ENVIRONMENT & ECOLOGY

Study Material for UPSC and State PCS Exams

NS

ENVIRONMENT & ECOLOGY
Topics Covered


ECOLOGY


ECOSYSTEM


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INTL. ORG. AND CONVENTIONS


ACTS & POLICIES (INDIA)

1- ECOLOGY

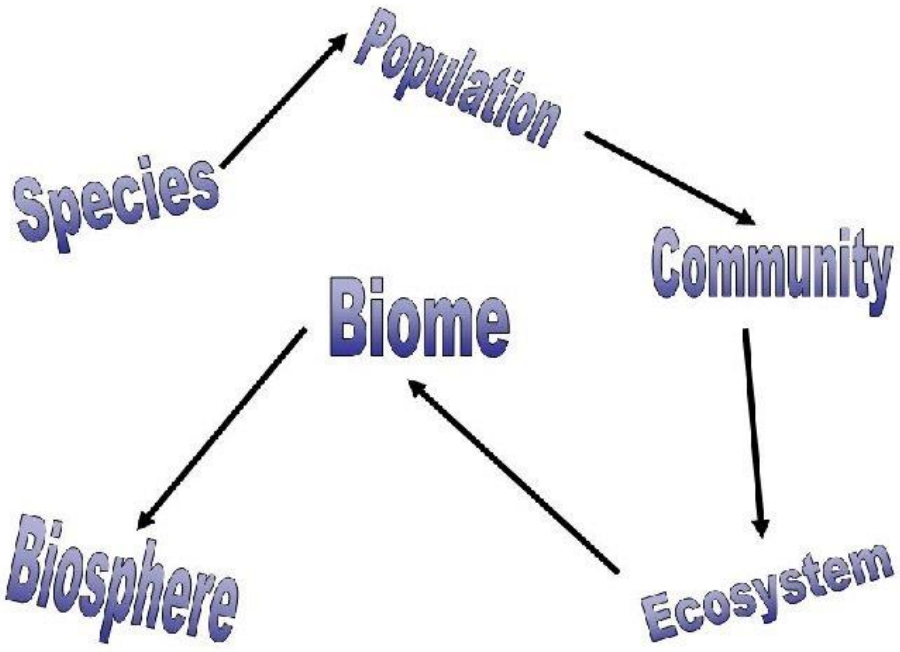
1.1 Ecology and Its Organization

The people, place, and things in nature that surround living organisms in totality form environment. Basically, the term environment means the surroundings of an organism. It is a combination of both the natural and human-made phenomenon. The environment includes both the living and the non-living components, which influence the lives of organisms present in a specific area at a given point of time.

Ecology and Its Organization

- The term ecology (Oekologie) was coined by a German biologist, Hanns Reiter in 1868 by combining two Greek words – Oikos (house) and logos (a study of).
- Ecology is the scientific study of animals and plants in relation to their environment and to each other.
- Ecology is one of the disciplines of environmental science which studies reciprocal relationship between organisms within their environment.

Levels of Organisation in Ecology



Organism

- An organism is an individual living being which can function independently
- It is a fundamental functional unit in ecology because it interacts directly with the environment as well as with other organisms, e.g., a rabbit, fungi etc.

Population

- It refers to a group organism of the same species that are in proximity to one another, e.g., a group of rabbits.
- Population density which is the number of individuals of a population in a unit area may vary in different regions or during different times in the same region.

Community

- It includes all the populations occupying a given area.
- A community may have one or several species.
- The size of a community depends on our scale of reference.
- We might use the community to refer to all of the living things in a particular area like a pond, or we might restrict our interest to the fish community or the plant community.

Ecosystem

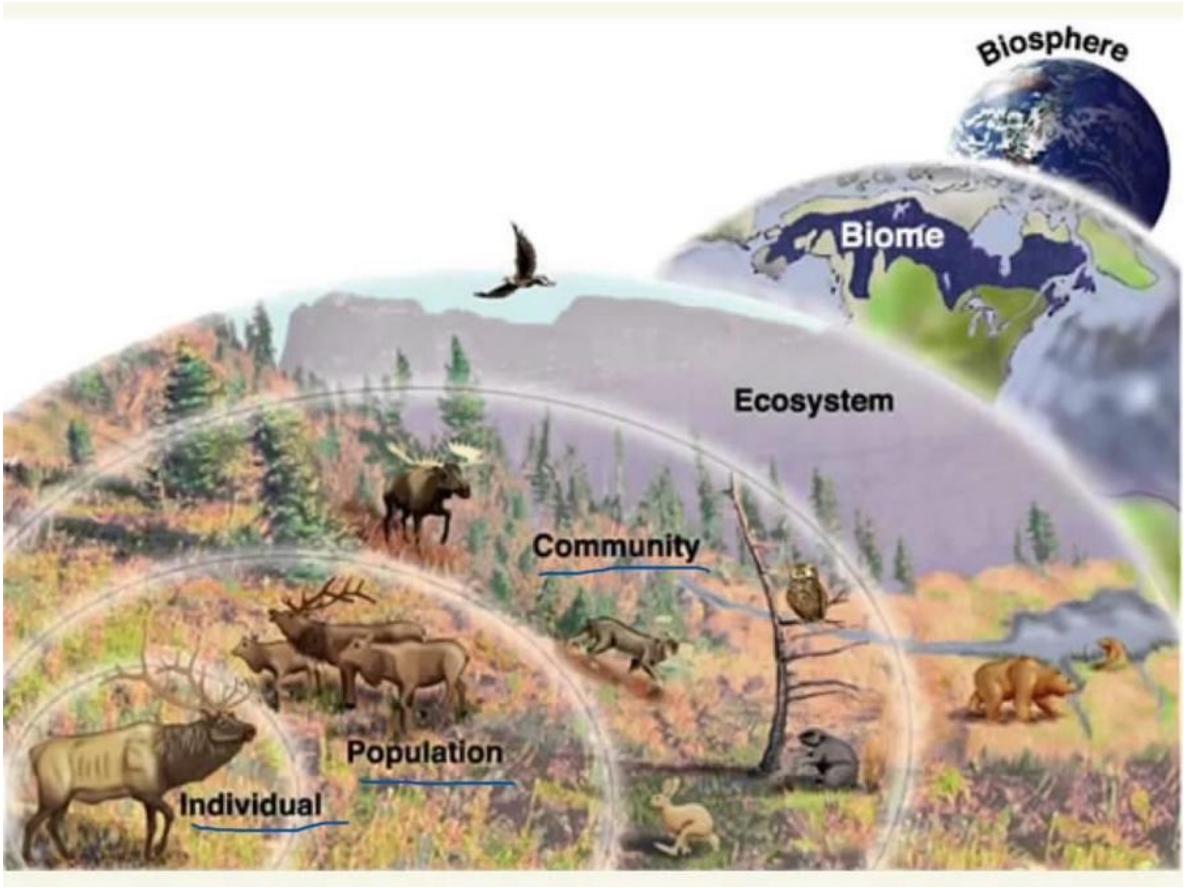
- The community and the non-living environment together are referred to as an ecological system or ecosystem, e.g., a pond with fish and plants.
- The term “ecosystem” was coined by Sir Arthur Tansley in 1935
- An ecosystem has two basic components biotic or living components and abiotic or non-living components.
- The living or biotic components include the community with all the animals and plants.
- The non-living or abiotic component includes the organic and inorganic substances together with climatic factors.

Biomes

- It refers to a large regional or sub-continental ecosystem characterized by similarity in vegetation and climate.
- It is made of many similar ecosystems.
- An ecosystem is much smaller than a biome which is enormous in size.
- For example, a grassland biome implies many ecosystems that are similar because grasses are their principal plants and grazer are their predominant animals

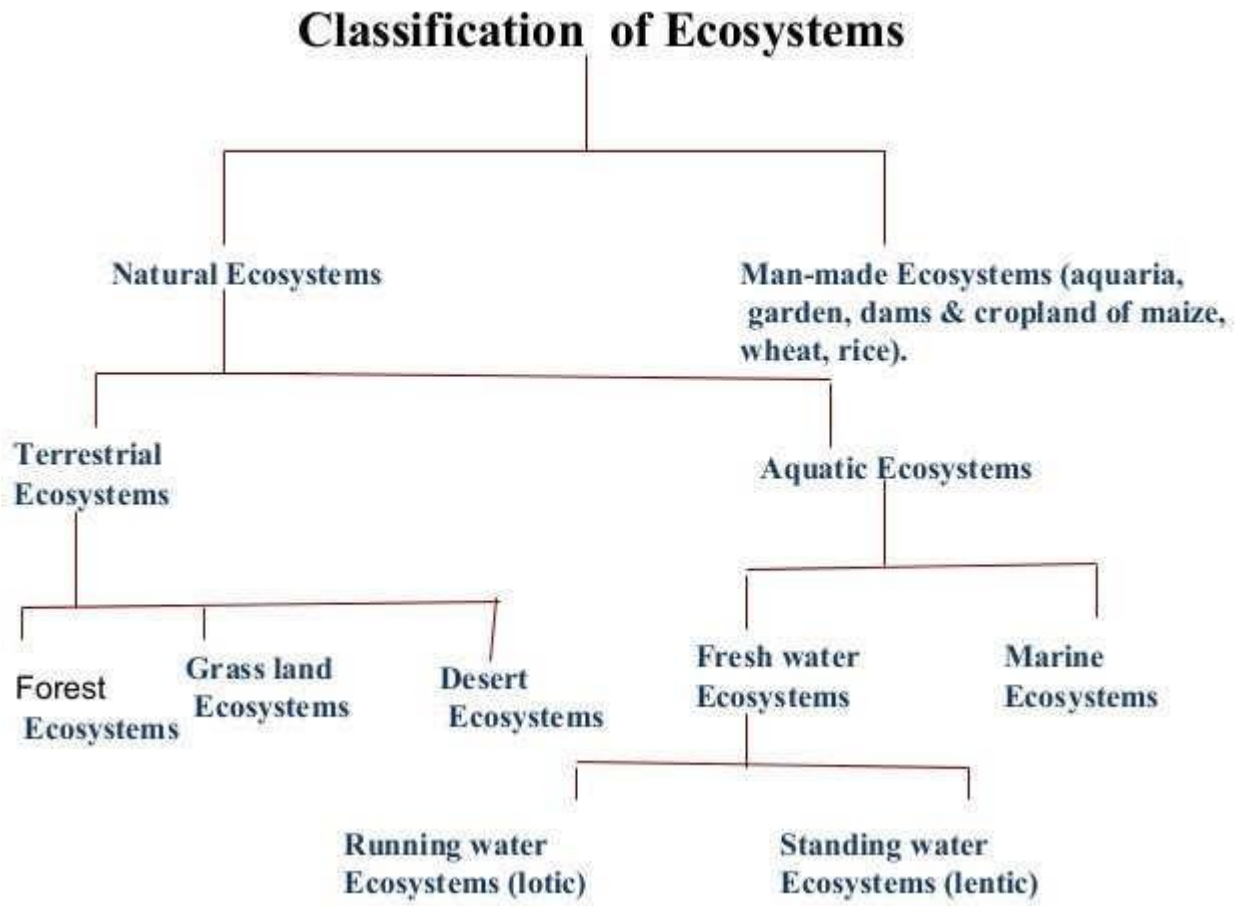
Biosphere

- The biosphere is a relatively thin layer around the planet earth where life exists.
- It is also referred to as the "Zone of Life", comprising of the atmosphere (air), hydrosphere (water), and lithosphere (land).
- It extends from few kilometres into the atmosphere to the depth of the oceans including many trenches.
- The biosphere is unique as so far, the existence of life has not been found elsewhere in the universe.
- The energy required to support life on earth comes from the sun in the form of solar energy which is captured by producers like green plants to produce food through photosynthesis.
- Water is another major factor on which all life forms depend.
- The biosphere is characterized by continuous cycles of matter which is continuously recycled for life to continue.



Classification of Ecosystem

Basically, there are two types of ecosystems – Natural Ecosystems and Artificial Ecosystem. However, there are several subtypes of these two types of ecosystem.



Natural Ecosystem

- They are self-regulating systems without much direct human interferences and manipulations.
- There are several examples of natural ecosystem Viz. River, pond, lake, ocean, forest, desert, and grassland etc.
- Based on the type of habitat, the natural ecosystems are further categorized into terrestrial and aquatic.
- Terrestrial ecosystems include deserts, forests, and grasslands.
- Aquatic ecosystems can be either freshwater like lakes, ponds, streams, or salt water like marine, estuaries type.

A forest – an example of a natural ecosystem

Artificial Ecosystem

- They are man-made.
- Human activities modify or convert natural ecosystems into man-made ecosystems.
- For example, natural forests are cut and the land is used for tree plantations or agricultural activities.
- Other examples of artificial ecosystems include gardens, parks, and aquaria. In these ecosystems, man manipulates the physio-chemical environment for his own benefit.

A city park – an example of an artificial or man-made ecosystem

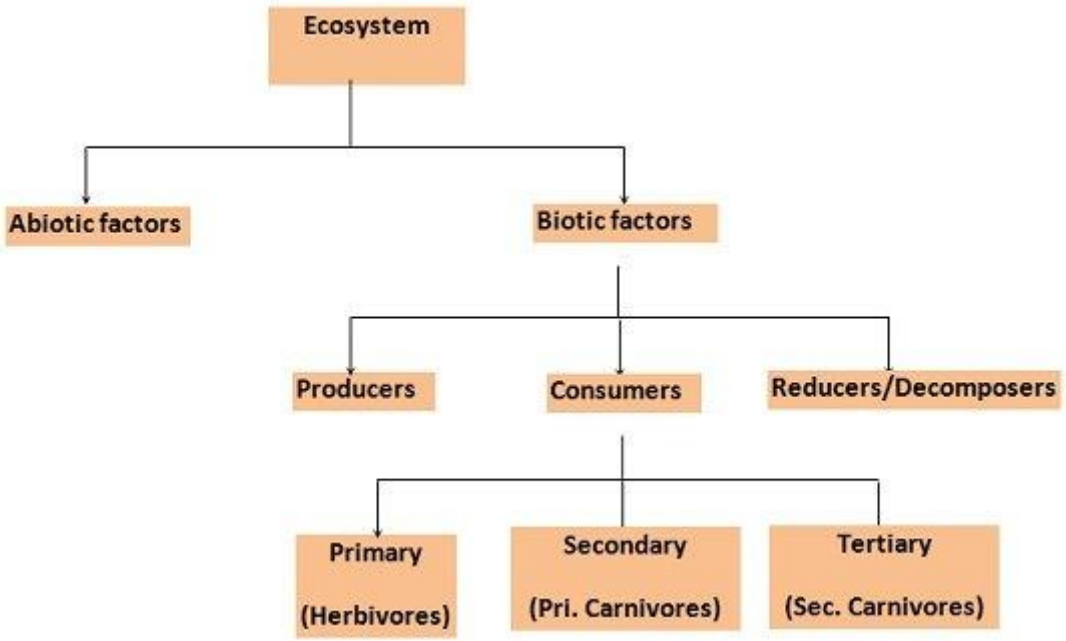
1.2 Components of An Ecosystem

An ecosystem is a self-sustaining and self-regulating structural and functional unit of the biosphere. The ecosystem includes a group of organisms interacting among themselves and with the environment.

Components of an Ecosystem

The ecosystem consists of both the living and the nonliving components. Living organisms cannot live in isolation from their non-living environment. This is because the non-living environment provides materials and energy for the very survival of the living organisms.

The community with all the plants and animals forms the living or biotic component. The organic and inorganic substances together with climatic factors constitute the non-living or abiotic component of the ecosystem.



Biotic Component

These include the living components of the ecosystem that interact with the non-living components. They are (1) Producers, (2) Consumers and (3) Decomposers.

Producers

- Since they are autotrophic or self-nourishing, they are also known as autotrophs.
- Producers include organisms, which produce their own food by fixing solar energy in the presence of abiotic substances
- Since they produce food for the other organisms, they are known as producers.
- Producers mainly include green plants, algae, and certain bacteria etc.

Consumers

- Since they are heterotrophic, they are also called heterotrophs
- They are also known as “Phagotrophs”
- Consumers include those organisms which consume the food produced by the producers.
- Consumers cannot produce their own food. So they have to depend on other organisms for food and nutrition.
- They derive nutrition by feeding on other living organisms.

Types of Consumers

1. **Primary Consumers** – they are commonly called herbivores. They are animals that derive nutrition directly from consuming producers or green plants. E.g. insects, rabbits, cow, and goat etc. are some of the common herbivores in the terrestrial ecosystem. Small crustaceans, snails, and fishes etc. are herbivores in the aquatic ecosystem.
2. **Secondary Consumers** – They are commonly called carnivores. They are flesh-eating animals. A carnivore is an animal that gets nutrition indirectly from producers by eating herbivores. The organisms which can feed on both plants and animals is called an omnivore such as human beings, fox etc. Omnivores are both herbivores and carnivores.

3. **Tertiary Consumers** – these are the top carnivores which prey upon carnivores, omnivores, and herbivores. Lions, tigers, sharks, eagle etc. are considered tertiary consumers

Decomposers

- They are micro-organisms mostly bacteria, fungi, protozoa etc.
- They are also known as "Saprotrophs".
- Instead of ingesting food as done by the heterotrophs, they release enzymes into the dead organic matter and then absorb some of the degraded product.
- Decomposers attack the dead remains of producers and consumers and degrade the complex organic substances into simpler compounds.
- They utilize the organic matter, derive energy and release inorganic substances for recycling.
- These inorganic substances are reused by producers for the process of photosynthesis.
- Recycling of nutrients in the ecosystem through the process of mineralization of dead organic minerals in the most important role of decomposers.
- Mineralization is the conversion of dead organic matter into simple forms of nutrients that can be used again by producers.
- Apart from processing and removing organic wastes, decomposers regenerate ecosystem fertility by releasing nutrients that were locked up in the organic matter.

Abiotic Components

These are non-living components that affect the distribution, number, metabolism, and behaviour of organisms in an ecosystem. Abiotic factors influence the presence of biotic components in a large way. There are three broad categories of abiotic components in all ecosystems:-

1. Inorganic substances
2. Dead organic matter

3. Ecological factors

Inorganic Substances

- The different life processes of living organisms depend on various elements
- Elements that are needed in large amounts are called macronutrients.
- Examples of macronutrients are carbon, hydrogen, oxygen, nitrogen, potassium, calcium, sodium, magnesium, iron, phosphorus and sulphur.
- Substances required in small amounts are called micronutrients. Some
- Examples of micronutrients are Copper, Manganese, Selenium, Zinc, Molybdenum, Boron, Silicon etc.
- Some of these micronutrients may often serve as limiting factors to affect the growth, survival, and propagation of living organisms.

Organic Substances

- These include carbohydrates, proteins, Lipids and their derivatives.
- These are formed as a result of degradation of various dead and decomposed bodies of the organisms and excretory materials of different organisms.
- Decomposing organic matter releases nutrients into the soil.
- It also forms a dark, soft spongy substance known as humus, which is important for soil fertility.
- This humus gets converted into mineral elements as a result of climatic factors and action of microorganisms.

Ecological Factors

Ecological factors are classified as

- **Climatic Factors** – Light, temperature, wind velocity, atmospheric gases, rainfall and atmospheric humidity.
- **Edaphic Factors** – Soil-mineral matter, organic matter, soil water and soil air.
- **Topographic Factors** – Altitude, steepness of slope and direction of the slope.

Limiting Factors

- Plants and animals all have a range of tolerance for certain environmental factors like light, soil, water, temperature, humidity, etc.
- If an environmental factor essential for life is absent or is below or above the critical range for a particular species, the factor is called a limiting factor for that species.
- An organism may have a wide range of tolerance for one factor but a narrow range for another.
- For example, freshwater fishes have a wide range of tolerance for temperature but a narrow range of tolerance for salts; so they perish when the concentration of salts in water increases {i.e., in seawater).
- Limiting factors are both biotic and abiotic.
- They control the actual distribution and abundance of organisms in nature.

The interaction between Biotic and Abiotic Components in an Ecosystem

- The different components of an ecosystem keep on continuously interacting with each other.
- There exists an interdependence of living organisms (biotic factors) and the physical environment (Abiotic factors) in all ecosystems.
- For example, animals cannot produce their own food so they depend on plants directly or indirectly, for their nutrition.
- Plants are able to synthesize their own food but they are dependent on the physical environment for the raw materials like water, light, carbon dioxide etc.
- Micro-organisms like fungi and bacteria depend on dead animals and plants as well as their waste products decomposing them to enrich the physical environment with nutrients.
- Thus, the biotic and abiotic components interact intimately and greatly influence each other.
- The biotic and abiotic components do not exist in isolation from one another.

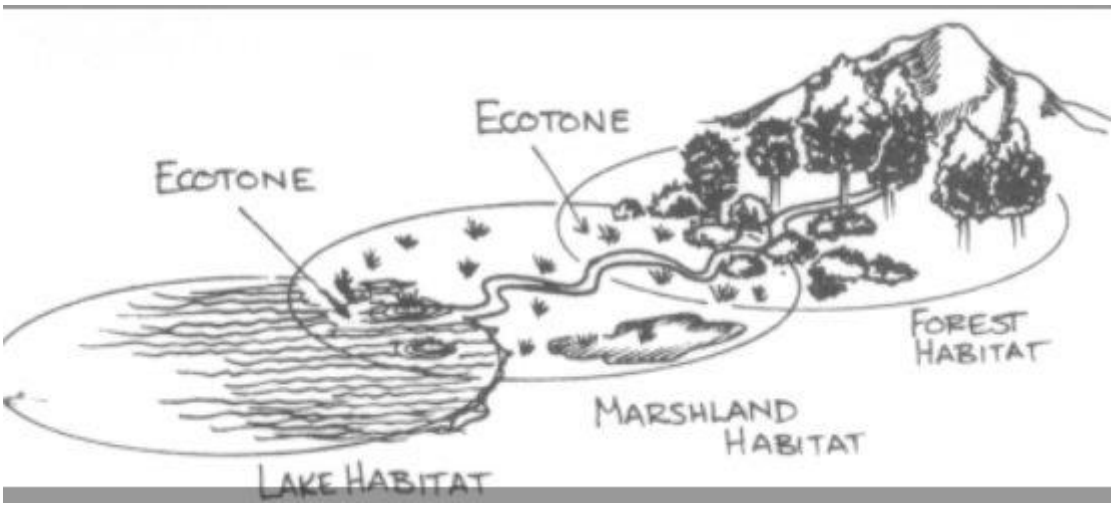
- The living organisms not only depend on the physical environment but also affect the conditions of the physical environment. For example, there is a change in the global climate as a result of human technology and land use patterns.

1.3 Ecotone

Ecosystems represent an assemblage of communities that exist at different successional stages. Along the edges of each of the patches are areas called ecotones.

Ecotone

Ecotone is a transitional area of convergence between two diverse ecosystems such as mangroves which represent a transitional zone or junction between terrestrial and marine ecosystems. Other examples of such ecotones include estuary which is a transitional zone between freshwater rivers and marine ecosystem, marshland between river and riverbank, grassland between forests at one end and deserts at the other, lagoons etc.



Characteristics of Ecotones

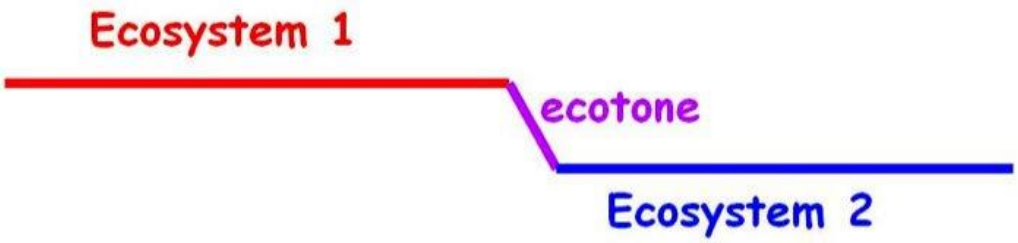
- Ecotones represent overlapping boundary regions or junctions where two major terrestrial or aquatic biomes meet.
- They may vary in sizes from being very narrow to quite wide.
- The transitional zones of ecotones are very clearly cut and marked by distinctiveness in the vegetation.
- Ecotones are found along an ecological gradient. The gradients are created as a result of spatial shifts in elevation, climate, soil, and many other environmental factors.
- Ecotones are very rich in biodiversity and are known for their species richness.

- They often contain species from each of the overlapping communities as well as some other species that have become adapted specifically for living in these zones and not found in any of the adjoining communities.
- In many cases, the number of species and the population density are greater within the ecotones than in the surrounding communities, a phenomenon known as the edge effect.
- Ecotones are usually very sensitive to climate change as well as human-induced changes.
- Such changes in ecotones can cause changes in biodiversity, functioning, structure and species composition of an ecosystem.
- Ecotones are a very important source of information and insights on the process of evolution.

Formation of Ecotones

An Ecotone can basically be formed in two ways

1. **Naturally** – naturally ecotones can be formed through abiotic factors such as changes in soil composition. Ecotones are very common on mountain ranges due to a wide variety of climatic conditions observed on the slopes of mountains.
2. **Human interaction** – ecotones can also be formed as a result of **human interaction**. For example, the transition between areas of forest and cleared land.



Importance of Ecotones

- The Ecotone has the characteristics of the two bordering ecosystem. As a result, it has a very high density of organisms and variety of species can be found in an ecotone.
- They act as a bridge for gene-flow from one community to other and provide habitat to a large number of species.
- Due to these characteristics, ecotones have a very rich and vibrant biodiversity. Therefore, ecotones are areas of a great environmental importance.
- An Ecotone can act as a “buffer-zone” protecting the neighbouring ecosystem from possible environmental damage. For example, Mangrove forests provide a natural buffer against Tsunamis and a wetland could absorb pollutants to prevent them from entering into an estuary.
- Ecotones are very ecologically sensitive areas. They are natural indicators of climate change and its consequences. Thereby, they have been a matter of greater scientific interests.

Edge Effect

- Ecotones are the transitional zone between two diverse ecosystems.
- Often, these transitional zones have increased variety and population of different plants and animal species. Some of the species in these zones are much greater than either of the bordering communities.
- This phenomenon or characteristic of ecotones is known as the “edge effect”.

- The edge effect is observed mainly due to the contrasting influences of the two bordering ecosystems

1.4 Ecological Niche

Certain environmental conditions are essential for a species to survive, function and reproduce. These environmental conditions include physical factors, chemical factors, biological factors etc. Ecological Niche includes the sum total of all the resources and physical conditions required by a species to maintain its existence and function is an ecosystem.

Ecological Niche

"Niche" is basically the ecological or functional role of a species in an ecosystem, especially with regards to food consumption. A niche can also be described as the interactions, a species has with its biotic and abiotic environment.

Components of Niche

- **Habitat** – Habitat refers to the place and the type of environment where an organism normally lives. A habitat supplies all the factors necessary for the existence of a species.
- **Food** – food niche includes the food resources that the species obtains from its environment.
- **Environmental condition** – Environmental conditions include physical and chemical factors such as temperature, soil, humidity etc.
- **Relationships** – that includes the interaction of the species with other organisms in the ecosystem which includes competition, predation etc.

Characteristics of Niche

- Niche refers to the way a species relates to or fits in with its environment.
- The niche may include descriptions of the organism's life history, habitat, and its place in the food chain.
- Niche also includes all the interaction of a species with other members of its community including predation, competition etc.
- Physical conditions in an area such as temperature, rainfall, soil, availability of food etc. influence and help mould Niche of an organism.

- As the physical and biological factors evolve in the community, “Niche” of a particular species also undergoes changes.
- Species commonly do not exploit their entire niche due to the presence of other species.
- The potential niche that would prevail in the absence of competition and other factors that might constrain its acquisition and use of the resources is called as **Fundamental Niche**
- As a result of competition for the resources from other members of the community, a species only occupies a part of its niche. The port that it utilizes is called their “**Realized Niche**”.
- Fundamental niche is always greater than the realized niche.
- Niche overlap occurs when two organisms use the same resources or other environmental variables.
- Every species has a unique niche. No two species can have exactly identical niches.
- If two species have identical niches, there will be competition for the available resources and the less well-adapted species will eventually be eliminated.

Importance of Niche

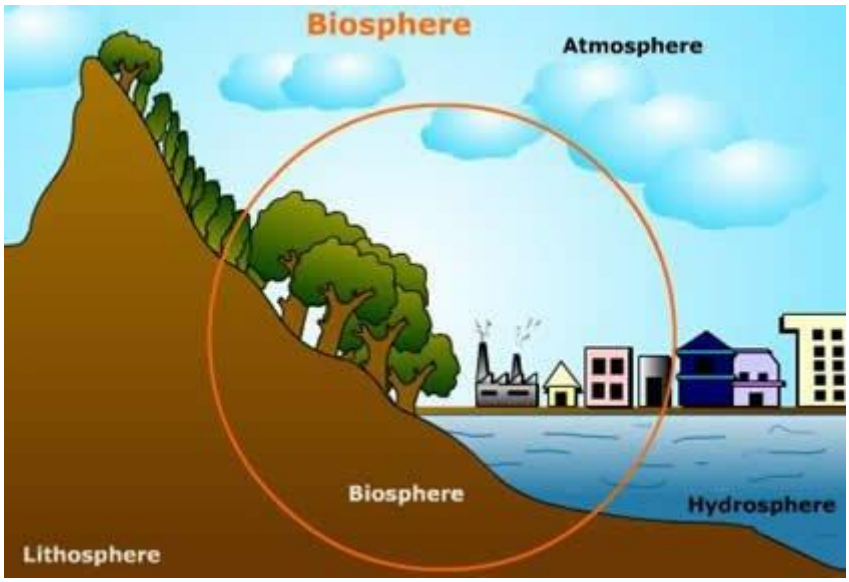
- The niche is often proclaimed as one of the most important concepts in community ecology.
- Niche can help in identifying patterns of species diversity and composition in an ecosystem.
- As niche provides valuable information about all the factors responsible for the existence of a species, it can play a vital role in the conservation of organisms.
- Due to unique niche possessed by different species, competition for resources can be avoided in a community.
- Niche helps maintain stable coexistence of different species in a community.

- Segregation of different species in a community according to their niches results in full exploitation of all available resources.
- Segregation of species into niches also helps maintain an orderly and efficient functioning of the ecosystem.

1.5 Biosphere

Biosphere

- The term biosphere is formed from Greek words bios (meaning life) and sphaira (meaning sphere).
- It is a relatively narrow layer around the surface of the earth where life can exist.
- It extends from few kilometres in the atmosphere to the depth of the oceans.
- It is also referred to as the "Zone of Life", comprising of the atmosphere (air), hydrosphere (water), and lithosphere (land).
- The vast network of all interconnected ecosystems constitutes the biosphere.
- The energy required to support life on earth comes from the sun in the form of solar energy which is captured by producers like green plants to produce food through photosynthesis.
- Water is another major factor in which all life forms depend.



Origin of Biosphere

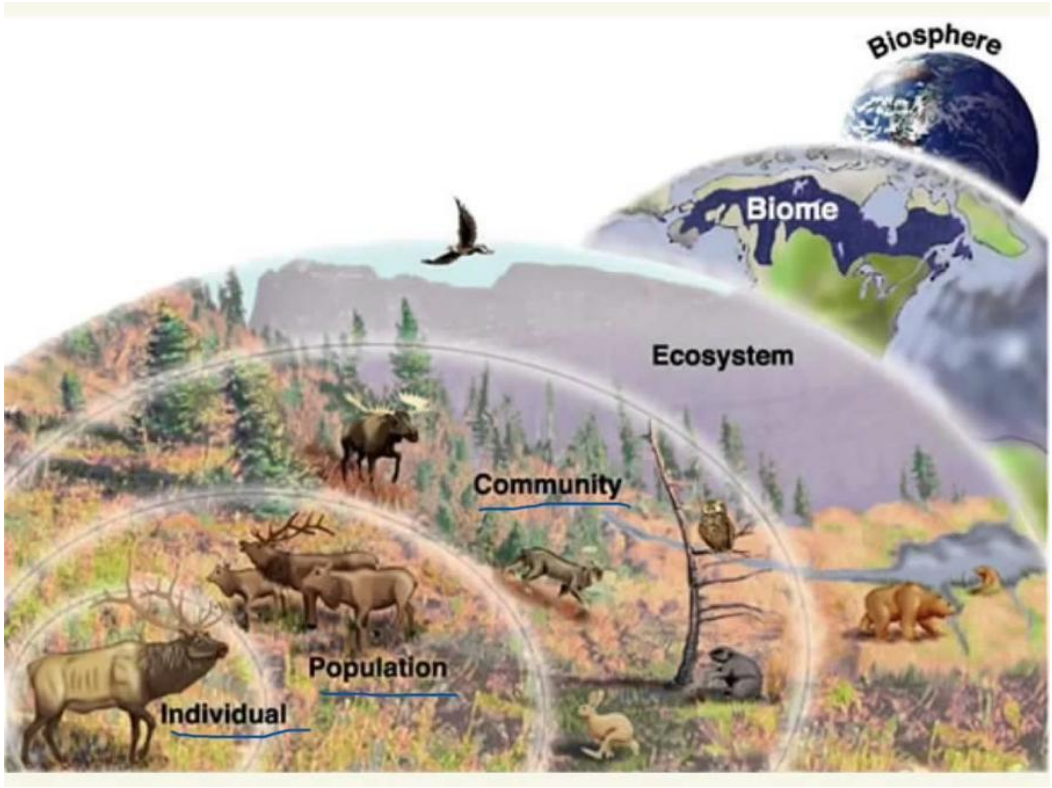
- The term "biosphere" was coined in 1875 by a geologist named ***Eduard Suess.***
- He defined biosphere as "the place on the earth where life dwells".

- The earliest evidence of life on the earth was found about 3.5 billion years ago.
- The earliest life forms on the earth included prokaryotes. They were single-celled organisms like bacteria which survived without oxygen.
- Some of these prokaryotes were able to use sunlight to make sugar and oxygen from water and carbon dioxide, a process which came to be known as photosynthesis.
- By the process of photosynthesis, these organisms were able to completely change the structure of the biosphere.
- Over a long time, the atmosphere of the earth developed oxygen and other gases that could support life.
- By this addition of oxygen to the biosphere, more complex life-forms were evolved which included millions of different plants (producers) and animals (consumers and decomposers) species.
- Thus the biosphere developed a food web which helps in sustaining life on the earth.
- The remains of dead plants and animals release nutrients into the soil and ocean. These nutrients are reabsorbed by growing plants.
- This exchange of energy and food makes the biosphere a self-regulating and self-supporting system.

Characteristics of Biosphere

- The biosphere is unique as so far, the existence of life has not been found elsewhere in the universe.
- The biosphere is characterized by continuous cycles of matter which is continuously recycled for life to continue on earth.
- Biosphere comprises both biotic (living) and abiotic (non-living) components which continuously interact with each other.
- The biosphere can be thought of as one large ecosystem—a complex community of living beings and nonliving things functioning as a single unit.
- More often, however, the biosphere is described as having many ecosystems.

- The biosphere measures about 20 kilometres from top to bottom, almost all life exists between about 500 meters below the ocean's surface to about 6 kilometres above sea level.
- Since life exists on the ground, in the air, and in the water, the biosphere overlaps all three spheres vis-à-vis lithosphere, atmosphere and hydrosphere.



Importance of Biosphere

- The biosphere has great importance for all the living beings as it is termed as the "zone of life" on the earth. It is basically the layer around the earth where life exists.
- It supports life on the earth by providing shelter and food etc. to all the living beings.
- It helps in preserving biodiversity on the planet earth.
- Biosphere allows the interaction between different life forms and the environment or between biotic and abiotic components.
- The biosphere is self-regulating. It plays an important role to maintain ecological balance on the earth.

- Water cycles and different nutrient cycles which takes place in the biosphere has vital importance to support life on the earth.
- Biosphere helps to maintain the nutritional balance of the earth through the process of decomposition.
- The food chain in the biosphere makes it possible for different animals and plants to coexist on the earth.

2- ECOSYSTEM

2.1 Energy Flow in an Ecosystem

Sun is the source of energy for almost all the activities on the earth. Of the incident solar radiation, that we receive on earth, less than 50 per cent of it is photosynthetically active radiation (PAR is the light in the 400-700 Nano-meter wavelength range which is available for photosynthesis) and Plants capture only 2-10 per cent of the PAR; this small amount of energy sustains the entire living world.

Energy is vital for the sustenance of life on earth as all the metabolic activity in plants and animals require energy. Plants and trees are autotrophic and so capable of converting the solar energy into a usable form of energy for their sustenance, but animals are not capable to convert solar energy into usable form and so animals depend on plants and other animals for their energy need. Thus the sustenance of life on earth is dependent on the flow of energy from autotrophs to consumers, and so the study of this energy flow in an ecosystem is vital to understand whether an ecosystem is sustainable or not.

Flow of Energy

- The energy flow in the ecosystem is unidirectional i.e. energy flows from producer to the top consumer.
- Either directly or indirectly all the organisms are dependent on the producer for their food.
- Trophic level interaction gives the idea of energy flow within an ecosystem.
- The energy trapped into an organism does not remain in it forever, it is either passed to the next trophic level (for example from Producer to the consumer) or when the organism dies, the death of the organism leads to the start of the detritus food chain/ web.

Trophic Levels

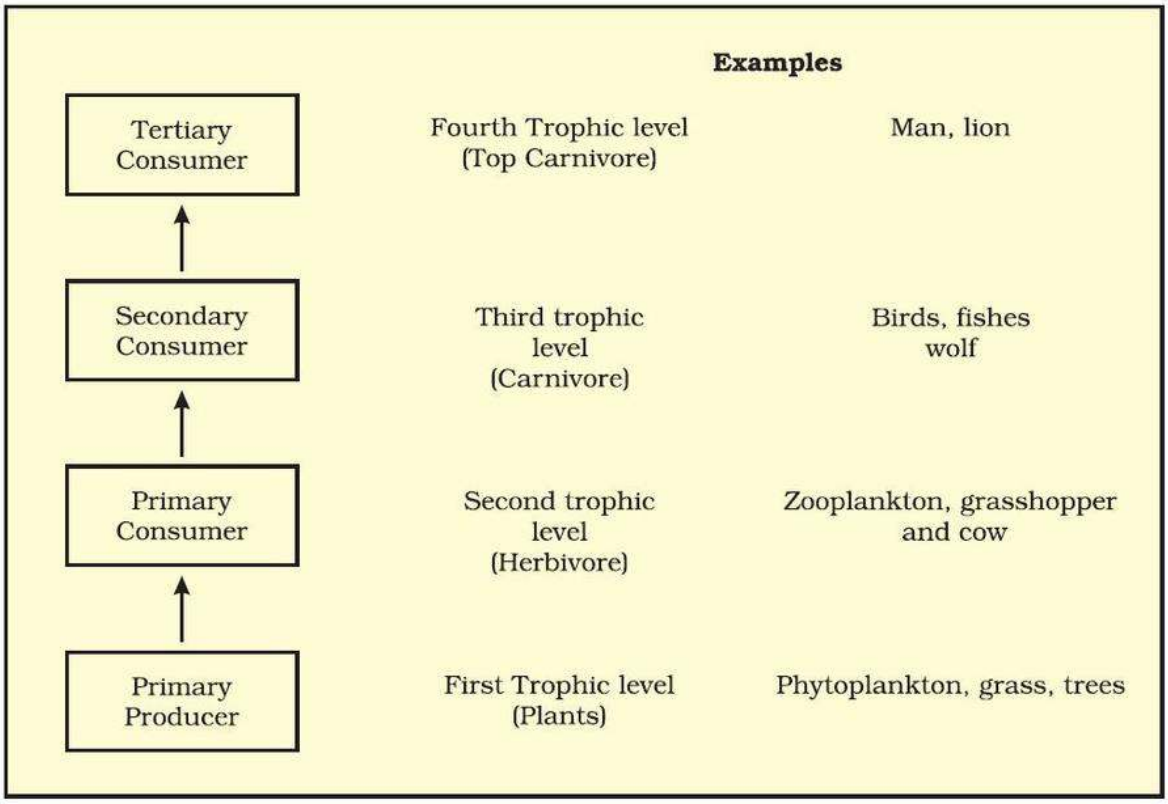


Figure- Diagrammatic representation of trophic levels in an ecosystem

Autotrophs

- They are also known as the producer since they can produce their own food through the process of photosynthesis. Plants fall under this category.
- Phytoplankton, Algae, Higher Plants are the primary producer in an aquatic ecosystem.

