in their industrial plants.

- This is assisted by the World Bank with the Ministry of Environment and Forests acting as the nodal ministry.
- The project is being implemented with the assistance of the National Productivity Council (NPC), New Delhi.
- The initiative aims to realise the objectives of the Policy Statement for Abatement of Pollution (1992), which states that the government should educate citizens about environmental risks, the economic and health dangers of resource degradation and the real economic cost of natural resources.
- The policy also recognises that citizens and non-governmental organisations play a role in environmental monitoring, therefore, enabling them to supplement the regulatory system and recognizing their expertise where such exists and where their commitments and vigilance would be cost effective.

Electronic waste | E-WASTE

- The discarded and end-of-life electronic products ranging from computers, equipment, home appliances, audio and video products and all of their peripherals are popularly known as Electronic waste (E-waste).
- E-waste is not hazardous if it is stocked in safe storage or recycled by scientific methods or transported from one place to the other in parts or totality in the formal sector.
- The e-waste can, however, be considered hazardous if recycled by primitive methods.

Source and health effects

Particulars	Source	Health Effects
Lead	Used in glass panels and gaskets in computer monitors Solder in printed circuit boards and other Components	Lead tends to accumulate in the environment and has high acute and chronic effects on plants, animals and microorganisms.
Cadmium	Occurs in SMD chip resistors, infra-red detectors, and semiconductor chips Some older cathode ray tubes contain cadmium	Toxic cadmium compounds accumulate in the human body, especially the kidneys.

Mercury	It is estimated that 22 % of the yearly world consumption of mercury is used in electrical and electronic equipment Mercury is used in thermostats, sensors, relays, switches, medical equipment, lamps, mobile phones and in batteries Mercury, used in flat panel displays, will likely increase as their use replaces cathode ray tubes	Mercury can cause damage to organs including the brain and kidneys, as well as the foetus. The developing foetus is highly vulnerable to mercury exposure. When inorganic mercury spreads out in the water, it is transformed to methylated mercury which bio-accumulates in living organisms and concentrates through the food chain, particularly via fish.
Hexavalent Chromium/ Chromium VI 29	Chromium VI is used as corrosion protector of untreated and galvanized steel plates and as a decorative or hardener for steel housings Plastics (including PVC): Dioxin is released when PVC is burned. The largest volume of plastics (26%) used in electronics has been PVC. PVC elements are found in cabling and computer housings. Many computer mouldings are now made with the somewhat more benign ABS plastics	Chromium VI can cause damage to DNA and is extremely toxic in the environment.
Barium	Barium is used in computers in the front panel of a CRT, to protect users from radiation	Studies have shown that short-term exposure to barium causes brain swelling.
Beryllium	Beryllium is commonly found on motherboards and finger clips It is used as a copper-beryllium alloy to strengthen connectors and tiny plugs while maintaining electrical conductivity	Exposure to beryllium can cause lung cancer. Beryllium also causes a skin disease that is characterised by poor wound healing and wart-like bumps.

Toners	Found in the plastic printer cartridge containing black and colour toners.	Inhalation is the primary exposure pathway, and acute exposure may lead to respiratory tract irritation. Carbon black has been classified as a class 2B carcinogen, possibly carcinogenic to humans.
Phosphor and additives	Phosphor is an inorganic chemical compound that is applied as a coat on the interior of the CRT faceplate.	The phosphor coating on cathode ray tubes contain heavy metals, such as cadmium, and other rare earth metals, for example, zinc, vanadium as additives. These metals and their compounds are very toxic.

Radioactive Pollution

- Radioactive Pollution is defined as the increase in the natural radiation levels in the environment that pose a serious threat to humans and other life forms.
- Radioactive contamination is the deposition of or presence of radioactive substances on surfaces or within solids, liquids or gases (including the human body), where their presence is unintended or undesirable (International Atomic Energy Agency definition).

The use of nuclear energy has two very serious inherent problems:

1. Accidental leakage, as occurred in the Three Mile Island, Chernobyl and Fukushima incidents and
2. Safe disposal of radioactive wastes.

- At high doses, nuclear radiation is lethal, but at lower doses, it creates various disorders, the most frequent of all being cancer.
- Continued small dose exposure to nuclear radiation can cause childhood leukaemia, miscarriage, underweight babies, infant deaths, increased susceptibility to AIDS and other immune disorders.

Artificial Sources of Radioactive pollution

- Accidents in nuclear power plants and nuclear waste.
- Nuclear weapon testing and explosion (Nuclear fallout). The fall Out contains radioactive substances such as strontium-90, caesium-137, iodine-131, etc.
- Uranium mining and mining of other radioactive material like thorium (monazite is the ore of thorium).
- Radiation therapy and direct exposures to radiation for diagnostic purposes (e.g. X-rays), chemotherapy etc.
- The slow nuclear radiations can emanate from a variety of sources viz. nuclear reactors, laboratories, etc.

Natural Sources

They include cosmic rays from space and terrestrial radiations from radio-nuclides present in earth's crust such as radium-224, uranium-238, thorium-232, potassium-40, carbon-14, etc.

Ionizing and Non-Ionizing Radiation

- Radioactivity is a phenomenon of spontaneous emission of proton (alpha-particles), electrons (beta-particles) and gamma rays (short wave electromagnetic waves) due to the disintegration of atomic nuclei of some elements. These cause radioactive pollution.
- Radiations can be categorized into two groups namely the non-ionizing radiations and the ionising radiations.

Non-ionizing radiations

- Non-ionizing radiations are constituted by the electromagnetic waves at the longer wavelength of the spectrum ranging from near infra-red rays to radio waves (includes higher wavelength ultraviolet rays, microwaves).
- These waves have energies enough to excite the atoms and molecules of the medium through which they pass, causing them to vibrate faster but not strong enough to ionise them.
- They may damage eyes which may be caused by reflections from coastal sand, snow (snow blindness) directly looking towards the sun during an eclipse.
- They injure the cells of skin and blood capillaries producing blisters and reddening called sunburns.

Ionising radiations

- Ionising radiations cause ionisation (one or more electrons are pealed out from the outer shells of an atom) of atoms and molecules of the medium through which they pass.

  Ionisation is the process by which an atom or a molecule acquires a negative or positive charge by gaining or losing electrons to form ions, often in conjunction with other chemical changes.
- Electromagnetic radiations such as short wavelength ultraviolet radiations (UV), X-rays and gamma rays and energetic particles produced in nuclear processes, electrically charged particles like alpha and beta

particles produced in radioactive decay and neutrons produced in nuclear fission, are highly damaging to living organisms.

- Electrically charged particles produced in the nuclear processes can have sufficient energy to knock electrons out of the atoms or molecules of the medium, thereby producing ions.
- The ions produced in water molecules, for example, can induce reactions that can break bonds in proteins and other important molecules.
- An example of this would be when a gamma ray passes through a cell, the water molecules near the DNA might be ionised and the ions might react with the DNA causing it to break.
- They can also cause chemical changes by breaking the chemical bonds, which can damage living tissues.
- Short range effects include burns, impaired metabolism, dead tissues and death of the organisms.
- Long range effects are mutations increased the incidence of tumours and cancer, shortening of life-span and developmental changes.

Biological Damage Due to Ionizing Radiations

- Radiation damage can be divided into two types: (a) somatic damage (also called radiation sickness) and (b) genetic damage.
- Somatic damage refers to damage to cells that are not associated with reproduction.
- Effects of somatic radiation damage include loss of hair, fibrosis of the lungs, a reduction of white blood cells, and the induction of cataract in the eyes. This damage can also result in cancer and death.
- Genetic damage refers to damage to cells associated with reproduction.
- This damage can subsequently cause genetic damage from gene mutation resulting in abnormalities.
- Genetic damages are passed on to the next generation.

Radiation dose

- A traditional unit of human-equivalent dose is the rem, which stands for radiation equivalent in man.
- At low doses, such as what we receive every day from background radiation (<1 m rem), the cells repair the damage rapidly.

- At higher doses (up to 100 rem), the cells might not be able to repair the damage, and the cells may either be changed permanently or die. E.g. radiation sickness.
- Cells changed permanently may go on to produce abnormal cells when they divide and may become cancerous.

The damage potential of radiation particles

- Alpha particles can be blocked by a piece of paper and human skin.
- Beta particles can penetrate through the skin, while they can be blocked by some pieces of glass and metal.
- Gamma rays can penetrate easily to human skin and damage cells on its way through, reaching far, and can only be blocked by a very thick, strong, massive piece of concrete.

Half-Life – Period of Radioactivity

- Each radioactive material has a constant decay rate.
- Half-life is the time needed for half of its atoms to decay.
- The half-life may vary from a fraction of a second to thousands of years.
- The radionuclides with long half-time are the chief source of environmental radioactive pollution.

Accidents at nuclear power plants

- Nuclear fission in the reactor core produces a lot of heat which if not controlled can lead to a meltdown of fuel rods in the reactor core.
- If a meltdown happens by accident, it will release large quantities of highly dangerous radioactive materials in the environment with disastrous consequences to the humans, animals and plants.
- To prevent this type of accidents and reactor blow up, the reactors are designed to have a number of safety features.
- Inspire of these safety measures three disasters in the nuclear power plants are noteworthy – Three Mile Island' in Middletown (U.S.A.) in 1979, Chernobyl (U.S.S.R.) in 1986 and Fukushima Daiichi nuclear disaster in 2011.
- In the first two cases, a series of mishaps and errors resulted in overheating of the reactor core and a lot of radiation was released into the environment.

- The leakage from the Three Mile Island reactor was low, and no one was injured immediately.
- However, in the case of Chernobyl, the leakage was very heavy causing the death of some workers and radiation spread over large areas scattered all over Europe.
- The latest one – Fukushima Daiichi nuclear accident was triggered by an earthquake.

Safe Disposal of Nuclear Wastes

Radioactive wastes are of two types

1. Low-level radioactive wastes (LLW) which include civilian applications of radionuclides in medicine, research and industry, materials from decommissioned reactors, protection clothing worn by persons working with radioactive materials or working in nuclear establishments.
2. High-level radioactive wastes (HLW) results from spent nuclear fuel rods and obsolete nuclear weapons.

Some proposed methods of disposing nuclear waste are:

- Bury it under the ice sheet of Antarctica or Greenland ice cap. The ice could be destabilised by heat from the waste. The method has been prohibited by international law.
- Dump it into deep oceans by keeping the waste into glass and steel cases. But the containers might leak and contaminate the ocean.
- Change it into harmless or less harmful isotopes. Currently, no method is known to do that, and the method would be too costly.
- Presently waste fuel rods are being stored in special storage ponds at reactor sites or sent to reprocessing plants. Even though reprocessing is more expensive, but some countries use reprocessing as an alternative to waste storage.

Impact of Radiation

- The radiation that comes from mobile tower radiation is non-ionizing radiation.

Health Impacts

- Every antenna on cell phone tower radiates electromagnetic radiation (power).
- One cell phone tower is being used by a number of operators, more the number of antennas more is the power intensity in the nearby area.
- The power level near towers is higher and reduces as we move away.
- EMR may cause cellular and psychological changes in human beings due to thermal effects that are generated due to the absorption of microwave radiation.
- The exposure can lead to genetic defects, effects on reproduction and development, Central Nervous System behaviour etc.
- EMR can also cause non-thermal effects which are caused by radio frequency fields at levels too low to produce significant heating and are due to movement of calcium and other ions across cell membranes.
- Such exposure is known to be responsible for fatigue, nausea, irritability, headaches, loss of appetite and other psychological disorders.
- The current exposure safety standards are purely based on the thermal effects considering few pieces of evidence from exposure to non-thermal effects.