Primary Consumer

- They are also known as Herbivore and they feed on the primary producer.
- In terrestrial ecosystem Insects, Birds, Mammals are some common herbivores while in aquatic system Molluscs are more common as Herbivore.

Secondary Consumer

- Secondary Consumers are the organisms that eat Primary Consumers and they can either be Carnivore (meat eater) or Omnivores (eat both plant and animal matter), unlike Primary consumers which are only, Herbivore (eat plant only).

Tertiary Consumer

- They feed largely on Primary and Secondary consumers and are generally carnivores. Frog and Snake fall under this category.

Quaternary Consumer

- They feed on tertiary consumer and are considered as Top Carnivores. Hawk is considered among this category which feeds upon the snake i.e. tertiary consumer.

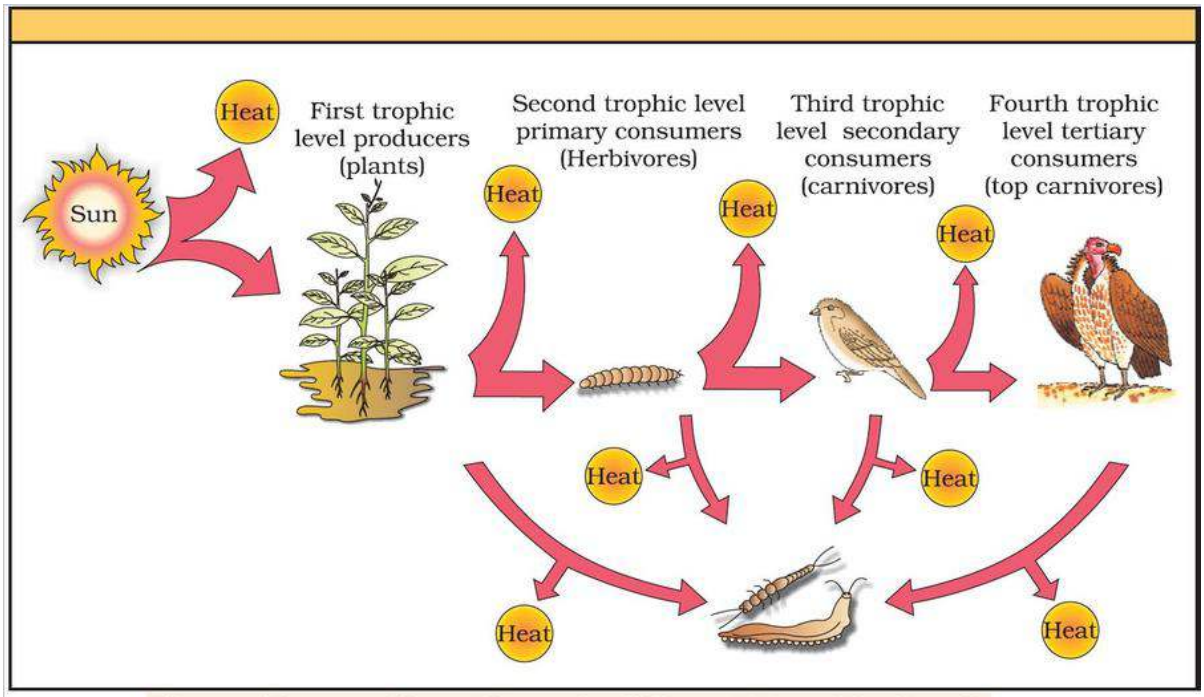


Figure-Energy flow through different trophic levels

Energy Flow via Trophic Level Interaction

- The energy flows from the lower trophic level (producer) to higher trophic level (herbivore, carnivore etc.) and it does not flow in the opposite direction i.e. from Carnivore to Producer etc.
- The trophic level interaction leads to the formation of Food Web, Food Chain and Ecological Pyramid.

Energy Flow and No. of Trophic Levels

At each trophic level there is a loss of energy in form of heat and as tiny as 10% of the total energy at any trophic level is moved to the next level. Due to this reason there exist limited no. of trophic levels generally, 4 or 5 and seldom 6 since the energy left to support the organism is very less.

Example– Suppose there is 1000 kilocalorie of energy present at the Grassland trophic level, only around 100-kilocalorie energy will be transferred to the next level i.e. Primary consumer and very little around 1 kilocalorie will reach till the tertiary consumer level.

2.2 Food Chain - Food Web And Ecological Pyramid

The trophic level interaction among the organisms leads to the formation of Food Web, Food Chain and Ecological Pyramid.

Food Chain

All the organisms are related to the sequence in which one feeds on another and the transfer of food energy takes place from the producer to the Consumers (Autotrophs to Carnivores or Omnivores etc.). This sequence is known as Food Chain.

Types of Food Chains

There are basically two types of food chains known in nature – Grazing and Detritus Food Chain.

Grazing Food Chain

- This food chain starts with the green plants (or primary producers) at the first trophic level and the green plants are utilised by the consumers as a part of their food.
- This food chain is usually large and it derives its energy from the sun.

An example of the simple food chain can be given as:

Grass->Insects->Frogs->Snake->Hawk

In the above food chain grass is the primary producer which is eaten by the insects who are the primary consumers. The frog is the secondary consumer as it feeds upon the insects and the Snake is the tertiary consumer since it feeds upon the frog. Hawk is the top carnivore and it eats the snake which is a tertiary consumer.

An example of the food chain in the aquatic ecosystem-

Phytoplankton (Primary producer)-> Zoo Plankton->Fishes->Pelicans

Detritus Food Chain

- In detritus food chain the primary source of energy is dead organic matter (called detritus) of decaying animal or plants. Primary consumers are detritivores which include Bacteria, Fungi, Protozoans and these detritivores feed upon the detritus. Detritivores are eaten by the secondary consumers like nematodes, insect larvae etc.
- In general, the Detritus food chains are shorter compared to the Grazing Food Chains.
- Detritus food chains are vital in the ecosystem since the detritivores act upon the dead organic matter of grazing food chain and help in recycling the elements in the ecosystem.

Example of the Detritus Food Chain

Litter->Earthworms->Chicken->Hawk

Food Web

Food chain as an isolated relationship represents only one part of the energy flow. This type of Individual relationship in forms of Food Chain seldom occurs in an ecosystem. Thus, in nature organisms are interconnected with each other via the multiple feeding relationships of nutrient and energy transfer, which is known as Food Web.

A food web demonstrates all the possible flow of energy as well as nutrients among the organism within an ecosystem, unlike a food chain which runs only single pathway.

Food web provides multiple alternatives for the food to organisms and if any of the intermediate food chains is removed the other succeeding links of the food chain will also get affected to a larger extent. Thus, multiple food chain which is directly related to biodiversity is also vital for the very existence of an ecosystem. Suppose any critical element like Vulture/ Hawk is eliminated from the food chain, in that case, it may affect the whole ecosystem.

Due to the variability of the taste, preferences, and various other climatic factors there exist the multiplicity and complexity within the food web. For Example, a

tiger which is not having deer as a food due to lack of deer in that region or other factors may resort to other alternatives thus giving origin to another food chain and in turn more complex Food Web.

Ecological Pyramid

An Ecological Pyramid is the graphical representation of trophic levels in terms of Biomass, Energy concentrated at a particular trophic level, Number of Organisms etc. When the organisms are plotted in terms of energy, Biomass, Number associated at trophic levels, they assume the shape of the Pyramid known as Ecological Pyramid.

They are also known as Eltonian Pyramid, named after the Charles Elton who developed the concept of Ecological Pyramid.

The horizontal bars in the pyramid signify the No. of Trophic Level and the Primary producer from the base of Pyramid while top carnivore forms the tip.

Types of Ecological Pyramid

- Pyramid of numbers
- Pyramid of Biomass
- Pyramid of Energy

Pyramid of Numbers

- Pyramid of the number shows the presence of total no. of organisms of different species at each Trophic level.
- This type of Pyramid shows a relationship between the number of Primary producers, primary consumer, secondary consumer, tertiary and Quaternary consumers etc.
- Depending upon the size and Biomass of the ecosystem the Pyramid of Number can be upright/partially upright or inverted.
- Since it is not possible all the time to count all the organisms, thus the pyramid of number does not define the trophic structure of an ecosystem. Along with it, this pyramid also does not take into account the variation in the size of organisms present in each trophic level.

Upright- Pyramid of Numbers (Grassland and Aquatic (Pond) Ecosystem)

- No of organism successively decrease as we progress from lower to higher trophic level (i.e. from producer to the consumers).
- In the grassland ecosystem grasses occupy the lowest trophic level, grasshoppers are the primary consumer which are less in numbers. Rats are the secondary consumer whose number is even lesser than the grasshopper and next higher trophic level is a tertiary consumer (snake) which feed upon rats. The next higher trophic level is occupied by Hawks in the grassland ecosystem which is even lesser in no. compared to snakes. Thus, with each successive level, the no. of the organisms is decreasing and making the shape of Pyramid upright.
- In the same manner in the Pond ecosystem, the number of the organism decreases with each successive trophic levels.
- The lowest trophic level is occupied by the snails-> next trophic level by the smaller fishes (Lesser in no compared to Snails) ->Bigger Fishes(Primary Carnivore)->Crane (Secondary Carnivore; lesser in number compared to bigger fishes).

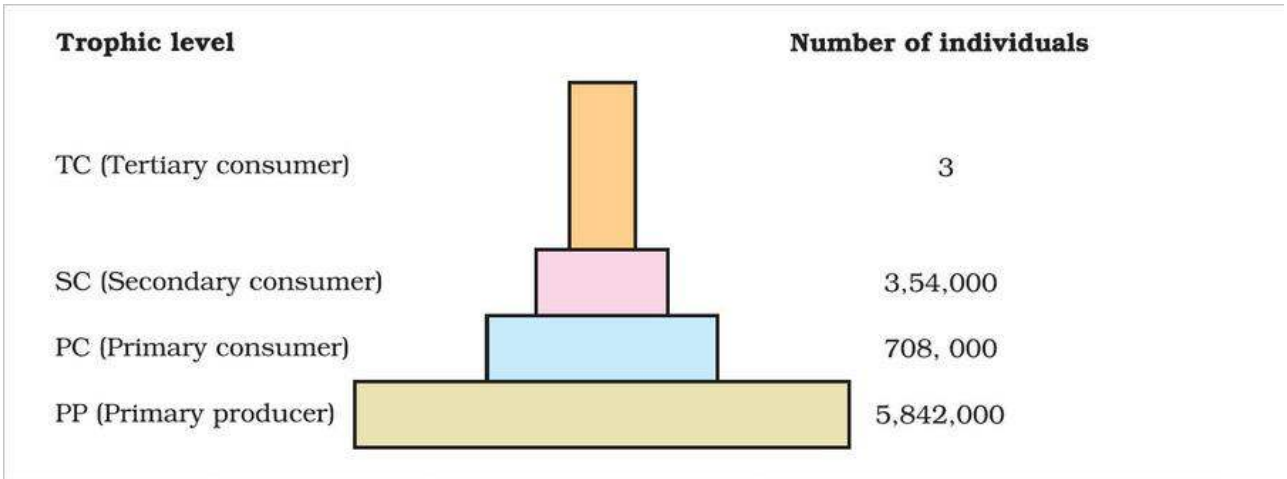


Figure-Pyramid of numbers in a grassland ecosystem. Only three top-carnivores are supported in an ecosystem based on production of nearly 6 millions plants

Partially Upright

The forest ecosystem is an example of Partially upright ecosystem since fewer producer (Tree- a single tree is capable of supporting a large no of Primary consumers) support more primary consumers but afterwards, the Pyramid

attains the normal shape since there are lesser secondary and tertiary consumers.

Inverted Pyramid of numbers

In the inverted pyramid of numbers, the organism who are dependent on lower trophic level grows closer towards the apex as in case of Parasitic Food Chain.

Example-In this food chain primary producer is a large tree which supports a large no. of parasites or hyper-parasites as primary and secondary consumers. Thus the resultant shape of the pyramid is inverted.

Pyramid of Biomass

- Pyramid of Biomass includes the total weight of the organic matter i.e. Biomass, at each trophic level.
- Because pyramid of number does not give any idea of weight since it does not take into account the varying shape and sizes of the organisms, so to fulfil the shortcoming of Pyramid of Numbers the Pyramid of Biomass has been introduced.
- Pyramid of Biomass measure the total biomass in grams per meter^2 or Calories per meter^2 and this also signifies the amount of matter lost between successive trophic levels.
- Pyramid of Biomass doesn't give any idea about the rate of ecological/ ecosystem productivity.

Upright Pyramid of Biomass

- In the upright pyramid, the total weight of the producer is larger than the total weight of the consumers.
- Example- In case of a forest ecosystem, the tree which is producer/autotroph is having larger biomass compared to primary or secondary consumer like Birds, insects etc. Thus, the attained shape is upright.

Inverted Pyramid of Biomass

- In case of the inverted pyramid, the total weight of the producer is smaller than the total weight of the primary or secondary consumers.

- Example- In case of an aquatic ecosystem, phytoplankton which supports smaller fishes have lesser biomass, while at the next trophic level the herbivore fishes have lesser biomass than the carnivore fishes. Thus, we attain an inverted shaped pyramid.

Pyramid of Energy

- In order to find an idea about the ecological productivity Charles Elton, developed a Pyramid of Energy.
- The pyramid of energy represents the total amount of energy present at each trophic level per unit area per unit time and energy is generally expressed in terms of Kcal/m^2/day or Kcal/m^2/year.
- The pyramid of energy is always upright since the total energy available for utilization for the successive trophic level is less than the energy available for the previous trophic level. Successive reduction in energy is due to the use of energy for activities like respiration or simply due to heat loss.
- The energy pyramid helps in the comparative study of productivities of a different ecosystem.
- Energy pyramid also helps to explain the concept of Biological magnification in which the toxic substances are deposited more at successively higher trophic level.

2.3 Bio-accumulation and Bio-magnification

Few toxic substances especially non- biodegradable (which cannot be metabolized by the living organism) ones, often present in the industrial waste have the ability to move through the various trophic level. Higher concentration of these elements in the food chain creates a lot of serious problems and may even cause life-threatening diseases like cancer. The process of movement of toxic elements is of two type– Bio-accumulation and Bio-magnification.

Bio-accumulation

- It is the process of increase in the concentration of toxic elements within the body of particular organism (i.e. it refers to how an element first made an entry into the food chain) and in general the concentration of such pollutants become higher in the body of the organism compared to the external environment like air, water etc.
- Moreover, this accumulation will grow until it leads the organism to a deadly situation.
- Example- The air pollution which is caused due to various factors including the vehicular emission, progresses to an accumulation of toxic elements like PM2.5 and PM10 inside an organism and can have dangerous impacts on humans as well as other organisms.

Bio-magnification

- Biomagnification is also known as bio amplification, in this the concentration of the toxicants increases at the successive trophic levels. It is due to the reason that toxic elements cannot be absorbed and simultaneously they get transferred to the successive higher trophic levels resulting in more concentration of toxicants at the higher trophic level.

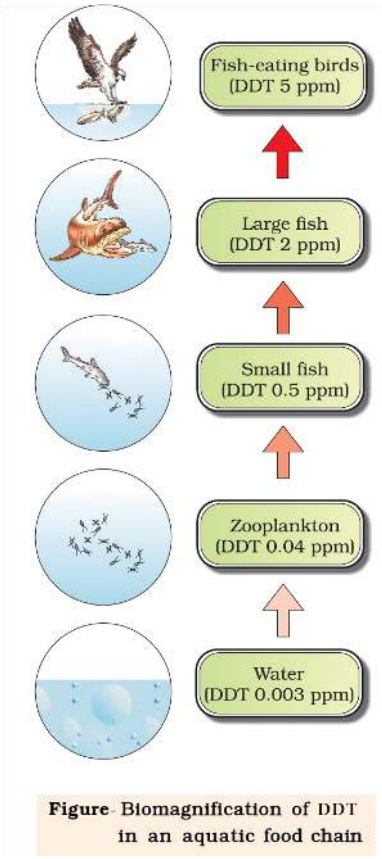


Figure Biomagnification of DDT in an aquatic food chain

- Biomagnification can be seen in the case of Mercury or DDT. The concentration of Mercury/DDT increases at the successive trophic levels. DDT concentration in zooplankton gets magnified when DDT contaminated water is consumed by the Zooplanktons. In the successive trophic levels like, small fish, big fish, and at top carnivore, the magnification is much higher, which proves the event of Biomagnification.
- A pollutant having properties like long life, mobile, soluble in fat, biologically active will lead to the process of biomagnification.
- Persistent Organic Pollutants (PoPs), dioxins, heavy metals all are agents of biomagnification since they persist in the environment and magnify in the food web.
- In the case of an Oil spill, the oil can get absorbed by the fatty tissues of the fishes and which accumulates there and later when they are consumed by the bigger fishes or successively by humans this will cause Bio-Magnification as the concentration of toxicant gets increased across the entire food chain.

2.4 Types of Biotic Interaction

All biotic components of the ecosystem are interlinked with each other and Biotic interaction between the organism is fundamental for survival and functioning of an ecosystem and it determines the sustainability of the ecosystem.

Types of Biotic interaction

Parasitism

- It is a type of interaction between two species which results in damage and harm to one member and benefit to another member.
- As in case of tick-host relationship, tick gains benefit by sucking blood while host is harmed as it loses blood.
- Ticks, lice and mites are external parasites while tapeworm, roundworm etc. are an example of internal parasites.
- The life cycle of a parasite is quite complex; they need hosts (most of the parasite make host weak and vulnerable to the predation) and vectors in order to complete their life cycle, as in case of a malarial parasite which requires a vector (mosquito) to spread to other hosts.

Commensalism

- In this type of relationship one species benefits without affecting the other.
- Barnacles growing on the back of the whale, Orchid growing as an epiphyte on some mango branch, cattle egret and grazing cattle in close association, Sea anemone and the Clown Fish are some of the classic examples of the Commensalism.

Mutualism

- In this type of relationship both the partners benefit from one another.
- When similar interaction occurs within a species, it is known as cooperation.

Examples-

- Rhizobium a bacterium which is found at the root nodules of a leguminous plant is a good example of the Mutualism. In this relationship, the plant supplies the water, mineral, food to the bacterium while Rhizobium fixes the atmospheric nitrogen which is used by the plant.
- Lichens a mutual relationship between algae and fungus. In this mutual cooperation, fungus gives protection and raw material for the preparation of the food while Green Algae synthesizes the food for both.
- Pollination is also an example of Mutualism, as the pollinator gets the nutrition/food (nectar, pollen) from the plant and plants gets its pollen transferred to other flowers for cross-fertilization thus helping the plant to reproduce similar kind of species.

Saprophytism

- In this kind of biotic interaction, certain organisms live on dead and decaying organic matter.
- Dung Beetles, Vultures, Fungi, Bacteria, Protozoa are the example of Saprophytism.

Predation

- In this type of Biological interaction, a predator feeds upon its prey and in this type of relationship, one species is benefitted while other is harmed.
- Although the predator may or may not kill its prey, the act of predation often results in the death of its prey and the tissues of the prey are eventually consumed by the predator.
- Example- An interaction between Lion and Deer results in predation.
- Sometimes a species can act as both as a prey and as a predator. Like in case of Snake, as it becomes prey to Hawk while acts as a predator with Frog.

Competition

- In this type of interaction both the species compete with each other for the resources like food, shelter, mating, and both the species get harmed out of the process of competition.
- Two species consuming the same kind of resources and due to limited availability of resources conflict arises between them (Remember competition in UPSC exam, can you explain how the people are getting harmed due to the competition in UPSC?). Competition may also occur between two different species like Trees, shrubs, herbs competing with each other for water, light etc.
- Competition leads to the elimination of the less fit or the weaker species from the ecosystem (Survival of the fittest by Darwin).

Amensalism

- In this relationship, one species is harmed while other is neither harmed nor benefitted and remains unaffected.
- When an organism excretes the chemicals as a part of the normal metabolism of its own, but which may severely impact other nearby species, this kind of relationship is seen.
- Example-A large tree inhibits the growth of small plants laying nearby due to its shades, while small plants have no effect on the large tree.

2.5 Bio-Geo-Chemical Cycle

The earth is a partially closed system, it receives external energy from the sun but the matter on the earth is almost constant.

Bio-Geo-Chemical Cycle

The nutrients are vital for the growth of organisms and sustenance of life in the biosphere is derived by the interaction of matter and energy. The organic and inorganic matters move reversibly in the atmosphere, hydrosphere, biosphere and Lithosphere through various cycles known as a Biogeochemical cycle.

Characteristics of the Biogeochemical Cycle

- As the necessary nutrients are provided by the soil and the roots of the phototrophic green plants play a major role in recycling of the nutrients these cycles are also known as Geochemical Cycle.
- Since the plant has a Major role to play in the cycling of nutrients these cycles are termed as a biogeochemical cycle.
- The elements which have been derived from the atmosphere and sediments are ultimately pooled into the soil.
- The processes like weathering and erosion of rocks are responsible for the pooling of nutrients into the soil in the sedimentary phase.

Nutrient Cycling as a part of Biogeochemical Cycle

- The regular exchange of the matter and nutrients between living and non-living world is known as Nutrient cycling.
- Nutrient Cycling is very important for the existence of life and ecology in any region.

The pattern of Biogeochemical cycle

As the nutrient passes through the various trophic levels, they get assimilated and these nutrients become the organic matter and get stored in the biotic reservoir. This organic element of plant and animal is generally released in the following ways to complete the cycle.

1. Decomposition of plants, litter etc. The dead organic matter is decomposed by the saprophytes and these materials after decomposition get converted into an inorganic material which ultimately joins the soil pool.

2. Due to the burning of vegetation, lightning etc. the portions of organic matter are released into the atmosphere, and due to the impact of precipitation, they get converted into the inorganic material and ultimately join the soil.

3. Waste Material excreted or released by the animals; decomposed by the microbes and which is converted into inorganic elements and which get their way in soluble form to soil storage.

Types of Biogeochemical Cycle

Gaseous Cycle

- In this type of cycle, the reservoir is either atmosphere or hydrosphere and it includes Water, Carbon, Nitrogen Cycle etc.

Sedimentary Cycle

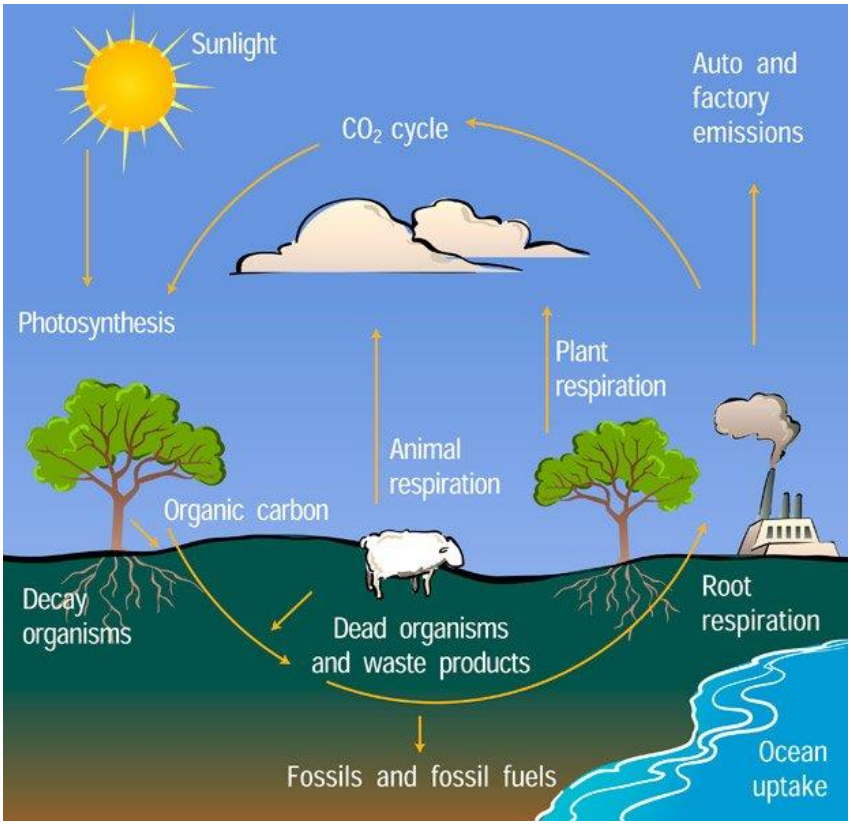
- In this type of cycle, the reservoir is the earth crust and it includes Potassium, Calcium, Magnesium, Phosphorus, Sulphur Cycle etc.

2.6 Gaseous Cycle

Major Gaseous cycles

1. Carbon cycle
2. Nitrogen cycle
3. Hydrological cycle (Water cycle)

Carbon Cycle



A typical Carbon Cycle

The major source of carbon are:

- Bio-molecules in organic form
- Carbon oxides in the atmosphere
- The organic form of carbon in soil.
- Fossil fuels and sedimentary rocks

- Dissolved compounds in oceans

Atmospheric carbon in the form of carbon dioxide is the critical source of carbon in an ecosystem. The Ecosystems gain most of the carbon from the atmosphere by the process of photosynthesis. In the process of photosynthesis carbon dioxide from the atmosphere, together with solar energy and water is converted into food and carbon gets trapped in the biomolecules.

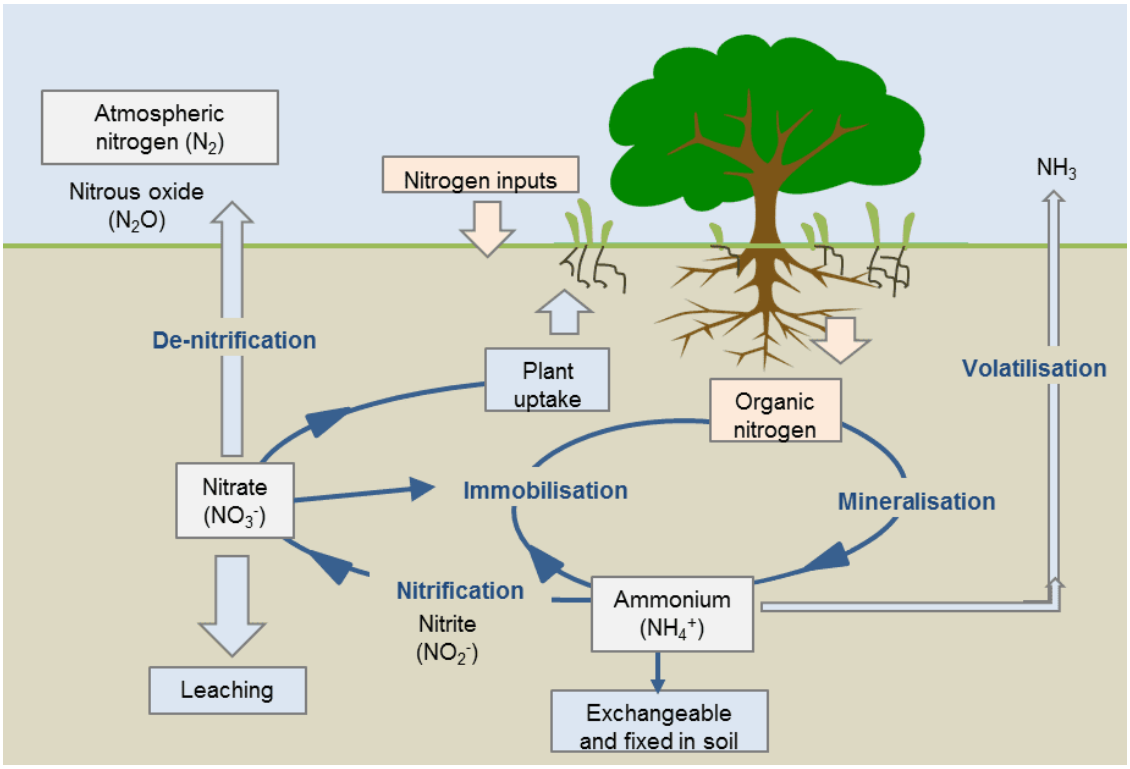
The carbon trapped in the food is used by the living organisms to fulfill their energy and nutrient requirements. After fulfilling their requirement the excess carbon is released by organisms either in gaseous form as a byproduct of the process of respiration or is organic form through excretion.

The gaseous form directly combines to the nutrient pool, i.e. the atmosphere but the organic form undergoes further decomposition to convert the organic form of carbon into either gaseous carbon oxides or in inorganic form to become the part of the carbon cycle.

Atmospheric carbon can directly dissolve in the ocean water through the process of diffusion and can remain dissolved in oceans. The Carbon dioxide dissolved in oceans may convert in inorganic compounds such as carbonate salts or may be used by living organisms in their biochemical cycle. When such organisms die, their shells and body parts sink to the ocean floor where they accumulate as carbonate-rich deposits. It is to be noted that ocean deposits are by far the biggest sink of carbon on the planet.

The lithosphere is again a major sink of carbon. The carbon in organic and inorganic forms gets deposited in the lithosphere and remains inside the earth crust trapped for millions of years. These carbon are trapped in the form of fossil fuels and also sedimentary rocks such as limestone, dolomite etc. The trapped becomes the part of the carbon cycle when the fossil fuel is used by humans to fulfil their energy needs or when the rocks undergo melting due to tecto-volcanic activities.

Nitrogen Cycle



A typical Nitrogen Cycle

Nitrogen is an essential constituent of protein and is a basic block of all living tissue. It constitutes nearly 16% by weight of all proteins. Almost 2/3 rd of the atmosphere is composed of Nitrogen so the availability of Nitrogen is inexhaustible but the elemental Nitrogen is useless for living organism. The elemental nitrogen is needed to be converted into organic compounds which can be absorbed by the living organisms.

Nitrogen fixation on earth is accomplished in three different ways:

- By microorganisms- bacteria and blue-green algae.
- By man using industrial processes- e.g., fertilizer factories.
- To a limited extent by atmospheric phenomena such as thunder and lighting.

Certain microorganisms are capable of fixing atmospheric nitrogen into ammonium ions. These include free-living nitrifying bacteria, specialized-Azotobacter and anaerobic Clostridium and symbiotic nitrifying bacteria living in association with leguminous plants and symbiotic bacteria living in non-

leguminous root nodule plants, eg-Rhizobium as well as blue-green algae, e.g., Anabaena, Spirulina, etc.

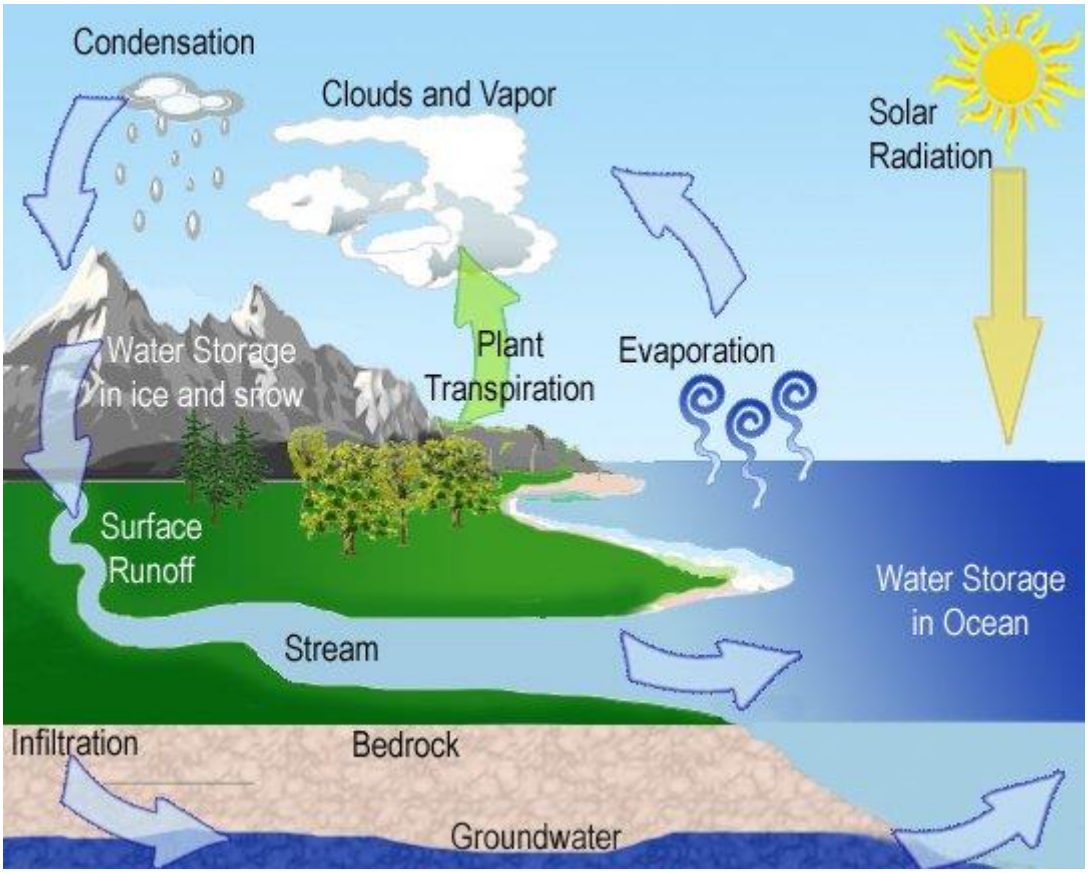
Ammonium ions can directly be taken up as a source of nitrogen by some plants, or are oxidized to nitrates or nitrites by two groups of specialised bacteria: Nitrosomonas bacteria promote the transformation of ammonia into nitrite. Nitrite is then further transformed into nitrate by the bacteria Nitrobacter.

The nitrates converted by bacteria is assimilated by plants to form amino acids. The amino acids are transferred into the food chain and reach to the highest trophic level of an ecosystem. This amino acid is the source of nitrogen for other living organisms. The nitrogen trapped in living organisms is released when they excrete or when detritus bacteria decompose the living organisms, thus completing the cycle.

The certain quantity of soil nitrates, being highly soluble in water, is lost to the system by being transported away by surface runoff or groundwater. In the soil as well as oceans there are special denitrifying bacteria, eg-Pseudomonas, which convert the nitrates/nitrites to elemental nitrogen. This nitrogen escapes into the atmosphere, thus completing the cycle.

The periodic thunderstorms convert the gaseous nitrogen in the atmosphere to ammonia and nitrates which eventually reach the earth's surface through precipitation and then into the soil to be utilised by plants.

Hydrological Cycle(Water Cycle)



A typical Water Cycle

The hydrological cycle is a theoretical model that describes the exchange of water among the atmosphere, lithosphere, biosphere, and hydrosphere. All these also act as a reservoir of water. The various process such as evaporation, condensation, diffusion etc. help in the exchange of water among the atmosphere, lithosphere, biosphere, and hydrosphere.

The driving forces for water cycle are- solar radiation, gravity. Evaporation and precipitation are 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 sun's heat energy. Plants also transpire huge amounts of water. Water remains in the vapour state in air and form clouds which drift with the wind. Clouds meet with cold air in the mountainous regions above the forests and condense to form rain precipitate which comes down to gravity.

The ocean supply most of the evaporated water found in the atmosphere. On an average 84% of the water is lost from 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%.

2.7 Sedimentary Cycle

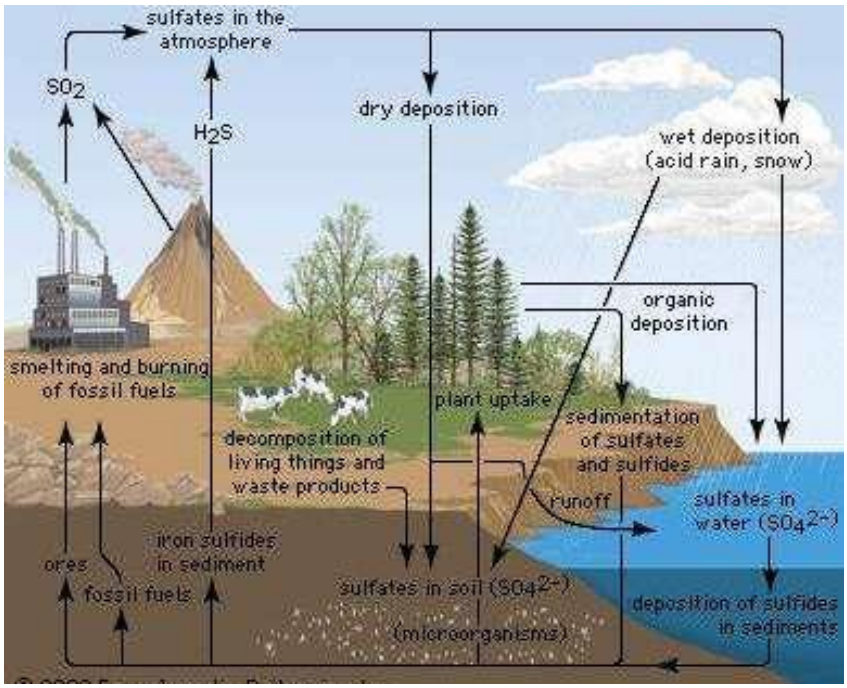
Sedimentary Cycle

Sedimentary cycles are the ones in which the reservoir is the Earth's crust. Sedimentary cycles include those of phosphorus, sulphur, iron, calcium, and other more-earthbound elements.

In this article, we will discuss two major sedimentary cycles-

1. Sulphur cycle
2. Phosphorus cycle

1. Sulphur Cycle



A typical Sulphur cycle

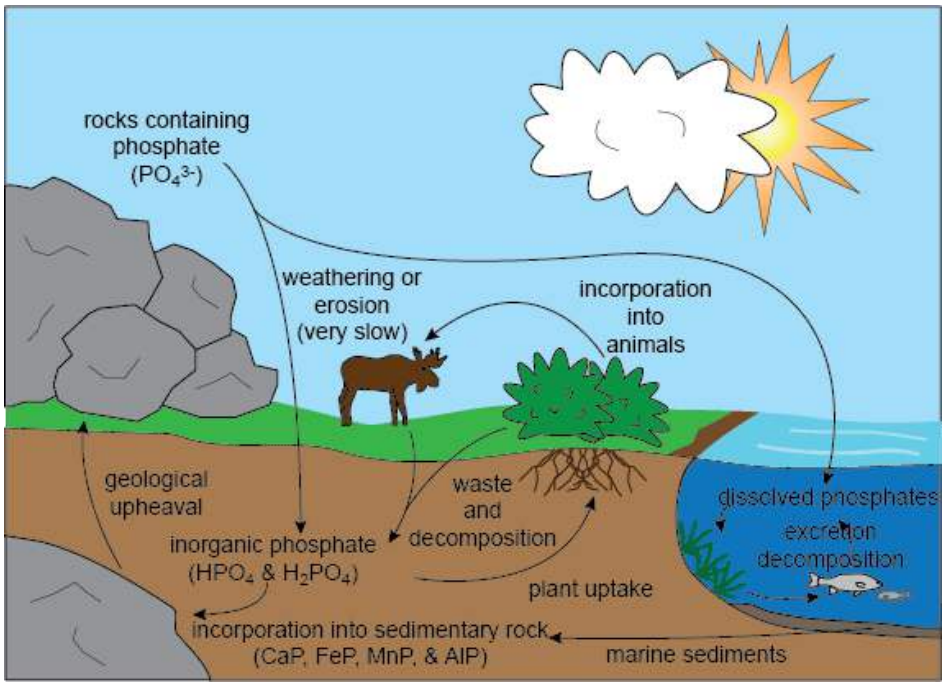
Sulphur is one of the components that make up proteins and vitamins. Proteins consist of amino acids that contain sulphur atoms. Plants absorb sulphur when it is dissolved in water. Animals consume these plants, so that they take up enough sulphur to maintain their health. The sulphur reservoir is in the soil and sediments where it is locked in organic (coal, oil and peat) and inorganic deposits (pyrite rock and sulphur rock) in the form of sulphates, sulphides and organic sulphur. It is released by weathering of rocks, erosional runoff and

decomposition of organic matter and is carried to terrestrial and aquatic ecosystems in salt solution.