Impact on birds

- The surface area of a bird is relatively larger than their body weight in comparison to the human body, so they absorb more radiation.
- Also, the fluid contained in the body of the bird is less due to small body weight, so it gets heated up very fast.
- The magnetic field from the towers disturbs birds' navigation skills; hence when birds are exposed to EMR they disorient and begin to fly in all directions.
- A large number of birds die each year from collisions with telecommunication masts.

Bioremediation

- Bioremediation is the use of microorganisms (bacteria and fungi) to degrade the environmental contaminants into less toxic forms.
- Microorganisms can be specifically designed for bioremediation using genetic engineering techniques.

In situ bioremediation

- In situ — It involves treatment of the contaminated material at the site.
- **Bioventing:** supply of air and nutrients through wells to contaminated soil to stimulate the growth of indigenous bacteria.
- **Biosparging:** Injection of air under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of contaminants by naturally occurring bacteria.
- **Bioaugmentation:** Microorganisms are imported to a contaminated site to enhance the degradation process.

  Using bioremediation techniques, TERI has developed a mixture of bacteria called 'Oilzapper and Oilivorous-S' which degrades the pollutants of oil-contaminated sites, leaving behind no harmful residues.

Ex situ bioremediation

- Ex situ — involves the removal of the contaminated material to be treated elsewhere.
- **Landfarming:** contaminated soil is excavated and spread over a prepared bed and periodically tilled until pollutants are degraded. The goal is to stimulate indigenous biodegradative microorganisms and facilitate their aerobic degradation of contaminants.
- **Bioreactors:** it involves the processing of contaminated solid material (soil, sediment, sludge) or water through an engineered containment system.
- **Composting:** Composting is nature's process of recycling decomposed organic materials into a rich soil known as compost.

Advantages of bioremediation

- Useful for the destruction of a wide variety of contaminants.
- The destruction of target pollutants is possible.
- Less expensive.
- Environment-friendly.

Disadvantages of bioremediation

- Bioremediation is limited to biodegradable compounds. Not all compounds are susceptible to rapid and complete degradation.
- Bioremediation often takes a longer time than other treatment processes.

Phytoremediation

- Phytoremediation is the use of plants to remove contaminants from soil and water.
- Natural phytoremediation is carried out by mangroves, estuarine vegetation and other wetland vegetation.
- Phytoextraction/phytoaccumulation: plants accumulate contaminants into the roots and aboveground shoots or leaves.

Renewable energy

Renewable energy is useful energy that is collected from renewable resources, which are naturally replenished on a human timescale, including carbon neutral sources like sunlight, wind, rain, tides, waves, and geothermal heat. Renewable energy often provides energy in four important areas: electricity generation, air and water heating/cooling, transportation, and rural (off-grid) energy services. Renewable energy often displaces conventional fuels in four areas: electricity generation, hot water/space heating, transportation, and rural (off-grid) energy services.

- **Power generation**

By 2040, renewable energy is projected to equal coal and natural gas electricity generation.

- **Heating**

Solar water heating makes an important contribution to renewable heat in many countries, most notably in China, which now has 70% of the global total (180 GWh)

- **Transportation**

Bioethanol is an alcohol made by fermentation, mostly form carbohydrates produced in sugar or starch crops such as corn, sugarcane or sweet sorghum. Cellulosic biomass, derived from non-food sources such as trees and grasses is also being developed as a feedstock for ethanol production.

Essentiality of Renewable Energy

India is currently the world's third largest carbon emitter. 80 % of the world's proven coal, oil and natural gas reserves must remain in the ground in order to avoid warming the planet beyond the internationally agreed limit of 2°C rise in average temperature. So, from an ecological point of view, renewable energy must come up.

From an economic point of view also, India is facing a power crisis. Coal reserves are depleting and getting expensive. Many major plants in the country are facing severe coal shortages.

Solar Energy

The radiation that is received from the sun and utilized in the form electricity and thermal energy by using various available technology like photovoltaic panels, solar heater etc.

Background

- India lying in tropical belt has an advantage of receiving peak solar radiation for 300 days, amounting 2300-3,000 hours of sunshine equivalent to above 5,000 trillion kWh.
- India's current installed solar power capacity, according to Central electricity authority, is 26025.97 MW which is 34% of total renewable energy sources i.e, 75055.92 MW till February 2019.
- India facing problems in fulfilling its energy demand, solar energy can play an important role in providing energy security.
- Debate of global warming and climate change is compelling the world to move from fossil based energy towards clean and green energy.
- With its pollution free nature, virtually inexhaustible supply and global distribution, solar energy is very attractive energy resource.
- India's Intended Nationally Determined Contributions (INDC's) commitment include 100 GW of solar power out of 175 GW renewable energy by 2022.

Need of solar energy

Energy security:

- India energy demands is largely fulfilled by non-renewable source of energy.
- The scarcity of these fossil resources stresses the need for renewable energy sources.
- Abundance of solar energy can fulfill India clean energy demands.
- India is dependent on imports to fulfill its energy demands, thereby incurring huge expenditure and uncertainty with regards to energy security.

- India being a developing economy needs proper electricity for industrial growth and agriculture.
- India also needs self sufficiency and minimal cost in power generation, assured regular supply, which will boost industries and economy.
- The problem of power cuts and unavailability of electricity especially in rural area, leads to improper human development.
- Mostly energy demands are fulfilled by subsidised kerosene, leading to loss for exchequer.
- India's large part of energy demand is fulfilled by thermal energy largely dependent on fossil fuels.
- It also causes environment pollution
- Solar energy is clean form of energy resource, which can be a substitute.

Technology

- **Solar Photovoltaic**: Solar photovoltaic (SPV) cells convert solar radiation (sunlight) into electricity. A solar cell is a semi-conducting device made of silicon and/or other materials, which, when exposed to sunlight, generates electricity.
- **Solar thermal**: Solar Thermal Power systems, also known as Concentrating Solar Power systems, use concentrated solar radiation as a high temperature energy source to produce electricity using thermal route.

Types

- Solar for grid connected electricity:
    - Grid interactive solar energy is derived from solar photovoltaic cells and concentrated solar power Plants on a large scale.

- Solar for off-grid solutions:
    - While, the areas with easier grid access are utilizing grid connectivity, the places where utility power is scant or too expensive to bring, have no choice but to opt for their own generation.
    - They generate power from a diverse range of small local generators using both fossil fuels (diesel, gas) and locally available renewable energy technologies (solar PV, wind, small hydro, biomass, etc.) with or without its own storage (batteries). This is known as off-grid electricity.

Advantages

- Solar Energy is available throughout the day which is the peak load demand time.
- Solar energy conversion equipments have longer life and need lesser maintenance and hence provide higher energy infrastructure security.
- Unlike conventional thermal power generation from coal, they do not cause pollution and generate clean power.
- Abundance of free solar energy in almost all parts of country.

Challenges in adoption

- India's solar story is largely built over imported products.
- India's domestic content requirement clause ia facing legal challenge at WTO.
- India is facing challenge to balance Prioritising domestic goals and WTO commitments.
- The dumping of products is leading to profit erosion of local manufacturers.
- Indian domestic manufacturers aren't technically and economically strong to compete with Chinese companies.
- China's strong manufacturing base is giving stiff challenge to domestic manufacturer.
- Land availability in India for solar plant is less due to high population density.
- India's solar waste is estimated to be around 1.8 million by 2050 also needs to be tackled.

Government initiatives

- Ministry of new and renewable energy is the nodal agency to tackle India's renewable energy issues.
- National Solar Mission is a major initiative of the Government of India and State Governments to promote ecologically sustainable growth while addressing India's energy security challenge.
- The Indian Renewable Energy Development Agency (IREDA) is a Non-Banking Financial Institution under the administrative control of this Ministry for providing term loans for renewable energy and energy efficiency projects.
- National institute of solar energy is created as autonomous institution under MoNRE is apex body for R&D.

- Establishment of solar parks and ultra major solar power project and enhancing grid connectivity infrastructure.
- Promotion of canal bank and canal tank solar infrastructure.
- Sustainable rooftop implementation of Solar transfiguration of India (SRISTI) scheme to promote rooftop solar power projects in india.
- Suryamitra programme to prepare qualified workforce.
- Renewable purchase obligation for large energy consumer customers.
- National green energy programme and green energy corridor.

Potential

For a developing country like India, where electricity for every home was once considered a dream is now close to reality. The government initiative of 'power for all' is changing the socio-economic structure of the country.

- The sector also has immense potential to create new jobs; 1 GW of Solar manufacturing facility generates approximately 4000 direct and indirect jobs.
- In addition solar deployment, operation and maintenance creates additional recurring jobs in the sector.
- Advancements are underway for storage, which has the potential to revolutionise this sector globally, till then dependence on fossils can be reduced by gradually increasing the share of renewables.
- India is expected to be 8% of global solar capacity by 2035. With the future potential capacity of 363 Gigawatts (GW), India can be a global leader in term of encashing energy sector advantages.

International initiatives

- India's commitment as part of INDC at Paris climate deal to reduce the emissions intensity of its GDP by 33 to 35% by 2030 from 2005 level.
- To achieve about 40 per cent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030, with the help of transfer of technology and low cost international finance, including from Green Climate Fund.
- The establishment of International Solar Alliance (ISA) of more than 122 countries initiated by India, most of them being sunshine countries, which lie either completely or partly between the Tropic of Cancer and the Tropic of Capricorn to promote solar energy.

- To mobilize more than US $ 1000 billion of investments needed by 2030 for massive deployment of solar energy, and pave the way for future technologies adapted to the needs.

Way Forward

- Strong financial measures are required to finance the solar projects, innovative steps like green bonds, institutional loans and clean energy fund can play a crucial role.
- Promotion of research and development in renewable energy sector, especially in storage technology.
- Proper mechanism should be provided to tackle China's dumping of solar equipments.
- Framework to avoid unnecessary delays in policy decision making and implementation.
- India needs a Solar Waste Management and Manufacturing Standards Policy.

Hydel Energy

India ranks 5th in terms of exploitable hydropotential on global scenario. As per assessment made by CEA, India is endowed with economically exploitable hydropower potential of 148 GW of installed capacity. Hydropower projects are generally categorized in two segments i.e. small and large hydro.

In India, hydro projects up to 25 MW station capacities have been categorized as Small Hydro Power (SHP) projects. While Ministry of Power, Government of India is responsible for large hydro projects, the mandate for small hydro power projects (up to 25 MW) is given to Ministry of New and Renewable Energy.

Advantages

- Flexibility
- Low cost/high value power
- Suitability for industrial applications
- Reduced CO_2 emissions
- facilities for water sports, and become tourist attractions

Disadvantages

- Ecosystem damage and loss of land
- Water loss by evaporation
- Siltation and flow shortage
- Relocation
- Failure risks

Environmental Impact Assessment (EIA)

- Development projects in the past were undertaken without any consideration to their environmental consequences.
- In view of the colossal damage to the environment, governments and public are now concerned about the environmental impacts of developmental activities.
- Thus, to assess the environmental impacts, the mechanism of EIA was introduced.
- EIA is a tool to anticipate the likely environmental impacts that may arise out of the proposed developmental activities and suggest mitigation measures and strategies.
- EIA was introduced in India in 1978, with respect to river valley projects.
- Later the EIA legislation was enhanced to include other developmental sections.
- EIA comes under Notification on Environmental Impact Assessment (EIA) of developmental projects 1994 under the provisions of Environment (Protection) Act, 1986.
- Besides EIA, the Government of India under Environment (Protection) Act 1986 issued a number of other notifications, which are related to environmental impact assessment.
- EIA is now mandatory for more than 30 categories of projects, and these projects get Environmental Clearance (EC) only after the EIA requirements are fulfilled.
- Environmental clearance or the 'go ahead' signal is granted by the Impact Assessment Agency in the Ministry of Environment and Forests, Government of India.