Sulphur can also be found in the atmosphere. It enters the atmosphere through both natural and human sources. Natural resources can be for instance- combustion of fossil fuels (coal, diesel etc.), volcanic eruptions, bacterial processes, evaporation from water, or decaying organisms. When sulphur enters the atmosphere through human activity, this is mainly a consequence of industrial processes where sulphur dioxide, SO2 and Hydrogen Sulphide, H2S gases are emitted on a wide scale.

When Sulphur Dioxide enters the atmosphere it will react with oxygen to produce sulphur trioxide gas, S03 or with other chemicals in the atmosphere, to produce sulphur salts. Sulphur dioxide may also react with water to produce sulphuric acid, H2SO4. All these particle will settle back onto earth, or react with rain and fall back into earth as acid deposition. The particle will then be absorbed by plants again and are released back into the atmosphere, so that sulphur cycle will start over again. And the sulphur bound in living organism is carried back to the soil, to the bottom of ponds and lakes and seas through excretion and decomposition of dead organic material.

2. Phosphorus Cycle



A typical Phosphorus cycle

The phosphorus cycle is the nutrient cycle which characterises the transport and chemical transformation of phosphorus through the lithosphere, hydrosphere and biosphere. Unlike many other biogeochemical cycles, the atmosphere does not play a significant role in the movement of phosphorus, since phosphorus and phosphorus-based compounds are typically solids at the normal ranges of temperature and pressure found on Earth. Therefore, most of the phosphorus remains within rock, sediments, sand, and the ocean floor, with a fraction in living biomass. Phosphorus plays a central role in aquatic ecosystems and water quality. Unlike carbon and nitrogen, which come primarily from the atmosphere, phosphorus occurs in large amounts as a mineral in phosphate rocks and enters the cycle from erosion and mining activities. This is the nutrient considered to be the main cause of excessive growth of rooted and free-floating microscopic plants (phytoplankton) in lakes [Eutrophication]. The main storage for phosphorus is in the earth's crust. On land phosphorus is usually found in the form of phosphates. Phosphorus moves among trophic levels in an ecosystem by plant growth, herbivores and carnivores.

2.8 Ecological Succession

Ecological Succession

Ecological Succession is the gradual process by which ecosystems change and develop over time. Nothing remains the same and habitats are constantly changing.

It is the observed process of change in the species structure of an ecological community over time. Within any community some species may become less abundant over some time interval, or they may even vanish from the ecosystem altogether. Similarly, over some time interval, other species within the community may become more abundant, or new species may even invade into the community from adjacent ecosystems.

This observed change over time in 'what is living' in a particular ecosystem is Ecological Succession.

Ecological Succession may also occur when the conditions of an environment suddenly and drastically change. A forest fires, wind storms, and human activities like agriculture all greatly alter the conditions of an environment. These massive forces may also destroy species and thus alter the dynamics of the ecological community triggering a scramble for dominance among the species still present. The rise and fall of numerous species within our various communities illustrate two types of motive forces of succession: the impact of an established species to change a site's environmental conditions, and the impact of large external forces to suddenly alter the environmental nature of a site.

The "engine" of succession, the cause of ecosystem change, is the impact of established species on their own environments. The original environment may have been optimal for the first species of plant or animal, but the newly altered environment is often optimal for some other species of plant or animal. Under the changed conditions of the environment, the previously dominant species may fail and another species may become ascendant.

Stages of Ecological Succession

Ecological Succession proceeds through various stages, starting from Pioneer Community to Climax stage. Each such stage is called sere or seral community.

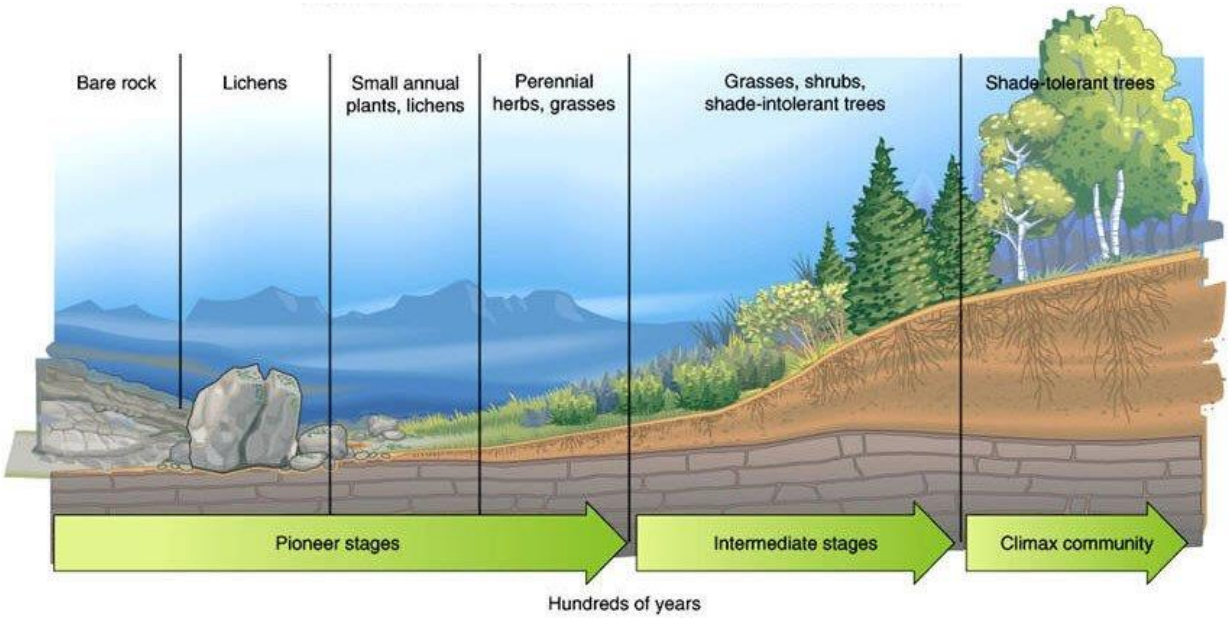
As seral community is an intermediate stage found in ecological succession in an ecosystem advancing towards its climax community. In many cases, more than one seral stage evolves until climax conditions are attained. A pri-sere is a collection of seres making up the development of an area from non vegetated surfaces to a climax community. A seral community is the name given to each group of plants within the succession.

Ecological succession breaks down into three fundamental phases: Primary Succession, Secondary Succession and a Climax Community.

Primary Succession

It occurs when organisms colonise an area devoid of life, usually after a catastrophic natural event that leaves the land barren. Often the first organisms to take hold are algae, fungi and simple plants such as lichens and mosses. Over time a thin layer of soil builds up so that more advanced plants, such as grasses and ferns, can take root. Along with the successful colonisation of plants come animals, insects, birds and small invertebrates.

One example of primary succession is the pioneer communities that begin to inhabit a newly created lava bed, where life cannot exist until the rock surface cools to a moderate temperature.



Primary Succession

Pioneer Community

It is a group of organisms that invade a new area in the process of Ecological Succession. These organisms are typically plants, animals and fungi. They are the first to move into a new habitat and often make the habitat more hospitable for future inhabitants. The pioneers through their death and decay leave patches of organic matter in which small animals can live. Organic debris accumulates in pockets and crevices, providing soil in which seeds can become lodged and grow. As the community of organisms continues to develop, it becomes more diverse and competition increases, but at the same time new niche opportunities develop. The pioneer species disappear as the habitat conditions change and invasion of new species progresses, leading to the replacement of the preceding community.

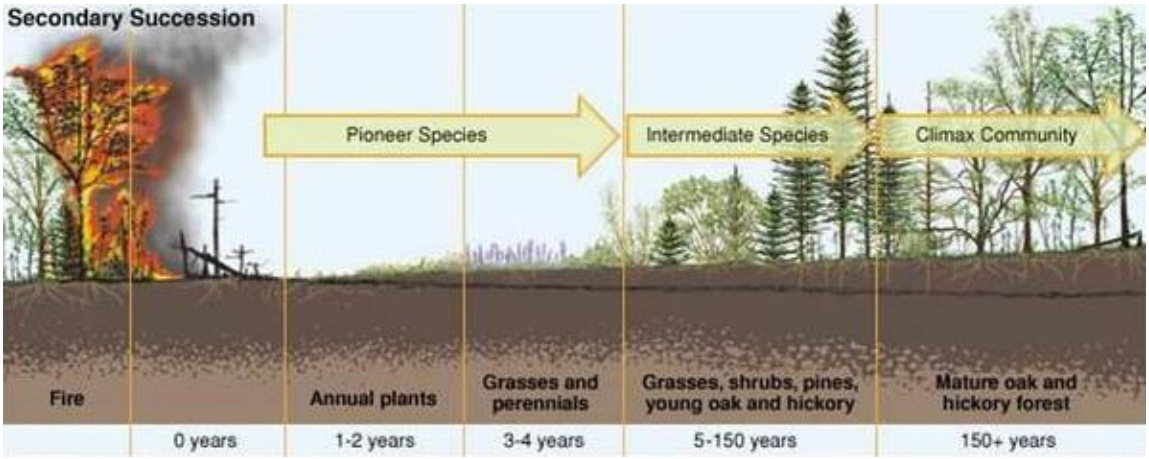
Climax community

The culminating stage in the succession is the establishment of a stable community in the area, which is known as the climax community. That is, the final stage of ecological succession is the formation of the climax community. Climax communities are relatively stable and can vary widely in a given region. Some of the features of the climax community are: the vegetation of this region is tolerant to the environmental conditions. The species diversity is large and the food chains of these species are complex and with spatial structure. It is a balanced ecosystem. There is also equilibrium between the nutrients taken in from the soil and the return of the nutrients to the soil by litter fall. The individual organisms in the climax ecosystem are replaced by other organisms of the same kind. Thus it maintains species equilibrium.

Secondary Succession

Secondary Succession happens when an established community is replaced by a different set of plants and animals. Most ecological changes occur as secondary succession. In fact, most biological communities are in a continual state of secondary succession. Secondary succession is gradual, always moving toward the climax community. It occurs when an area that has previously had an ecological community community is so disturbed or changed that the original community was destroyed and a new community moves in.

Such successions are comparatively more rapid. This is more common than primary succession, and is often the result of natural disasters such as fires, floods, and winds, as well as human interface such as logging and clear-cutting. It starts from previously built-up substrata with already existing living matter. This type of succession starts in a given area where the conditions for life are favourable because of the fact that the area was occupied earlier by well-developed community. For example- succession in an abandoned crop field.



Secondary Succession

Other prominent types of Ecological Succession:

Autotrophic Succession

Autotrophic Succession is characterised by early and continued dominance of autotrophic organisms like green plants. It begins in a predominantly inorganic environment and the energy flow is maintained indefinitely.

Allogenic Succession

In Allogenic Succession, the replacement of the existing community is caused largely by any other external condition and not by the existing organisms.

Autogenic Succession

Autogenic Succession refers to that type when the community itself, as a result of its reactions with the environment, modifies its own environment and thus causing its own replacement by new communities.

3- TERRESTRIAL ECOSYSTEM

3.1 Tundra Ecosystem

The word tundra refers to a “barren land” where the environmental conditions are so severe that life cannot sustain. Tundra can be of two types – Alpine tundra and Arctic tundra.

Tundra Ecosystem

Alpine Tundra

It is found to occur on the high mountain ranges of the world, on the peaks of the mountains at altitudes above the tree line. At such altitudes, there exists a permanent snow cover throughout the year. Alpine tundra is different from Arctic tundra. The former shows diurnal variations in temperature because the mountain ranges can be found at all latitudes, unlike the latter which is only found in polar latitudes. All the major mountain ranges of the world such as the Himalayas, the Alps, the Rockies, the Andes etc., have the alpine tundra.

Arctic tundra

It occurs as a continuous belt south of the polar ice caps and north of the tree line in the northern hemisphere. It is found in Russia (in Siberia), Canada, USA (in Alaska) and in a few islands of the Arctic Ocean. In the southern hemisphere, tundra is mostly absent. It is found only in a few areas of South America close to the south pole. This is because there is little landmass in the southern hemisphere close to polar latitudes and most of the area is covered by the Southern Ocean. Since it is found in polar latitudes, the diurnal variations in temperature are very low.

Characteristics of Arctic Tundra

- The region has a very low mean annual temperature. In winters, the temperatures drop to as low as 50 degrees Celsius below the freezing point, especially in the Arctic tundra of the continental interiors such as Siberia.
- Most of the precipitation occurs during winters in the form of snow and sleet. Extreme snow storms, also known as blizzards, can occur during winters which lead to heavy snowfall.

- Since the ground (soil) remains frozen for most of the time in a year, trees cannot grow in this region. The only vegetation that is found here includes mosses, lichens, cotton grass, dwarf heath, sedges, willows, and birches.
- Hardy grasses and reindeer moss are found to occur close to coastal lowlands which are the only pastures which support the population of reindeers in the Arctic tundra.
- The brief summer period in Arctic tundra supports the growth of berry-bearing bushes and flowers. Several insects are found to survive on these flowers and berries. These insects have a very short lifespan, coinciding with thaw season. Birds are attracted to the north in summers because of this insect population.
- The prominent wildlife which is found in the Arctic tundra includes the polar bear, arctic willow, musk ox, arctic hare, arctic fox, reindeer, wolf, lemming etc. The animals found in this region have a long lifespan. E.g., Arctic Willow, also known as Salix Arctica, can survive for 150 to 300 years.
- These animals have a thick cuticle and epidermal hair which protects them from the chilly weather of the region. Mammals which are found in this region have a large body size and small tail and ear in order to prevent the loss of heat from their bodies. Most of the animals have fur-covered bodies which act as an insulator.

3.2 Forest Ecosystem

The forest ecosystem is a complex assemblage of different types of biotic communities. Forest communities are formed in the presence of optimum conditions of temperature and soil moisture. The vegetation of the forest is determined by the nature of the soil, local topography, and climate. These factors affect the distribution of trees and their abundance.

Forest Ecosystem

The forest ecosystems are classified into three major types viz., tropical forest, temperate forest, and coniferous forest. These forests are distributed around the earth generally on a gradient, from latitudes north to south, or from low altitudes to high altitudes. Forests can also be evergreen and deciduous based on the season in which the trees shed their leaves. On the basis of types of leaves, they can be distinguished into broad-leafed or needle-leafed forests.

Tropical Rain Forests

- These are found close to the equator where the temperature and humidity remain high throughout the year.
- They are found in areas where the annual rainfall exceeds 200 cm and is distributed throughout the year.
- Tropical rainforests are among the richest ecosystems in terms of biodiversity. They have very high floral and faunal diversity
- An important feature of the flora here is that it is vertically stratified. The forests have very tall trees with a dense canopy at the top. The trees are often covered with vines, creepers, lianas, epiphytic orchids, and bromeliads. The layer below it consists of shrub variety trees like ferns and palm.
- The soils in tropical rainforests are known as red latosols or lateritic soils. They are very thick. They have undergone high rates of leaching which makes them unsuited for agriculture. However, if left undisturbed without high precipitation, they experience fast recycling of nutrients from the decomposing litter and can regain their lost nutrient value.

- These forests do not have a dense undergrowth due to lack of adequate sunlight at the bottom. The dense canopy of these forests blocks most of the sunlight from reaching the bottom layer.

Subtropical Rain Forests

- These are broad-leaf evergreen forests found in the regions of high rainfall with a low annual range of temperatures.
- The biodiversity in these forests is similar to that found in the tropical rainforests. Epiphytes are common here.

Tropical Seasonal Forests

- Also known as the monsoon forests, they are found in regions where the annual rainfall is high but is concentrated in a few months of the year and there are distinct wet and dry seasons.
- These forests are found in India, South-east Asia, northern Australia, central and South America, western Africa, and the tropical islands of the western Pacific.

Temperate Rain Forests

- These are found in temperate latitudes which exhibit a marked seasonality with respect to rainfall and temperature.
- These forests experience dense fog and high rainfall. Fog is considered to be a more important water source than rainfall.
- Biodiversity of these forests is higher than other temperate forests but not as high as tropical rainforests.

Temperate Evergreen Forests

- These forests are found in regions with a Mediterranean type of climate. The summers are warm and dry, and the winters are cool and moist.
- The region supports the growth of short, broad-leaved evergreen trees.

- Dry summers make this region prone to forest fires. However, the plants here have adapted themselves to forest fires which enables them to regenerate quickly even after getting burnt.

Temperate Deciduous Forests

- These are found in regions with a moderate climate. The trees are broad-leaved which shed their leaves in autumn in order to save water during the dry season by reducing transpiration losses. The forest appears bare in winters but new foliage starts to appear in the spring.
- The rainfall is uniformly distributed throughout the year.
- These forests contain podzolic soils and are sufficiently deep.

Coniferous Forests

- These are also known as boreal forests.
- These are found in regions with long and cold winters and short and cool summers. They are found in the northern latitudes close to the Arctic circle.
- The trees are of evergreen variety with prominent plant species such as pine, spruce, fir etc.
- They harbour unique faunal species such as red fox, lynx, arctic wolf, squirrel, amphibians such as Hyla, Rana (both are frogs) etc.
- The soils of coniferous forests are thin podzols which are rather poor in nutrient content. This is because the weathering of rocks and the decomposition of ground litter proceeds slowly in the cold climate. Microbial activity on the dead organic matter is slow under cold conditions.
- The soils are also acidic in nature. This is because of the movement of water through the soil in large quantities without any significant counter-movement upwards due to slow evaporation. Essential soluble nutrients such as calcium, nitrogen, potassium are leached from the soil even beyond the reach of the roots. Since there are no alkaline cations which can neutralize the accumulating organic acids from the litter, the soils become acidic. They are also mineral deficient.

- The productivity of a coniferous forest is much less than a tropical or a temperate forest due to insufficient solar radiation. These forests have a low level of community stability as against other forest types due to lower biodiversity.

3.3 Grassland Ecosystem

Grassland ecosystem is found to occur in regions where the annual rainfall ranges between 25-75 cm which is more than the precipitation in a desert but not enough to support the growth of a forest.

Grassland Ecosystem

Grasslands are typically a vegetative formation which is found in temperate climates. In India, the grasslands are a mix of tropical savanna and temperate steppe variety. In the high altitudes of the Himalayas, temperate grasslands are found.

In India, steppe formations are found to occur in western Rajasthan where the climate is semi-arid with a dry season of 10-11 months, and the average annual rainfall is less than 20 cm. They occupy large areas of sandy and saline soil. The soil here is always exposed, sometimes rocky but often sandy with fixed or mobile sand-dunes. Forage is found only during the brief wet season. The layer of grass is sparse and mainly consists of annual grass species.

In eastern and central parts of Rajasthan, dry savanna type of grasslands has developed. The region experiences an annual rainfall of around 500mm with a dry season of 6 to 8 months. The rainfall supports the growth of a sparse population of trees like Khetri (Prosopis Cineraria) whose light shade favours the growth of the grasses.

A major difference between savannas and steppes is that savanna forage is largely from grasses that not only grow during the wet season but also from the small amount of regrowth in the dry season whereas in the steppes all the forage is provided only during the brief wet season.

Types of Grasslands

Four major types of grasslands found to occur in different regions of the Indian subcontinent based on climatic conditions.

Semi-Arid Zone

- The grassland here is of the Sehima-dichanthium type.

- It is found in the northern portion of Gujarat, Rajasthan (excluding Aravalis), western Uttar Pradesh, Delhi, and Punjab.
- The region's topography consists of hills spurs and sand dunes.
- The vegetative species found here include Calotropis gigantic, Cassia auriculata, Prosopis cineraria, Salvadora oloides and zizyphus Nummularia which make the grassland look like a scrub.

Dry sub-Humid Zone

- This climatic zone covers the whole of peninsular India, except the Nilgiris.
- The grassland found here is of the Dichanthium cenchrus-lasitrrus type which covers the maximum area among all the grassland types found in India.
- The vegetative species here include thorny bushes such as Acacia catechu, Mimosa Zizyphus (ber) and sometimes fleshy Euphorbia, along with short tree varieties such as Anogeissus latifola, Soymida febrifuga and other deciduous species
- Dichanthium grass is found on level soils and covers up to 80 percent of the ground. Sehima grass is found on the gravel and coverage is around 27 percent.

Moist sub-Humid Zone

- This climatic zone covers the alluvial plains of Ganga in northern India.
- The grassland found here is of the Phragmities-sacchrum-imperata type.
- The topography of the region is flat, low lying, and poorly drained soils.
- The grasses found here include Bothriochloa pertusa, Cynodon dactylon, and Dichanthium annulatum which grow in the transition zones.
- The common vegetative species found here include Acacia arabica, Anogeissus latifolia, Butea monosperma, Phoenix sylvestris and Zizyphus nummularia. However, some of these species are replaced by Borassus species in the palm savannas particularly in the ones near Sunderbans.

Humid Montane Zone

- The grassland found here is of the Themeda – Arundinella type.
- This climatic zone covers the humid montane and moist sub-humid areas of Jammu and Kashmir, Himachal Pradesh, Punjab, Uttar Pradesh, West Bengal, Assam, and Manipur.
- The grasslands here are formed as a result of shifting cultivation and sheep grazing.

The economic importance of grasslands

- India supports a huge livestock population of all varieties. According to 19th Livestock Census, 2012 India's total livestock population is over 512 million.
- Livestock plays a crucial rule in the rural economy. It's a major source of food, nutrition, draught power, fuel, and raw material for cottage industries in the village. They also supplement the income of farmers dependent on crop cultivation.
- The livestock needs fodder for survival and growth but there is a dearth of it in India. Only around 13 million hectares are classified as permanent grazing lands. Large portions of these lands are categorized as degraded lands.
- Hence it is essential to preserve and revive the grassland ecosystems, not only to sustain the livestock population but also to support the biodiversity associated with the region.
- In order to promote research in the development of grassland ecosystems the government has created two institutions viz., Indian Grasslands and Fodder Research Institute, Jhansi; and Central Arid Zone Research Institute, Jodhpur.

Impact of Grazing on Grasslands

- Excessive grazing by livestock has resulted in the deterioration of grassland ecosystems. The mulch cover on the soil reduces which makes the microclimate of the region dry facilitating the invasion by xerophytic plants.
- Due to the removal of humus cover, the soil surface gets trampled upon heavily. This reduces the infiltration capacity of the soil and accelerates soil runoff during the rains. This also makes the region vulnerable to drought.

- These changes disrupt the energy flow in the ecosystem and affect the stratification and periodicity of primary producers. This can lead to a breakdown of the biogeochemical cycles of nitrogen, water, and carbon.
- Intensive grazing of grasslands opens up the bare soil which facilitates the growth of populations of burrowing animals such mice, jack-rabbits, prairie dogs, gophers etc. The new habitat for these animals can render large areas of forage lands sterile.

Role of Fire

- Fire is known to play an important role in the management of grassland ecosystem.
- In moist conditions, fire favours grass over trees whereas in dry conditions fire often protects the grasslands against the invasion of alien species such as desert shrubs.
- The forage yields also increase after a cycle of burning and regrowth. E.g., Cynodon dactylon.

3.4 Desert Ecosystem

A desert is a geographical region in which the annual rainfall is less than 25 cm. Sometimes, in hot regions even if the rainfall exceeds 25 cm in a year, deserts can form if the rainfall is concentrated only for a few days. In the sub-tropics, a desert is formed due to the presence of high-pressure belt which restricts cloud formation and rainfall. In the temperate latitudes, a desert is formed in the rain shadow region such as an inter-montane plateau where high mountains block moisture-laden winds blow from the sea.

The type of desert, particularly its climate, is defined by latitude and altitude. In the tropics, close to the mean sea level hot deserts are formed (e.g., Thar desert), whereas at high altitudes cold deserts can be found (e.g., Ladakh). As the distance from the equator increases, cold deserts are found to occur particularly in the continental interiors (e.g., Gobi desert in China).

Desert Ecosystem

The common plant species which are found in deserts include the creosote bush, cactus, Ferocactus etc. In shallow depression with salt deposits Sarcobatus, geesewood, seepwood and salt grasses are the common vegetative species.

Water is the dominant limiting factor which determines the productivity of a desert ecosystem. If the soils are suitable, irrigation can convert the region into a productive agricultural land (e.g., parts of Rajasthan irrigated by the Indira Gandhi canal). The productivity of a desert ecosystem is mainly dependent on how the biogeochemical cycles and energy flow of the region are managed by man because of artificial irrigation. As the rate of irrigation increases, salts are left behind on desert soils, due to capillary action combined with excessive evaporation, which can limit their productivity in the long run.

Adaptation by plants in a desert

- Leaves are modified into thorns to reduce water loss. The leaves and the stem are succulent and water-storing.
- In some plants, the stem contains chlorophyll to facilitate photosynthesis in the absence of leaves.

- They have an extensively developed root system to absorb water from greater distances and depths.
- The seeds only germinate during the short rainy season. Similarly, the plants reproduce and bloom only when the water is available.

Adaptation by animals in a desert

- Many animals are fast movers/runners. They are nocturnal in order to escape the sun's heat during the day. They conserve water by excreting concentrated urine.
- Birds and animals usually have longer legs to keep their body away from the hot ground.
- Certain lizards in the desert can survive without water for several days.
- Herbivorous animals have developed the ability to extract water from the seeds they eat.
- Camel, known as the ship of the desert, can survive without drinking water for several days and can travel long distances in the desert.

Hot Desert in India

- It is known by the name, Thar desert.
- The climate of the region is characterized by continuous drought with rainfall being irregular and scanty. The monsoon winds do not bring any significant rainfall to this region since the adjoining Aravallis lie parallel to the rain-bearing winds. The winter rains of north India, brought by Western disturbances, do not penetrate into this region.
- The cold weather (winter) season begins from the middle of November and continues up to the middle of March. This season is characterized by extreme variations in temperatures. The temperatures often drop below the freezing point at nights.
- The rest of the year experiences hot weather. During April to June, the heat becomes intense with scorching winds prevailing over the region. These winds have a desiccating effect, removing all the moisture from the surrounding atmosphere. The relative humidity in the region is always low. Such hostile

climate necessitates that the flora and fauna which survive in the region possess certain special adaptations.

- The adaptations of desert species are mainly for two reasons – to enable them to obtain water, and to retain the water thus obtained.
- Most of the desert vegetation consists of scrub variety species including perennial herbs and shrubs which are capable of resisting and surviving drought for a long period. There a few species of trees which can be found. These are usually stunted and thorny, adaptations which are necessary to survive the dry weather and to protect themselves from herbivores.
- The desert vegetation is mainly of two types viz., the one which is directly dependent on rains, and the other which is dependent on subterranean water.
- The plant species which are directly dependent on rain are subdivided into two types – ephemerals and rain perennials. The ephemerals are delicate species without any special (xerophilous) adaptations. They have slender stems, root-systems and also large flowers. They appear soon after the rains, grow and bloom with flowers and fruits for a very short period. They die out as soon as the soil moisture dries up. The rain perennials have an elaborate underground root system. Only during the rainy season, they become visible above the ground.
- The second variety of plant species is dependent on subsurface water. Most of these plants are capable of absorbing water from deep below the ground with the help of a well-developed root system. The main part of the root system is usually a slender, woody tap root of great length.
- Various other xerophilous adaptations by the plants in this region include reduced leaves, succulence, coatings of wax, thick hairy growth, protected stomata, thick cuticle etc. All of these become necessary to reduce water loss due to transpiration.
- Some endemic floral species of the Thar desert include Calligonum Polygonoides, Tecomella undulate, Prosopis cineraria, Sueda fruticosa, and Cenchrus biflorus etc.
- The important mammal species of the desert include chinkara, blackbuck, desert fox, wild ass, caracal, sandgrouse etc. These are found in the grasslands, open plains and also near saline depressions. the desert ecosystem and its

grasslands are home to the Great Indian Bustard, India's largest flying bird. The Great Rann of Gujarat is known for the nesting grounds of flamingoes and the only known population of Asiatic wild ass. The Great Rann is along the way of migration of many cranes and flamingoes.

Cold Desert or Temperate Desert

The cold desert in India covers the areas of Ladakh, Leh, and Kargil in Jammu and Kashmir; Spiti Valley of Himachal Pradesh; parts of Uttarakhand and Sikkim. These areas remain arid because they do not come under the influence of monsoon winds over India. They lie in the rain shadow areas of the Himalayas.

The weather in this region is severe with extremely cold conditions during winters. The terrain is denuded of soil which can support the growth of plants, due to prolonged dry spells and fast blowing winds. Scattered and isolated shrubs can be found here but they are overgrazed. The grazing period is short, less than 4 months in duration. Important floral species such as oak, pine, birch, deodar, and rhododendron are found at the edges of the desert. Yaks, goats, and dwarf cows are the prominent animals found in this region. Other important species include the highly adaptative, rare and endangered fauna such as Asiatic Ibex, Tibetan Argali, Tibetan Antelope (chiru), Tibetan Gazelle, Snow Leopard, Brown Bear, Tibetan Wild Ass (Kiang), Ladakh Uriyal, Bharal, Tibetan Wolf, Wild Dog etc.

Prolonged dry spells characterize the region with mean annual precipitation being less than 40 cm. Much of it occurs as snowfall during the months of November through March. The temperatures remain close to the freezing point throughout the year and drop as low as -50 degrees Celsius in winters. The soils are sandy to loamy with neutral to alkaline in character. They are poor in organic content, have a low water retention capacity and prone to severe wind erosion.

3.5 Desertification

Desertification is a process in which there is a gradual destruction of the biological potential of land which ultimately results in desert-like conditions. In semi-arid and arid areas, the ecosystem is fragile. The process of restoration of the disturbed ecosystem in these areas is very slow. Human interventions like deforestation, mining etc. further hasten the process of desertification in these areas. In India, the problem of desertification is severe in the states of Rajasthan, Gujarat, Haryana, and Punjab which contain areas adjoining the desert (Thar).

Desertification

The most important cause of desertification is human intervention. Natural factors such as changes in climate, drought etc get worsened by growing population pressures and lack of alternative employment opportunities in these areas. This forces the people in areas surrounding the Thar to fall back on animal rearing which often leads to excessive grazing of pastures. Thus the main reasons for desertification can be identified as population pressure, the spread of agriculture, deforestation, increase in cattle population, other developmental activities.

Status of Desertification in India

According to the Desertification and Land Degradation Atlas of India, 2016 (released by ISRO), 96 million hectares or close to 29 percent of India's area is undergoing degradation. However, the good news is that the extent of desertification is slowed down due to efforts such as land reclamation. According to the Desertification Atlas of 2007, the extent of degraded lands in India is over 105 million hectares or about 32 percent of India's areas.

Control Measures taken by India

India became a signatory to the United Nations Convention to Combat Desertification (UNCCD) and has submitted several National Reports to UNCCD, including the data of Desertification Atlas, detailing the steps taken to combat desertification. In 2001, a National Action Programme to combat desertification was prepared. Other major programmes to address the issues of desertification and land degradation include:

- Desert Development Programme.

- Integrated Watershed Management Programme which is now subsumed under Pradhan Mantri Krishi Sinchai Yojana.
- National Mission on Green India which is a part of National Action Plan on Climate Change.
- National Afforestation Programme.
- Soil Conservation in the Catchment of River Valley Projects and Flood Prone Rivers.
- National Watershed Development Project for Rainfed Areas.
- Fooder and Feed Development Scheme – a component of Grassland Development including Grass Reserves
- Command Area Development and Management Programme.

Afforestation

The desert and its adjoining areas in the states of Rajasthan, Gujarat, Haryana, Punjab, and the Trans-Himalayan region contain scarce vegetation which accelerates the problem of desertification. Population pressures such as consumption of wood for fuel (firewood), timber, fodder, grazing of pastures etc., increase the susceptibility of the region to soil erosion by wind and water. Presence of vegetative cover reduces the effect of forces of soil erosion and also modifies the micro-climate in a hostile region. Thus, afforestation is a major tool to combat desertification and also to meet the livelihood needs of the population living in and around the desert areas.

However, afforestation measures have to address the challenges of a hostile climate, a poor nutrient content of the soil and its lack of moisture retaining capacity, excessive grazing by cattle, erosion due to wind and water etc.

4- AQUATIC ECOSYSTEM

4.1 Aquatic Organism and factors limiting the productivity of Aquatic Habitat

The organisms (both flora and fauna) in the aquatic ecosystem i.e. having water as their main habitat are known as aquatic organisms. They can be found in different types of aquatic ecosystem viz,

(a) freshwater ecosystem like lakes, ponds (Lentic ecosystem); streams, rivers (Lotic ecosystem),

(b) the marine ecosystem like shallow seas and open oceans,

(c) Brackish water ecosystem like estuaries, mangroves swamps etc.

Aquatic Organisms

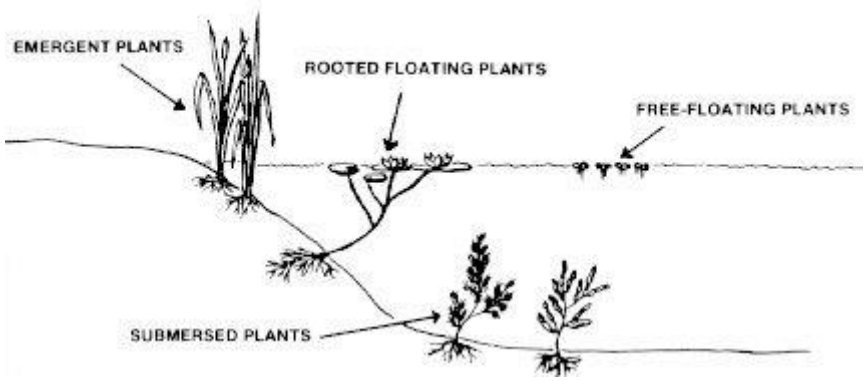
They have varied biological characteristics, adaptations and habitats but are linked within a complex network of ecological roles and relationships. These linkages provide the ecosystem with its unique characteristics and the ability to perform its crucial functions.

Classification of Aquatic Organisms

I. Based on their Ability to Produce Food

1. Autotrophic Organisms – They are producers that generate organic compounds from inorganic material.

- Plants and algae (phytoplankton) use photosynthesis to generate biomass from carbon dioxide and solar energy.
- Chemosynthetic bacteria are present at deep benthic marine floors. They are in abundance near areas of volcanic activities in the sea.



2. Heterotrophic Organisms – They consume autotrophic organisms to produce energy.

- Euryhaline organisms are salt tolerant and can live in marine water, brackish water or freshwater.
- Stenohaline organisms are salt intolerant and can live only in the freshwater ecosystem.

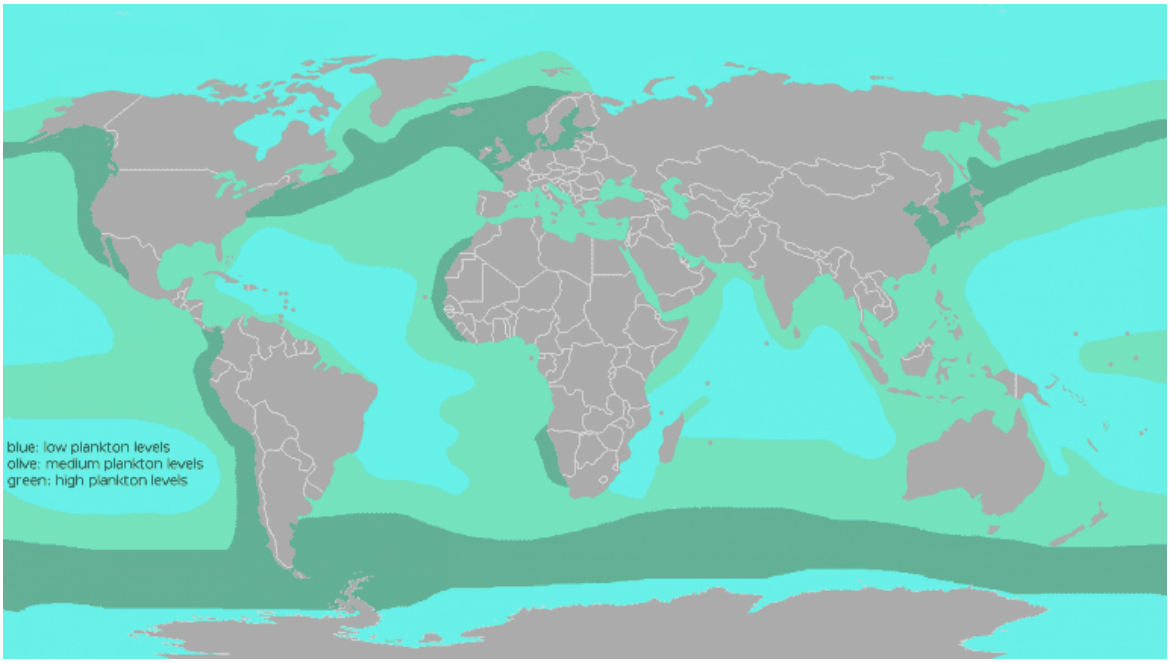
II. Based on their Life Forms and Habitat Location

1. **Neuston –** They are the organisms living at the air-water interface and are unattached to the bottom of the water body. For example, floating plants like lotus, water lily, water hyacinth; animals like water striders, beetles etc.
2. 

3. **Periphyton –** These organisms remain attached to the submerged surfaces or the parts of rooted plants in the aquatic ecosystem. They are used in aquaculture food production for the removal of solid and dissolved pollutants. They also serve as indicator species to the water quality. For example, green algae (Cyanobacteria), diatoms etc.

4. **Plankton –** They are passive swimmers due to their limited locomotory power. They typically flow with the water current. For example, phytoplankton, zooplankton (protozoa), mycoplankton (fungi) and some large animals like Jellyfish. Some organisms like sea urchins and starfish, begin their life as plankton and later on become benthic or nektons, they are termed as Meroplankton.

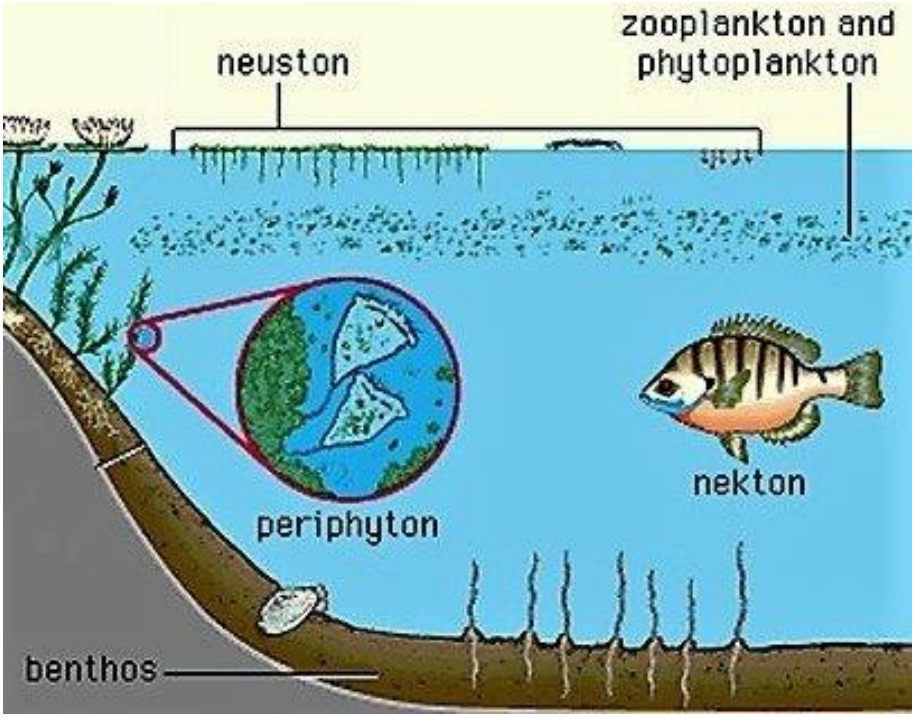
Figure – World Distribution of planktons.