All projects that require clearance from central government can be broadly categorized into the following:

1. Individual projects that need require clearance from central government,
2. Nuclear power and related projects,

3. River valley projects including hydel power, major irrigation and flood control,
4. Ports, harbours, airports (except minor ports and harbours),
5. Petroleum refineries including crude and product pipelines,
6. Chemical fertilizers and pesticides,
7. Petrochemical complexes and petrochemical intermediates and production of basic plastics,
8. Bulk drugs and pharmaceuticals,
9. Exploration for oil and gas and their production, transportation and storage,
10. Synthetic rubber,
11. Asbestos and asbestos products,
12. Hydrocyanic acid and its derivatives,
13. Primary metallurgical industries (such as production of iron and steel, aluminium, copper, zinc, lead, and ferro-alloys),
14. Chlor-alkali industry,
15. Integrated paint complex including manufacture of resins and basic raw materials required in the manufacture of paints,
16. Viscose staple fibre (biodegradable fibre similar to cotton) and filament yarn,
17. Storage batteries integrated with manufacture of oxides of lead and lead antimony alloy,
18. All tourism projects between 200m-500 metres of High Water Line and at locations with an elevation of more than 1000 metres with investment of more than Rs. 5 crores,
19. Thermal power plants,
20. Mining projects (with lease more than 5 hectares),
21. Highway projects except projects relating to improvement work provided it does not pass through ecologically sensitive areas such as National Parks, Sanctuaries, Tiger Reserves, Reserve Forests,
22. Tarred roads in the Himalayas and forest areas,
23. Distilleries,
24. Raw skins and hide,
25. Pulp, paper and newsprint, dyes,
26. Cement,
27. Electroplating,

28. Meta aminophenol, etc.

The important aspects of EIA are

- Risk assessment,
- Environmental management and
- Post product monitoring.

EIA is to

- Serve as a primary environmental tool with clear provisions.
- Apply consistently to all proposals with potential environmental impacts.
- Use scientific practice and suggest strategies for mitigation.
- Address all possible factors such as short term, long term, small scale and large scale effects.
- Consider sustainable aspects such as capacity for assimilation, carrying capacity, biodiversity protection.
- Lay down a flexible approach for public involvement.
- Have in built mechanism of follow up and feedback.
- Include mechanisms for monitoring, auditing and evaluation.

Environmental Components Of EIA

- The EIA process looks into the following components of the environment.

Air environment

- Quality of ambient air present and predicted.
- Meteorological data: Wind speed, direction, humidity etc.
- Quantity of emission likely from project.
- Impact of the emission on the area.
- Pollution control desires/air quality standards.

Noise

- Levels of noise present and predicted

- Strategies for reducing noise pollution.

Water environment

- Existing ground and surface water resources, their quality and quantity within the zone.
- Impact of proposed project on water resources.

Biological environment

- Flora and fauna in impact zone.
- Potential damage (likely) due to project, due to effluents, emissions and landscaping.
- Biological stress (prediction).

Land environment

- Study of soil characteristics, land use, and drainage pattern, and the likely adverse impact of the project.
- Impact on historical monuments and heritage site.

EIA Process and Procedures

Steps in EIA process

- EIA involves the steps mentioned below. However, EIA process is cyclical with interaction between the various steps.
- Screening: The project plan is screened for scale of investment, location and type of development and if the project needs statutory clearance.
- Scoping: The project's potential impacts, zone of impacts, mitigation possibilities and need for monitoring.
- Collection of baseline data: Baseline data is the environmental status of study area.
- Impact prediction: Positive and negative, reversible and irreversible and temporary and permanent impacts need to be predicted which presupposes a good understanding of the project by the assessment agency.

- Mitigation measures and EIA report: The EIA report should include the actions and steps for preventing, minimizing or by passing the impacts or else the level of compensation for probable environmental damage or loss.
- Public hearing: On completion of the EIA report, public and environmental groups living close to project site may be informed and consulted.
- Decision making: Impact Assessment Authority along with the experts consult the project-in-charge along with consultant to take the final decision, keeping in mind EIA and EMP (Environment Management Plan).
- Monitoring and implementation of environmental management plan: The various phases of implementation of the project are monitored.
- Assessment of Alternatives, Delineation of Mitigation Measures and Environmental Impact Assessment Report: For every project, possible alternatives should be identified, and environmental attributes compared. Alternatives should cover both project location and process technologies.
- Once alternatives have been reviewed, a mitigation plan should be drawn up for the selected option and is supplemented with an Environmental Management Plan (EMP) to guide the proponent towards environmental improvements.
- Risk assessment: Inventory analysis and hazard probability and index also form part of EIA procedures.

Steps in Preparation of EIA report

- Collection of baseline data from primary and secondary sources;
- Prediction of impacts based on past experience and mathematical modelling;
- Evolution of impacts versus evaluation of net cost benefit;
- Preparation of environmental management plans to reduce the impacts to the minimum;
- Quantitative estimation of financial cost of monitoring plan and the mitigation measures.

Environment Management Plan

- Delineation of mitigation measures including prevention and control for each environmental component and rehabilitation and resettlement plan.