5. **Nekton –** They are actively swimming aquatic organisms. They are relatively large and powerful as they have to overpower the water currents. Their size, however, ranges from swimming insects (about 2 mm long) to the largest animals like a blue whale.

6. **Benthos –** They are found living on the bottom of the water body. They are most abundant in the shallower waters. They can be of three types – (a) epifaunal, living on the surface of the sea floor; (b) infaunal, living buried in sediments; (c) nekto-benthos, swim or crawl through water above the seafloor. For example, crabs, water bears, corals, seagrass etc.

Figure – Classification of Aquatic Organisms

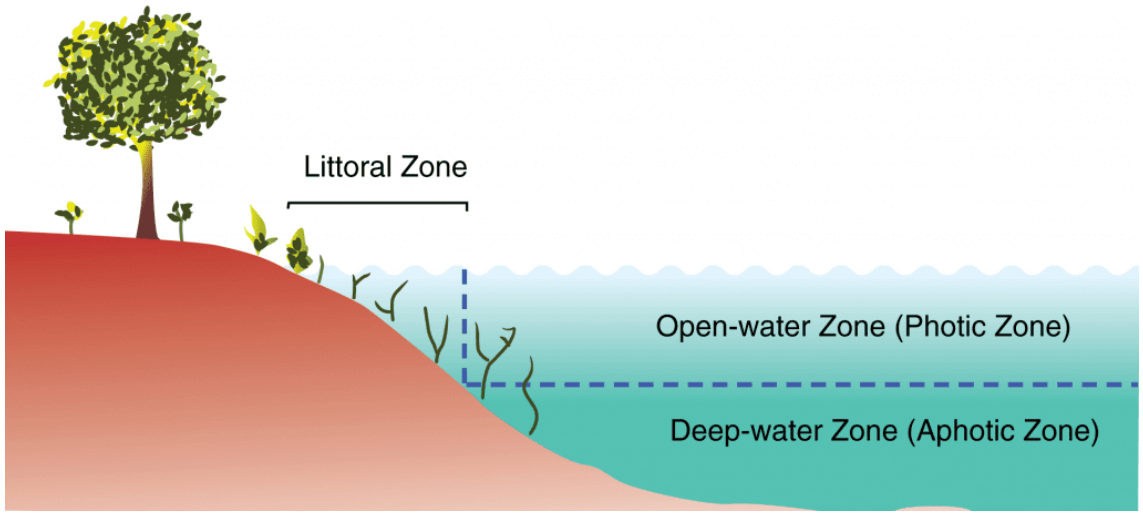


Factors Limiting the Productivity of Aquatic Habitats

Limiting factors can suppress the productivity of an ecosystem because there is too much or too little of it. Major limiting factors in an aquatic ecosystem are as follows

Sunlight

- The depth to which sufficient sunlight is available for the photosynthesis to take place limits the vertical extent of plant distribution under water. This zone is known as Photic Zone or Euphotic Zone.
- The depth of photic zone depends on the transparency of water, increased levels of pollution may reduce its depth.
- Typical depth may vary from a few meters in a turbid eutrophic waterbody to around 200 meters in the open ocean.
- Aphotic zone is the lower layer, where the intensity of sunlight is below 1 % of the surface levels.
- Here, respiration activity takes place and hence it is a region of oxygen consumption.



Nutrient levels

- Apart from sunlight, nutrients such as nitrates and phosphate are required for photosynthesis. As their presence is maximum in the littoral zone (region close to the shore), high productivity is found here.
- Zones of convergence of cold and warm ocean currents and upwellings regions (where water from the bottom of oceans rises to the surface), are rich in nutrients and hence have high biodiversity.
- For example, Grand Banks of Newfoundland are famous fishing ground in Atlantic, due to the mixing of Gulf Stream (warm current) and Labrador Current (cold current).
- However, too many nutrients can cause too many algae to grow in an aquatic ecosystem and lead to eutrophication, resulting in oxygen depletion in the water body.

Dissolved Oxygen

- Oxygen dissolved in water is used by the aquatic animals (and plants) for respiration and a drop in its concentration below 3-5 ppm may lead to the death of many aquatic organisms.
- Source – Photosynthesis by aquatic plants, entry through the air-water interface
- Consumers – Respiration, decomposition, escape through the air-water interface

- Increased organic pollutants in the water can increase decomposition and deplete oxygen levels of the aquatic ecosystem.
- Accidents like oil spills can cut off the air-water link. Furthermore, fire in such an area can consume the dissolved oxygen from the water body.

Temperature

- Aquatic organisms have narrow temperature tolerance limit, so small changes in water temperature can be a great threat to the survival of many species.
- If temperatures are too high, fishes may not be able to survive. In contrast, too low temperatures leading to cover of ice on water body can effectively cut off sunlight, stopping photosynthesis and depleting oxygen.
- The temperature may affect the oxygen level as well. Oxygen is less soluble in warm water and also the warm water enhances the decomposition activity.

Salinity

- Different organisms have varied tolerance towards the salinity (or salt concentration) in the aquatic ecosystem.
- High concentrations like those of Dead Sea (350 Parts per thousand) can be fatal to aquatic organisms.
- Salinity variation arises more due to addition or removal of water from the system. For example, regions where fresh water gets added like river deltas, high rainfall, melting snow are less saline. While, regions where fresh water gets removed due to high evaporation, have high salinity.

Apart from these some other factors like an introduction of alien species, pH level of water, a flow of water and presence of suspended particulate matter etc. can limit the productivity of the aquatic habitat.

Important Terms for Preliminary Examination in the Article

Lentic Ecosystem, Lotic Ecosystem, Phytoplanktons, Euryhaline, Stenohaline, Neuston, Periphyton, Cyanobacteria, Plankton, Necton, Benthic, Photic Zone, Euphotic Zone, Littoral zone.

4.2 Eutrophication and Algal Blooms

Both eutrophication and algal blooms occur when chemicals run off into the water system. But these two terms are slightly different. Eutrophication is the pollution of water because of over-supply of nutrients while algal blooms are excessive growth of algae in water. Eutrophication leads to algal blooms causing the bacteria population to increase and use up all oxygen by consuming the dead algae. This creates a condition of hypoxia (situation of less supply of oxygen) which is not suitable for the growth of other aquatic organisms.

The **OECD** defined the process of eutrophication as follows: “Eutrophication is an enrichment of water by nutrient salts that causes structural changes to the ecosystem such as: increased production of algae and aquatic plants, depletion of fish species, general deterioration of water quality and other effects that reduce and preclude use”. For example, the green colour of Potomac river in the U.S.A had been due to this process of eutrophication leading to excessive growth of cyanobacteria. Likewise, the process of eutrophication has been witnessed on the coast of Qingdao in Eastern China where children are found swimming in a sea of seaweed. Both these examples represent an abnormal growth of algae, a clear manifestation of a process called eutrophication.

Eutrophication comes from the Greek word “eutrophos” which means “well-nourished”. In this process, excessive growth of plants and algae take place because of over-supply of nutrients. This process also leads to oxygen depletion of the water body. Eutrophication is almost always catalysed by the disposal of nitrate or phosphate-containing detergents, fertilizers, or sewage into an aquatic system. It promotes overgrowth of plants and algae. After such organisms die, the bacterial degradation of their biomass consumes the oxygen in the water, thereby creating the state of hypoxia (state of having less oxygen). Eutrophication can also occur outside water bodies. For example, soils can be eutrophic when they have high levels of nitrogen, phosphorous or other nutrients.

Eutrophication is a critical environmental problem as it leads to a decline in water quality. According to the Survey of the State of the World’s Lakes, “eutrophication affects 54% of Asian lakes, 53% of those in Europe, 48% of those in North America, 41% of those in South America and 28% of those in Africa”.

All water bodies undergo a natural and slow eutrophication process which is called **natural eutrophication** process. However, in recent decades there has been a rapid increase in the process of eutrophication due to the presence of man and his activities leading to pollution in water bodies. This is called **cultural eutrophication**. The cultural eutrophication process comprises of a steady and rapid increase in the contribution of nutrients, mainly nitrogen and phosphorus in water bodies. This load exceeds the capacity of the water body to purify itself naturally which in turn activates structural changes in the water body. Such adverse changes are not conducive to the growth of other aquatic organisms.

A bloom often results in a colour change in the water. Algal blooms can be any colour, but the most common ones are red or brown. These blooms are commonly referred to as red or brown tides. Most algal blooms are not harmful but some produce toxins and do affect fish, birds, marine mammals and humans. The toxins may also make the surrounding air difficult to breathe. These are known as Harmful Algal Blooms (HABs).

Harmful Algal Blooms are considered an environmental hazard because these events can make people sick when contaminated shellfish or finfish are eaten, or when people breathe toxins near the beach.

These structural changes in water bodies occur because of three reasons:

- Use of fertilisers: Agricultural practices like the excessive use of fertilisers in the soil contribute to the stocking of nutrients. A time comes when these nutrients reach high concentration levels and the ground is no longer able to assimilate them, they are carried by rain into rivers and groundwater that flow into lakes or seas. The phosphate-containing detergents were major sources of phosphorus offload into water bodies. However, with the phasing out of phosphate-containing detergents in the 1970s, industrial/domestic run-off and agriculture have emerged as the dominant contributors to eutrophication.
- Discharge of waste water into water bodies: Water pollution is a common phenomenon in various parts of the world, and particularly in developing countries. Waste water is discharged directly into water bodies such as rivers, lakes and seas. This results into the release of a high quantity of nutrients which leads to excessive growth of algae.

- Reduction of self purification capacity: Over the years, lakes accumulate large quantities of sediments. These sediments assimilate large amounts of nutrients and pollutants. This phenomenon results into further deterioration of water quality amplifying the processes connected with eutrophication.

Effects

With the process of eutrophication the enrichment of water occurs mainly by nutrients such as phosphorus and nitrogen. An aquatic environment with a limited availability of phosphorus and nitrogen is described as “oligotrophic” while one with high availability of these elements is called “eutrophic”. The intensification of the eutrophication phenomenon produces adverse effects leading to environmental imbalances.

- The two serious impacts of eutrophication are hypoxia (lack of oxygen) in the deep part of the lake and algal blooms that produce harmful toxins. These developments demolish aquatic life in the affected areas.
- The substantial loss of aquatic life has a devastating effect on fisheries and the fishing industry. Its adverse impact goes beyond the fishing industry. Recreational fishing which is the backbone of the tourism industry also suffers from a loss of revenues.
- Algal blooms can have a severe impact on human health. Humans become seriously ill from eating oysters and other shellfish contaminated with toxins produced as a result of eutrophication process. It can cause eye, skin and respiratory irritation to swimmers, boaters and residents of coastal areas.
- Fish mortality: Affluence of organic substances leads to deterioration of water quality catalysing threats to fish population in water bodies. This scenario logically leads to an increment in fish mortality.
- Loss of fresh water lakes: Eutrophication eventually creates a layer of wastes in lakes and produces successively shallower depth of surface water. Eventually the water body is reduced into marsh whose plant community is transformed from an aquatic environment to recognizable terrestrial environment.
- New species invasion: Eutrophication may make the ecosystem competitive by transforming the normal limiting nutrient to abundant level. This causes shifting in species composition of ecosystem.

- Toxicity: Some algal blooms (upon death or being eaten) release toxins which can kill aquatic organisms and pose threat to humans. For example, shellfish poisoning.
- Loss of coral reefs: This can occur due to decrease in water transparency as a result of eutrophication.
- Adverse impact on navigation: Affects navigation due to increased turbidity (increased cloudiness or haziness in water bodies).

Thus, it is observed that eutrophication is a threat to marine ecosystem. Hence, there is a crying need to curb the progress of eutrophication in order to prevent the collapse of the affected marine ecosystems.

How to Control Eutrophication

- Conventionally, there have been some methods to control/reduce eutrophication viz. “the alteration of excess nutrients, physical mixing of the water, application of powerful herbicides and algaecides” among others. These methods have proven to be ineffective, expensive and impractical for large ecosystems.
- Today, the major control mechanism against eutrophication process is premised on prevention techniques like taking out of the nutrients that are introduced into water bodies. The strategy is to limit the concentrations of one of the two main nutrients (nitrogen and phosphorus) in water bodies. It is scientifically proven that in particular phosphorus is the main limiting factor for the growth of algae. Hence, when the offload of nitrogen or phosphorus is controlled then there is visible reduction in the process of eutrophication in water bodies.
- Experts also call for “improvement of the purifying performance of waste water treatment plants and installing tertiary treatment systems to reduce nutrient concentrations; implementation of effective filter ecosystems to remove nitrogen and phosphorus present in the run-off water; reduction of phosphorous in detergents; rationalisation of agricultural techniques through proper planning of fertilisation and use of slow release fertilisers; use of alternative practices in animal husbandry to limit the production of waste water”.

- Increasing the size and diversity of wetlands, estuaries and riverside natural areas helps to manage the runoff of nutrient-rich water into streams and oceans. And better sewage treatment facilities and septic tank regulations greatly reduce nutrient flows, resulting in fewer algal blooms.
- Checking water pollution is the ultimate solution to eutrophication. There is a need to treat industrial effluents and domestic sewage to remove nutrient rich sludge through waste water processing.
- Riparian buffer: Interfaces between a flowing body of water and land created near the waterways, farms, roads, etc. in an attempt to filter pollution. Sediments and nutrients are deposited in the buffer zones instead of deposition in water. Wetlands, estuaries are natural riparian buffers and they must be protected.
- Increase in efficiency of nitrogen & phosphorous fertilizers and using them only in adequate levels.
- Nitrogen testing and modelling: It is a technique to find the optimum amount of fertilizer required for crop plants. It will reduce the amount of nitrogen lost to the surrounding area.
- Encouraging organic farming.
- Reduction in nitrogen emission from vehicles and power plants.
- There is an ever-increasing population pressure and hence sustained food security will become a more serious concern. This will magnify the already increasing demands on farmland productivity. But organic farming is very costly and hence farmers will turn to continued increased use of phosphate- and nitrogen-rich fertilizers. These fertilizers will catalyse the growth of eutrophic zones. Hence, there is a need to address this dimension of the eutrophication problem.

However, there are cases where water quality is severely compromised and any preventive measures prove to be ineffective. In this scenario, curative procedures can be implemented, such as:

- removal and treatment of deep water in contact with the sediments rich in nutrients since in direct contact with the release source;

- drainage of the upper part of sediment subject to biological reactions and with high phosphorus concentrations;
- oxygenation of water for restore the ecological conditions,
- chemical precipitation of phosphorus by the addition of iron or aluminium salts or calcium carbonate to the water, which give rise to the precipitation of the respective iron, aluminium or calcium phosphates, thereby reducing the negative effects related to the excessive presence of phosphorus in the sediments.

Conclusion

Eutrophication is a leading cause of serious impairment of many freshwater and coastal marine ecosystems in the world. Eutrophication occurs naturally over centuries as lakes age and they are filled in with sediments. However, human activities have accelerated the rate and extent of eutrophication through both point-source discharges and non-point loadings of limiting nutrients, such as nitrogen and phosphorus.

Water is not a commercial product but rather a heritage which must be defended and protected, especially in the presence of a global decline in the availability of drinking water and increase in its demand. Despite the considerable efforts made to improve the water quality by limiting nutrient enrichment, eutrophication and the resulting algal blooms continue to remain a source of concern. Management of the eutrophication process is a complex issue that will require the collective efforts of scientists, policy makers and citizens.

4.3 Wetland Ecosystem

Wetland ecosystems are the world's most important environmental assets and part of our natural wealth. They are not only home to a large number of species but also provide a wide array of ecosystem services worth trillions of dollars every year – entirely free of charge, to the mankind.

Wetland Ecosystem

Most commonly a wetland ecosystem is defined as the transitional land between terrestrial and aquatic ecosystem, where the land surface is saturated or covered with standing water for at least a part of the year.

Ramsar Convention on Wetlands define wetlands as: "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres".

The Convention uses a very broad definition of wetlands. It includes among others all lakes and rivers, underground aquifers, wet grasslands, estuaries, deltas, mangroves coral reefs, and all human-made sites such as fish ponds, rice paddies, reservoirs and salt pans.

Sometimes to distinguish wetland ecosystem from other ecosystems, the amount of aquatic vegetation (macrophytes) in the wetland is considered.

What are the different types of wetlands?

Ramsar convention divides wetlands into three main categories –

1. **Marine and Coastal wetlands** – For example, permanent shallow marine waters, coral reefs, estuarine waters, marshes, mangroves, freshwater or saline lagoons etc.
2. **Inland Wetlands** – For example, inland deltas, rivers, creeks, permanent or seasonal lakes, Tundra wetland, Alpine wetland, peatland, geothermal wetlands etc.
3. **Man-made Wetlands** – For example, aquaculture, ponds, irrigation channels, flooded rice fields, salt pans, reservoirs etc.

What are the benefits of wetlands?

1. **Flood control –** They increase downward percolation of water, reducing runoff.
   The Chennai Floods of 2015 were worsened by damage to wetland ecosystem in the region due to illegal human development activities.

2. **Groundwater replenishment** – This also helps in recharging aquifers and increasing water table.
   In Alwar district of Rajasthan, the revival of Arwari river and traditional water storage structures have improved water table significantly.

3. **Shoreline stabilisation & storm protection** – They protect coastal erosion due to wave action. Also, the trees and vegetation of coastal wetlands like mangroves act as a barrier to the storms, providing protection to inland regions.

4. **Sediment & nutrient retention** – Sediments from water runoff are dumped into wetlands near the river mouth due to reduced flow. Wetland vegetation recycles the nutrients from land and water by uptaking and storing them.

5. **Water purification** – Wetlands act as natural filters, purifying water from toxic substances that have come from pesticides, industrial discharges, and mining activities.
   East Kolkata Wetlands are used to treat Kolkata's sewage.

6. **Reservoirs of biodiversity** – Most wetlands are transitory between territorial and aquatic ecosystem known as E**cotones.** This creates **an edge effect** leading to high species diversity and density as compared to any of the neighbouring biomes.

7. **Wetland products** – They provide important raw material for industries. For example, fish and other marine life forms, salt production, medicinal plants like mangrove bark, fibre for textile, dyes and tannins, Timberwood etc.

8. **Cultural values** – Many wetlands are important to aboriginal people. There are sacred groves with high cultural and religious values.

9. **Recreation & tourism** – Many wetlands are areas of great natural beauty like coral reefs, important sites for bird-watchers like Chilika lake (Odisha), Keoladeo bird sanctuary (Rajasthan), and huge biodiversity hotspots. They attract millions of tourists and boost the local economy.

10. **Climate change mitigation and adaptation** – They are one of the major carbon sinks of the world, helping in mitigating climate change. They are part of the **Blue Carbon** initiative**,** which is carbon captured by oceans and coastal ecosystem and stored in the form of biomass and sediments. Wetlands are also a significant source of methane and nitrous oxide emission.

Conservation of Wetlands

In the 20th century, the global extent of wetlands is estimated to have declined between 64-71%, the more rapid decline is seen in the case of inland wetlands. Furthermore, the trend is continuing in the 21st century.

Factors Responsible for Wetland Depletion

The increasing population pressure, climate change and attraction of short-term economic gains continue to drive the destruction and degradation of wetlands. Some of the human activities that have a negative effect on wetland ecosystem –

1. Conversion of land for real estate development and agricultural activities.
2. Deforestation and overgrazing.
3. Industrial and domestic pollution
4. Unsustainable economic exploitation of resources.

Conservation Efforts

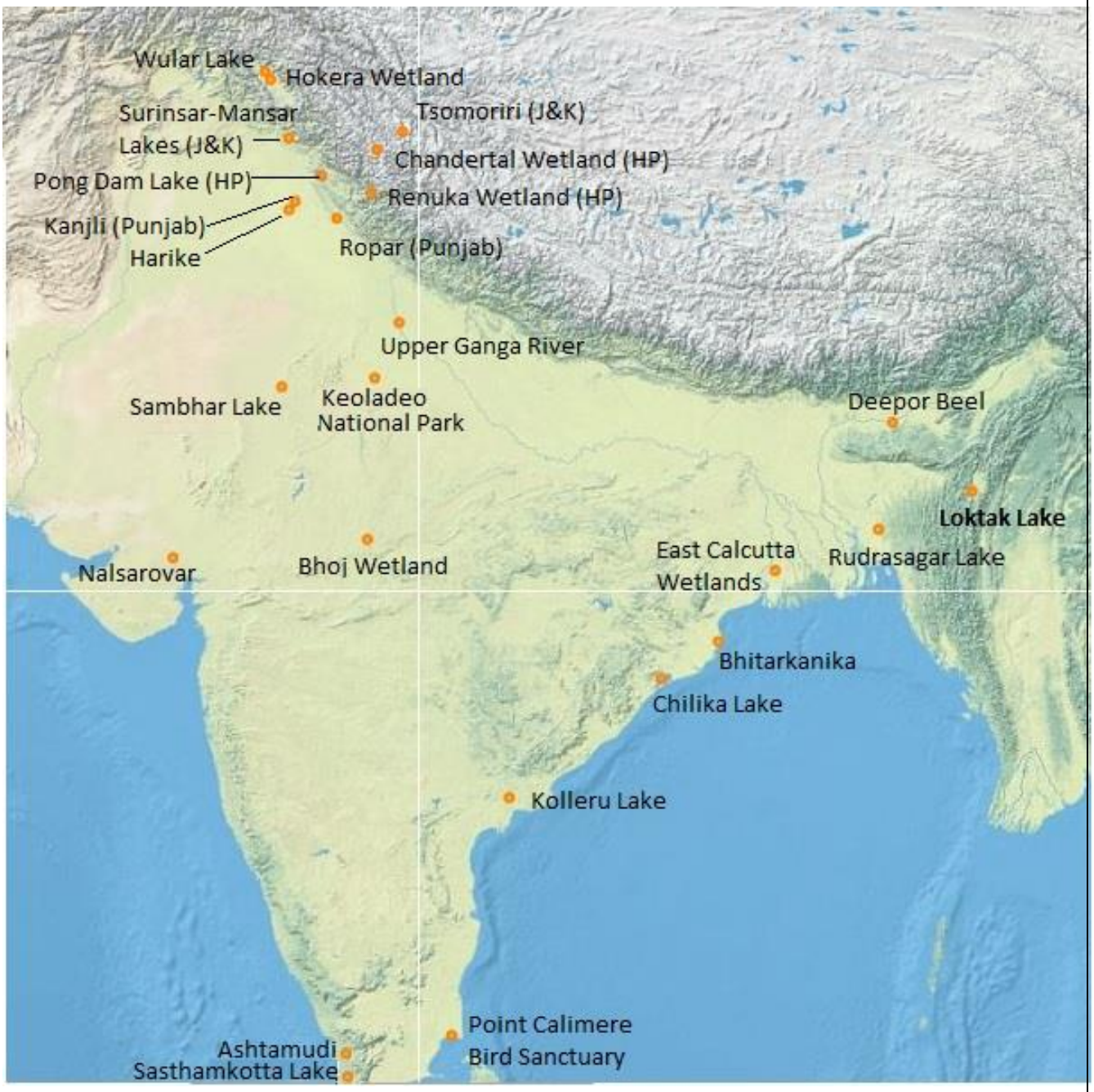
The most important global convention to protect wetland ecosystem is **the Ramsar Convention of 1971**. In 2018, the convention has 170 members, more than 2300 designated Ramsar sites with an area of around 245 million hectares.

- Formal title – The Convention on Wetlands of International Importance especially as Waterfowl Habitat
- The intergovernmental treaty was signed in Ramsar (Iran) on February 2, 1971. It came into force in 1975. February 2 is celebrated as World Wetland Day.
- Aim – the conservation and wise use of all wetlands through local and national actions and international cooperation
- Under the “three pillars” of the Convention, the Contracting Parties commit to:

- 1. work towards the wise use of all their wetlands;
- 2. designate suitable wetlands for the list of Wetlands of International Importance (the “Ramsar List”) and ensure their effective management;
- 3. cooperate internationally on transboundary wetlands, shared wetland
- It isn’t legally binding.
- It isn’t part of United Nations and UN Environment Conventions.
- Ramsar secretariat is hosted by International Union for the Conservation of Nature (IUCN) in Gland, Switzerland.

Ramsar sites – Wetlands of International importance in India

India currently has 26 sites designated as Wetlands of International Importance (Ramsar Sites), with a surface area of 689,131 hectares.


Wular Lake
Hokera Wetland
Surinsar-Mansar
Lakes (J&K)
Tsomoriri (J&K)
Chandertal Wetland (HP)
Pong Dam Lake (HP)
Renuka Wetland (HP)
Kanjli (Punjab)
Harike
Ropar (Punjab)
Upper Ganga River
Sambhar Lake
Keoladeo
National Park
Deepor Beel
Loktak Lake
Nalsarovar
Bhoj Wetland
East Calcutta
Wetlands
Rudrasagar Lake
Bhitarkanika
Chilika Lake
Kolleru Lake
Point Calimere
Bird Sanctuary
Ashtamudi
Sasthamkotta Lake

Name	State
Kolleru Lake	Andhra Pradesh
Deepor Beel	Assam
Nalsarovar	Gujarat
Chandertal Wetland	Himachal Pradesh
Pong Dam Lake	Himachal Pradesh
Renuka Wetland	Himachal Pradesh
Hokera Wetland	Jammu & Kashmir
Surinsar-Mansar Lakes	Jammu & Kashmir
Tsomoriri	Jammu & Kashmir
Wular Lake	Jammu & Kashmir
Ashtamudi Wetland	Kerala
Sasthamkotta Lake	Kerala
Vembanad-Kol Wetland	Kerala
Bhoj Wetland	Madhya Pradesh
Loktak Lake	Manipur
Bhitarkanika Mangroves	Odisha
Chilika Lake	Odisha
Harike Lake	Punjab
Kanjli	Punjab
Ropar	Punjab
Keoladeo National Park	Rajasthan
Sambhar Lake	Rajasthan

Point Calimere Wildlife and Bird Sanctuary	Tamil Nadu
Rudrasagar Lake	Tripura
Upper Ganga River	Uttar Pradesh
East Calcutta Wetlands	West Bengal

The combined efforts of international communities have increased awareness and understanding of economic and environmental benefits of wetlands. This has resulted in significant expenditure in some countries on wetland restoration and rehabilitation of lost or degraded hydrological and biological functions of wetlands. However, concerted action at a global scale will be needed if we are to avert the worst consequences of global climate change and increased pressure on water resources.

Important Terms/Facts for Prelims- Ramsar Convention, Ecotone, Edge effect, Keoladeo Bird Sanctuary, Chilika lake, Blue Carbon initiative, February 2 – World Wetland Day, Ramsar sites in India.

4.4 National Wetland Conservation PROGRAM

The Wetland Ecosystem in India is spread over a wide range of varied climatic conditions, which is ranging from the wetlands in cold Jammu and Kashmir to hot and humid conditions in Peninsular India. Thus there is a great diversity of these Wetlands. Many of these wetlands are unique from the point of biodiversity, scenic beauty, the shelter of migratory and resident birds, etc.

Wetlands Conservation – India

However, the very existence of these unique resources is under threat due to developmental activities and population pressure. On February 2, 1971, an intergovernmental treaty was signed in Ramsar (Iran), to protect and conserve wetlands around the globe.

The Ramsar convention entered into force in India in 1982. As of today, there are 26 Ramsar sites in India.

To conserve and control degradation of wetlands in India, the National Wetland Conservation Program (NWCP) was initiated in 1987. It aimed at conservation and wise use of wetlands in the country, so as to prevent their further degradation

National Wetland Conservation Program (NWCP)

Under this, the Ministry of Environment, Forest and Climate Change (MoEFCC) is responsible for overall coordination of the program and to provide financial and technical assistance to the State Governments. State governments, on the other hand, are responsible for the management of wetlands and implementation of the NWCP (as land is state subject).

Objectives of the Scheme

- to lay down policy guidelines for conservation and management of wetlands in the country;
- to undertake intensive conservation measures in priority wetlands and provide financial assistance for the same;

- to monitor implementation of the programme; and
- to prepare an inventory of Indian wetlands.

Significant Achievements under NWCP

- Over the years, based on the recommendations of the National Wetlands Committee, **115 wetlands** have been identified for conservation under the NWCP.
- **Wetland mapping** and inventory by analysis of digital IRS LISS III data and **creation of a digital database** in GIS environment.
- **State wise Atlas of wetlands** in the scale of 1:50000 have been prepared through Space Applications Centre (ISRO), Ahmedabad to bring information on wetlands above the size of 2.25-hectare area.
- Notification of 'Wetlands (Conservation and Management) Rules, 2010', under the Environmental Protection Act 1986.
- **Central Wetlands Regulatory Authority** (CWRA) was constituted under the chairmanship of secretary (MoEFCC), as per the wetland rules, 2010.
- CWRA merged conservation schemes for wetlands, mangroves and coral reefs in 2011, as Ramsar convention deals them all under wetlands.

National Plan for Conservation of Aquatic Eco-systems (NPCA)

For conservation of lakes and wetlands, the MoEFCC was earlier implementing two separate Centrally Sponsored Schemes, namely the National Wetlands Conservation Programme (NWCP) and the National Lake Conservation Plan (NLCP).

To avoid overlap, promote better synergies, both schemes have been merged into one integrated scheme of 'National Plan for Conservation of Aquatic Eco-systems' (NPCA).

It aims at conserving aquatic ecosystems (lakes and wetlands), through the implementation of sustainable conservation plans and governed with the application of uniform policy and guidelines.

Objectives

- to conserve and restore lakes and wetlands
- to achieve desired water quality enhancement
- to improve biodiversity and the ecosystem
- to reduce pollution load; and
- to provide for wise use of wetland resources and their services.

Wetlands (Conservation and Management) Rules, 2017

In September 2017, the Central government notified Wetland (Conservation and Management) Rules 2017, superseding the 2010 Rules.

Salient features and amendments in the new Rules

Definition: The new rule excludes – River channels, paddy fields, water bodies specifically constructed for drinking water purposes, aquaculture, salt production, recreation and irrigation purpose; from the definition of wetland.

Applicability of Rules

- Applicable to wetlands categorized as 'wetlands of international importance' under the Ramsar Convention,
- wetlands as notified by the Central Government, State Government and Union Territory Administration,
- not applicable to wetlands falling in forest areas, protected areas and Coastal Regulation Zone (CRZ) areas.

Decentralisation

- Creation of State Wetlands Authority (SWAs) in each State and union territories (in place of CWRA).
- The Wetland Authorities to identify and manage the wetlands. They will determine the 'wise use' principle for wetland conservation and management.
- State/UT governments to notify wetlands.

Setting up a National Wetlands Committee:

- to monitor implementation of Wetland Rules;
- to advise the Central Government on appropriate policies and action programmes;
- to recommend new Ramsar sites and review the progress of their management.

Activities in the notified area

- Rules contain a list of prohibited activities like solid waste dumping, discharge of untreated waste, poaching of animals, setting up of industries, etc.
- Wetland Authorities have the power to determine regulated and permitted activities.

Issues

1. Changes in the definition are seen as diluting the provisions of the rules and shifting priority from environmental conservation to developmental activities.
2. The possibility that loose definitions like 'Ecological Character' of wetland, the principle of 'wise use' can be abused in favor of short-term economic gains.
3. The responsibility of identification and notification of wetlands has been passed on to states, but with their poor record, the implementation of new rules may not fructify on the ground.

Other legal frameworks available for Wetland Conservation

1. Article 51A(g) of Indian Constitution – It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers, and wildlife, and to have compassion for living creatures;
2. The Environmental (Protection) Act, 1986 – under which the Wetland Rules 2010 and 2017 had been notified.
3. National Environment Policy, 2006 – recognizes the need for conservation of critical environmental resources including wetlands.

4. Numbers of wetlands have been recognized as part of National Parks and Sanctuaries like Keoladeo National Park, Keibul Lamjao National Park (Loktak Lake), etc.

While wetlands provide a wide array of ecosystem services worth trillions of dollars every year, the hard economic data that proves the value of retaining intact ecosystems is not widely available. This generates the unnecessary conflict between environmental and developmental goals. Our advancements in technology may sometimes give us an illusion of conquering or controlling nature, but the reality is that we still depend on properly functioning ecosystems to sustain us.

4.5 Montreux Record

The Montreux Record is a register of wetland sites or 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.”

Montreux Record

It is the principle tool under the Ramsar convention for highlighting wetlands sites in need of priority conservation status. It is maintained as part of the Ramsar Database and is subject to continuous review.

Establishment of Montreux Record

In the 4th meeting of Conference of Contracting Parties to Ramsar Convention at Montreux, Switzerland in 1990, it was discussed that only listing of sites under Ramsar convention isn’t sufficient. So, it recommended the creation of a database of sites that are facing change in ecological character or have a potential threat. These sites to get priority attention and possible application of the Monitoring Procedure.

Difference between Wetlands, Ramsar List and Montreux Record

While all three terms are part of the Ramsar convention, they have certain differences

Wetlands	Ramsar List	Montreux Record
The convention uses a broad definition including all areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.	The Ramsar List of Wetlands of International Importance includes those wetland sites which are important for the conservation of global biological diversity and for sustaining human life.	The Montreux Record of wetland sites on Ramsar List, 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.
Estimated Area – 700-900 million hectare	Number of Sites: 2,314 Area – 245 million hectare	Number of sites – 48

The process of Addition of a site to Montreux Record

1. The country (contracting party) in which the site lies, should request for inclusion of it in the record.
2. Alternatively, if a piece of information on actual or possible adverse change regarding a site is received, the bureau may draw the attention of the Contracting Party concerned to this information and enquire whether a Ramsar site should be included in the Montreux Record. **Note** – However, a site can only be included in the Record with the approval of the Contracting Party concerned.
3. The contracting party is required to provide all the information regarding the site.
4. The Scientific and Technical Review Panel (STRP) of the convention provides technical advice on the change/potential change in ecological character.

5. The contracting party will then take the decision as to whether the site should be included in the Montreux Record, in consultation with the Bureau.

6. Contracting Parties are required to provide a report to the Convention Bureau on the conservation status of sites in Montreux Record.

The process of Removal of a site from Montreux Record

1. The bureau may receive such request from the country or other sources, suggesting that the risk is no longer there.

2. Contracting party to provide detail on success of measure taken, proposed monitoring and assessment procedures and the extent to which the ecological character has been restored.

3. The Scientific and Technical Review Panel (STRP) is consulted for technical advice, which is forwarded to the contracting party.

4. A wetland will be removed based on the request of the Contracting Party and after consideration of advice and/or comment from the STRP

Benefits of inclusion in Montreux Record

The voluntary inclusion of a site on Montreux Record is a useful tool as –

1. It would assist Contracting Parties in their domestic commitment to resolve the adverse changes;

2. Highlighting particularly serious cases would be beneficial at national and/or international level;

3. Inclusion on the Record would provide guidance in the allocation of resources available under financial mechanisms; and

4. The Bureau can also provide technical assistance known as Ramsar Advisory Mission, on the request of Contracting Party.

Montreux Record Sites in India

At present, there are two Indian sites Loktak Lake, Manipur and Keoladeo National Park, Rajasthan on the Montreux Record.

Chilika Lake, Odisha was the first Indian site to be placed on Montreux Record in 1993 due to siltation, which was choking the mouth of the lake. This resulted in a drop in salinity of the lake. After a range of interventions, primarily the successful dredging of lake-mouth, opening it to the Bay of Bengal, it was removed from the list in 2002. Studies have shown that every rupee spent on the restoration of the Chilika Lake since 1991 has yielded INR 15 in return, making it a model case for the restoration of other wetlands in India.

Montreux Record has provided an important tool for management and conservation of important wetland sites from the harmful effects of human interventions. It compliments the domestic efforts of the countries and helps augment their resources and efforts towards conservation of our natural assets. As of 2018, 32 sites which had been listed on the Montreux Record had since been removed from it, after successfully restoring their ecological character (though one of those had been placed upon it again).

4.6 Estuary Ecosystem

The estuaries and their adjoining wetlands are bodies of water usually found where rivers meet the sea. Estuaries have distinct plant and animal communities which have adapted to brackish water—a mixture of fresh water draining from the land and salty seawater. The major examples of estuaries are river mouths, coastal bays, tidal marshes, lagoons and deltas. Estuaries are formed due to rise in sea level, movement of sand and sandbars, glacial processes and tectonic processes.

Estuaries are one of the most productive ecosystems in the world. They are more productive than wetlands. They are so useful that many organisms depend on estuaries for food, breeding place, and migration stopovers. Estuaries are also affected by the tides. There is a vigorous rush of salty water further upstream during high tides. However, there is a movement of fresh water close to the ocean during low tides. In some narrow estuaries, tidal bores are significant. Tidal bores cause great damage to the estuarine ecology.

There can be generation of clean, renewable energy at estuaries using the salinity gradient. Salinity gradient is the salinity difference between the fresh water and the salt water. The energy produced by this method is directly proportional to the salinity difference. Thus, greater the salinity difference, greater energy can be produced. This has been postulated that estuaries around the world can help in meeting 7% of the world's energy demand if energy is produced by using the salinity difference.

An estuarine ecosystem is the junction where fresh water meets salty water. Hence, it is naturally affected by tides as well as changing salinity. As a logical result of this estuarine ecosystems face far more unique stresses in contrast to other aquatic ecosystems.

Differences between Lagoon and Estuary

A lagoon is a stretch of salt water separated from the sea by a low sandbank or coral reef. Backwaters in Kerala are mostly lagoons where sea water flows inwards through a small inlet that is open towards the sea.

The main point of difference between lagoons and estuaries is in the very flow dynamics of the water bodies. In estuaries, the water flows very fast and strong, while in lagoons the water is shallower and flows in a sluggish manner.

Estuaries are usually deeper than lagoons. Additionally, lagoons mostly don't have any fresh water source while the estuaries have at least one. Lagoons are more saline than estuaries.

Lagoons are formed due to fall in sea levels. They are coastlines of emergence. For example, Kerala coast. Estuaries are mostly formed due to rise in sea levels. They are coastline of submergence. For example, Konkan coast.

Estuarine Vegetation

The estuaries form a very unique ecosystem and hence only certain types of plants and animals specially adapted to the "brackish" estuarine waters flourish in them. The major factors which impact upon the growth and distribution of organism in an estuary are its salinity and the amount of flooding. Estuaries are actually supportive of diverse habitats, such as mangroves, salt marshes, sea-grass, mudflats etc. Estuaries are very dynamic and productive ecosystems. This is largely because of the fact that the river flow, tidal range and sediment distribution is continuously changing in the estuaries which catalyses the productivity of this ecosystem.

Estuaries give shelter to all kinds of terrestrial plants and animals, such as wood storks, pelicans, coniferous and deciduous trees and butterflies. Estuaries also give shelter to unique aquatic plants and animals, such as sea turtles, sea lions, sea catfish, saltworts, eelgrass, saltgrasses, cordgrasses, sea grass, sedge, bulrush etc.

Indian Estuarine Ecosystem

India has 14 major, 44 medium and 162 minor rivers which drains into the sea through various estuaries. Major estuaries in India occur in the Bay of Bengal. Some of the major sea ports are also situated within many estuaries in India.

Most of the India's major estuaries occur on the east coast. In contrast, the estuaries on the west coast are smaller. Two typical examples of estuaries on the west coast are the Mandovi and Zuari estuaries.

Problems of Indian Estuarine Ecosystem

- The changes in the estuarine catchments result in changes in water flow in various estuaries. There are two types of changes: the water flow can either be far in excess or much lower than required. (E.g: Hooghly, Narmada, Krishna, Godavari, Pulicat etc.)
- Estuaries are increasingly faced with pollution through effluents that flow out of industries.
- The city sewage discharges also pollute estuaries in a very serious way.
- Recreational boating and fishing are additional sources creating stress and strains in the estuarine ecosystem.
- There are also issues like navigation, dredging and shipping in estuaries (e.g. Hooghly).
- There has been an exponential expansion of urban and rural settlements which lead to huge dumping of solid wastes in estuarine ecosystem. The rapid expansion of agriculture, mining & industries also adversely impact upon the estuarine ecosystem.
- Fisheries are a thriving business in India and over-exploitation of target fish stock due to increased demand puts stress on the estuaries.
- There have also been instances of reclaiming of the fringed areas of estuaries for intensive aquaculture. This is also a source of additional pressure on estuaries.
- There are also problems related with pollution of the estuarine environment through feeding of stocked fish and prawns (e.g.Chilka lake).