Environmental Appraisal

- An Appraisal Committee constituted by the Ministry of Environment and Forests will first scrutinized a project based on the data presented by the project authorities.
- If necessary, the MoEF may also hold consultations with the investors and experts on specific issues as and when necessary.
- After considering all the facets of a projects, 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.

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.

Single window clearance

- Environmental clearance + 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.

The Main Participants Of EIA

- EIA applies to public and private sections. The six main players are:
- Those who propose the project

- The environmental consultant who prepare EIA on behalf of project proponent.
- Pollution Control Board (State or National).
- Public has the right to express their opinion.
- The Impact Assessment Agency.
- Regional centre of the Ministry of Environment and Forest.

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.

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

1. Screening
2. Scoping
3. Public hearing
4. Appraisal
5. Category A projects require mandatory environmental clearance and thus they do not undergo the screening process.
6. Category B projects undergoes screening process and they are classified into two types.
7. Category B, projects (Mandatorily requires EIA).
8. Category B2 projects (Do not require EIA).
9. Thus, Category A projects and Category B, projects undergo the complete EIA process whereas Category B2 projects are excluded from complete EIA process.

Benefits of EIA

- EIA links environment with development for environmentally safe and sustainable development.
- EIA provides a cost effective method to eliminate or minimize the adverse impact of developmental projects.
- EIA enables the decision makers to analyse the effect of developmental activities on the environment well before the developmental project is implemented.

- EIA encourages the adaptation of mitigation strategies in the developmental plan.
- EIA makes sure that the developmental plan is environmentally sound and within limits of the capacity of assimilation and regeneration of the ecosystem.

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).

Public hearing

- Public comments are not considered 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 reports 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.

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 project will have. This should be a separate chapter and not hidden within technical details.
- It is critical that the preparation of an EIA is completely independent of the project proponent.

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.

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.

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.

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.

BIODIVERSITY

As per united nations earth summit, 'Biodiversity is defined as ‘the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems.'

1) Levels of Biodiversity

Three levels include

- **Genetic Diversity-** It is concerned with the variation in genes within a particular species. Genetic diversity allows species to adapt to changing environments. The genetic diversity gives us beautiful butterflies, roses, parakeets or coral in a myriad hues, shapes and sizes.

- **Species Diversity-** It refers to the variety of living organisms on earth. Species differ from one another, markedly in their genetic makeup, do not inter-breed in nature. ‘Zero’ would be infinite diversity, and ‘one’ represents only one species present.

- **Ecosystem/Community Diversity-** This refers to the different types of habitats. A habitat is the cumulative factor of the climate, vegetation and geography of a region. There are several kinds of habitats around the world.Corals, grasslands, wetland, desert, mangrove and tropical rain forests are examples of ecosystems.

Note- One genus and several species.

2) Measurement of Biodiversity

Biodiversity is measured by two components

a) Species richness
b) Species evenness

a) Species richness- It is the measure of number of species found in a community.

- **Alpha diversity-** It refers to the diversity **within** a particular area or ecosystem, and is usually expressed by the number of species (i.e. species richness) in that ecosystem.
- **Beta diversity-** It is a comparison of diversity **between** ecosystems, usually measured as the change in amount of species between the ecosystems
- **Gamma diversity-** It is a measure of the **overall diversity** for the different ecosystems within a region.

b) Species evenness- It measures the proportion of species at a given site, e.g. low evenness indicates that a few species dominate the site.

3) Services provided by Biodiversity-

- **Ecosystem services-** Protection of water resources, Soils formation and protection, Nutrient storage and recycling, Pollution breakdown and absorption, Contribution to climate stability, Maintenance of ecosystems, Recovery from unpredictable events.
- **Biological services-** food, medicinal resources, wood products, ornamental plants, breeding stocks, diversity in genes and species and ecosystem
- **Social services-** research,education and training, recreation and tourism, cultural values

Note- Keep in mind the services under various categories, direct questions asked from here.

4) Modes of Conservation-

- **Ex-situ conservation-** Conserving biodiversity outside the areas where they naturally occur is ex-situ conservation.
  E.g. Bioventing, Biosparging, Biostimulation, Bioaugmentation, Botanical Parks and Zoological Parks, Zoo Parks

- **In-situ conservation-** Conserving the animals and plants in their natural habitats is known as in-situ conservation.
  E.g. Composting, Landfill, Incineration, National Parks, Wildlife Sanctuaries, Protected Forests, Community Reserves, Conservation Reserves

The red data book

"Red" of course is symbolic of danger that the species both plants and animals presently experience throughout the globe.

- **Extinct**
- **Extinct in wild**
- **Critically endangered** - great indian bustard, gharial, kashmiri stag, bengal florican, jerdon curser, vulture, malabar civet, **pygmy hog**
- **Endangered** - asiatic lion, tiger, elephant, nilgiri tahr, sangai deer, **lion tailed macaque**,**irrawady dolphins**, gangetic dolphins, indus river dolphin,
- **Vulnerable** - olive ridley turtles, snow leopard, dugong, **greater-one-horned rhino**, cheetah, clouded leopard, black necked crane
- **Least concern** - Amur falcon, nilgai

Note- keep in mind the species under various categories.direct questions asked from here.

B) Indian Biodiversity Diverse Landscape-

Flora

Biomes- The term biome means the main groups of plants and animals living in areas of certain climate patterns. It includes the way in which animals, vegetation and soil interact together.

Five biomes of India are-

Tropical evergreen- Ebony, Mahogany, Rosewood

Tropical deciduous forests- Sal, Teak, Sandalwood, Jamun, Mango, Bamboo

Warm deserts and semi deserts- Acacia, Babool, Cactus

Coniferous forests- Pine, Fir, Spruce

-alpine meadows

Fauna

Vertebrates- Vertebrates are animals with backbones and spinal columns. Vertebrates are the most advanced organisms on Earth. Include-

- Fish
- Amphibians
- Reptiles
- Birds
- Mammals

Invertebrates- Invertebrates do not have backbones. More than 98% animal species in the world are invertebrates. Invertebrates don't have an internal skeleton made of bone. Include-

- Annelids
- Molluscs
- Anthropods
- Arachnids
- Protozoa

Note- Keep in mind the trees under various biomes, direct questions asked from here.