- There are also issues related with destruction of biodiversity through prawn seed collection and operation of small-meshed nets (e.g., Hooghly, Chilka, Pulicat).
- There are also serious issues related with submergence of catchment areas due to rise in water level.

Importance of Estuaries

- The transitional zones like mangroves, wetlands, estuaries, grasslands etc. have far greater productivity compared to natural ecosystems like forest ecosystem, ocean ecosystem, pond ecosystem, riverine ecosystem, desert ecosystem etc. This is because of the presence of greater species diversity in these transition ecosystems.
- An estuary is faced with very little wave action. Hence, it provides a calm refuge from the open sea and becomes ideal for the survival of numerous aquatic species.
- Estuaries are most heavily populated areas throughout the world. They account for about 60% of the world's population living along estuaries and the coast.
- The vast mangrove forests on the sea-ward side of an estuary act as barrier for the coastal habitat to check the wind speed during cyclones and high velocity landward winds.
- Estuaries have an important role in absorbing, trapping and detoxifying pollutants. Thus, they act as a natural water filter.
- Estuaries with their wetlands, creeks, lagoons, mangroves and sea-grass beds are rich in natural resources including fisheries.
- They are deep and well protected. Hence, they are ideal locations for the construction of ports and harbours.
- The banks of estuarine channels form a favourable location for human settlements, which use the estuaries for fishing and commerce.
- Estuaries perform an important role in the economic survival and development of coastal communities. In the historical past people settled

around estuaries as they were rich and productive places which offered humans opportunities for food requirements as well as trading needs.

- Estuarine ecosystems perform a critical role in supplying services to enhance the quality of human lives. There are very dynamic and productive deep estuaries supplying plenty of access for ships and abundant fish harvests.
- Estuaries also have a provisioning role as they provide food and building materials to nearby households.
- Estuarine ecosystems produce plants and animals that are used directly by people. For example, plants such as reeds, sedges and mangroves are also produced in quantities that can be harvested and used for house construction.
- The floodplains adjacent to estuaries can be used as places that cattle can use for grazing.
- The vegetation, such as mangroves trees, sedges and reeds, grow in and around estuaries. They are an excellent source of poles and fibres that can be used in household construction, particularly for low-income households. For example, they can be used for building the walls of huts when bricks are not available or too expensive. Some mangroves are also used for roof-poles. There are poor households which sell these housing materials to generate income for them.
- Estuaries are an excellent source of fisheries which can be utilised for subsistence purpose as well as for commercial purposes.
- **Storehouse of Medicinal Plants:** There are diverse varieties of medicinal plants which grow in and around estuaries. They have become an important source of traditional medicine. For example, the roots and stem of Barringtonia racemosa or the Powder-puff Tree has high medicinal value. They are used to treat fever, stomach aches, and skin diseases.
- **Storehouse of Ornamental Plants:** A number of native plants found in and around estuaries which can be used for ornamental or landscaping purposes in gardens. For example, the Pondoland Coconut Palm is a rare palm in South Africa. It grows on the Mtentu and Msikaba Estuaries. This palm is used in gardens and as a street tree. Hence, estuaries provide a significant source of plants and seeds for landscaping.

- **Cultural and Religious Significance:** Estuaries also have immense cultural and religious significance. There are a good number of cultures and religions which give spiritual or religious values to natural areas like estuaries. For example, the Christians use estuaries for performing baptism ceremonies. Likewise, the Hindus perform cremation (Shraddha ceremonies) for dead persons on the banks of estuaries.

- Estuary ecosystems have a dynamic ability to regulate the impacts of environment on society. Such impacts could be either from man-made impacts, such as pollution, or from natural disasters. There are services such as the regular flushing of estuaries associated with tidal ebb and flow. Estuaries also perform the role of supply services such as waste discharge dilution and disease control. As estuaries are one of the most productive ecosystems they have very rich plant growth which helps in prevention of erosion protecting the adjacent built infrastructure.

- **Role in Disaster Reduction:** Estuaries also have a role in disaster reduction. They have a dynamic ability to minimize disasters such as floods, coastal storm surge, pollution events and high winds. The estuaries absorb these high energy events. Thus, they limit their volatile impacts on built infrastructure and human life rendering very valuable services to society. Thus, healthy and dynamic estuaries are act as risk-reduction assets.

- **Climate Management:** Nature has an inbuilt sustainability structure. It plays an important role in regulating the global climate by moderating temperature fluctuations and maintaining existing rainfall patterns. One of the major routes through which this regulation takes place is via carbon sequestration. Carbon sequestration is the process of taking carbon from the atmosphere and fixing it in plant tissues or underground in the soil thereby reducing the load of carbon in atmosphere. It has an immensely consequential role in moderating temperature. The estuarine vegetation such as mangrove swamps takes the carbon out of the atmosphere. It also gives an additional opportunity of earning revenue from the supply of this ecosystem service through the carbon trading market.

- The estuaries also have a role in regulating local climate, particularly in moderating temperature extremes (which can be fatal at times). The vegetation around estuaries is able to reflect and absorb a significant amount of sunlight, thereby reducing day time temperatures. The water in the estuary keeps the temperatures on land stable.

- **Critical role in promoting soil stability:** They have a role in soil stability. Estuaries are situated at the interface between inland rivers and the ocean. This a very dynamic zone where rivers, tides, and strong winds erode the surrounding landscapes. The estuarine vegetation plays a very important role in preventing soil loss because of erosion processes. This is a critically important ecosystem service as it saves the possible cost of repairing infrastructure, such as buildings and roads, when eroded embankments collapse.

- **Act as lifeline for beaches:** Soil erosion is natural process which is vital for landscape processes, such as beach formation. Estuaries play a significant role as a supplier of sediment from inland regions to the coastal zone. For example, beaches critically need regular supplies of sand to avoid shore line erosion and even the loss of beaches. By this mechanism, estuaries help to maintain the main tourist attractions, i.e. beaches in many coastal towns and cities.

- The water quality in estuaries and the near-shore is adversely affected by the large number of wastewater treatment works, industries, and stormwater drainage, which discharge wastewater into rivers. The plants (like algae), which are available in the vicinity of estuaries, take up excess nutrients (e.g. nitrates) which they need in order to grow. This makes the water cleaner for people to use thereby helping to maintain the dynamic character of river ecology. The diatoms present in estuaries are able to assimilate the pathogens or parasites that can have adverse impact on the health of people. This mechanism saves the people from serious water-borne diseases.

- Estuaries also play a critical role in diluting the wastewater effluent discharged into rivers. This makes the water safe to a point where people can be in contact with the waste. If the estuary is an open system, the tides play a significant role in diluting and regularly flushing out the waste that is carried into estuaries. This is a critically important as magnified concentrations of wastewater also reduce the amenity value of the estuary and surrounding area for tourist purposes.

- **Critical role in Flood Control:** Estuaries have an important role in flood control. They are naturally suited to creating an obstacle in the path of floodwaters due to their good vegetation cover and unique landscape features. Hence, it is vital to maintain good vegetation cover on the fringes of estuaries in order to have flood control. In this way, coastal towns and infrastructure can have

protection from floodwaters which also avoids the cost of repairing damaged infrastructure.

- Estuaries also have an important role in pest control. Estuaries provide a shelter to many natural predators like snakes, spiders and birds, which control these pest populations.

- Estuaries also have a role in fire control. It is being held that "estuaries can act as natural fire breaks, preventing runaway fires from spreading. The thick woody vegetation on the fringes of estuaries also limits the extent of fire damage due to their low fuel loads".

- The good vegetation cover and unique landscape features of estuaries have a vital role in reducing the impacts of the coastal storms surges. For example, mangrove forests are able to absorb the extraordinary high tides and unusual waves which are associated with coastal storms. This plays a role in reducing damage to inland infrastructure. This is a well-documented fact as exemplified by the less damage done to coastal areas with deep mangroves cover during the 2004 Indian Ocean tsunami as compared to adjacent coastal areas without the natural protection of mangroves cover.

- There has been a perceptible decline of pollinators such as bees around the world. The vegetation cover in the vicinity of estuaries gives shelter to a variety of species including pollinators. For example, the roots of mangrove forests provide an important nursery for a number of coral reef fish species. Estuaries also help the tourism industry by sheltering many of the coral reef fish species which are sources of attraction for divers and fisherman to coral reefs. Estuaries also play a role in fundamentally helping the commercial fishing industry by providing nurseries for a number of commercial fish species.

- Have immense tourism potential: An aesthetic value is attached with the estuaries which catalyses its tourism potential. The estuaries also provide important avenues for photography, art, advertising, architecture and national heritage. They are natural quiet places for people seeking solitude as well as recreation. Thus, they are good for tourism.

- **Part of natural heritage:** Estuaries are also important as part of natural heritage. In India and in other countries as well supreme value is given to the maintenance of elegance of historically important landscapes and culturally significant locations. Estuaries are critically significant because they are a part

of rich natural heritage and they give a natural habitat to many vital endemic and endangered species. It becomes doubly significant that estuaries are protected, nourished and nurtured not only for the current generation, but also for future generations to enjoy following a sustainable development ethics.

Conclusion

The estuaries have a multi-dimensional role and are vitally important. They render invaluable ecosystem services from climate management via carbon sequestration to disaster risk reduction. They also have immense cultural and aesthetic value. They are facing stress and strains as a result of increasing marine pollution. Hence, there is a need to control pollution in the estuarine environment by all the stakeholders concerned. The government needs to follow a calibrated approach towards tourism in the vicinity of estuaries as it is also creating stress in the estuarine ecosystem in multiple ways. The estuaries should be cared well by following sustainable development ethics in letter and spirit.

4.7 Mangroves

Mangroves are a variety of species of broad-leaved trees (10–40 feet high) lying in muddy creeks and tidal estuaries. They are located on the intermediate zone between the land and the sea and represent one of the best examples of ecotone. They require warm saline water and so they are situated along tropical coastlines. Mangrove plants survive in the saltwater zones between water and land.

Mangroves have a “complex salt filtration system” and complex root system to cope with salt water immersion and wave action. They are also adapted to the low oxygen conditions of waterlogged mud. Mangroves occur worldwide in the tropics and subtropics, mainly between latitudes 25° N and 25° S. They require high solar radiation to filter saline water through their roots. Hence, mangroves are confined to only tropical and sub-tropical coastal waters.

It has been found that there are about 80 different species of mangrove trees. Mangroves grow in areas with low-oxygen soil and in this soil slow-moving waters allow fine sediments to pile up. Mangrove forests only grow at tropical and subtropical latitudes near the equator as they cannot bear freezing temperatures. Mangrove forests serve an important role in stabilizing and reinforcing coastlands. In this way, they protect these coastlands from erosion that results from action of waves and tides that occur regularly. They act as a shield against storms. This capability of the mangrove forests has saved valuable property and countless lives around the world from imminent destruction.

Mangrove plants have several unique adaptations that allow them to survive in harsh environment. Mangroves are extremely important to the coastal ecosystems they inhabit. Physically, they serve as a buffer between marine and terrestrial communities. They protect coastlines from damaging winds, waves, and floods. Mangrove has an important role in improving water quality by filtering pollutants and trapping sediments from the land. They reduce coastal erosion.

Ecologically, they provide habitat for a diverse array of terrestrial and marine organisms. The area of mangroves has greater species diversity as it is the junction of terrestrial and marine ecosystems. They have very high salt tolerance and so some species which require this ambience also thrive upon mangroves. According to one of its oft-quoted definition, “Mangroves represent a

characteristic littoral (near the sea shore) forest ecosystem and they 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".

There are three important types of mangroves:

Red mangroves: They grow along coastlines and are the hardiest of the three major mangrove plant types.

Black mangroves: They are named so because of their dark bark. They usually grow at slightly higher elevations than red mangroves. They have access to more oxygen because the roots are more exposed.

White mangroves: They grow at higher elevations than red and black mangroves. Generally they do not have aerial roots. But sometimes there is unique growth of peg roots when oxygen is depleted due to flood.

Location of Mangroves

There are 15.9 million hectares of mangrove forests in the warm waters of tropical oceans all over the world. Along the Atlantic coast they are found from Florida till Argentina in a vast expanse. Mangroves grow on both the western and eastern coasts of Africa. They stretch into India, Burma, and south-east Asia. Mangrove forests are also common in New Zealand and Australia.

Mangroves in India

They are found in the following states and Union Territories in India: West Bengal, Odisha, Andhra Pradesh, Tamilnadu, Andaman and Nicobar Islands, Kerala, Karnataka, Goa, Maharashtra and Gujarat. India has just 3 % of the world's mangrove area. In India it is only scattered only in 4,740 square kms. The major concentrations of mangroves are in the Sunderbans delta and Andaman & Nicobar Islands. However, the mangroves are also found in the deltaic areas of Mahanadi, Godavari and Krishna river basins.

The Government of India formed an Indian Mangrove Committee in 1976. M.S. Swaminathan Research Institute, Chennai is also engaged in management of mangroves in states of Tamil Nadu, Andhra Pradesh and Odisha.

Importance of Mangroves

- Mangrove forests give sturdy support to the coastline by minimizing erosion from storm surges, currents, waves, and tides. The intricate root system of mangroves is unique as they allow them to shelter fish and other organisms in an ecologically benign environment. For example, the area of Sunderbans is the world's largest mangrove forest and they have wider species diversity. This biodiversity hotspot is home to 180 species of trees and plants growing within its marshy boundaries, the Gangetic dolphin, estuarine crocodiles, river terrapins, hawksbill turtles, horseshoe crabs and the famous Bengal tiger. They are a World Heritage site and the biggest carbon-sink in South Asia. They have an important role in carbon sequestration and hence climate management.
- Mangroves are the first line of defence against cyclones and rising seas. They also support coastal communities in multiple ways.
- Mangroves provide important nesting and breeding sites for fish and shellfish, migratory birds and sea turtles. This underscores their importance to coastal fishing communities. According to a global research, an estimated 80% of the global fish catch relies on mangrove forests either directly or indirectly.
- They soften the blow caused by tsunamis and cyclones. Mangroves stabilise and reinforce coastlines with their sturdy support by slowing erosion and provide natural barriers protecting coastal communities from increased storm surges, flooding and hurricanes. For example, the coastal areas with deep cover of mangroves witnessed less damage from the Indian Ocean Tsunami in 2004.
- About 20 percent of India's population lives on the coast. There are many big cities including Mumbai, Chennai, Puducherry, Thiruvananthapuram, Kochi etc. which lie on the sea shore. A robust and dense cover of mangrove forests can protect these areas, which are vulnerable both to sea level rise and to the more intense and frequent weather events caused by climate change.
- Mangroves also act as great carbon sinks. Some researchers at the global level have postulated that mangroves "isolate carbon at two to four times the rate of tropical forests like the Amazon and store three to five times more carbon per equivalent area than tropical forests".

- Mangroves are used for timber, mining, agriculture, harbour development and human settlements. Mangrove areas were used earlier for commercial shrimp farming. However, using mangrove areas for shrimp farming has proved to be unsustainable now-a-days.
- Mangroves are an ecosystem with multi-dimensional use. It is held that they are the “best form of coastal bioshield” as they perform a “critical role in reducing the impact of cyclonic storms, hurricanes and tsunami on human lives and properties”.
- It controls/reduces soil erosion. It magnifies fishery productivity of the adjacent coastal waters. This occurs as they act as a nursery ground for commercially important fish, prawn and crabs. Additionally, they supply organic and inorganic nutrients. They are also rich in biodiversity and act as habitats for wildlife.
- It is being held that “the physical environment lays the foundations and draw limits for how and where mangroves thrive, as ‘ecosystem engineers’ mangroves themselves are partially responsible for shaping their physical environment”.
- The highly intricate and very structured roots of mangroves promote the trapping of sediments (i.e. from rivers) and organic debris helping them to adjust with the sea level rise, making them invaluable in promoting climate resilient coasts.
- Mangroves create an excellent diverse habitat as they combine animal species of terrestrial and marine environment in a single ecosystem. Major groups range from insects, molluscs and crustaceans to fish, reptiles, birds and mammals. Mangroves are rich in food and provide shelter to offshore species which use their complex structures as nurseries. Mangroves also provide terrestrial habitat for many species. For example, the vast mangroves of the Sundarbans currently host the largest intact tiger population in the world.
- Mangroves have a seminal role in the ecosystem as they nurture and nourish biodiversity as nursery grounds for many coastal and marine species and support fisheries.

Need for Conserving Mangroves

- Mangroves are immensely beneficial but unfortunately half of the world's mangroves (about 32 million hectares) have already been cleared or destroyed and the remaining ones are also facing grave threat.
- Mangroves are faced with a lot of threats. For example, a large part of land has been cleared for establishing shrimp farms in Latin America and Southeast Asia which have adversely impacted mangroves. Climate change, changing land-use patterns and tourism also affect the future of the mangrove plant.
- A serious impediment to the unhindered growth of mangroves is prompt and mostly unregulated coastal development. Although India has framed laws to protect its coastline, they are breached quite often. According to a research by the Indian Institute of Science, "India has lost 40% of its mangrove area in the last century, mainly due to agriculture, aquaculture, tourism, urban development and overexploitation".
- The State of Forest Report 2017, released by the Forest Survey of India, says that "the mangrove cover in the country is increasing only marginally in the past two decades and now covers some 4,921 sq.km". These facts very clearly illustrate that there is a lot to be done as far as the sustainable management and conservation of mangroves is concerned. There is an urgent need to restore degraded mangroves by the governmental action as well as participation of local communities.
- Many countries have realized the immense value of mangroves to the overall environmental sustainability. They have adopted mangrove restoration and conservation programs. Strict legislation to protect mangroves is in place in many countries. For example, Indonesia has 25 percent of the world's mangrove population. Coastal fish farmers on the Indonesian island of Java are given 4–5 hectares of land. However, the rider is that these farmers are required to plant mangroves on 20% of this land. Seeds are gathered from budding sprouts and planted 6 to 9 feet apart. This sort of reforestation improves the environment, while feeding people and encouraging the economy. This is a sustainable long term solution devised in Indonesia.
- Many Mangroves sites are protected under the Ramsar convention at the global level. The IUCN and The Nature Conservancy have laid down a global scientific map for the purpose of mangrove restoration. It is being held that

two billion hectares of deforested and degraded lands worldwide have the potential for forest landscape restoration and this well-calibrated potential for restoration is related to climate change adaptation and mitigation – including priority areas for mangrove restoration.

- The mangrove forests are important for food, carbon storage and sequestration, coastal protection, tourism and water purification. Hence, there are efforts made to halt further losses as well as to increase mangroves through restoration.
- The organizations like the Global Mangrove Watch are working tirelessly towards mangroves conservation. It is providing mangrove extent at multiple points of time from the mid-1990s to the present day. It is being postulated that "this time series of mangrove extent will allow us to identify areas of recent mangrove loss, with the assumption that recently converted areas are more restorable than those that were lost long ago".
- The organization has outlined the **following factors** contributing towards mangrove degradation: Urbanisation and industrial development, Conversion to agriculture and aquaculture ponds, Deforestation for fuelwood or timber, Rapidly changing patterns of freshwater regimes, Pollution and coastal erosion.
- The scientific studies have found that large areas in Southeast Asia were converted into shrimp cultivation ponds but they were later abandoned. The Global Mangrove Watch in its study has found that these ponds can be major areas of mangrove restoration.

Adaptation Mechanism of Mangroves

Mangrove environment is very vital and robust. The mangrove species are adapted to deal with these severe environmental conditions in multifarious ways.

Breathing roots: Oxygen for the purposes of respiration is needed by the underground tissue of any plant. As far as the mangroves are concerned, oxygen in the soil is in very limited supply. This means that the mangroves take up oxygen from the atmosphere. For this purpose, mangrove species have specialized above ground roots called breathing roots or pneumatophores. These roots have numerous pores through which oxygen enters into the underground tissues. In some plants buttress roots function as breathing roots and also provide mechanical support to the tree.

Stilt roots: In some mangrove species, roots emerge from stems and branches. Such roots get into the soil some distance away from the main stem as in the case of banyan trees. These stilt roots are endowed with many pores through which atmospheric oxygen enters into the roots.

Vivipary: It is postulated that “saline water, unconsolidated saline soil with little or no oxygen is not a conducive environment for seeds to germinate and flourish. To overcome this, mangrove species have unique way of reproduction, which is generally known as vivipary”. This is a very unique method of reproduction. In this method, seeds germinate and develop into seedlings while the seeds are still attached to the parent tree. These seedlings are normally known as propagules. They photosynthesize while still attached to the mother tree. The parent tree supplies water and necessary nutrients. They remain buoyant and float in the water for sometime before rooting themselves on suitable soil.

Role of gender equity in mangrove conservation and restoration

It has been a realistic experience that climate change and issues of water and food security have a gender dimension that cannot be overlooked. Likewise, the complex issue of mangroves conservation also have a gender dimension. Women and men in coastal communities are inextricably inter-connected to their coastal ecosystems with pre-defined gender roles. There is a clear demarcation line of gender roles. Women and men relate differently as to “how

they interact and depend upon mangroves – how they use the ecosystem, which mangrove products they choose, and the benefits they receive".

Mangrove forests have abundance of directly harvestable seafood, timber, firewood and other plant products such as tea and roofing materials. The coastal communities are directly dependent on products and services obtained from mangrove forest ecosystems especially in developing countries.

Unfortunately, there has been unsustainable use of mangrove forests leading to its reckless overexploitation and destruction. The impacts of disappearing mangroves have been particularly adverse to the lives and livelihoods of the local coastal communities. It is being acknowledged that local coastal communities have a key role in global mangrove conservation efforts. Being a key stakeholder in this regard, local coastal communities provide critical inputs towards mangrove conservation.

There is a need to acknowledge the differential roles women and men play in any conservation initiative and this applies equally well to mangrove conservation initiative. We can ill-afford to overlook the differentiated inputs and impacts women could make in the conservation effort as they are more integrated to the local ecosystem. However, women are generally over-looked in mangrove conservation efforts as they have less socio-economic and political power in the entrenched inequitable societal structures marked by the over-arching influence of patriarchy. Women can also be overlooked as they have less decision-making powers.

However, it is fortunate that a gender-responsive approach is being mainstreamed into conservation efforts of mangroves. The IUCN's Global Gender Office has been highly appreciative of this approach and says that "gender equality is central to sustainable global environmental solutions" in a range of issues. The IUCN and other organisations are working in the field of mangroves conservation with a gender-responsive approach. For example, **Mangroves for the Future (MFF)** is an initiative co-chaired by IUCN and the United Nations Development Programme (UNDP). It is held that the organisation is "running mangrove restoration and sustainable development projects with gender integration as a core strategy in several Asian countries. Participatory, community-based project approaches ensure that women's and men's voices are considered equally and aim to improve women's social and economic empowerment".

Some projects run by MFF have supported women by giving sustainable livelihoods and financial leadership training. This fortunately gives women with alternative livelihoods and income-generating opportunities. For example, where women have received training on the advantages of cultivating mangrove plants, the resulting increases in fish stocks have provided an additional income opportunity. Additionally, their newly acquired financial skills have given them magnified levels of business success.

Another example of gender-sensitive approach in conservation efforts is found in Vietnam. It is held that "in Vietnam, gender integrated management in Xuan Thuy National Park allowed local impoverished fisherwomen to build sustainable livelihoods while actively contributing to the park's conservation". Before these women were integrated into this effort they were dependent on increasingly scarce harvests of shells, molluscs and crabs which were gathered illegally within the park's mangrove forests. But their proper mainstreaming into the park's mangrove conservation efforts is now a win-win situation for all stakeholders.

The Guyana Mangrove Restoration Project is another bright example. It saw women take a central leadership role with their efforts to increase the resilience of Guyana's coasts against flooding and coastal erosion. Women were most severely impacted upon by coastal flooding and erosion of Guyana's coast. Women were provided with resources for economic empowerment and capacity building trainings. As a result of these positive measures, women got positively involved with various activities like honey production, tourism activities and mangrove cultivation. The active participation of women catalysed the formation of a women-led volunteer organisation for mangrove awareness and restoration as well as the 'Mangrove Cooperative Society' to support other women with training and resources on activities like beekeeping.

All these positive examples show that integrating gender equality into conservation initiatives promotes the success and sustainability of projects. This can also contribute additional value to its outcomes in supporting both women and men with various benefits for their homes, communities and nations. It is postulated that "a gender integrative approach recognises women not as passive project beneficiaries, but as active drivers of change toward conservation, sustainable development and their own sustainable livelihoods".

Mangroves Conservation and Sustainable Development Goals (SDGs)

Nurturing and nourishing mangroves helps fulfil multiple objectives like improving the life of aquatic animals, reducing poverty and hunger, enhancing the quality of life of coastal communities etc. The importance of restoration and protection of mangroves is amply reflected in Sustainable Development Goal (SDG) 14 (which focuses on sustainably governing our oceans and coasts and recognises mangroves' immense value to local communities). But restoring mangrove forests also supports the achievement of many other SDGs like:

- Eliminating poverty and hunger (SDG 1 and SDG 2),
- Ensuring livelihoods and economic growth (SDG 8),
- Taking actions against climate change impacts (SDG 13) and
- Halting biodiversity loss (SDG 15).

They do so in numerous ways. The mangroves have very rich species diversity. For example, India's mangroves are home to 4,011 species (the highest in the world). The mangroves give sufficient and nutritious food to local coastal communities. This becomes particularly useful to poor and vulnerable populations.

Various income-generating opportunities are offered by mangroves. The sustainable harvest of mangrove products meant for market sales present business opportunities for local communities. This benefits women, native tribes, farmers, pastoralists etc. These local income opportunities can be enhanced through the creation of management and planning jobs involved in restoration projects.

Mangrove forests are important in climate management as they are "carbon-rich protective buffer zones between land and sea". The restoration of mangrove forests is directly related to goals which are in sync with climate adaptation and mitigation. The mangroves should be restored in order to promote the resilience of coastal communities from various climate-induced threats. It is held that "mangrove restoration sites can also be strategically placed to contribute to upgrading infrastructure with greater adoption of environmentally sound technologies through applying infrastructures for coastal protection". In this way, the resilience of coastal communities can be

magnified by minimizing their exposure to climate-induced environmental shocks and disasters.

It has been acknowledged time and again that mangroves are extremely "efficient carbon sinks". Hence, well-calibrated actions meant for mangrove restoration efforts help in adapting to adverse impacts of climate change. Various scientific studies have attested the importance of restoration of mangroves in smart climate management.

There is a need for an integrated approach to mangrove restoration. By this approach the local coastal communities can emerge as participatory stakeholders in the process of mangrove restoration. The local people can have sustainable development lifestyles in harmony with nature and can also help the government in promoting sustainable tourism. This will also enhance eco-friendly business opportunities for local communities in multiple ways.

The restoration of mangroves helps in addressing the following components of SDGs (directly or indirectly):

- By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters.
- By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.
- By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.
- By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value.
- Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species.

- By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products.
- By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.
- By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.
- Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries.
- Integrate climate change measures into national policies, strategies and planning.

Role of the IUCN and the Global Mangrove Alliance in Mangroves Conservation

The world is facing the loss of mangrove forests with alarming rapidity. It is estimated that 50 percent of our mangroves have disappeared during the last five decades. Every year there is a loss of another 1 percent of mangroves which is enough to highlight the seriousness of mangrove destruction. It is postulated that at this rate all unprotected mangroves could disappear in the next century. The organization Global Mangrove Alliance (GMA) is supporting the target of increasing mangrove coverage by 20 percent over current extent by 2030. However, it needs to be acknowledged that it is an overly ambitious goal. In order to come to fruition, this requires collaborative partnership among all the stakeholders connected with the mangroves.

There have been some positives made in recent times in the field of mangrove conservation. However, we need to accelerate the conservation efforts to reverse the rate of global destruction which has already demolished 50 percent of mangroves in the world. Hence, various organizations are working in a collaborative framework towards conservation. Towards this end, the IUCN has partnered with Global Mangrove Alliance. According to the IUCN Director General, this is “an alliance that represents a renewed spirit of collaboration and one that will help the international community achieve our target to expand mangrove habitat by 20% by 2030”.

The IUCN has a critical role to play in mangrove conservation as well as restoration. It is the critical link in the club of various organizations working towards mangrove conservation. It has a broad "portfolio of global mangrove work and a history of engaging governments, civil society organizations, experts, and local communities to enable the creation and implementation of solutions to a wide range of environmental challenges". The scientific experts say that the partnership between the IUCN and the Global Mangroves Alliance (GMA) is going to work well as the IUCN comes to the GMA with prior experience in developing and co-chairing Mangroves For the Future (MFF). The MFF is an initiative in Asia and the Pacific that promotes coastal ecosystem conservation.

IUCN has been the driving force behind the restoration movement through the Bonn Challenge. It is a global effort to bring 150 million hectares of degraded and deforested landscapes (including mangroves) into restoration by 2020 and 350 million hectares by 2030. As per the IUCN, "Currently, 44 governments, private associations and organisations have committed 156.05 million hectares to the Bonn Challenge".

The need for collaboration and new partnerships is very much evident as human activity continues to destroy mangroves in various ways. The coastal communities face amplified threats due to climate change, coastal migration, and unsustainable development and fishing practices.

The organizations like the Wetlands International also have reasonable experience in allying with various stakeholders in mangroves conservation. In league with few other organizations it has partnered with the IUCN and the Global Mangrove Alliance (GMA) to work towards mangrove conservation.

Conclusion

We rely on mangroves for coastal protection, food, disaster reduction and carbon storage. Hence, there is a need to work together to address the serious threats to mangrove forests and enable stakeholders like governments, NGOs and coastal communities to sustainably manage them. We need to understand the preciousness of these coastal ecosystems in letter and spirit and work accordingly towards its conservation.

4.8 Coral Reefs and Coral Bleaching

Coral reefs are composed of multitude of tiny animals called coral polyps. These polyps are shallow water organisms with a soft body covered by a skeleton (which has contents of calcium carbonate). The polyps extract calcium salts from sea water to form these hard skeletons. The polyps live in colonies which are attached to the rocky sea floor. The skeletons have a tubular structure which grows upwards and outwards in the form of cemented rocky mass (with calcium carbonate contents) called corals.

When these coral polyps die, they discard their skeletons on which new polyps grow. The cycle is repeated for over millions of years leading to accumulation of layers of corals. The resultant shallow rock created by these depositions is called reef. These layers at different stages actually give rise to various marine landforms. One such important landform is called coral reef. Coral reefs over a period of time metamorphose into coral islands (e.g. Lakshadweep island in India).

Corals have a symbiotic relationship with the single cell algae known as Zooxanthellae. Zooxanthellae live symbiotically within the coral polyp tissues and assist the coral in nutrient production through its photosynthetic activities. These activities provide the coral with fixed carbon compounds for energy increasing calcification.

The host coral polyp in return provides its zooxanthellae with a protected environment to live within. Plus, the coral polyps provide an assured supply of carbon dioxide for the photosynthetic processes of zooxanthellae. The corals receive their coloration from the zooxanthellae living within their tissues.

Coral reefs are one of the most diverse ecosystems. They soak a large amount of carbon-dioxide and are often called “the rainforests of the sea”.

Corals have flexibility in their reproduction procedures. They are naturally endowed with multiple reproductive strategies as they can be male or female or both, and can reproduce either asexually or sexually. Asexual reproduction is important for increasing the size of the colony, and sexual reproduction increases genetic diversity and starts new colonies that can be far from the parents.

Different Relief Features of Coral Reefs

Fringing reef, barrier reef and atoll are the most important relief features. Coral islands are formed on atolls.

Fringing Reefs

Fringing reefs are reefs that grow directly from the coast. They are located in close proximity of the land. They often form a shallow lagoon between the beach and the main body of the reef. A fringing reef runs as a narrow belt. This type of reef grows from the deep sea bottom. Coral polyps do not extend outwards because of sudden and large increase in depth. The fringing reef is by far the most common of the three major types of coral reefs, with numerous examples in all major regions of coral reef development.

Barrier Reefs

Barrier reefs are extensive linear reef complexes that lie parallel to the coast, and are separated from it by lagoon. This is the largest of the three reefs in size (It is not the largest in terms of distribution). They run for hundreds of kilometres and width also goes for several kilometres. It extends as a broken, irregular ring around the coast or an island, running almost parallel to it.

Barrier reefs are far less common than fringing reefs or atolls. The Great Barrier Reef off the coast of Australia is the world's largest example of this reef type. It is a very large complex consisting of many reefs.

Atolls

An atoll is an approximately circular oceanic reef system surrounding a large and quite often central lagoon. The lagoon has a depth 80-150 metres and may be joined with sea water through a number of channels cutting across the reef. Atolls are located at great distances from deep sea platforms, where the submarine features may assist in formation of atolls.

Atolls are far more common in the Pacific than any other ocean. The Fiji atoll is a well known example of atolls. A large number of atolls also occur in the Lakshadweep Islands in India. In the South Pacific, most atolls occur in mid-ocean. Examples of this reef type are common in French Polynesia, the Caroline and Marshall Islands, Micronesia, and the Cook Islands.

The Indian Ocean also contains numerous atoll formations. Examples are found in the Maldives and Chagos island groups, the Seychelles, and in the Cocos Island group.

Coral Reefs in India

They are found in following areas in a major way in India:

- Andaman and Nicobar Islands (the highest coral reef area in India).
- Kutch Region (Gujarat)
- Gulf of Mannar
- Lakshadweep islands.

Apart from these areas, they are also found in some areas of Maharashtra and Karnataka.

Suitable Conditions for Coral Growth

- **Balanced climatic conditions:** Corals are highly sensitive to quick temperature changes. They grow in regions where climate is significantly stable for a long period of time.
- **Constant warm waters:** Corals actually flourish in tropical waters (30°N and 30°S latitudes). The tropical waters have very narrow diurnal and annual temperature ranges. The temperature of water around 20°C is considered to be ideal for the growth of coral formation. This is the reason that corals are absent on the west coast of tropical continents as they do not thrive there under the cold ocean currents because of their preference for warm waters.
- **Shallow water:** Coral require fairly good amount of sunlight to survive. The ideal depths for coral growth are 45 m to 55 m below sea surface, where there is abundant availability of sunlight.
- **Clear salt water:** Clear salt water is very suitable for corals to thrive. However, both fresh water and highly saline water create adverse conditions for coral growth.

- **Plentiful Plankton:** Sufficient supply of oxygen and phytoplankton is vital for growth of corals. As the plankton is more plentiful on the seaward side, corals grow swiftly on the seaward side.
- **Negligible pollution:** Corals are highly delicate and are very sensitive to climate change and pollution. So, even a slight increase in marine pollution can be catastrophic.

Coral Bleaching

Coral Bleaching is the ecological damage/degradation of coral reefs as a result of natural and man-made factors. In recent times, coral bleaching has increased with alarming rapidity. This increase has been largely because of "anthropogenic impacts like overexploitation, overfishing, increased sedimentation and nutrient overloading in water".

There are natural disturbances which cause damage to coral reefs. Such disturbances are violent storms, flooding, high and low temperature extremes, El Nino Southern Oscillation (ENSO) events etc.

Coral reef bleaching is a common stress response of corals to many of the various disturbances. Bleaching occurs when the densities of zooxanthellae reduce. It also occurs when the concentration of photosynthetic pigments within the zooxanthellae fall. It is held that when corals bleach they commonly lose 60-90% of their zooxanthellae and each zooxanthellae may lose 50-80% of its photosynthetic pigments. However, if the disturbing factor is not severe and its impact reduces over time, then the affected corals usually regain their symbiotic algae over a period of time. However, if zooxanthellae loss is prolonged over a period of time in which degradation of zooxanthellae is beyond recovery, the coral host eventually dies.

Coral Bleaching because of ecological causes

- **Temperature**: Magnified levels of sea-surface temperatures because of climate change related factors as well as warm El-Nino events are the main reasons behind coral bleaching. Coral species live within a relatively narrow temperature range. They cannot thrive in extremely high or extremely low sea

temperatures. Corals are not present on the west coast of tropical temperate continents because of the cold ambience created by cold currents. Extreme temperature conditions induce coral bleaching. Bleaching events occur during sudden temperature drops accompanying intense upwelling episodes (El-Nino) and seasonal cold-air outbreaks. Coral bleaching has occurred mostly during the summer seasons or near the end of summer season with elevated temperature scenario. For Example, the bleached corals in the Gulf of Mexico are the result of increased water temperatures.

- **Ocean Acidification**: As a result of intense global warming, there has been increased presence of carbon in oceans catalysing elevated levels of ocean acidification. While the rising temperatures have increased the frequency and intensity of bleaching, acidification has decreased calcifying ability of corals. It is also postulated that "by 2085 ocean conditions will be acidic enough for corals around the globe to begin to dissolve" as per scientific predictions.

- Coral bleaching also occurs during times of low wind velocity, clear skies, calm seas and low turbidity. These conditions favour localised heating and high ultraviolet (UV) radiation. UV radiation readily penetrates clear sea waters. The corals actually contain UV-absorbing compounds which can block potentially damaging UV radiation. But rising temperatures mean reduction in the concentration of these UV absorbing compounds in corals.

- **Dilution of fresh water:** Quick dilution of reef waters from storm-generated precipitation and runoff also cause coral reef bleaching.

- **Increased concentrations of inorganic Nutrients:** An enhanced level of ambient elemental nutrient concentrations like ammonia and nitrate actually increases zooxanthellae densities many times. It causes secondary adverse effects such as lowering of coral resistance and greater susceptibility to diseases.

- When corals are exposed to high concentrations of chemical contaminants like copper, herbicides and oil, coral bleaching happens.

- Coral reefs are also threatened by invasive species like the lionfish. The lionfish is native to Indo-Pacific waters having a rapidly growing population in waters of the Atlantic Ocean. It is reported that the lionfish could potentially impact coral reef ecosystems. This could happen through consumption of and competition with native coral reef animals.

- Even activities like deforestation threaten coral reefs. Deforestation quickens the pace of soil erosion which increases the load of sentiments into seas adversely affecting coral reefs.

Thus, the major causes of coral bleaching are temperature changes and ocean acidification (both causes have gained prominence because of global warming). However, coral bleaching can also occur because of diseases, pollution from urban or agricultural run-off, changes in the salinity of seawater, sedimentation from undersea activities like dredging etc.

Effects of global coral bleaching

Coral reef ecosystems are less than 0.1% of the ocean area but provide food and shelter to 25% of all marine species. They support fish stocks on which some 500 million people are dependent globally. Coral reefs make up less than 1 percent of Earth's undersea ecosystems, but they are important in the following ways:

- They shelter 25 percent of marine species,
- Protect shorelines,
- Support fishing industries,
- Provide income through tourist activities.
- Could prove to be the avenue of the next big, undiscovered medical breakthrough as many medicinal plants are present there.

Thus, the degradation of corals is a bad news not only for marine ecosystem but also for humans and larger biodiversity. It will adversely impact fisheries sector, coastal ecosystem, tourism potential and possible medicinal plants in the oceans.

Conservation of Coral Reefs

Coral reefs are one of the most resilient parts of the ecosystems. Hence, coral bleaching cannot be permanent and it can be reversed. There are some healthy reefs which are called "resilient reefs" as they are capable of coming back to life again.

In India the Zoological Survey of India has opened the National Coral Reef Research Institute in Port Blair, Andaman and Nicobar Islands. The Government

of India is taking the help of Australian government to get scientific and technical know-how regarding the intricacies of coral reef conservation.

There are also organisations like the Global Coral Reef Monitoring Network and International Coral Reef Initiative. The organisations like Nature Conservancy have been working for promoting reef resilience. They also share their science-based strategies and on-the-ground experience with partner organizations and local reef practitioners within the larger coral reef conservation programme. They also play a key role in enlisting the vital support of local communities towards conservation efforts. They also coordinate with countries to "establish resilient marine protected area networks" by integrating the design of reef resilience into marine parks. They are also keen to implement better tuned bleaching response plans.