Indian State of Forest Report- Biennial publication of Forest Survey of India (FSI), an organization under the Ministry of Environment Forest & Climate Change;assesses the forest and tree cover, bamboo resources, carbon stock and forest fires (does not include coral reefs)

1) Total Forest Cover- 21.67%.

2) Total Forest+Tree Cover- 24.56%

Forest Cover (Area-wise) - Madhya Pradesh > Arunachal Pradesh > Chhattisgarh > Odisha > Maharashtra.

Forest Cover (Percentage) - Mizoram (85.4%) > Arunachal Pradesh (79.63%) > Meghalaya (76.33%)

The top five states to have shown an increase in forest cover include Karnataka (1,025 sq km) > Andhra Pradesh (990 sq km) > Kerala (823 sq km) > J&K (371 sq km) > Himachal Pradesh (334 sq km).

Invasive Species

Flora

Needle Bush, Black Wattle, Goat weed, Alternanthera paronychioides, Prickly Poppy, Blumea eriantha, **Water Hyacinth**, Impatiens, Balsam, Datura, Mad Plant, Thorn Apple, Palmyra, Toddy Palm, Ipomoea / the pink morning glory, Lantana camara / Lantana, Wild Sage,Black Mimosa, 4 '0' clock plant, Prosopis juliflora / Mesquite, Townsend grass.

Fauna

Leptocybe invasa - a new insect, Crazy ant, Giant African snail, Myna, Gold Fish, Pigeon, Donkey, House Gecko, Tilapia.

Medicinal plants

Beddomes Cycad / Perita / Kondaitha, Blue vanda / Autumn Ladies Tresses Orchid, Kuth / Kustha / Pooshkarmoola / Uplet, Ladies Slipper Orchid, Red vanda, Sarpagandha, Ceropegia species, Emodi / Indian Podophyllum, Tree Ferns, Cycads, Elephant's foot

Protected Area Network

Includes wildlife sanctuaries, national parks, biosphere reserves, community reserves, conservation reserves, coastal protected areas, sacred groves of India etc.

Wildlife Sanctuary- The Wild Life (Protection) Act of 1972 provided for the declaration of certain areas by the State Government as wildlife sanctuaries if the area was thought to be of adequate ecological, geomorphological and natural

significance.

National Park- The Wild Life (Protection) Act (WPA) of 1972 provided for the declaration of National Parks by the State Government in addition to the declaration of wildlife sanctuaries.

Difference between Wildlife Sanctuary and National Parks

- National Parks enjoy a greater degree of protection than sanctuaries.
- Certain activities, which are regulated in sanctuaries, such as grazing of livestock, are prohibited in National Parks.
- Wildlife sanctuary can be created for a particular species (for e.g. Grizzled giant squirrel W.L.S in Srivalliputhur) whereas the national park is not primarily focused on a particular species.

Note-

1) The Central Government may also declare, Wild Life Sanctuary and National Park under certain conditions.

2) Area of National Parks and Wildlife Sanctuaries is altered by State Governments.

Conservation Reserve and Community Reserves- Conservation Reserve and Community Reserves are the outcome of Amendments to the **Wild life protection act in 2003.**

Conservation Reserves-

- The Amendment Act of 2003 provided for the creation of a new type of protected area called a Conservation Reserve.
- It is an area owned by the State Government adjacent to National Parks and sanctuaries for protecting the landscape, seascape and habitat of fauna and flora. It is managed through a Conservation Reserve Management Committee.
- The State Government may, after having consultations with the local communities, declare any area **owned by the Government** as conservation reserve.

Community Reserves

- The Amendment Act of 2003 provided for the creation of a new type of protected area called a Community Reserve.
- The State Government may notify **any community land or private land** as a Community Reserve.
- No change in land use pattern shall be made within the Community Reserve, except in accordance with a resolution passed by the Management Committee and approval of the same by the State Government.

Coastal Protected Areas-

- It aims to protect and conserve the natural marine ecosystems in their pristine condition.
- The mpas in marine environment in India are-

1) Category-I: This covers National Parks and Sanctuaries and having entire areas in intertidal/sub-tidal or mangroves, coral reefs, creeks, seagrass beds, algal beds, estuaries, lagoons.

2) Category-II: This includes Islands, which have major parts in marine ecosystem and some part in terrestrial ecosystem.

3) Category-IIIA: This includes sandy beaches beyond intertidal line but occasionally interacting with the seawater.

4) Category-IIIB: This includes ever green or semi evergreen forests of Islands.

- The Marine Protected Areas (mpas) in India comprise of a 33 national parks and wildlife sanctuaries designated under the **Wildlife (Protection) Act, 1972.**

Biosphere Reserves-

Note- Used for Protection of Several Species, not Protected under any Law.

Biosphere Reserve (BR) is an international designation by UNESCO for representative parts of natural and cultural landscapes extending over large area of terrestrial or coastal/marine ecosystems or a combination thereof.

3 - Zones

- **Core Zone**- can be national park or wildlife sanctuary under wildlife protection act, 1972; **activities are completely prohibited**
- **Buffer Zone**- activities like restoration, demonstration sites for enhancing value addition, limited recreation, tourism, fishing, grazing etc.

Note- human activities affecting environment are completely prohibited.

- **Transition Zone**- settlements, croplands, managed forests etc.