Healthy coral reefs play a seminal role in the reduction of carbon footprint. They play a seminal role in keeping greenhouse gases out of the atmosphere contributing its worth in combating climate change and maintaining appropriately cool ocean temperatures. Hence, their conservation is a must. However, the issue of conservation cannot be left with the government alone. Various stakeholders like environmental NGOs, environmental organisations/institutions, local communities and common citizens can also contribute their worth towards conservation of coral reefs. Marine protected areas (MPAs) are an important tool for keeping coral reefs healthy. Large MPAs protect the Great Barrier Reef of Australia.

Citizens should do the following things towards this end:

- Support Afforestation plan. Trees store carbon and reduce agricultural run-off, which may ultimately end up in the ocean.
- Aware citizens should work with the local-self government institutions and NGOs to conserve reefs.
- Citizens should put pressure at the political level on legislatures to enact comprehensive climate legislation.
- Wealthy citizens should also come up with financial help for NGOs/organizations working in the field.
- Try to promote sustainable energy usage to reduce carbon footprint.

Conclusion

Coral reefs are also very significant to people. They have immense value in providing food, protection of coastlines, jobs based on tourism, and even medicines. Unfortunately, people also pose the greatest threat to coral reefs. Overfishing and destructive fishing, pollution, warming, changing ocean chemistry, and invasive species are all the various factors disturbing the benign oceanic ambience of coral reefs. These factors immensely highlight that we should continue accelerated efforts towards reef coral conservation in the interest of a climate-resilient developmental journey of our planet.

5- ENVIRONMENTAL POLLUTION

5.1 Air Pollution Causes and Control

Air Pollution is defined as the presence of one or more contaminants in the atmosphere in such quantity and for such duration as is injurious, or tends to be injurious, to human health, animal or plant life.

Air Pollution Causes and Control

Air pollution in the present times is aggravated by the following factors viz., rapid economic development, industrialization, increasing traffic, and growing cities.

Major Air Pollutants and their Source

Carbon Monoxide

- Carbon Monoxide is a poisonous gas as it can cause death if present beyond a certain limit. It is produced by an incomplete combustion process in various industrial activities and in the engines of automobiles.
- If Carbon monoxide is present in our blood, it will combine with the oxygen in the blood thereby decreasing the amount of oxygen in the blood which is required for various metabolic activities in the body.

Carbon Dioxide

- It is the principal greenhouse gas emitted due to human activities such as the burning of coal, oil, and natural gas.

Chlorofluorocarbons

- Also known as CFCs or freons, these are the gases released mainly from air-conditioning systems and refrigeration.
- When released into the air, CFCs rise to the stratosphere where they come in contact with few other gases which leads to the depletion of the ozone layer that protects the earth from the harmful ultraviolet (UV) rays in the incoming solar radiation.

Lead

- It is present in petrol, diesel, lead batteries, paints, hair dye products etc.

- Lead affects children in particular. It can cause damage to the nervous system, digestive problems, and in some cases, even cancer.

Ozone

- It is a naturally occurring gas, usually found in the upper layers of the atmosphere, shielding the earth from sun's harmful UV rays.
- However, Ozone can be harmful if present at ground level.
- Vehicles and industries are the major sources of ground-level ozone.
- Ozone causes itching and burning sensation in the eyes, turns them watery. It lowers our resistance to cold and pneumonia.

Nitrogen oxides (Nox)

- They are responsible for smog and acid rain. They are produced by burning fossil fuels such as coal, petrol, and diesel.
- They make children vulnerable to respiratory diseases, especially in winters.

Particulate Matter Suspended in Air (SPM)

- The dust particle, water vapour and smoke present in the air are called SPM. SPM crates haze and reduces the visibility.
- SPM may also cause damage to the respiratory system of humans as these fine particles when inhaled during breathing can deposit in the alveoli.

Sulphur Dioxide

- It is produced mainly by the combustion of coal, such as in the thermal power plants.
- Some industrial processes such as the production of paper, smelting of metals etc., also produce sulphur dioxide.
- It is a major contributor to smog and acid rain. It can also cause lung diseases.

Smog

- Smog is a combination of the words fog and smoke. It is a condition in which fog gets mixed with soot or smoke.

- Photochemical smog is a condition where smog is formed at the ground-level due to the interaction of certain air pollutants with the sunlight. One of the primary components of photochemical smog is ozone. Ground-level ozone is formed when nitrogen oxides contained in the vehicular emissions interact with volatile organic compounds (VOCs such as those found in paints, solvents, printing inks, petroleum products etc.) in the presence of sunlight.
- Smog refers to hazy air that causes difficulty in breathing. It is a combination of various gases mixed with water vapour and dust. Its occurrence is linked to heavy traffic, high temperatures, and calm winds. During winter, wind speeds are low and cause the smoke and fog to stagnate near the ground; hence the pollution levels can increase near ground levels.
- Smoke particles trapped in fog give it a yellow/black colour and this smog often settles over cities for many days

Effects of smog include:

- hampering visibility and harm to the environment
- respiratory problems
- deaths related to bronchial diseases
- heavy smog reduced the UV radiation
- reduction in the production of vitamin D leading to a rise in the occurrence of rickets (deficiency disease of vitamin D)

Indoor Air Pollution

- Indoor Air refers to the physical, chemical and biological makeup of the air inside our home, office etc.
- It is a cause for concern when energy efficiency improvements sometimes make houses relatively air-tight, reducing ventilation and raising pollutant levels.
- Indoor air problems can be subtle and do not always produce easily recognizable impacts on health.

- Different conditions are responsible for indoor air pollution in rural and urban areas.
- Rural areas face the greatest threat from indoor pollution because more people rely on traditional fuels such as firewood, charcoal, and cow dung for cooking and heating. Burning such fuels produces a large amount of smoke and other air pollutants in the confined space of the house resulting in a high exposure. Women and children are the groups most vulnerable as they spend more time indoors and are exposed to the smoke. Four of the most serious pollutants identified in the smoke from biofuels include particulate matter, carbon monoxide, polycyclic organic matter, and formaldehyde.
- In urban areas, exposure to indoor air pollution has increased due to a variety of reasons such as the construction of tightly sealed buildings, reduced ventilation, use of synthetic materials for buildings and furnishing, use of chemical products, pesticides, and household care products. Indoor air pollution can begin within the building or be drawn in from outdoors. Nitrogen dioxide, carbon monoxide, lead etc. are important contaminants affecting the quality of air indoors.

Other Pollutants

Volatile Organic Compounds

- The source of VOC's are perfumes, hair sprays, furniture polish, glues, air fresheners, moth repellents, wood preservatives, and other products.
- Health effects include irritation of the eye, nose and throat, headaches, nausea and loss of coordination. Long-term effects can include damage to the liver and other parts of the body.

Tobacco

- Its smoke generates a wide range of harmful chemicals which can be carcinogenic.
- Health effects include burning sensation in the eyes, nose, throat irritation, cancer, bronchitis, severe asthma, and a decrease in lung function.

Biological pollutants

- They include pollen from plants, mite, hair from pets, fungi, parasites, and some bacteria. Most of them are allergens and can cause asthma, hay fever, and other allergic diseases.

Formaldehyde

- Mainly from carpets, particle boards, and insulation foam. It causes irritation to the eyes, nose, and allergies

Radon

- It is a gas that is emitted naturally by the soil. Since many modern houses have poor ventilation, it is confined inside the house and causes lung cancers.

Asbestos and Pesticides are other major sources of indoor pollution in urban areas.

Fly Ash

- It is a residue of coal combustion which tends to rise with other gases produced by the burning of coal. It is very fine powder and tends to travel far in the air.
- Composition – aluminium silicate, silicon dioxide, calcium oxide. The particles of fly ash are rich in oxides and consist of silica, alumina, oxides of iron, calcium, magnesium, and toxic heavy metals such as lead, arsenic, cobalt, and copper.
- Fly ash is collected by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal-fired power plants.
- Fly ash can cause many problems such as respiratory illnesses, contamination of soils and groundwater, affecting the leaves of crops in the vicinity of thermal power plants if it is not captured and disposed of properly.
- Fly ash has many advantages. It can be used as a replacement for cement, up to 35 percent, reducing the cost of construction. Fly ash bricks are light in weight and offer high strength and durability. It is a good filler material for road embankments and in concrete roads. It can be used in the reclamation

of wastelands. Abandoned mines can be filled up with fly ash. It can increase crop yields and also enhances the water holding capacity of the land.

Pollution control measures

- Destroying the pollutants by thermal or catalytic combustion.
- Conversion of the pollutants to a less toxic form. e.g., use of catalytic converters in automobiles.
- Particulate matter can be controlled by using arresters and scrubbers. Arresters are used to separate particulate matter from the contaminated air. Scrubbers are used to clean air from dust and gases by passing it through dry or wet packing material.
- Gaseous pollutants can be controlled by techniques of combustion, absorption, and adsorption. Automobile exhaust can be controlled by use of efficient engines (e.g., multi-point fuel injection engines), use of catalytic converter filters (to reduce nitrogen oxides to nitrogen), use of good quality fuels such as lead-free petrol, CNG etc.

National Air Quality Index

It was launched in 2015 starting with 14 cities to disseminate air quality information. The AQI has six categories of air quality viz., good, satisfactory, moderately polluted, poor, very poor, and severe with a distinct colour scheme. Each of these categories is associated with likely health impacts. AQI considers eight pollutants – PM10, PM2.5, nitrogen dioxide, sulphur dioxide, carbon monoxide, ozone, ammonia, and lead – up to 24 hourly average periods for which National Ambient Air Quality Standards are prescribed.

National Ambient Air Quality Standards (NAAQS)

They were first notified in 1982, revised in 1994 based on health criteria and land uses. The standards were revised again in 2009 to include 12 pollutants viz., sulphur dioxide, nitrogen dioxide, PM10, PM2.5, ozone, lead, carbon monoxide, arsenic, nickel, benzene, ammonia, and benzopyrene. The NAAQS prescribe the acceptable levels for each of these pollutants beyond which the air is considered to be polluted.

5.2 Water Pollution

Water pollution can be defined as the addition of certain substances to water which can be organic, inorganic, biological, radiological, heat etc., which degrade the quality of water so that it becomes unfit for use.

Water Pollution

Water pollution is not only confined to the surface but it has also spread to groundwater, as well as seas and oceans. Most of the major water bodies in cities are facing the brunt of the water pollution. Disposal of waste-water from industries, untreated waste from municipalities and solid waste dumping close to water sources has remained the major cause of water pollution.

Sources of pollution

They can be point sources or non-point sources. Point sources are those whose influence can be directly attributable. Here the pollutant travels directly from the source to the water body. Point sources are easy to regulate. Non-point sources are also known as diffused sources. They are difficult to attribute and can be many in number. They vary spatially as well as temporally and hence are difficult to regulate.

The following are the major sources of water pollution

Community wastewater: It includes discharge from domestic, commercial, and industrial establishments which are connected to the public sewerage system. The sewage contains human and animal excreta, food residues, cleaning agents, detergents and other wastes.

Industrial wastes: The industries discharge several inorganic and organic pollutants which may prove highly toxic to the living beings.

Agricultural sources: Fertilizers contain plant nutrients such as nitrogen, phosphorous, and potassium. Excess fertilizers may reach the groundwater by leaching or may get mixed with surface water bodies such as rivers, lakes, and ponds via drainage and runoff. Chemicals such as pesticides, insecticides, herbicides, fungicides, rodenticides, and soil fumigants contain harmful substances such as chlorinated hydrocarbons, organophosphates, metallic salts, carbonates, thiocarbonates, derivatives of acetic acid etc. Many of these chemicals are non-biodegradable and have a long residue life. Animal wastes

such as excreta from cattle, poultry farms, piggeries, and slaughterhouses can also reach the local water bodies through runoff and surface leaching during the rainy season.

Thermal Pollution: Major sources of thermal pollution are the thermal and nuclear power plants which use water as a coolant. They release the hot water after using it back to the original source. A sudden rise in the water temperature reduces the dissolved oxygen levels and kills many fish and other aquatic animals.

Groundwater Pollution: Groundwater is threatened with contamination due to seepage from industrial and municipal wastes, effluents, sewage channels, and agricultural runoff.

Marine Pollution: Oceans are the ultimate sinks of all natural and man-made pollutants. Rivers discharge their pollutants into the sea. The sewage and garbage of coastal cities mostly get dumped into the sea. Other sources of oceanic pollution include navigational discharges of oil, grease, detergents, ballast waters, sewage, garbage, radioactive wastes, and offshore oil spills.

Effects of Water Pollution

- Polluted water contains lower dissolved oxygen due to higher biological and chemical oxygen demand, which is needed to degrade the organic and inorganic pollutants present in the water, and can threaten or even eliminate sensitive organisms such as plankton, molluscs, and several species of fish.
- Hot waters discharged from industries lower the dissolved oxygen content and threaten the survival of several species.
- Biocides, polychlorinated biphenyls (PCBs) and heavy metals are highly toxic to aquatic species.

Effects on human health

- Polluted waters contain disease-causing pathogens such as viruses, bacteria, parasitic protozoa, worms etc. They are a cause of water-borne diseases such as jaundice, cholera, typhoid, amoebiasis etc.
- Mercury compounds in wastewater are converted by bacterial action into extremely toxic methyl-mercury, which can cause numbness of limbs, lips,

tongue, deafness, blurring of vision and mental derangement. They are known to cause the Minamata disease.

- Water contaminated with cadmium can cause itai-itai disease which is also called ouch ouch disease. It is a painful disease of bones and joints. It can also cause cancers of lungs and liver.
- The compounds of lead can cause anaemia, headache, loss of muscle power, and a bluish line around the gums.

Hazards of groundwater pollution

- Presence of excess nitrate in drinking water is dangerous for human health and may be fatal for infants. Excess nitrate in drinking water interacts with haemoglobin to form non-functional methaemoglobin which impairs oxygen transport. This condition is called methemoglobinemia or blue baby syndrome.
- Excess fluoride in drinking water causes neuro-muscular disorders, gastrointestinal problems, teeth deformity, hardening of bones and stiff and painful joints (skeletal fluorosis). High concentration of fluoride ions is present in drinking water in 13 states of India. The maximum level of fluoride, which the human body can tolerate is 1.5 parts per million. Long-term ingestion of fluoride ions causes fluorosis.
- Overexploitation of groundwater may lead to leaching of arsenic from soil and rock sources and contaminate groundwater. Chronic exposure to arsenic causes black foot disease. It also causes diarrhoea, peripheral neuritis, hyperkeratosis and also lung and skin cancer.
- Arsenic contamination is a serious problem in the tubewell dug areas of the Gangetic delta.
- Biological magnification and eutrophication.

Control Measures

- Treatment of sewage water and industrial effluents should be done before releasing them into water bodies.
- Hot water should be let to cool off before its release from the power plants.

- Domestic cleaning (of clothes and utensils) should be prohibited in water bodies which supply drinking water such as tanks, streams, and rivers
- Excessive use of fertilizers and pesticides should be avoided.
- Organic farming and efficient use of animal residues as fertilizers should be encouraged.
- Water hyacinth (an aquatic weed) can purify water by absorbing toxic materials and a number of heavy metals from water.
- Oil spills in water can be cleaned with the help of bigoli – a byproduct of paper industry resembling sawdust, oil zapper microorganisms.

5.3 Soil Pollution

The soil is a thin layer of organic and inorganic materials that cover the earth's rocky surface. It is the most important resource which makes life possible on the earth. The population explosion in the world in the last decade has increased the demand for food. This has lead to the exploitation of soil to produce more food by using harmful chemicals. Consumerism has increased the demand for Industrial products and the waste generated by these industries has been dumped indiscriminately in the soil. All these human activities has lead to an increase of soil pollution.

Soil Pollution

Addition of certain substance in soil degrades its physical, chemical and biological characteristics and reduces the productivity of the soil; this change is termed as soil pollution.

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. A soil pollutant is any factor which deteriorates the quality, texture, and mineral content of the soil or which disturbs the biological balance of the organisms in the soil.

Causes of Soil Pollution:

- Indiscriminate use of fertilizers, pesticides, insecticides, and herbicides.
- Dumping of large quantities of solid waste.
- Deforestation and soil erosion.
- Pollution due to Urbanisation.

Sources of Soil Pollution

- Industrial wastes: Industrial wastes include chemicals such as mercury, lead, copper, zinc, cadmium, cyanides, thiocyanates, chromates, acids, alkalies, organic substances etc.
- Pesticides: Pesticides are a broad category of chemicals that include insecticides, fungicides, algicides, rodenticides, weedicides, sprayed in order to improve the productivity of agriculture, forestry and horticulture.

- Fertilizers and manures: Chemical fertilizers are added to the soil for increasing crop yield. Excessive use of chemical fertilizers reduces the population of soil-borne organisms and the crumb structure of the soil, productivity of the soil and increase the salt content of the soil.
- Discarded materials: It includes concrete, asphalt, rungs, leather, cans, plastics, glass, discarded food, paper, and carcasses.
- Radioactive wastes: Radioactive elements from mining and nuclear power plants find their way into water bodies and then into 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 the weathering of certain rocks

Effects of Soil Pollution

On Agriculture

- Reduced soil fertility
- Reduced nitrogen fixation
- Increased erosion
- Loss of soil and nutrients
- Reduced crop yield
- Increased salinity
- Deposition of silt in tanks and reservoirs

On Health

- Dangerous chemicals entering the underground water.
- Biomagnification
- The release of pollutant gases
- The release of radioactive rays causing health problems

On Environment

- Reduced vegetation
- Ecological imbalance
- Imbalance of soil flora and fauna

On Urban Areas

- Clogging of drains

- Inundation of areas
- Foul smell and release of gases
- Problem of waste management

Control measures

- Reducing chemical fertilizer and pesticide use
- Use of biopesticides, biofertilizers
- Organic farming
- Four R's – refuse, reduce, reuse, and recycle
- Afforestation and reforestation
- Solid waste management
- Reduction of waste from construction areas

5.4 Noise Pollution

Noise pollution is an unpleasant noise created by people or machines that can be annoying, distracting, intrusive, and/or physically painful.

Noise Pollution

Noise pollution comes from sources such as “road traffic, jet planes, garbage trucks, construction equipment, manufacturing processes, leaf blowers, boom boxes” etc. Sound is measured in decibels (dB). An increase of 10 dB is approximately double the increase in loudness. A person’s hearing can be damaged if exposed to noise levels over 75 dB over a prolonged period of time. The World Health Organization recommends that sound levels indoors should be less than 30 dB.

Ambient Noise Level Monitoring

- Noise Pollution (Control and Regulation) Rules, 2000 define ambient noise levels for various areas as follows:

Category of Area/Zone	**Limits in dB (A) Leq**	
	Day Time	Night Time
	6 a.m to 10 p.m	10 p.m to 6 a.m
Industrial Area	75	70
Commercial Area	65	55
Residential Area	55	45
Silence Zone	50	40

- The Government of India in March 2011 launched a Real-time Ambient Noise Monitoring Network. Under this network, in phase – I, five Remote Noise Monitoring Terminals each have been installed in different noise zones in seven metros viz., Delhi, Hyderabad, Kolkata, Mumbai, Bangalore, Chennai, and Lucknow.
- In Phase II another 35 monitoring stations will be installed in the same seven cities. Phase III will cover the installation of 90 stations in 18 other cities.
- Phase III cities are Kanpur, Pune, Surat, Ahmedabad, Nagpur, Jaipur, Indore, Bhopal, Ludhiana, Guwahati, Dehradun, Thiruvananthapuram, Bhubaneswar, Patna, Gandhinagar, Ranchi, Amritsar, and Raipur.
- Silence zone is the area comprising not less than 100 metres around hospitals, educational institutions, courts, religious places or any other area declared as such by a competent authority.

Impacts of noise

- **Annoyance** – It creates annoyance to the receptors due to sound level fluctuations. The aperiodic sound due to its irregular occurrences causes displeasure to hear and causes annoyance.
- **Physiological effects** – The physiological features like breathing amplitude, blood pressure, heart-beat rate, pulse rate, blood cholesterol are affected.
- **Loss of hearing** – Long exposure to high sound levels cause loss of hearing. This is mostly unnoticed but has an adverse impact on hearing function.
- **Human performance** – The working performance of workers will be affected as it distracts their concentration.
- **Nervous system** – It causes pain, ringing in the ears, feeling of tiredness, thereby affecting the functioning of the human nervous system.
- **Sleeplessness** – It affects the sleeping thereby inducing people to become restless and lose concentration and presence of mind during their activities.
- **Damage to structures** – The buildings and materials may get damaged by exposure to infrasonic or ultrasonic waves and even get collapsed.

Control

Various techniques to control the noise levels have been broadly classified as follows:

Control at source

- Reducing the noise levels from domestic sectors
- Maintaining of automobiles
- Control of vibration
- Prohibition on the usage of loudspeakers
- Selection and maintenance of machinery

Control in the transmission path

- Installation of barriers
- Design of building
- Greenbelt development (planting of trees)

Using protective equipment

- Job rotation
- Reduced exposure time
- Hearing protection
- Documentation of noise measurements, continuous monitoring and awareness are the need of the hour.

5.5 Radioactive Pollution

Radioactivity is a phenomenon of spontaneous emission of particles such as protons (alpha particles), electrons (beta particles), and gamma rays (short wave electromagnetic radiation) due to the disintegration of atomic nuclei of some elements.

Radioactive Pollution

The natural environment has radioactive radiation but these radiations are present in a quantity which can be easily tolerated by living organisms. However, with the development of Nuclear Technology for electricity generation, medical uses or Weapon of mass destruction, there is a constant threat of radioactive pollution if any of the safety standards fail to prevent leakage of radiation to the outer environment.

Types of Radiation

- Non-ionising radiation: It affects only those components which absorb them and have low penetrability.
- Ionising radiation: It has high penetrability and causes the breakage of macro-molecules.

Radiation Particles

- Alpha Particles: It can be easily blocked by human skin and so is not harmful.
- Beta Particles: It can penetrate human skin but can be blocked by using metals or glasses.
- Gama Rays: It is the most harmful as it can easily penetrate human skin and damage the human cells. It can only be blocked by massive concrete structures.

Sources of Radioactive Radiations

Natural

- 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.

Man-made

- Nuclear power plants
- Nuclear weapons
- Transportation of nuclear material
- Disposal of nuclear waste
- Uranium mining
- Radiation therapy

Effects of Radioactive Radiation

The effects of radioactive pollutants depend upon the following factors,

- Half-life
- Energy releasing capacity
- The rate of diffusion and
- The rate of deposition of the pollutant
- various environmental factors such as wind, temperature, rainfall also influence their effects

The effect of radiation also depends on the type of radiation waves

Effects of non-ionizing radiation

- They include short-wave radiations such as the ultraviolet rays which form a part of solar radiation.
- They have a low penetrating power and affect only the cells and molecules which absorb them.

- They can damage eyes which may occur due to reflection from coastal sand, snow (known as snow blindness) or by directly looking at the sun during an eclipse.
- They can injure the cells of skin and blood capillaries producing blisters and reddening. This condition is known as sunburn.

Effects of ionizing radiation

- They include x-rays, gamma rays, cosmic rays and other atomic radiations caused by the emissions of radioactive elements.
- Ionizing radiation has high penetration power and can cause a breakage of macro-molecules
- The molecular damage may produce short range (immediate) and long range (delayed) effects.
- Short range effects include burns, impaired metabolism, dead tissues and death of several organisms.
- Long range effects include mutations leading to increased incidence of tumours and cancers, shortening of life-span and developmental changes. The mutated gene can persist in living organisms and may affect their progeny.
- The actively dividing cells such as the embryo, foetus, cells of the skin, intestinal lining, bone marrow and gamete forming cells are more sensitive to radiation.

Control Measures

Prevention is the best control measure as there is no cure available for radiation damage.

- All safety measures should be strictly enforced. Leakage of radioactive elements should be totally checked.
- Safe disposal of radioactive waste.
- Regular monitoring through frequent sampling and quantitative analysis.
- Safety measures against nuclear accidents.

- Nuclear explosions and use of nuclear weapons should be completely banned.
- Appropriate steps should be taken to protect oneself from occupational exposure.

5.6 E-WASTE

The discarded and end-of-life electronic products ranging from computers, equipment used in information and communication technology (ICT), 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 in totality in the formal sector. The e-waste can, however, be considered hazardous if recycled by primitive methods.

Source of e-waste and its health effects:

Lead:

- It is used in glass panels and gaskets in computer monitors, solder in printed circuit boards and other components
- It causes damage to the central and peripheral nervous systems, blood systems, kidney and reproductive systems in humans. It also affects the endocrine system and impedes brain development among children. Lead tends to accumulate in the environment and can have acute as well as chronic effects on plants, animals an microorganisms.

Cadmium:

- It occurs in SMD chip resistors, infrared 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 percent of the 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 batteries.
- Mercury's use in flat panel displays is likely to increase as they are replacing the 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.
- Chromium VI can cause damage to DNA and is extremely toxic to the environment

Plastics (including PVC):

- The largest volume of plastics (26 percent) used in electronics has been PVC. PVC elements are found in cabling and computer housings.
- Many computer moldings are now made with somewhat more benign ABS plastics.
- Dioxins are release when plastics such as PVC are burned. These are considered to be carcinogenic

Brominated Flame Retardants (BFRs):

- They are used in the plastic housings of electronic equipment and in circuit boards to prevent flammability

Barium:

- It is a soft silvery-white metal that 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, muscle weakness, damage to the heart, liver, and spleen.

Beryllium:

- Beryllium is commonly found on motherboards and finger clips.

- It is used as a copper-beryllium ally 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 characterized by poor wound healing and wartlike bumps.
- Studies have shown that people can develop beryllium disease many years following the last exposure.

Toners:

- Found in the plastic printer cartridge containing black and color 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.
- Reports indicate that color toners (cyan, magenta, and yellow) contain heavy metals.

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 the cathode ray tubes contains heavy metals, such as cadmium, and other rare earth metals such as zinc, vanadium as additives. These metals and their compounds are very toxic. This is a serious a hazard posed for those who dismantle CRTs by hand

E-waste in India:

- According to “The Global E-Waste Monitor 2014”, 17 lakh tonnes of e-waste generation was reported in the country in 2014. No comprehensive state-wise inventorization of e-waste generation has been done.
- In India, among top ten cities, Mumbai ranks first in generating e-waste followed by Delhi, Bangalore, Chennai, Kolkata, Ahmedabad, Hyderabad, Pune, Surat, and Nagpur.

- 65 cities in India generate more than 60 percent of the total e-waste generated, whereas, 10 states generate 70 percent of the total e-waste.
- Most of the e-waste generated in India is recycled by unorganized units, which engage significant manpower. Recovery of the metals embedded in e-waste by primitive means is a hazardous activity. The recycling process, if not carried out properly, can cause damage to humans through inhalation of gases during recycling, contact of the skin with hazardous substances and contact during acid treatment used in the recovery process.
- Proper education, awareness, and most importantly alternative cost-effective technology need to be provided so that better means can be provided to those who earn their livelihood from handling e-waste in the unorganized sector.
- A holistic approach is needed to address the challenges faced by India in e-waste management. A suitable mechanism needs to be evolved to include small units in unorganized sector and large units in the organized sector into a single value chain.

5.7 Solid Waste

Solid waste refers to all non-liquid wastes that is including Solid as well as semi-solid wastes, but excluding Human and Animal excreta. Solid waste can create very serious health problems and an unpleasant living environment if not disposed of in a proper and a safe manner, such waste may then also provide breeding sites for insect-vectors, pests, snakes and vermin that increase the risk of disease transmission. It may also pollute water sources and the environment.

Different categories of solid waste include:

- Organic waste: Food waste, Market associated wastes etc.
- Dead animals: Carcasses of animals (Cows, Buffaloes, Dogs etc.)
- Combustibles: Paper, wood, dried leaves etc. (high organic and low moisture content)
- Non-combustibles: Metal, tin cans, bottles, etc.
- Ashes: Residue from fires used for cooking.
- Bulky waste: Tree branches, tyres, etc.
- Hazardous waste: Battery acid, medical waste etc.
- Construction waste: Roofing, broken concrete, etc.

Factors behind the generation of Solid Waste

Solid wastes are generated from Rural as well as Urban areas in India. The main factors affecting these are:

Geographical – Industrially and technologically developed regions like Delhi, Bengaluru generate more solid wastes when compared with less industrialized places like Shimla or Kashmir.

Socio-cultural practices – Practices such as dumping waste in rivers, performing rituals which generate a lot of solid wastes.

The packaging of food items – use of packaged food items, that too more often, leads to generation of solid waste. It is seen that the volume of waste generated is likely to be small and degradable where the population is of rural origin while the urban populations are more likely to generate larger volumes of non-degradable waste, especially where packaged food are consumed more.

Associated Risks

Spread of Diseases

Decomposing solid waste attracts animals, mosquitoes, vermin and flies. They play a major role in the transmission of faecal-oral diseases and the transmission of diseases such as leptospirosis, typhoid, dengue, yellow fevers, microfilariae, gastro-enteritis, dysentery and other illnesses.

Water, Soil and Air Pollution

Poor management of the collection and disposal of solid waste may lead to Water Pollution (pollution of surface water/groundwater). This may also result in deterioration of Soil (Soil Pollution).

Where large quantities of Solid dry waste are stored in hot climates this may create a fire hazard. Related hazards include Air pollution and fire threat to surrounding buildings and people.

Issues of Solid Waste in India

India's 40 crore people live in cities, where around every year 6 crore tonnes of solid waste is generated. But as of 2018, only 70 percent of waste is collected by the concerned municipal authorities and only 20 percent of the solid waste which is collected is treated, while the rest of 80 percent is dumped in landfill sites.

There are many issues which are responsible for such slow pace of solid waste management. Prominent ones are –

• Very casual approach of the governments and municipal authorities which result in inadequate monetary grants for the Solid waste management.
• There is a lack of technical expertise with regards to disposal of solid wastes and unavailability of land with the municipal bodies.

• Very less capital is provided for processing and disposal of Solid waste.
• Lack of private investment in this area.

• Indifferent attitude of citizens at large towards the problem of solid waste.

Managing Solid Wastes

Solid waste management can be divided into four key components:
• Generation

• Storage and Collection

- Transportation
- Disposal

Generation

Generation of solid waste is the stage at which materials become of no use to the owner and they wish to get rid of them.

Storage and Collection

Storage takes place after the materials have been discarded. Key here is to not discard items directly into family pits and poorly defined heaps close to dwelling areas, but an effective storage system must be at place, like the Government of India has directed municipal corporations to undertake Door to Door collection of Solid wastes under Jawahar Lal Nehru National Urban Renewal Mission (JNNURM).

Whereas under Swacch Bharat Abhiyan, two different dustbins have been provided (*Blue and Green Dustbins)* which are used to segregate two different kinds of wastes, the green is meant for wet wastes while the blue one is for Solid dry waste.

Transportation

This is the stage when solid waste is transported to the final disposal site. There are various modes and method which may be adopted depending upon availability and the volume of waste to be transported.

In India, Solid wastes are generally transported first by small municipal vehicles to a dumping site, then big municipal vehicles carry them for final disposal, be it to landfills or to recycling plants.

Disposal

The final stage of solid waste management is safe disposal where associated risks are minimised. There are six main methods for the disposal of solid waste:

1) Land application: Open dumps or landfilling

Open dumps and landfills are uncovered/covered areas that are used to dump solid waste of all kinds. The waste is not treated neither it is segregated and thus

it is also a place where a lot of insects and other disease causing organisms breed.

They are generally located in urban areas. For landfills, a pit is dug where garbage is dumped and the pit is covered with soil everyday thus preventing the breeding of flies and rats.

Open dumps are more harmful than landfills as landfills after they are full can be used as a park/parking lot after covering it, but open dumps cannot be treated as such.

2) Composting

Composting is a biological process in which micro-organisms such as fungi or bacteria decompose in the presence of oxygen the degradable organic wastes. The finished product is very rich in carbon and nitrogen thus acting as a great medium for plant cultivation.

3) Burning or incineration

The process of burning solid wastes in a large furnace at a very high temperature whereby producing ash is called Incineration. It is only used as a last resort because it also produces a lot of toxic gases resulting in Air Pollution.

4) Pyrolysis

The process of burning solid wastes, but in the absence of oxygen in a large furnace at a very high temperature whereby producing charcoal, tar, methyl alcohol, acetic acid, acetone which can be used as fuels is called Pyrolysis.

Vermiculture

It is also known as Earthworm farming. In this method, Earthworms are added to the compost. These worms break the solid waste and along with the earthworms excreta, the compost becomes rich in nutrients.

6) Recycling

Solid wastes are also recycled, where the solid wastes are first taken to compost plants which are either set up by Government or by Private companies (under Corporate Social Responsibility), then they are either converted to fertilizers or they are recycled to produce various other items such as Plastics bottles, electronic instruments, building materials etc.

Electricity is also produced from these solid waste products with the help of process of gasification.

Government Interventions/Policies

There have been various government policies and interventions as to effective management of solid wastes. Prominent among them were –

• The constitution of a *Task force on Waste to energy* under the erstwhile Planning Commission in 2014, with the chairmanship of Dr. Kasturirangan, which gave various suggestions on proper management of solid waste and focussed on recommended adoption of the principles of reduce, reuse, recover, recycle and remanufacture (**5Rs**).

It also recommended setting up of centralised and decentralised waste processing facilities.

• Replacing of Municipal Solid Waste Rules, 2000 with *Solid Waste Management Rules, 2016* whereby expanding the ambit of rule application to every urban local body, including outgrowths in urban agglomerations, census towns and areas under Railways and airports.

Apart from this, It puts the burden of segregation on the waste generator and require segregation into 6 categories – biodegradable, non-biodegradable, domestic-hazardous, sanitary, construction-demolition and horticulture.

It forbids the throwing, burning, or burying solid wastes on streets, open public spaces, in the drain, or water bodies. Introduction of levying of 'user fee' on the consumer and 'spot fine' for littering and non-segregation.

• Organizing of "*Kachra Mahotsav*" in order to sensitise people about the benefits of recycling solid wastes. In 2018 itself, it was organised in Raipur and Varanasi.

Way Ahead

The future of effective Solid waste management lies in Recycling solid wastes as it is environment friendly, beneficial and quite handy to the economy too. More and more compost plants must be set up in order to prevent “Mountains of waste” here and there.

The idea should be converting *waste into wealth*, I.e. deriving benefits out of the solid wastes, from producing electricity to manufacturing recycled products and compost.

Government estimates that around 511 MW of energy and 54 lakh metric tonnes compost can be manufactured today with the help of solid wastes being generated in India today, that is around 6 crore tonnes. Currently, only 88 MW of electricity and around 13.11 lakh metric tonnes compost is being manufactured, need of the hour is to increase this.

It is therefore essential to incentivise and focus on this aspect of solid waste management as this will be beneficial for us and our future generations too.

5.8 Bioremediation

What is Bioremediation?

Rapid industrialization and unlimited extraction of natural resources have contributed to large scale environmental contamination and pollution. Huge amounts of toxic waste have spread in thousands of contaminated sites spread across the world. These pollutants belong to two main classes: inorganic and organic.

Bioremediation is a method of biological interventions of biodiversity for mitigation/complete elimination of the noxious effects caused by environmental pollutants in a given site. It operates through the principles of biogeochemical cycling.

It has been successfully applied for cleanup of soil, surface water, groundwater, sediments and ecosystem restoration. It has also been unequivocally demonstrated that a number of other substances including nitro-glycerine (explosive) can be cleaned up through bioremediation.

Bioremediation is considered to include natural attenuation (little or no human action), bio-stimulation or bio-augmentation, the addition of natural or engineered micro-organisms (Bacteria, Fungi etc.) to accelerate the desired catalytic capabilities and it can definitely contribute to the removal of such hazardous wastes from the biosphere.

Factors of Bioremediation

Bioremediation depends upon various factors, such as –

- Microorganisms-Microorganisms may be either Aerobic Bacteria (Pseudomonas, Alcaligenes, Sphingomonas etc.) or Anaerobic Bacteria or evenLignolytic fungi.
- Natural Biological processes of microorganism such as Catabolism and Anabolism play a very important role in Bioremediation.
- Environmental Factors such as optimum Temperature (20-30 Degree Celsius), suitable pH(6.5-8.00), desirable oxygen content and Electron acceptor/donor are very essential factors.

- Nutrients such as Carbon ,Nitrogen ,Oxygen etc must be present in a desirable quantity.
- Soil Moisture with 25-28% of water holding capacity is a prerequisite for Bioremediation.
- Soil with Low clay or silt content is required for bioremediation.

Bioremediation Techniques

There are two types of Bioremediation

- In-situ bioremediation – If the process of Bioremediation occurs in the same place affected by pollution.
- Ex-situ bioremediation –if the process involves deliberate relocation of the contaminated material (soil and water) to a different place.

1. In-situ bioremediation

In-situ bioremediation is generally most desired than ex-situ bioremediation due to its lower cost and less disturbance as it provides the treatment in place avoiding transport of harmful contaminants.

In situ treatment is limited by the nature of the soil (depth) that can be effectively treated. In a lot of soils, effective rate for oxygen diffusion of bioremediation extend to only a few centimeters to about 30 cm into the soil.

Different types of In-situ bioremediation techniques are-

Bio-venting is the most common in situ treatment and involves supplying of air and nutrients through wells to contaminated soil to stimulate the growth of microorganisms.

Bio-venting provides only the amount of oxygen necessary for the bio degradation and the rate of air flow is also quite low where release of contaminants to the atmosphere is lowered significantly.

It works for simple hydrocarbons and can be used where the contamination is deep under the land surface. It involves supplying oxygen and nutrients by aqueous solutions through contaminated soils to accelerate naturally occurring microorganisms to degrade organic impurities.

This technique includes circumstances like the infiltration of water-containing nutrients and oxygen for groundwater treatment.

Bio-sparging – It involves the pressurised injection of air below the water table to increase the content of groundwater oxygen concentration and also increase the rate of biological degradation of wastes by naturally occurring Microorganisms.

Bio-sparging enhances the mixing in the saturated zone and causing it to increases the contact between soil and groundwater. The biggest advantage with the use of Bio-sparging technique is its handling ease and low cost of installing small-diameter air injection points.

Bioaugmentation – Bioremediation involves the continuous addition of microorganisms (indigenous or exogenous) to the contaminated sites. It is basically a process of the release of substantial quantities of microorganisms, sometimes of recombinant species, to carry out a specific remediation task in a given contaminated environment.

2. Ex-situ bioremediation

This technique involves the excavation, removal and transportation of contaminated soil from ground to a different site.

Land farming is a simple technique in which contaminated soil is excavated and then spread over an already prepared bed and at regular intervals tilled until pollutants are degraded.

The objective is to accelerate indigenous microorganisms and smooth the progress of their aerobic degradation of contaminants. In general, the procedure is restricted to the treatment of superficial 10–35 cm of soil. Since land farming has the capability to decrease monitoring and maintenance costs, as well as clean-up liabilities, it has received much consideration as a disposal alternative.

Composting is a procedure that involves bringing together contaminated soil with non-hazardous organic materials such as manure or agricultural wastes. The presence of these organic materials maintains the growth of a rich microbial population and optimum temperature feature of composting.

Bio piles – They are a mixture of land farming and composting. Fundamentally, engineered cells are built as aerated composted piles. Characteristically used for treatment of surface contamination with petroleum hydrocarbons they are a refined version of land farming that have a propensity to control physical losses of the contaminants by leaching and volatilization. Bio piles provide an advantageous atmosphere for indigenous aerobic and anaerobic microorganisms.

Bioreactors – Slurry bio reactors are used for ex situ treatment of polluted soil and water pumped up from a contaminated plume. Bioremediation in reactors includes the processing of polluted and infected solid material (soil, sediment, sludge) or water through an engineered containment system.

A slurry bioreactor is a containment vessel and machinery used to create a three-phase (solid, liquid, and gas) mixing condition to expand the bioremediation rate of soil-bound and water-soluble pollutants as a water slurry of the polluted soil and biomass (usually indigenous microorganisms) capable of disintegrating target contaminants.

The rate and magnitude of biodegradation are bigger in a bioreactor system than in situ or in solid-phase systems because the contained environment is more handy and hence more controllable and foreseeable. In spite of the advantages of reactor systems, there are some disadvantages. The contaminated soil requires pre-treatment (e.g., excavation) or on the other hand the contaminant can be taking out of the soil via soil washing or physical extraction before being placed in a bioreactor.

Advantages of Bioremediation

- Bioremediation is a natural process and therefore Government and People perceive it as an acceptable waste treatment process for contaminated material such as soil or water. Microbes are very well able to degrade the contaminant when they increase in numbers and are degraded. The remains for the treatment are generally harmless products and include products such as carbon dioxide, water, and cell biomass.
- Notionally, bioremediation is useful for the absolute destruction of a wide variety of contaminants. A lot of compounds that are legally considered to be

hazardous can be changed to harmless products. This eradicates the chance of future liability related with treatment and disposal of contaminated material.

- As an alternative to transferring contaminants from one environmental medium to another, for example, from land to water or air, the complete destruction of target pollutants is probable.
- Bioremediation can over and over again be carried out on site, often without causing a major disturbance of normal activities. This also gets rid of the need to transport quantities of waste and the possible threats to human health and the environment that can take place during transportation.
- Bioremediation is also relatively less expensive than other technologies that are used for disposal of hazardous waste.

Disadvantages of Bioremediation

- Bioremediation is restricted to those compounds that are biodegradable. Not all compounds are liable to quick and complete degradation.
- There are some apprehensions that the products of bio degradation may be more lasting or toxic than the parent compound.
- Biological procedures are often extremely definite. Significant site factors required for success comprise the presence of metabolically capable microbial populations, suitable environmental growth conditions, and suitable levels of nutrients and pollutants.
- More of research is required to develop bioremediation technologies that are suitable for sites with complicated mixtures of pollutants that are not evenly disseminated in the environment. Pollutants may be present as solids, liquids or gases.
- Bioremediation time and again takes much more time than other treatment options, such as pyrolysis or incineration.
- There are also certain regulatory uncertainties regarding acceptable performance measures for bioremediation.

5.9 Acid Rain

In July this year, the Supreme Court came down very heavily on the Uttar Pradesh government for its lackadaisical approach to the situation of turning of Taj Mahal from white to yellow due to environmental pollution and resulting Acid Rain.

Discoloration of Taj Mahal because of Acid Rain is a very grim situation as it will destroy the elegance and beauty of the monument.

We must first understand as to what Acid Rain is, how does it occur, it's consequences and the way it can be prevented.

What is Acid Rain?

The phenomenon of Acid rain was discovered in the 19th century by Robert Angus Smith, a pharmacist from Manchester (United Kingdom), who noted that there were high levels of acidity in rain falling over industrial regions of England and compared them to the much lower levels of acidity in rain falling over less polluted areas near the coast and agricultural regions.

But not much attention was paid to his work until the 1950s, when several other biologists noticed an alarming decline of fish populations in the lakes of southern Norway due to acid rain. Same findings were observed in the 1960s in North America (the Adirondacks, Ontario, Quebec). These findings led to more research to understand the origin of the acid rain phenomenon.

Acid rain is also termed as acid deposition (Primary being Sulphuric Acid and Nitric Acid) to differentiate it from other forms of acidic precipitation such as snow. There are two types of deposition, Wet Deposition and the other Dry deposition.

Wet Deposition

Wet deposition refers to depositions in form of rain, fog, snow or mist. When the acidic chemicals in the air are blown into areas where the weather is wet, the chemicals 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 various plants and animals.

Dry Deposition

Dry deposition refers to depositions in form of dust or smoke. When the acidic chemicals in the air stick to buildings, homes, cars, trees or fall on ground. Dry deposited chemicals and gases can be washed from these surfaces by storms, leading to increased runoff.

How does Acid Rain occur?

Sulphur dioxide (SO2), Oxides of nitrogen (NOx) and ozone (O3) are the primary causes of acid rain. These chemicals interact with other chemicals and reactants present in the atmosphere and result into acid deposition.

The natural sources of sulphur are primarily oceans and volcanic eruptions. The man-made sources of sulphur emissions are the burning of fossil fuels such as coal and petroleum and various industrial processes. Other sources include the smelting of iron and other ores, manufacture of sulphuric acids, and in the petroleum industry.

The levels of NOx are small in comparison to SO2, but its contribution is also increasing in the production of acid rain. They are released by vehicular emissions.
The degree of acidity is measured by pH value and the rain that presents pH value less than 5.6 is considered as Acid Rain.

The chemical reaction that results in the formation of acid rain involves the interaction of SO2, NOx and O3. When the pollutants are released into the atmosphere by tall smoke chimneys and stakes, molecules of SO2 and NOx gets caught up in the winds in the presence of sunlight where they interact with vapours to form sulphuric acid (H2SO4) and nitric acid (HNO3).

But as the temperature is quite high, therefore these acids remain in vapour state and when the temperature falls, condensation takes the form of aerosol droplets, which due to the presence of unburnt carbon is black, acidic and carbonaceous in nature.

It is to be noted that not only Sulphuric acid (H2SO4), Nitric acid (HNO3) and Ozone (O3) are responsible for acid rain, but some other organic acids like formic and acetic acids also contribute to 5-20% acidity in total acid rain after Peroxy radicals react with formaldehyde and acetaldehyde.

What are the Consequences of Acid Rain?

Acid Rain affects various organisms, places, vegetation and environment as a whole.

Aquatic Ecosystem

Aquatic Ecosystem are the most clearly impacted by acid deposition as acidic precipitation falls directly into them. Both dry and wet deposition also runs off of forests, fields, and roads and flows into oceans, seas, lakes, rivers, and streams.

When this acidic rain mixed with water, it results in proliferation of aluminium in lines or paisa. The acidic water also affects eggs of frogs and marine organisms in general.

Health

The harm to people from acid rain is not direct, but indirect as the pollutants that cause acid rain such as Sulphur dioxide (SO2) and nitrogen oxides (NOx) damage health where these gases interact to form fine sulphate and nitrate particles that can be transported long distances by winds and inhaled deep into people's lungs.

Fine particles of these acid pollutants can also penetrate indoors as elevated levels of fine particles increase the illness and cause premature death from heart and lung disorders, such as asthma and bronchitis to Cancer.

India's Situation -

Delhi-based Centre for Science and Environment (CSE) published a report in 1983 titled *The State of India's Environment: A Citizen's Report* where it warned that air pollution, "after engulfing the large cities of India… has begun to hurt the residents of small towns and once sleepy villages where thermal power stations and large industries are now being located."

It also observed that problem of Acid Rain will aggravate in near future and will lead to human health problems and indeed now it holds true.

Plants and Trees

Acid rain can harm plants and trees very profusely impacting their growth. Acid rain causes harm to plants leaves and stems, resulting in disturbance in respiration and photosynthesis.

Also over the past few years, scientists have noted a slowed growth of some forests where tree leaves and needles turn brown and fall off when they should be green and healthy.

In extreme situations, individual trees or entire areas of the forest simply die off without an obvious reason as observed in parts of Norway and United States of America.

India's Situation -

With increasing population, energy requirements in India is also growing rapidly in tune with the economy and so is the coal dependence and thus making the clouds of acid rain heavier over many highly sensitive areas in the country – Jharkhand, Orissa, West Bengal, North East and the southern coastal areas.

The soils of these areas have a low pH value and acid rain will aggravate it further making it infertile and unsuitable for agriculture.

The *Green India 2047 Report* published by TERI estimates that India has lost around 11 per cent and 26 per cent of agricultural output on account of soil degradation. Acid rain will increase this figure exponentially.

Stone Buildings and Monuments

Acid rain is very much responsible for destruction of monuments and building primarily built of Marble and limestone which have long been preferred materials for construction.

Marble and limestone both consist of calcium carbonate ($CaCO_3$) where Limestone consists of smaller crystals and is more porous than marble whereas Marble, with its larger crystals and smaller pores, attains a good polish and is therefore preferred for monuments.

Due to acid rain, buildings and monuments made of marble and limestone are now being gradually eroded away where calcium carbonate (Primary Material of Buildings) and Sulphuric acid (Acid Rain Causing Chemical) result in the

dissolution of CaCO3 to give aqueous ions, which in turn are washed away in the water flow.

CaCO3 +H2SO4 → Ca2+(aqueous ions)+SO42- +H2O+CO2

This phenomenon takes place at the surface of the buildings or monuments; thus acid rain can easily erode the relief of the monuments (e.g., the faces on a statue), but generally does not affect the structural existence of the monuments.

India's situation

The problem of Acid Rain has created havoc on some of the most beautiful structures such as Taj Mahal. In 1980s, Mathura Refinery was opened, which was located just 40 km from Taj Mahal and Fatehpur Sikri and there were fears from the outset that the pollution which will be caused by the refinery would slowly destroy the Taj Mahal and surrounding areas in spite of government officials denying the possibility.

But for the past few years, the colour of Taj Mahal is changing from white to yellow and this is quite an alarming situation.

What are the ways for prevention of Acid Rain?

Acid Rain can be prevented, it can be achieved by following ways:

***Liming*:-** The damage to water bodies can be prevented and eliminated by adding lime. Many chemicals such as caustic soda, sodium carbonate, slacked lime and limestone are most popular for increasing pH of acidified water. Liming completely removes only some of the symptoms of acidification and it is expensive and also not real cure.

Reducing Sulphur – Reducing the amount of emission of So2 from power plants by burning less fossil fuels whereby also focussing on alternate energy sources like Tidal, Wind or Hydropower will do great wonders in reducing Acid Rain.

Decreasing NOx emissions from Power stations and Vehicles.

Policy Interventions

There have been many policy interventions for prevention of Acid Rain by global community as well as India.

• In 1980s, Several north-eastern States of USA and the Ontario, Canada, sued the US Environment Protection Agency in 1980 to take action to control acid precursor emissions emanating from United States and subsequently U.S congress formed the National acid precipitation assessment programme (NAPAP) and mandated it to conduct a 10-year scientific, technological and economic study of the acid rain menace under the Acid Precipitation Act of 1980.

The purpose of the study was to inform public policy by providing information on Acid Rain and it's effect and also consequences arising out of it.

• In India, stress is laid down on controlling Acid Rain by two interventions, firstly reducing SOx emission and secondly by reducing NOx emissions.

SOx emission is reduced by governments making it mandatory for energy producers to clean smoke stacks by using scrubbers which trap pollutants before they are released into the atmosphere.

NOx emission is reduced by the introduction of catalytic converters in cars, where they chemically convert emissions to less harmful substances before the gas leaves the tail pipe of the car.

Also India has decided to skip BS-V all together as it is directly adopting BS-VI norms from BS-IV norms, being commenced from 2020 all over the country instead of earlier thought 2022. The main distinction between BS-IV and BS-VI is in the amount of sulphur in the fuel.

BS-VI fuel is expected to bring around an 80% reduction in sulphur content — from 50 parts per million (ppm) to 10 ppm. Also NOx emissions from diesel cars will come down by nearly 70% for diesel cars and by 25% for petrol cars.

6- RENEWABLE ENERGY

6.1 Solar Energy

Solar energy incident on the earth's surface on a clear day at sea level, also known as energy density, is around 1000 W/sq.m. This is a never exhausting source of energy which, if tapped efficiently, can turn into a sustainable source of power for mankind.

Solar Energy

India, being a tropical country, experiences around 300 clear sunny days in a year, on average. The total solar energy received by India's landmass is around 5000 trillion kilowatt-hours (kWh) per year which translates into 4-7 kWh per square meter per day. According to the Ministry of New and Renewable Energy, India has a potential to generate over 750 GW of solar power which is close to 68 % of its total renewable energy potential.

Technology to Covert Solar to Electricity

The two major types of solar technologies are the solar photovoltaic cells (SPV) and the solar thermal technologies.

- solar photovoltaic cells (SPV) convert the sunlight incident on them into electricity by a phenomenon known as the photoelectric effect. These are made of semiconducting materials such as silicon, cadmium telluride (CdTe), copper indium gallium diselenide (CIGS), carbon-rich polymers etc. Of these, silicon-based and cadmium telluride based SPV cells are the most commonly used ones. These cells convert solar energy into direct current (DC)
- solar thermal technologies use sunlight reflectors and concentrators to either convert the solar heat into electricity or use the heat energy itself for domestic and commercial heating purposes. Solar heat is used to turn water into steam which is used to run the turbines, producing alternating current (AC) power.

Initiatives in India to promote solar power

The National Solar Mission (earlier known as Jawaharlal Nehru National Solar Mission) is India's biggest solar power generating programme. It has an ambitious target of generating 100 GW of solar power by 2022 (upgraded from the earlier target of 20 GW), under the overall renewable energy generation target of 175 GW by 2022. NSM has two components – solar utility based

generation and solar rooftop generation. The target under the former is 60 GW while that under the latter is 40 GW.

Other major initiatives to encourage solar power generation include

- Transmission charges have been waived off on the interstate transmission of solar (and wind) power from plants commissioned up to March 2022, for a period of 25 years.
- Solar photovoltaic cells have been exempted from excise duty and import duty on solar panels has been reduced to 5 % to incentivise private solar power companies.
- According to the Economic Survey 2017-18, renewables (including solar) have been identified as one of the 12 champion sectors under Make in India 2.0.
- Under the KUSUM (Kisan Urja Suraksha evam Utthan Maha Abhiyan) scheme, farmers are encouraged to install up to 2 MW of grid-connected solar power plants by buying the extra power generated from such plants via the state DISCOMs.
- Under the Solar Cities programme, 60 cities have been identified which have to reduce their dependence on conventional energy by at least 10 %.
- India, along with France, was instrumental in the formation of the International Solar Alliance (ISA). It is the first treaty-based international organization to be headquartered in India which aims to encourage the adoption of solar technologies by reducing their cost, through R&D, and scaling up their utilization.
- 35 solar parks with a generation capacity of over 20 GW have been sanctioned in 21 states which are in various stages of execution.

According to the Ministry of New and Renewable Energy, India's installed solar power capacity has gone up from around 2.6 GW in 2014 to over 22 GW in 2018 (March).

6.2 International Solar Alliance

About ISA

International Solar Alliance (ISA) is a group of 121 solar-resource rich countries which are predominantly, but not exclusively, situated between the Tropic of Cancer and the Tropic of Capricorn. Most of the countries are situated either partly or fully within the tropics. The overarching goal of the ISA is to efficiently harness the solar energy that is available for the member countries in order to reduce their dependence on fossil fuels for their energy needs.

ISA was conceived during the Conference of Parties (CoP) to the United Nations Framework Convention on Climate Change (UNFCCC) at Paris in 2015. It is a joint initiative of India and France with the former hosting the ISA Secretariat and the latter providing technical and financial assistance. The interim headquarters of ISA is situated at the National Institute of Solar Energy (NISE) campus at Gurugram, Haryana. ISA is the first international treaty-based organization to have its headquarters in India. It is an intergovernmental organization which came into force after its treaty was ratified by 15 member countries. At present, 32 **countries have ratified** its treaty which was signed by 61 countries.

India has agreed to host its Secretariat and finance its operations for the initial five years of its operations after which ISA is expected to become self-sufficient

Governance Structure:

The official nomenclature of ISA is International Agency for Solar Policy and Application (IASPA). The proposed governance structure of the ISA includes an **Assembly**, a **Council**, and a **Secretariat**. The Assembly is expected to provide policy guidance, direction, and advice for the functioning of ISA. The Secretariat will look after the day-to-day activities of ISA and will report to the Council. The Secretariat will also assist in the functioning of the Assembly and the Council. This structure is subject to deliberations and agreement by the member countries.

ISA and UN:

The ISA is not a part of the UN system and is **not a specialized agency of the UN**. However, since the ISA was conceived at the Paris CoP to UNFCCC and its goal is linked with combating climate change (SDG 13), the UN has agreed to be a **strategic partner** to the ISA.

Objectives:

The primary objective of ISA is to increase the adoption of solar technologies, particularly among countries situated within the tropics. Incidentally, these are the countries which are poised to experience the highest growth in energy demand in the coming decades since a majority of them are emerging market economies and developing countries with a high GDP growth.

ISA acknowledges the fact that a faster adoption of solar technologies and products can only happen when the costs of deployment and generation of solar power become competitive vis-a-vis the traditional sources of power, mainly the fossil fuel based power. The ISA will work towards bringing down the cost of solar technologies and solar financing by adopting a three-pronged approach:

- To **boost the global demand** for solar technologies and products which can reduce the costs associated with their deployment.
- To **promote standardization** of the equipment and the processes involved in generating solar power. Standardization is essential to reduce the manufacturing costs of the associated hardware.
- To **encourage research and development** in solar technologies with a special focus on efficient storage systems (batteries).

Other major objectives of the agency include:

- To mobilize at least $ 1 trillion worth of investments by 2030 which are needed for the deployment of solar power in a massive way.
- The deployment of over 1000 GW of solar generation capacity.
- Creation of solar grids and solar credit mechanisms to reduce the cost of finance and the cost of technology.
- To act as a platform that enables deeper diplomatic engagements on crucial developmental issues associated with energy security.

India and ISA:

- The ISA becomes significant for India to take the global leadership in fighting climate change which threatens to disproportionately affect the developing countries and their teeming millions of poor people who still lack access to an affordable and sustainable form of energy.
- Recognizing the need for such body (ISA), India has agreed to host the Secretariat of ISA. It has also agreed to contribute $27 million for the creation of building infrastructure and to meet the recurrent expenditure of ISA for five years i.e., until 2020-21. Of this, $16 million will be used to create a corpus fund that can generate revenues for ISA's budget.
- India's commitment to produce 100 GW of solar power by 2022 as part of its INDCs makes it a crucial player in the field of solar power.

Challenges:

- The most important challenge is to mobilize $1 trillion worth investments, especially at a time when financial support from the industrialized countries is not forthcoming. The withdrawal of US from Paris Climate Agreement is a major setback for global clean energy financing.
- To avoid duplication and replication of efforts towards climate change by agencies currently working in this area such as the International Renewable Agency (IRENA), Renewable Energy and Energy Efficiency Partnership (REEEP), International Energy Agency (IEA), Renewable Energy Policy Network for the 21st Century (REN21), UN bodies, and other bilateral organizations.
- To involve not only public sources of finances, but also private financial resources towards solar power R&D, deployment, generation etc.

Recent developments:

With a rapid growth in the demand for solar power, the costs associated with solar power generation have reduced by around 80 percent in the last 7 years. During the same period, the total installed solar capacity has increased by over 8 times. Such developments create ideal working conditions for ISA to intensify its work towards enhancing solar power deployment.

6.3 International Renewable Energy Agency

The International Renewable Energy Agency (IRENA) was founded in 2009 as an intergovernmental organization which is aimed at promoting the adoption and sustainable use of renewable energy across the world. It provides assistance to countries in their transition towards a sustainable energy future. The headquarters of IRENA is situated at Abu Dhabi (UAE). It has the status of an observer at the United Nations.

International Renewable Energy Agency

- It serves as a platform for international cooperation, a centre of excellence and, as a repository of policy, resource, and financial knowledge of renewable energy.
- It works towards the adoption and sustainable use of all types of renewable energy, including solar, wind, geothermal, ocean thermal, and biomass.
- It strives to achieve a low-carbon economic growth which can ensure energy access and energy security as well as prosperity in the pursuit of sustainable development.
- It encourages governments across the world to adopt policies which facilitate renewable energy investments, knowledge sharing, and technology transfer in order to accelerate the deployment of renewable energy.
- It has more than 170 member states.

Governance Structure

IRENA has three principal organs viz., the Assembly, the Council, the Secretariat.

Assembly

- It is the highest decision-making body of IRENA with one representative from every member state.

- It meets annually to discuss and decide upon various issues such as budget, admission of new members, IRENA's work programme and possible amendments to its activities.
- The next session (9th Assembly) will be held in January 2019, in Abu Dhabi.

Council

- The Council has 21 member states who are elected for a term of two years. The members are elected on a rotation basis to ensure effective participation of all the member states, including developing and developed countries.
- The Council is accountable to the Assembly.
- Its responsibilities include facilitating consultation and cooperation among the member states, reviewing the drafts of its work programme, annual budget, and annual report.

Secretariat

- It is headed by a Director-General.
- Its staff provides the administrative and technical support for the functioning of the Assembly, the Council, and other subsidiary bodies

India and IRENA

- India is a founding member of IRENA.
- As the third largest consumer of primary energy, after China and the USA, India's inclusion in the group is crucial for a sustainable energy future.
- IRENA can help India in achieving its domestic renewable energy commitments, to produce 175 GW of renewable energy by 2022, through information sharing, and also by acting as a platform for technology transfer and financial assistance from the developed countries.

6.4 Wind Energy

Wind energy is a form of renewable energy which is generated by converting the kinetic energy present in the wind into mechanical energy which is, in turn, converted into electricity. Wind energy is a type of solar energy since wind is caused by the uneven heating of earth's atmosphere. This creates a pressure differential between two points at different temperatures resulting in wind flow.

Wind Energy

According to the Ministry of New and Renewable Energy, the estimated potential of generating wind energy in India, at a mast height of 100 metres above the ground, is 302 GW. By 2017, India had become the country with the fourth largest installed capacity of wind power, behind China, USA, and Germany. Wind energy accounted for around 53 % of the total installed renewable capacity by the end of 2017. It is the third largest source of power after thermal and hydro.

Initiatives by India

- Under the overall renewable energy generation target of 175 GW by 2022, wind energy accounts for 60 GW.
- To promote the generation of renewables such as wind energy, a renewable purchase obligation has been put in place for state DISCOMs and large consumers, which is enforced by the respective state electricity regulatory commissions.
- Ministry of Power has waived off the inter-state transmission charges on wind (and solar) power from power plants commissioned up to March 2022 for a period of 25 years.
- In the recent (February 2018) auctions conducted by the Solar Energy Corporation of India for India's largest wind capacity auction of 2000 MW, the lowest ever tariff of Rs. 2.44/unit for wind power was achieved. Such low tariffs can increase the demand for renewables such as wind, by placing them on par with fossil fuel based power.
- At present, the entire wind power generated in India is from onshore power plants. To utilize the potential of India's long coastline in generating wind

energy, India's first ever National Offshore Wind Energy Policy was released in 2015.

- To address the constraints of a large-scale land requirement, and the lack of grid-connectivity for renewables, National Wind-Solar Hybrid Policy was announced in 2018 for an efficient utilization of land and transmission infrastructure.

Facts about India's Wind Power Generation

- At present, most of the installed wind capacity is located in the north, south, and west. India's east and northeast do not have any grid-connected wind power plants.
- South India has the maximum grid-connected installed wind capacity followed by west and north.
- Tamil Nadu is the leading producer of wind energy followed by Maharashtra, Gujarat, and Rajasthan.
- Around 75 % of India's wind power generation occurs between the months of May and September i.e., in the southwest monsoon season.
- Until the end of 2017, around 33 GW of wind power has been installed, according to the Ministry of New and Renewable Energy.

6.5 Hydro Power

Hydropower is considered to be a renewable form of energy since it utilizes the earth's natural water cycle to generate electricity. Unlike fossil fuels based power, hydropower only utilizes the energy present in water, rather than the water itself, and hence it's a renewable source of power.

Hydro Power

According to an assessment by the Central Electricity Authority, the economically exploitable hydropower potential in India is around 148 GW. As of 2016-17, the installed utilizable hydropower capacity in India is around 45 GW or about 14 % of its total installed power capacity. As of now, around 31 % of its total utilizable hydropower capacity has been installed.

India's hydropower potential

Basin wise potential

- Brahmaputra basin – 23.9 GW
- Indus basin – 11.9 GW
- Ganga basin – 3.4 GW
- East flowing rivers of south India – 5.7 GW
- West flowing rivers of South India – 3.6 GW
- Central Indian river system – 1.6 GW

Region wise potential

India's northeast has the highest hydropower potent followed by the Himalayan region of north India and peninsular India.

Challenges associated with the development of hydropower in India

- **Geological constraints** – the Himalayan region is seismically unstable and construction of large dams in this region is considered to be structurally unsafe. Moreover, large dams themselves are found to be responsible for inducing seismicity (reservoir-induced seismicity) in a region. For example, the reservoir induced earthquake near Koyna Dam in 1967.

- **Ecological constraints** – dams submerge huge tracts of forest lands which makes it difficult to obtain forest clearances. Large dams pose a threat to the biodiversity in both upstream and downstream regions, by submerging forest lands in the former and restricting the river flow in the latter.

- **Socioeconomic constraints** – large dams lead to the displacement of communities from upstream and downstream regions. A large number of people displaced by dams in India are tribal communities. It is difficult to rehabilitate them elsewhere because they are extremely dependent on forests for their livelihood as well as for religious and cultural purposes.

- By restricting the flow of a river, dams reduce the flow of silt downstream. This can adversely impact deltas which as dependent on the silt deposition. For example, Farakka barrage in West Bengal has reduced the flow of silt to the Sundarbans delta which is now facing the threat of coastal erosion.

- Hydropower projects are highly capital intensive. Hence, the participation of private players in this sector is subdued, a compared to other forms of power. Only around 3100 MW of hydropower has been commissioned under private sector, reflecting their minimal participation.

Realizing these constraints, the government of India has taken the following steps

- seeking assistance from multilateral bodies such as World Bank, ADB etc.,

- encouraging the development of small hydro projects (capacity less than 25 MW). Small hydro is placed under the Ministry of New and Renewable Energy and such projects get faster environmental clearances.

6.6 Ocean Thermal Energy

Oceans can be the source of two main types of renewable energy – thermal energy (produced from the sun's heat) and mechanical energy (produced from wave action and tides).

Ocean Thermal Energy

Ocean thermal energy refers to the heat energy stored in the ocean waters which they receive from the sun during the day. Ocean thermal energy can be harnessed to produce electricity using a phenomenon termed as Ocean Thermal Energy Conversion (OTEC).

Ocean Thermal Energy Conversion

In the equatorial and tropical seas, there exists a substantial temperature differential between the surface waters and the deeper waters, often to an extent of 20 degrees Celsius. This temperature gradient can be utilized to produce electricity. The warm surface waters are made to pass through a heat exchanger in which the heat stored in ocean waters is transferred to a fluid with a low boiling point. This heat vaporizes the fluid which can be used to run turbines (similar to steam run turbines) and generate electricity.

Unlike other renewables, OTEC is a non-intermittent source of electricity i.e., electricity can be produced day and night, all-round the year. Hence, OTEC has the potential to be a source of base-load. OTEC is particularly suited for small island nations and island communities which are largely dependent on imported fossil fuels for their local power needs. Naval bases and other strategic, protected assets located in the tropical ocean waters can also rely on OTEC for a sustainable power supply. OTEC power plants can be set up offshore or on the coast.

India's potential

According to an estimate, India has the potential to generate around 180 GW of OTEC power. India's southern coast of around 2000 km has ocean waters with a temperature differential in the range of 20 degrees throughout the year, forming the ideal site for setting up OTEC plants. This implies 1.5 x 106 square kilometres of tropical waters in India's Exclusive Economic Zone with a power density of 0.2 MW per square kilometre.

Challenges

- OTEC can be highly capital intensive, as against conventional sources such as coal, diesel-based power.
- OTEC technology is still in its nascent stages and has not been deployed on a large scale anywhere in the world.
- OTEC becomes financially viable only when power is produced on a large scale.

Initiatives by India

- An OTEC plant was envisaged by the government as far back as in 1998, to be set up off the coast of Tamil Nadu. However, the plan was dropped.
- India has planned to set up its first OTEC plant in Kavaratti, Lakshadweep. National Institute of Ocean Technology (NIOT), Chennai (under Ministry of Earth Sciences) is working towards developing an indigenous OTEC technology including the design, assembly, and deployment of deep-sea pipelines. It is expected to be commissioned in 2019, with a capacity to generate 200 kW power. It will be used to power a low-temperature thermal desalination plant.
- Indian Navy is in the process of setting up OTEC power plants to supply power for Andaman and Nicobar islands which are currently dependent upon diesel-based power.

6.7 Geo-Thermal Energy

Geothermal energy is the heat energy present inside the earth. The interior of the earth has a temperature in the range of around 6000 degrees Celsius. The main source of this heat is the gradual decay of certain radioactive isotopes which have longer half-life such as U238, U235, Th232, K40 etc. This heat is continuously transferred from the earth's interiors towards the outer layers by conduction and convection. The upward movement of molten magma, which is the main source of heat transmission, results in a mean heat flux of approximately 80kW/sq.m at the earth's surface.

Geo-Thermal Energy

The movement of heat from the earth's interiors is not uniform throughout the earth. It is concentrated near active plate boundaries where volcanic activity occurs regularly transmitting the molten magma near to the earth's surface. A majority portion of this magma remains trapped at depths in the range of 5 to 20 km. The magma releases the heat to its surrounding rocks. In regions where water comes into contact with such rocks, high-temperature geothermal systems are formed such as hot water, water and steam mixture, or steam at depths in the range of 500 to 3000 m.

Characteristics of Geothermal Energy

- It's a renewable form of energy which is clean (with minimal emission of greenhouse gases), reliable (with a very high availability of heat energy), and homegrown (reduces the dependence of energy imports such as coal, oil, natural gas etc.)
- It has an extensive global distribution in both developed and developing countries, unlike fossil fuels.
- It can be produced independent of weather or season, unlike renewables such as wind and solar power.

Geothermal Technologies

Geothermal energy can be used for on-grid as well as off-grid power solutions. The main types of geothermal technologies include:

- Electricity production – where the hot water and/or steam are used to run turbines and generate electric power.
- Direct use – where heat energy is harnessed from the hot water and/or steam.
- Heat pump – heat energy from shallow sources is used to heat/cool buildings.

Challenges

- Unlike other renewables such as wind and solar, geothermal energy is less known and less popular. Geothermal technologies are not fully developed.
- Only a fraction of the potential geothermal energy sources/regions has been explored and mapped.
- Many geothermal sources are located in inaccessible and harsh areas (polar regions, high mountains etc.) which makes them difficult to exploit.
- Installation of geothermal technologies is highly capital intensive, though there is no cost of fuel use.
- safety issues arise from geothermal power plants since many harmful gases escape from the geothermal vents which can be difficult to contain and be disposed of properly.

India and Geothermal Energy

According to the Geological Survey of India, India's geothermal potential which can be harnessed is around 10 GWe. GSI has identified and mapped over 300 geothermal regions across the length and breadth of the country. The surface temperatures of these geothermal sources are in the range of 35 to 98 degrees Celsius. India's geothermal sources have been divided into two main categories:

- Orogenic sources – Himalayan region, Naga-Lushai hills of the Northeast, Andaman and Nicobar islands.
- Non-orogenic sources – Narmada-Son rift valley, Damodar rift valley, Godavari valley, Cambey graben etc.

Prominent geothermal regions in India where explorations have been conducted include – the Cambay Graben in Gujarat, Puga and Chhumathang in Jammu and

Kashmir, Tattapani in Chhattisgarh, Manikaran in Himachal Pradesh, Ratnagiri in Maharashtra, and Rajgir in Bihar.

At present, there are no geothermal electricity production plants in India. However, several direct use plants have been set up. India is planning to develop about 10 GW of geothermal energy by 2030 with the help of international collaboration. The Ministry of New and Renewable Energy has released a draft geothermal energy development framework in 2016 which presents a roadmap for harnessing India's geothermal potential. The draft emphasizes the role of states in land acquisition and the payment of royalties to the states in lieu of utilizing geothermal resources. The apex bodies involved in the exploration and production of geothermal energy are Geological Survey of India, National Geophysical Research Institute, and Oil and Natural Gas Corporation.

7- BIODIVERSITY

7.1 Biodiversity and its levels

The biosphere is characterised by different forms of the living organism including Plants and Animals and these species are the product of Billons of years of evolution. As the natural ecosystem varies from the equator towards the poles and at the same time from sea level upwards to sea level downwards, thus different Biomes having different physical and Biological characteristics have developed. This biological variety forms the basis of Biodiversity. Before the advent of humans, our earth had supported more biodiversity than in any other period and after the emergence of mankind, the Biodiversity has rapidly declined since there has been mass extinction in the Holocene Era due to various factors including Habitat Loss, Climate Change and Global Warming. Biodiversity keeps on evolving and it is not found evenly on earth, 99% of the species that have ever lived on earth are extinct.

Biodiversity

- The term Biodiversity was first coined by Walter G. Rosen.
- Biodiversity is a combination of two words, Bio (Life) and Diversity (Variety), thus Biodiversity means a variety of Plants, micro-organism and animal communities in an ecosystem.

Variation in Biodiversity

- As we move from tropics to the Poles the extent of Biodiversity decreases in general. The tropical region which accounts for only seven percent of the land surface on the earth has more than 50% of the species.
- Along the coasts in the western Pacific and mid-latitudinal bands in all oceans, the marine Biodiversity is higher, as Sea Surface temperatures are highest here.

Causes for High Biodiversity

- As lower latitudes have more energy available to them due to the more amount of insolation (incoming solar radiation from sun) which is the potential source of energy on earth and along with it they have sufficient amount of precipitation available which helps plants in Photosynthesis.

- In general, the Biodiversity is higher in the regions having wider temperature ranges, this statement somehow defies the general logic that it should be higher in the areas having lesser fluctuations in temperature across the seasons.

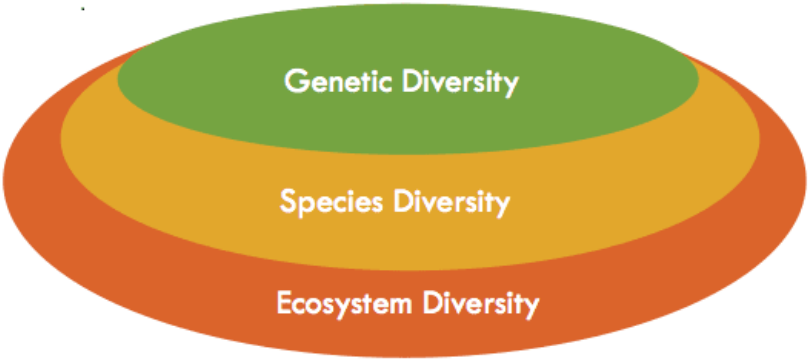
Levels of Biodiversity

Based on the Genetic, Species and Ecosystem variation of Biodiversity, it can be classified into following 3 types.

1.Genetic Diversity

2.Species Diversity

3.Ecosystem Diversity



Levels of organization of the concept of biodiversity

Genetic Diversity

- Genetic Biodiversity refers to the variation of genes within the species of plants and animals and in fact, the diversity among the genes leads to differentiation of species and which in turn determines the level of Biodiversity.
- More genetic diversity helps in the better adaptability of the individuals to the environmental conditions and at the same time, lesser genetic diversity leads to uniformity of species and thus greater susceptibility to the environmental hazards or other related impacts.
- This can be understood from the example that People living in hilly areas develop genes in accordance with the climatic condition in long run, as they have wider chest to suck more air from the environment where density of

gases is quite low, thus they have diversity in terms of genes from the individuals of same species i.e. Homo Sapiens.

- Distinct population of the same species i.e. high variety in the attributes like shape and size of Butterflies, Rhinoceros etc. are due to the possibility of variation among the genes and that is positive for the entire ecosystem too, while we can see low genetic variation among the Cheetah which can be considered as a major reason for them becoming vulnerable.

Species Diversity

- Species diversity refers to a variety of species in terms of plant, animal and microorganism of a particular ecosystem and species richness (no. of species available in a region) are mostly used to gauge the species diversity.
- Species diversity can also be expressed in more precise terms with the help of Taxonomic Diversity which shows the relationship among the species. For example, if at a place x, there are 4 species of reptiles and 2 species of birds while in other place y, there are 6 species of reptiles but no species of birds. Then, the Place x is more taxonomically diverse compared to a place y.
- Sometimes Species diversity is used as a synonym to the Biodiversity and the size of the species diversity is instrumental in making food chain longer / shorter.
- The equatorial rainforest has richest species biodiversity and they are known as the hotspots of the Biodiversity.

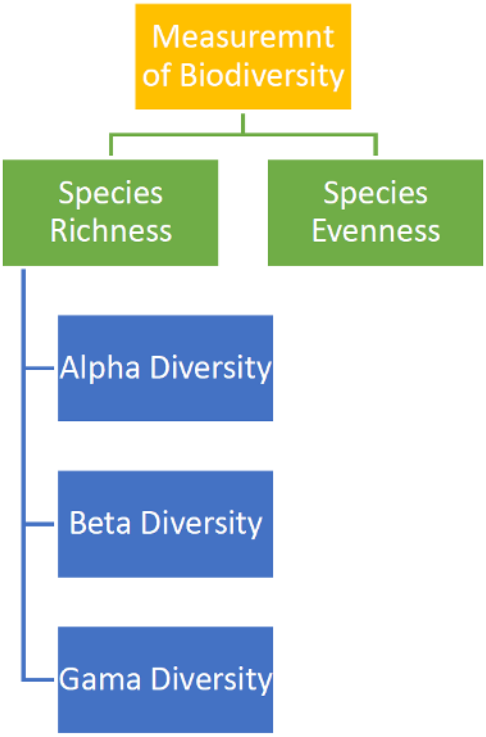
Ecosystem Diversity

- As in ecosystem, there are a variety of habitats and Niches (a role and position of species in the environment) for the biological processes and operations, thus the Biodiversity is also considered at the ecosystem level.
- The examples of ecosystem based on the habitat are Grassland, Coral, Desert, Mangrove, Wetland, Tropical Rain Forest etc.
- The Environmental conditions like land, soil, water, climate etc. determine the nature and variation of habitats for different Biological communities and also the change in the Climatic conditions is accompanied by the change in the

vegetation. Over the period of time, the species adapt to a particular kind of environment.

7.2 Measurement of Biodiversity

Paul Williams, Decair Right and Chris Humpreger made very first attempt to measure Biodiversity as they developed a software called world map to gauge the Biodiversity. Measurement of Biodiversity is done with the help of two major components which are Species Richness and Species Evenness.



Species Richness

- It shows the number of different species found in a community, region or landscape and it does not take into account the relative abundance distribution of the species.
- Species richness is used as a tool to asses the comparative conservation values of the habitat although it is not concerned with the identity of the species.
- H. Whittaker gave the idea of Alpha, Beta and Gama Diversity to describe the spatial component of species diversity.

Alpha Diversity

- Alpha Diversity shows the total no. of species found in a region and helps in the analytical study of the Biodiversity in various regions. In another word, it is diversity within a particular area.

Beta Diversity

- This is associated with the comparison of biodiversity between ecosystem, usually measured as the amount of species change between the ecosystem.
- It signifies the range of communities formed due to the replacement of the habitat and such variations in habitat occur due to the presence of different niches, Microhabitats and environmental factors.

Gama Diversity

- It is the measure of overall diversity for different ecosystem within a particular region i.e it is diversity in the overall landscape.
- The Alpha diversity and Beta diversity are the independent components of the Gama Diversity.

Species Evenness

- It shows the proportion of species at a given site. It shows relative abundance of species in a region i.e. if there is low evenness it means few species dominate the site.
- Mathematically, Species evenness is measured with the help of diversity Index.

Difference between Species Richness and Species Evenness

- Species richness shows how many species belonging to a particular area, while species evenness is comparing the no. of individuals across different species.
- For example, if there are many individuals of a species x while very less individual of another species y then the species evenness will be low since species from both x and y are not equally represented in the population.

7.3 Red Data Book

Species which are considered threatened are listed by various organisations including some private organisations, likewise, Red Data Book is published by the International Union for Conservation of Nature and Natural resources (IUCN) and provides information on research, studies and also helps in monitoring the program on rare and threatened species. Red Data Book was first issued in 1966, and it is continually updated by IUCN which is based on Morges, Switzerland. Red in the name of the book is symbolic of danger which is experienced by the plants and animals across the globe.

Red Data Book

- It contains Red, Pink and Green Pages.
- Red signifies the danger.
- Pink pages in the Red Data Book signify Critically Endangered Species.
- Green Pages show those species which were previously endangered but now has recovered to such a level that they are no longer threatened/ endangered and over the period of time the no. of green pages has kept on decreasing, while Pink Pages have kept on increasing.
- IUCN focuses on the re-evaluation of every species every 5 years if possible, or at least every 10 years and this is done in peer-reviewed (evaluation of work

by one or more people of similar competence) manner through IUCN Species Survival Commission (SSC) Specialist Groups.