Functions of Biosphere Reserves- Conservation, Development, Logistics support

Global Initiatives-

1) Man And Biosphere Programme- nilgiri, gulf of mannar, sunderbans, nanda devi, nokrek, pachmarhi, achanakmar, similipal, great nicobar, agasthyamalai, Kanchenjunga (total 18 biosphere reserves in india out of which 11 are part of man and biosphere programme).

Biodiversity Hot Spots-

- Biodiversity hot spot concept was put forth by Norman Myers in 1988. They are declared by **conservation international.**

To qualify as a hot spot, a region must meet **two strict criteria:**

- Species endemism- it must contain at least 1,500 species of vascular plants (> 0.5% of the world's total) as endemics, and
- Degree of threat- it has to have lost at least 70% of its original habitat.

Indian Biodiversity Hot Spots-

The Eastern Himalayas Hot Spot- It is the region encompassing Bhutan, northeastern India, and southern, central, and eastern Nepal.

Indo-Burma- It is spread out from Eastern Bangladesh to Malaysia and includes North-Eastern India south of Brahmaputra river, Myanmar, the southern part of

China's Yunnan province, Lao People's Democratic Republic, Cambodia, Vietnam and Thailand.

In India, it includes entire northeast except Assam and andamans.

Western Ghats and Sri Lanka- also known as the "Sahyadri Hills"encompasses the mountain forests in the southwestern parts of India and highlands of southwestern Sri Lanka.

Sundaland- in India, it includes Andaman and nicobar islands.

Note- the United Nations declared 2010 to be the International Year of Biodiversity.

International Day for Biological Diversity - 22 May

Un Decade on Ecosystem Restoration- 2021-30

E) Conservation Efforts-

Project Tiger (Current Status-Endangered), centrally sponsored scheme was launched in 1973

Objectives-

A) To ensure maintenance of available population of Tigers in India for scientific, economic, aesthetic, cultural and ecological value

B) To preserve, for all times, the areas of such biological importance as a national heritage for the benefit, education and enjoyment of the people

Aim-

A) Conservation of the endangered species and

B) Harmonizing the rights of tribal people living in and around tiger reserves

NOTE-The State Government shall, on recommendation of the National Tiger Conservation Authority, notify an area as a tiger reserve.

National Tiger Conservation Authority (NTCA) - The Amendment Act of 2006 provides for the constitution of a statutory authority known as the National Tiger Conservation Authority to aid in the implementation of

measures for the conservation of the tiger.

Aim- To approve the Tiger Conservation Plan prepared by the State Government, to evaluate and assess various aspects of sustainable ecology and disallow any ecologically unsustainable land use such as mining, industry and other projects within tiger reserves

Few Terms- M-stripes (developed by **wildlife institute of India**), CATS

Estimating Tiger Population- scattered among Bangladesh, Bhutan, Cambodia, China, Indonesia, Laos PDR, Malaysia, Myanmar, Nepal, Russian Federation, Thailand and Vietnam. In India alone, the number of wild tigers is now estimated at between 2,600 and 3,350 animals - which makes up around three-quarters of the world's population.

Top Performers- Mp > Karnataka > Uttarakhand

Increase in Tiger population- Madhya Pradesh (71%) > Maharashtra (64%) > Karnataka (29%)

Worst Performers- Chhattisgarh and Mizoram saw a decline in tiger population.

Few Important Facts-

1) Madhya Pradesh's Pench Sanctuary and Kerala's Periyar sanctuary emerged as the best-managed tiger reserves in the country.

2) Sathyamangalam Tiger Reserve in Tamil Nadu registered the "maximum improvement" since 2014.

3) The Dampa and Rajaji reserves, in Mizoram and Uttarakhand respectively are at the bottom of the list in terms of Tiger count.

4) No tiger has been found in the Buxa (West Bengal), Palamau (Jharkhand) and Dampa (Mizoram) reserves.

Note- 29th July is celebrated as global tiger day.

Tigers are "umbrella species."

Bandipur, Manas and Sunderbans are tiger reserves.

Project Elephant (Current Status-Endangered), centrally sponsored scheme, and started in 1992

Objectives-

- To protect elephants, their habitat & corridors
- To address issues of man-animal conflict
- Welfare of domesticated elephants

Programmes-

- Monitoring of Illegal Killing of Elephants(MIKE) Programme- states include garohills (assam), waynad (kerela), mayurbhanj (odisha), mysore, nilgiri (tn), shiwalik (uttarakhand)
- Haathi Mere Saathi
- Elephant - 8 Ministerial Meeting
- E-50:50 forum

Note- Tiger Census is Conducted every 4 years and Elephnat Census every 5 years.

One-Horned Rhino (Current Status-Endangered)

Indian Rhino Vision 2020- The vision of this program is to increase the total rhino foundation in Assam from about 2000 to 3000 by the year 2020. Initiated **by WWF**.

Note- Manas National Park was selected as the first site for translocation of rhinos.

Indian Crocodile Conservation Project

Project Hangul (Current Status-Critically Endangered)

It is the state animal of Jammu & kasmir.

In Kashmir, it is found in **Dachigam National Park** at elevations of 3,035 meters

Captive Breeding- Captive breeding means that members of a wild species are captured, then bred and raised in a special facility under the care of wildlife biologists and other expert. When the entire existing habitat is poor quality or other environmental problems occur, a captive population can be maintained until the problems can be solved or another appropriate habitat can be found for the animal in the wild.

Note- India Adopts Sawen

India has adopted the Statute of the South Asia Wildlife Enforcement Network (SAWEN) sand becoming its formal member in order to strengthen ties with the member countries in controlling the trans-boundary wildlife crime through communication, coordination, collaboration, capacity building and cooperation in the region.

SAWEN, a regional network is comprised of **eight countries in South Asia: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka**.

It aims at working as a strong regional inter governmental body for combating wildlife crime by attempting common goals and approaches for combating illegal trade in the region.