The goal of IUCN Red List

- It aims to provide information and analyse status, trends, threats to species in order to conserve the Biodiversity which is essential for the existence of life on earth since each single species have an important role to play.

Strategy to achieve the Goal

- A baseline to be established from which the change in the status of species can be monitored.
- A global context should be provided for the establishment of the conservation priorities at the local level and the representative selection of species should be continuously monitored.

Assessment

The Red List assessment work of IUCN is coordinated by the staff of the Global Species program and the work is supported through Global Species Assessment Project, and through partnership with other organizations, such as BirdLife International, Conservation International, Nature Serve, Texas A&M University, the Royal Botanic Gardens Kew, Botanical Gardens Conservation International etc.

7.4 IUCN Classification of Conservation

IUCN Red List which is considered as the most comprehensive inventory of global conservation status of plant and animal species, classifies species into 9 categories which are specified by the criteria such as population size, rate of decline, area of geographic distribution, degree of population and distribution fragmentation.

Extinct

- A taxon is Extinct when there is no reasonable doubt that the last individual has died/ eliminated from both natural wild areas and managed areas such as crop cultivation or hatcheries.
- A taxon like Asian Cheetah, Pink Headed Duck, Mammoth, Dinosaurs is presumed Extinct when exhaustive surveys in known and/or expected habitat, at suitable times (diurnal, seasonal, annual), throughout its historic range have remained unsuccessful to record an individual and surveys should be over a time frame appropriate to the taxon's life cycle and life form.

Extinct in the Wild

- A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity, and thus have become extinct in the natural conditions.

Critically Endangered

A species is Critically Endangered when the best available evidence indicates that it is facing an extremely high risk of extinction in the wild and follows any of the following criteria.

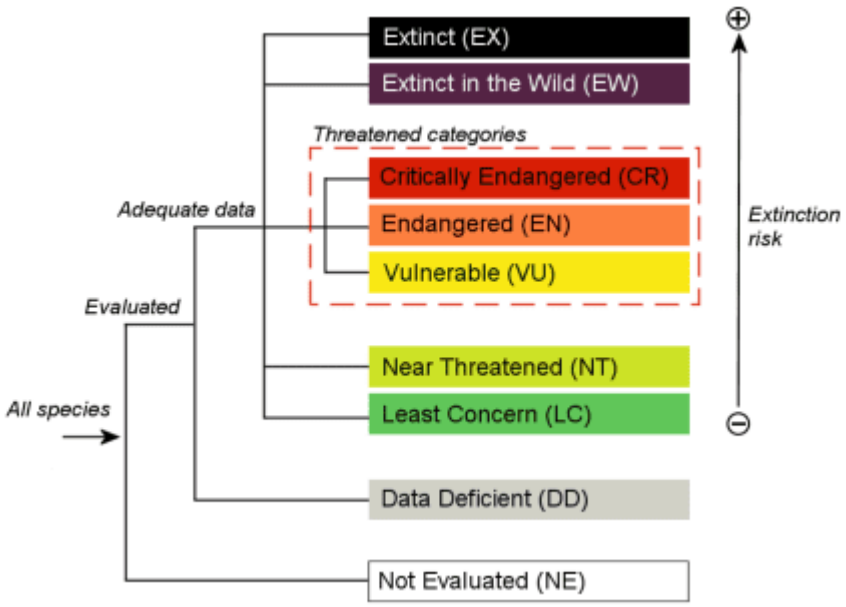
1. Population has reduced to less than 50 mature individuals.
2. The population has reduced by greater than 90% over the last 10 years.
3. Mathematical analysis showing the probability of extinction in the wild is at least 50% in 10 years.
4. Limited Geographical Range.

Endangered

A Species is Endangered when the best available evidence indicates that it meets any of the following below mentioned criteria for Endangered and it is therefore considered to be facing a very high risk of extinction in the wild.

1. Reduction in the population size (70% over the last 10 years).
2. Population has reduced to less than 250 mature individuals.
3. Mathematical analysis showing the probability of extinction in the wild at least 20% within 20 years.
4. Limited Geographical Range.

Vulnerable



- A taxon is Vulnerable when the best available evidence indicates that it meets any of the below mentioned criteria for Vulnerable, and it is therefore considered to be facing a high risk of extinction in the wild.

1. Reduction in population (>50 % over last 10 years).
2. Population size has reduced to less than 10,000 mature individuals.
3. Probability of extinction in the wild is at least 10% within 100 years.
4. Limited Geographical Range.

Near Threatened

- A species which does not qualify for criteria against Critically endangered, endangered, or Vulnerable but in near future it is close to qualifying for or is likely to qualify for threatened category, is known as near threatened.

Least Concern

- A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

Data Deficient

- A species is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status.
- A species in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking and listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate.
- Data Deficient is therefore not a category of threat.
- It is important to make positive use of whatever data are available.
- In many cases great care should be exercised in choosing between Data Deficient and a threatened status.

- If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

Not Evaluated

- A taxon is Not Evaluated when it has not yet been evaluated against the criteria.

Some Important Critically Endangered Species (IUCN) in India

Great Indian Bustard

- Great Indian Bustard is a Bustard (terrestrial birds living in grassland) found in India and adjoining regions of Pakistan (Found in Cholistan desert of Pakistan).

- Due to its large body and long bare legs it gets an Ostrich like appearance and this bird is also counted among the heaviest flying birds.
- Great Indian Bustard has a population of as less as 250 mature individuals and in India they are protected under the Wildlife Protection Act 1972.
- The bird is Critically endangered due to habitat loss, hunting (heavily hunted for their meat and for sport).
- In India the bird is found in the states of Maharashtra, Karnataka, Rajasthan, Gujarat and Madhya Pradesh.

Gharial (Gavialis gangeticus)

- It is native to the Northern part of the Indian subcontinent, total population is estimated lesser than 250 individuals and the drastic decline in Gharial population over last 60 years (3 generations for Gharial) is attributed to the loss of riverine habitat, depletion of fish resources, entanglement in the fishing nets, killing for indigenous medicine, over hunting for skin and trophies, killing by fisherman etc.

- The mature Gharial population was assessed by using Gharial Nest counts; based upon the counts and decline of population, Gharial qualifies for Critically Endangered category.
- The largest breeding subpopulation is estimated in the **Chambal River** which is around 48% of total population and only other large breeding centre of Gharial population in India is Katerniaghat Wildlife Sanctuary (Uttar Pradesh).
- In India the range of Gharial population has shrunk along the **Chambal, Girwa and Son Rivers**, while in Nepal they are found along the Narayani River.

Hawksbill sea turtle

- It is critically endangered sea turtle belonging to the family Cheloniidae and it has appearance to that of other marine turtles.

- They are predominantly found in the tropical coral reefs of Indian Ocean (coast of Indian Subcontinent, Red Sea, Persian Gulf, areas surrounding Madagascar), Pacific (Korean Peninsula, Japanese Archipelago) and Atlantic Oceans and to a lesser extent in the subtropical waters also.

Value Addition –

- 5 Species of turtle are known to inhabit the Indian coastal waters and Islands, they are-Olive Ridley Turtle, Green Turtle, Hawksbill Turtle, Loggerhead Turtle and the Leatherback turtles and except the Loggerhead Turtle other 4 nest along the Indian coast.
- Sea Turtles have a unique position within the food web since their uncommon life cycle plays a significant role in transportation of nutrient from highly productive marine surroundings like sea-grass beds to energy poor habitats such as sandy beaches (here waves are not that powerful to transport the nutrients).
- Threats to marine turtle in India include-by catch mortality (in trawl nets and gill nets), unplanned beach development (including tourism, ports, lighting, plantations), weak enforcement of laws related to fisheries etc.
- One of the world's largest mass nesting (arribada) of Olive Ridley Turtles occur along the eastern coast of India and especially along the coast of Odisha which supports around half million Olive Ridley population during their nesting season (October to April).

Siberian Crane

- Siberian Crane has breeding centres in the Arctic Tundra of eastern, central and western Russia, eastern population migrate to China during winters while the western population migrate to Iran, and India (Keoladeo National Park near Bharatpur, Rajasthan) receive the birds from central part.

- They are categorised as Critically Endangered by IUCN.

Jerdon's Courser

- This is a nocturnal (Active at night) bird and endemic to India found in Eastern Ghats of Andhra Pradesh.
- It is listed as Critically Endangered by IUCN, the reason for being critically endangered is Loss of Habitat.
- It is considered as insectivore and being a rare bird, nothing exactly is known about its behaviour and nesting habits.

Latest changes in IUCN Red List (2017)

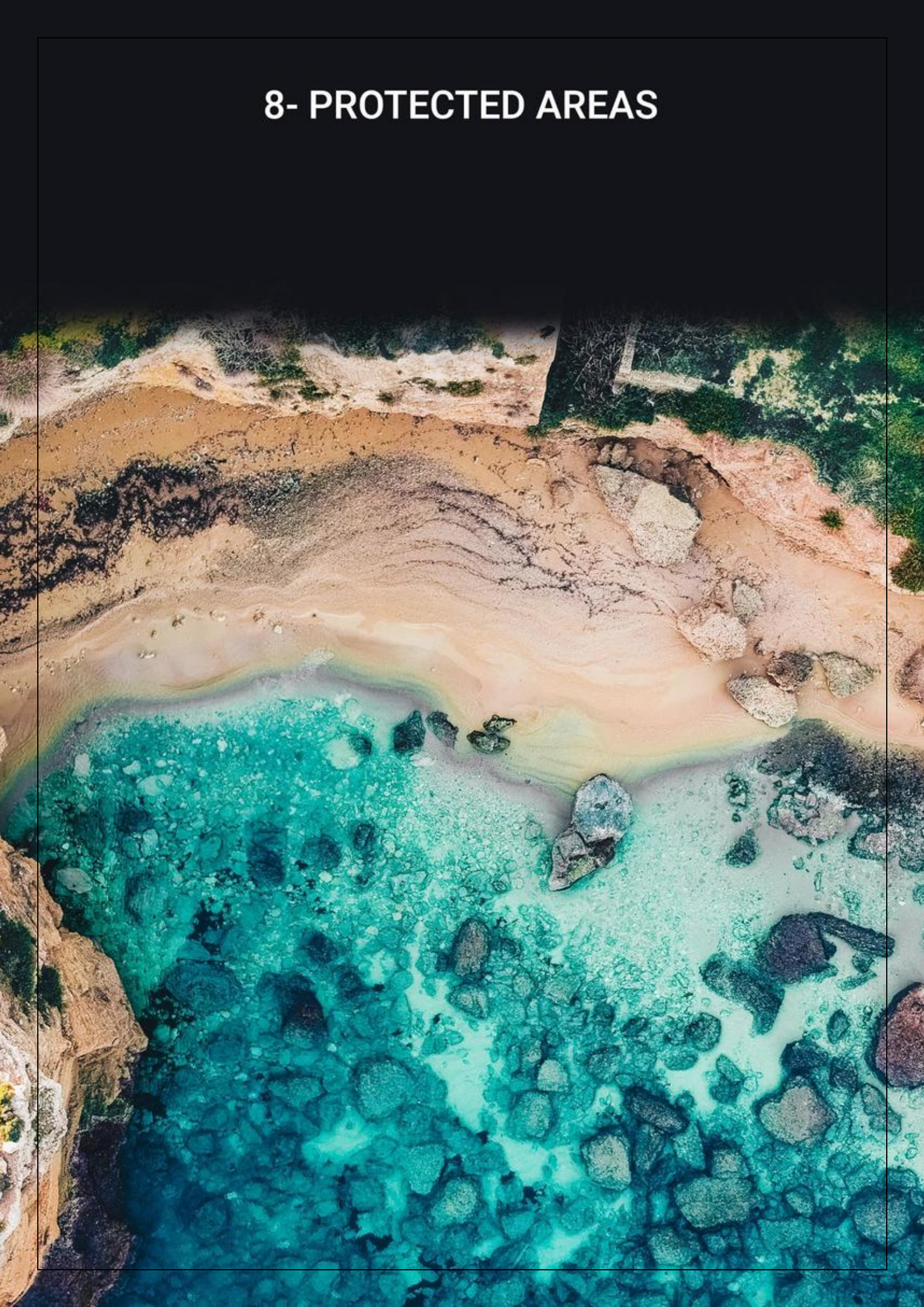
Irrawaddy Dolphin

- It occurs in the South and Southeast Asia and it has been moved from Vulnerable (VU) to Endangered (EN) in 2017, this is due to the reason that its increasing mortality from bycatch in fisheries has continued to threaten its population and this concern has not been duly addressed.

Christmas Island Whiptail-skink

- This species is endemic to the Christmas Island and it was declared Extinct in 2017 as extensive surveys after 2010 were not able to find any individuals and a captive breeding initiative was introduced for this species but that too failed, and the last individual of this species died in captivity in 2014.
- The decline and extinction of this species is supposed due to the impact of a range of introduced species in the Christmas Island including the Indian Wolf Snake and Yellow Crazy Ant and habitat destruction and mining activities.

8- PROTECTED AREAS



8.1 Wildlife sanctuary

The Wildlife (Protection) Act, 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. There are over 500 wildlife sanctuaries in the country. Some of them are categorized as tiger reserves and are governed by Project Tiger

National Park

The Wildlife (Protection) Act, 1972 provides for the declaration of National Parks by the State government in addition to the declaration of wildlife sanctuaries. National Parks are declared in areas that are considered to be adequate ecological, geomorphological and natural significance although, within the law, the difference in the conservation value of a National Park from that of a sanctuary is not specified in the WPA, 1972.

Difference between National Park and Wildlife Sanctuaries

- 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 sanctuaries can be created for a particular species (e.g., grizzled giant squirrel wildlife sanctuary in Srivilliputhur, Tamil Nadu) whereas the national park is not primarily focused on a particular species.
- The Central government can also declare a National park under certain conditions.

General Provision for Sanctuary and National Park

Declaration of the Protected Area by the State government:

- Initial notification: The State government may, by notification, declare its intention to constitute any area within or outside any reserve forest as a sanctuary/national park if it considers that such area is of adequate ecological, faunal, floral, geomorphological, natural or zoological significance, for the purpose of protecting, propagating or developing wildlife or its environment.

- Final notification: After the initial notification has been issued and the period for preferring claims has elapsed, the State government may issue a notification specifying the limits of the area which can be comprised within the sanctuary and declare the said area shall be a sanctuary/national park from such date as may be specified in the notification.

Declared by the Central government

- The Central Government may declare an area to be a sanctuary/national park if it is satisfied that the area is of adequate ecological, faunal, floral, geomorphological, natural or zoological significance, for the purpose of protecting, propagating or developing wildlife or its environment.

Boundaries

- The notification shall specify, as nearly as possible, the situation and limits of such area.
- In cases where territorial waters are included, the limits shall be determined in consultation with the Chief Naval Hydrographer of the Central Government, after taking adequate measures to protect the occupational interests of the local fishermen.
- No alteration of boundaries of a sanctuary/national park shall be made except on the recommendation of the National Board for Wildlife.
- The Amendment Act of 1991 provided for the inclusion of territorial waters in areas to be declared as sanctuaries for the protection of off-shore marine flora and fauna.

Settlement of rights

- The State government shall make alternative arrangements required for making available fuel, fodder and other forest produce to the persons affected, in terms of their rights as per the government records.
- The State government appoints an officer as a 'Collector' under the Act to inquire into and determine the existence, nature, and extent of the rights of any person in or over the land comprised within the sanctuary/national park which is to be notified.

- After the issue of a notification for the declaration of the Protected Area, no right shall be acquired in, on or over the land comprised within the limits of the area specified in such notification, except by succession, testamentary or intestate.

Claim of rights

- In the case of a claim to a right in or over any land referred to, the Collector shall pass an order admitting, or rejecting the same in whole or in part.
- If such claim is admitted in whole or in part, the Collector may either exclude such land from the limits of the proposed sanctuary or proceed to acquire such land or rights, except whereby an agreement between the owner of such land or holder of rights and the government, the owner or holder of such rights has agreed to surrender his rights to the government, in or over such land, and on payment of such compensation, as in provided in the LARR Act, 2013. The Collector may allow, in consultation with the Chief Wildlife Warden, the continuation of any right of any person in or over any land within the limits of the sanctuary.

Entry into the Protected Area

No person other than,

- A public servant on duty.
- A person who has been permitted by the Chief Wildlife Warden or the authorized officer to reside within the limits of the sanctuary/national park.
- A person who has any right over immovable property within the limits of the sanctuary/national park.
- A person passing through the sanctuary/national park along a public highway.
- The dependants of the person referred to in the clauses above,

shall enter or reside in the sanctuary/national park, except under and in accordance with the conditions of a permit granted.

Grant of permit for entry

The Chief Wildlife Warden may, on an application, grant to any person a permit to enter or reside in a sanctuary/national park for all or any of the following purposes:

- investigation or study of wildlife and purposes ancillary or incidental thereto
- photography
- scientific research
- tourism
- transaction of lawful business with any person residing in the sanctuary.

The Chief Wildlife Warden shall be the authority who shall control, manage, and maintain all protected areas. The National Board for Wildlife may make recommendations on the setting up of and management of national parks, sanctuaries, and other protected areas and on matters relating to restriction of activities in those areas. The State Board for Wildlife shall advise the State government on the selection and management of areas to be declared as protected areas.

8.2 Biosphere Reserve

The designation 'Biosphere Reserve' for natural areas was introduced for the first time by the International Coordinating Council (ICC) of UNESCO in November 1971. The functions of the biosphere reserves were clearly demarcated by the Man and Biosphere (MAB) Project area of "Conservation of natural areas and the genetic material they contain" under UNESCO in 1972. The biosphere reserve network was formally launched in 1976.

Definition

- A biosphere reserve is an international designation given by the UNESCO for representative parts of natural and cultural landscapes extending over a large area of territorial or coastal/marine ecosystems or a combination thereof.
- Biosphere reserves are special environments for both people and nature and are living examples of how human beings and nature can co-exist while respecting each other's needs.
- Biosphere reserves are sites established by the countries and recognized under UNESCO's Man and Biosphere (MAB) programme to promote sustainable development based on local community efforts and sound evidence.
- As places that seek to reconcile conservation of biological and cultural diversity and economic and social development through partnerships between people and nature, they are ideal to test and demonstrate innovative approaches to sustainable development from local to international scales.

Biosphere reserves are

- globally considered as sites of excellence where new and optimal practices to manage nature and human activities are tested and demonstrated.
- tools to help countries implement the results of the World Summit on Sustainable Development and in particular the Convention on Biological Diversity and its ecosystem approach.
- learning sites for the UN Decade on Education for Sustainable Development.

After their designation, biosphere reserves remain under the national sovereign jurisdiction, yet they share their experience and ideas nationally, regionally, and also internationally within the World Network of Biosphere Reserves (WNBR)

Characteristics of Biosphere Reserves

- Each of the biosphere reserves are protected areas of land and/or coastal environment wherein people are an integral component of the system. Together they constitute a worldwide network linked by international understanding for the exchange of scientific information.
- The network of biosphere reserves includes significant examples of biomes throughout the world.

Each biosphere reserve includes one or more of the following categories

- biosphere reserves are representative examples of natural biomes.
- biosphere reserves conserve unique communities of biodiversity or areas with unusual natural features of exceptional interest. It is recognized that these representative areas may also contain unique features of landscapes, ecosystems, and genetic variations such as one population of a globally rare species, their representativeness and uniqueness may both be characteristics of an area.
- biosphere reserves have examples of harmonious landscapes resulting from traditional patterns of land use.
- biosphere reserves have examples of modified or degraded ecosystems capable of being restored to more natural conditions.
- biosphere reserves have a non-manipulative core area, in combination with areas in which baseline measurements, experimental and manipulative research, education, and training is carried out. Where these areas are not contiguous, they can be associated in a cluster.

Functions of Biosphere Reserves

Conservation

- To ensure the conservation of landscapes, ecosystems, species and genetic variations.
- To encourage the traditional resource use systems.
- To understand the patterns and processes of the functioning of ecosystems.
- To monitor the natural and human-induced changes on spatial and temporal scales.

Development

- To promote at the local level economic development which is culturally, socially, as well as ecologically sustainable.
- To develop strategies leading to improvement and management of natural resources.

Logistics support

- To provide support for research, monitoring, education, and information exchange related to local, national, and global issues of conservation and development.
- Sharing of knowledge generated by research through site-specific training and education.
- Development of community spirit in the management of natural resources.

Beneficiaries

- Direct beneficiaries include the local community and the ecological resources of the biosphere reserve.
- Indirect beneficiaries include the world community as a whole.

Indian approach to biosphere reserves

India's enormous and abundant ecological diversity makes it one of the mega-biodiverse regions on the globe. Efforts are on to designate at least one biosphere reserve in each of the biogeographic provinces.

National Biosphere Reserve Programme

The programme was initiated in 1986. It has the following aims:

- To serve as a wider base for the conservation of the entire range of living resources and their ecological foundations, in addition, to already established protected areas network.
- To bring out representative ecosystems under conservation and sustainable use on a long-term basis.
- To ensure the participation of local inhabitants for effective management and devise means of improving the livelihood of the local inhabitants through sustainable use.
- To integrate scientific research with traditional knowledge of conservation, education, and training as part of the overall management of the biosphere reserve.
- The Core Advisory Group of Experts, constituted by Indian MAB Committee identified and prepared an inventory of potential sites for recognition as biosphere reserves. Subsequently, additional biosphere reserves were proposed by the National Committee as well as the State governments.

Objectives

It is important to note that the biosphere reserves are not a substitute or alternative, but a reinforcement, to the existing protected areas. The objectives of the biosphere reserve programme, as envisaged by the Core Group of Experts, are as follows

- To conserve the diversity and integrity of plants and animals within the natural ecosystems
- To safeguard the genetic diversity of species on which their continuing evolution depends
- To provide facilities for education and training, and

- To ensure sustainable use of natural resources through most appropriate technology for improvement of the economic well-being of local people.

These objectives are to be oriented in such a way that the biosphere reserves become the units wherein the biological, socio-economic, and cultural dimensions of conservation are integrated together into a realistic conservation strategy.

Criteria for selection of biosphere reserves:

The criteria for selection of sites for biosphere reserves as laid down by the Core Group of Experts in 1979 are as follows:

Primary criteria

- A site that must contain an effectively protected and minimally disturbed core area of value of nature conservation and should include additional land and water suitable for research and demonstration of sustainable methods of research and management.
- The core area should be typical of a biogeographical unit and large enough to sustain viable populations representing all trophic levels in the ecosystem.

Secondary criteria

- Areas having rare and endangered species.
- Areas having a diversity of soil and micro-climatic conditions and indigenous varieties of biota.
- Areas potential for preservation of traditional tribal or rural modes of living for harmonious use of the environment.

Structure and Design of Biosphere Reserves

- In order to undertake complementary activities of biodiversity conservation and development of sustainable management aspects, biosphere reserves are demarcated into three inter-related zones.

- The Core Zone, which is kept absolutely undisturbed. It must contain suitable habitat for numerous plant and animal species, including higher order predators and may contain centres of endemism. Core areas often conserve the wild relatives of economic species and also represent important genetic reservoirs. The core zones also contain places of exceptional scientific interest. A core zone secures legal protection and management and research activities that do not affect natural processes and wildlife are allowed. Strict nature reserves and wilderness portions of the area are designated as core areas of the biosphere reserve. The core zone is to be kept free from all human pressures external to the system.

- The Buffer zone adjoins or surrounds core zone. Its uses and activities are managed in ways that protect the core zone. These uses and activities include restoration, demonstration sites for enhancing value addition to the resources, limited recreation, tourism, fishing, and grazing, which are permitted to reduce its effect on core zone. Research and educational activities are to be encouraged. Human activities, if natural within the biosphere reserve, are likely to be permitted to continue if these do not adversely affect the ecological diversity.

- The Transition zone is the outermost part of a biosphere reserve. This is usually not delimited one and is a zone of cooperation where conservation, knowledge, and management skills are applied and uses are managed in harmony with the purpose of the biosphere reserve. This includes settlements, croplands, managed forests and area for intensive recreation, and other economic uses characteristic of the region.

- In Buffer zone and Transition zones, manipulative macro-management practices are used. Experimental research areas are used for understanding the patterns and processes in the ecosystem. Modified or degraded landscapes are included as rehabilitation areas to restore the ecology in a way that it returns to sustainable productivity.

Difference between Biosphere Reserves and other protected areas

- Biosphere reserves are not intended to replace existing protected areas but it widens the scope of the conventional approach of protection and further strengthens the Protected Area Network.

- Existing legally protected areas (National Parks, Wildlife Sanctuary, Tiger Reserve and reserve/protected forests) may become part of the biosphere reserve without any change in their legal status.
- On the other hand, the inclusion of such areas in a biosphere reserve will enhance their national value.
- It, however, does not mean that biosphere reserves are to established only around National Parks and Wildlife Sanctuaries.
- However, the biosphere reserves differ from protected areas due to their emphasis on:
- conservation of overall biodiversity and landscape, rather than some specific flagship species, to allow natural and evolutionary processes to continue without any hindrance.
- different components like landscapes, habitats, and species and landraces.
- developmental activities, and resolution/mitigation of conflicts between development and conservation.
- increase in broad-basing of stakeholders, especially local people's participation and their training, as compared to the features of the scheme on wildlife sanctuaries and national parks.
- sustainable environment-friendly development, and sustained coordination among different development organizations and agencies.
- research and monitoring to understand the structure and functioning of the ecological system and their mode of reaction when exposed to the human intervention.
- The Indian National Man and Biosphere Committee constituted by the Central Government identifies new sites, advises on policies and programmes, lays down guidelines, reviews progress and guidelines in the light of evaluation studies and feedback.
- management of biosphere reserves is the responsibility of the concerned State/UT with necessary financial assistance, guidelines for management and technical expertise provided by the Central Government.

- biosphere reserves are internationally recognized within the framework of UNESCO's Man and Biosphere (MAB) programme, after receiving the consent of the participating country.

8.3 World Network of Biosphere Reserve

World Network

- In order to facilitate cooperation among the nations, biosphere reserves are admitted into an international network by the International Coordinating Council (ICC) of Man and Biosphere (MAB) programme of UNESCO on the request of the participating country, subject to their fulfilment of prescribed criteria.
- The biosphere reserves remain under the sole sovereignty of the concerned country/state where it is situated, and their participation in the World Network is voluntary.
- Delisting from the international network is done as an exception on the grounds of violation of the obligations for conservation and sustainable development of biosphere reserves, after consulting with the concerned Government.
- The MAB programme's primary achievement is the creation of the World Network of Biosphere Reserves in 1977. At present, there are 669 biosphere reserves in 120 countries, including 20 transboundary sites in the world network under the MAB programme.
- It promotes North-South and South-South collaboration and represents a unique tool for international cooperation through sharing of knowledge, exchanging experiences, building capacity, and promoting best practices

Vision:

The World Network of Biosphere Reserves (WNBR) of the MAB programme consists of a dynamic and interactive network of sites of excellence. It fosters the harmonious integration of people and nature for sustainable development through:

- participatory dialogue.
- knowledge sharing
- poverty reduction

- human well-being
- respect for cultural values and society's ability to cope with change
- aiding the attainment of Sustainable Development Goals, 2030.

Accordingly, the WNBR is one of the main international tools to develop and implement sustainable development approaches in a wide array of contexts.

Mission:

The network aims to ensure environmental, economic, and social (includes cultural and spiritual) sustainability through:

- the development and coordination of a worldwide network of places acting as demonstration areas and learning sites with the aim of maintaining and developing ecological and cultural diversity, and securing ecosystem services for human well-being.
- the development and integration of knowledge, including science, to advance our understanding of interactions between people and the rest of nature.
- building global capacity for the management of complex socio-ecological systems, particularly through encouraging greater dialogue at the science-policy interface, environmental education, and multi-media outreach to the wider community.

Designation of Biosphere Reserves:

Articles 5 of 1995 Statutory Framework of the World Network of Biosphere Reserves, states the designation procedure for biosphere reserves. It reads as follows – Biosphere reserves are designated for inclusion in the Network by the International Coordinating Council (ICC) of the MAB programme in accordance with the following procedure:

- States, through MAB Committees, where appropriate, forward nominations with supporting documentation to the secretariat after having reviewed potential sites, taking into account the criteria as defined in Article 4
- The secretariat verifies the content and supporting documentation: in the case of an incomplete nomination, the secretariat requests the missing information from the nominating State.

- Nominations will be considered by the Advisory Committee for Biosphere Reserves for recommendations to the ICC.
- ICC of the MAB programme takes the decision on nominations for designation.
- The Director-General of UNESCO notifies the State concerned of the decision of the ICC.

States are encouraged to examine and improve the adequacy of any existing biosphere reserve, and to propose extension as appropriate, to enable it to function fully within the Network. Proposals for extension follow the same procedure as described above for new designations.

Biosphere reserves which have been designated before the adoption of the present Statutory Framework are considered to be already a part of the Network. The provisions of the Statutory Framework apply to them.

8.4 Biodiversity Hotspots

The concept of a biodiversity hotspot was put forward by Norman Myers in 1988. The criteria which are necessary for a region to be categorized as a biodiversity hotspot include:

- Species endemism – it must contain at least 1500 species of vascular plants, which is more than 0.5 percent of the world's total plant population, as endemic species.
- Degree of threat – it must have lost at least 70 percent of its original habitat due to human interventions.

Each of the biodiversity hotspots represents a remarkable universe of extraordinary floral and faunal endemicity which is struggling to survive in rapidly shrinking ecosystems. Over 50 percent of the world's plant species and 42 percent of all terrestrial vertebrate species are endemic to the 36 biodiversity hotspots.

The hottest hotspots:

Some hotspots are much richer than others in terms of their numbers of endemics. Five key factors have been taken into consideration and those biodiversity hotspots which top the list with respect to these factors are identified as the hottest hotspots. The five factors include:

- Endemic plants.
- Endemic vertebrates.
- Endemic plants/area ratio (measured as species per 100 sq.km.)
- Endemic vertebrates/area ratio (measured as species per 100 sq.km.)
- Remaining primary vegetation as a percentage of original extent.

The eight hottest hotspots in terms of five factors

- Madagascar
- Philippines

- Sundaland
- Brazil's Atlantic Forest
- Caribbean
- Indo-Burma
- Western Ghats/Sri Lanka
- Eastern Arc and Coastal Forests of Tanzania/Kenya

These eight hottest hotspots appear at least three times in the top ten listings for each factor.

Biodiversity hotspots in India

There are 3 such hotspots in India. They include:

- The Eastern Himalayas
- Indo-Burma
- The Western Ghats and Sri Lanka

The Eastern Himalayas

- The region encompasses Bhutan, northeastern India, and southern, central, and eastern Nepal. The region is geologically young and shows high altitudinal variation. The abrupt rise of the Himalayan mountain range from less than 500 metres to more than 8000 metres results in a diversity of ecosystems that range from alluvial grasslands and subtropical broadleaf forests along the foothills to temperate broadleaf forests in the mid-hills, mixed conifer and conifer forests in the higher hills, and alpine meadows above the tree line.
- The hotspot has nearly 163 globally threatened species (both flora and fauna) including the one-horned rhinoceros, the wild Asian water buffalo etc.
- There are an estimated 10000 species of plants in the Himalayas, of which one-third are endemic and found nowhere else in the world.

- Many plant species are found even in the highest reaches of the Himalayan mountains. For example, a plant species Ermania Himalayensis was found at an altitude of 6300 metres in the northwestern Himalayas.
- A few threatened endemic bird species such as the Himalayan Quail, Cheer Pheasant, Western Tragopan etc., are found here, along with some of Asia's largest and most endangered birds such as the Himalayan Vulture and the White-bellied Heron.
- The Himalayas are home to over 300 species of mammals, a dozen of which are endemic. Mammals like the Golden Langur, the Himalayan Tahr, the Pygmy Hog, Langurs, Asiatic Wild Dogs, Sloth Bears, Gaurs, Muntjac, Sambar, Snow Leopard, Black Bear, Blue Sheep, Takin, the Gangetic Dolphin, Wild Water Buffalo, Swamp Deer etc., have the Himalayan ranges as their home.

Indo-Burma Region

- The region encompasses several countries including Eastern Bangladesh, Malaysia, Northeastern India south of Brahmaputra river, Myanmar, the southern part of China's Yunnan province, Lao's People's Democratic Republic, Cambodia, Vietnam, and Thailand. The Indo-Burma region is spread over 2 million sq.km. of tropical Asia. Since the hotspot is spread over such a large area and across several major landforms, there is a wide diversity of climate and habitat patterns.
- Though a large part of this region is characterized by wilderness, it has been deteriorating rapidly in the last few decades. Recently, six species of large mammals have been discovered here viz., Large-antlered Muntjac, Annamite Muntjac, Grey-shanked Douc, Annamite striped Rabbit, Leaf Deer, and the Saola.
- This region is home to several primate species such as monkeys, langurs, and gibbons with populations numbering only in the hundreds.
- Many of the species, especially some freshwater turtle species, are endemic.
- Almost 1300 bird species exist in this region including the threatened White-eared night-heron, the Grey-crowned Crocias, and the Orange-necked partridge.

- It is estimated that there are about 13,500 plant species in this hotspot, with over half of them endemic. Ginger, for example, is native to this region.

The Western Ghats and Sri Lanka

- The Western Ghats, also known as the "Sahyadri Hills" encompasses the mountain forests in the south-western parts of India and highlands of south-western Sri Lanka.
- The entire extent hotspot was originally about 1,82,500 sq.km., but now due to tremendous population pressure, it has shrunk to just 12, 445 sq.km or about 6.8 percent of the original area, which is retained in its pristine condition.
- The wide variation of rainfall patterns in the Western Ghats, coupled with the region's complex geography, produces a great variety of vegetation types. These include scrub forests in the low-lying rain shadow areas and the plains, deciduous and tropical rainforests up to about 1500 metres, and a unique mosaic of montane forests and rolling grasslands above 1500 metres.
- In Sri Lanka, the diversity includes dry evergreen forests to the Dipterocarpus dominated rainforests to the tropical montane cloud forest.
- The important populations include Asian elephant, Nilgiri Tahr, Indian Tigers. Lion-tailed Macaque, Giant Squirrel etc.

8.5 World Heritage Sites

World Heritage Sites refer to any of the various areas or objects which are inscribed on the UNESCO World Heritage List. The sites are designated as having outstanding universal value under the Convention concerning the Protection of the World Cultural and Natural Heritage. The Convention was adopted by UNESCO in 1972 and came into force in 1975. It provides a framework for international cooperation in preserving and protecting cultural treasures and natural areas throughout the world.

The Convention defines the kind of sites which can be considered for inscription in the World Heritage List such as ancient monuments, museums, biodiversity and geological heritage etc. and sets out the duties of the State Parties in identifying and protecting them. Although many World Heritage sites fall into either the 'cultural' or 'natural' categories, a particularly important aspect of the convention is its ability to recognize landscapes that combine these values, and where the biological and physical aspects of landscapes have evolved alongside human activity.

The first list of World Heritage Sites was published in 1978. The World Heritage Convention reiterates the protection of sites should be dovetailed with regional planning programmes. Unfortunately, this doesn't happen all the time. For instance, the development of Agra city did not go well with the conservation of Taj Mahal.

Natural heritage sites are restricted to those areas that:

- furnish outstanding examples of the earth's record of life or its geological processes.
- provide excellent examples of ongoing ecological and biological evolutionary processes.
- contain natural phenomena that are rare, unique, superlative, or of outstanding beauty or.
- furnish habitats of rare, endangered animals or plants or are sites of exceptional biodiversity.

Until the end of 2004, there were six criteria for cultural heritage and four criteria for natural heritage. In 2005, this was modified so that there is only one set of ten criteria. Nominated sites must be of "outstanding universal value" and meet at least one of the ten criteria. The criteria are as follows:

- to represent a masterpiece of human creative genius.
- to exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design.
- to bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared.
- to be an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates a significant stage/stages of human history.
- to be an outstanding example of a traditional human settlement, land-use, or sea-use, which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change.
- to be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance (The Committee considers that this criterion should preferably be used in conjunction with other criteria).
- to contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance.
- to be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features.
- to be outstanding examples representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, freshwater, coastal and marine ecosystems and communities of plants and animals.

- to contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.
- The UNESCO funds numerous efforts to preserve and restore World Heritage Sites in developing nations. It also maintains a List of World Heritage Sites in danger of facing the threats of pollution and other natural hazards. Sites subject to unusual levels of pollution, natural hazards, or other problems may be places for restoration. Such designated sites facilitate the promotion of tourism.

World Heritage Sites in India:

Cultural Heritage Sites

Sl. No.	Name of Cultural World Heritage Site	State	Year of Notification
1	Agra Fort	Uttar Pradesh	1983
2	Ajanta Caves	Maharashtra	1983
3	Buddhist Monuments at Sanchi	Madhya Pradesh	1989
4	Champaner-Pavagadh Archaeological Park	Gujarat	2004
5	Chhatrapati Shivaji Terminus (Formerly Victoria Terminus)	Maharashtra	2004
6	Churches and Convents of Goa	Goa	1986
7	Elephanta Caves	Maharashtra	1987
8	Ellora Caves	Maharashtra	1983
9	Fatehpur Sikri	Uttar Pradesh	1986
10	Great Living Chola Temples	Tamil Nadu	1987
11	Group of Monuments at Hampi	Karnataka	1986

12	Group of Monuments at Mahabalipuram	Tamil Nadu	1984
13	Group of Monuments at Pattadakal	Karnataka	1987
14	Hill Forts of Rajasthan	Rajasthan (Chittorgarh, Kumbhalgarh, Ranthambhore, Amber Sub-Cluster, Jaisalmer, Gagron)	2013
15	Humayun's Tomb, Delhi	Delhi	1993
16	Khajuraho Group of Monuments	Madhya Pradesh	1986
17	Mahabodhi Temple Complex at Bodh Gaya	Bihar	2002
18	Mountain Railways of India	Tamil Nadu	1999
19	Qutb Minar and its Monuments, Delhi	Delhi	1993
20	Rani-Ki-Van (the Queen's Stepwell) at Patan, Gujarat	Gujarat	2014
21	Red Fort Complex	Delhi	2007

22	Rock Shelters of Bhimbetka	Madhya Pradesh	2003
23	Sun Temple, Konarak	Orissa	1984
24	Taj Mahal	Uttar Pradesh	1983
25	The Jantar Mantar, Jaipur	Rajasthan	2010
26	Archaeological Site of Nalanda Mahavihara (Nalanda University) at Nalanda	Bihar	2016
27	The Architectural Work of Le Corbusier, an Outstanding Contribution to the Modern Movement	Chandigarh	2016
28.	Historic City of Ahmadabad	Gujarat	2017

Natural Heritage Sites

Sl. No.	Name of Natural World Heritage Site	State	Year of Notification	Area (In Km^2)
1	Kaziranga National Park	Assam	1985	429.96
2	Keoladeo Ghana National Park	Rajasthan	1985	28.73
3	Manas Wildlife Sanctuary	Assam	1985	391.00
4	Nanda Devi National Park and Valley of Flowers	Uttarakhand	1982 2005	630.00 87.50
5	Sunderbans National Park	West Bengal	1984	1,330.10
6	Western Ghats	Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala	2012	1,60,000.00
7	Great Himalayan National Park	Himachal Pradesh	2014	905.4

Mixed Heritage Sites

Sl. No.	Name of Mixed World Heritage Site	State	Year of Notification
1	Khangchendzonga National Park	Sikkim	2016

9- CONSERVATION PROJECTS IN INDIA

9.1 Project Tiger

The national animal of India is tiger (panthera tigris). In 1900, the total population of Tigers in India was estimated to be around 20000 to 40000 Individuals. However, in the first country wide tiger census of 1972, the total number of tigers had declined to about 1800. This raised alarm bells in the government machinery and the wildlife conservationists.

Project Tiger – Tiger Conservation strategy in India

In response, Government of India launched Project Tiger in 1973. Project Tiger is a centrally sponsored scheme which is under the administrative control of Ministry of Environment and Forest. National Tiger conservation authority administers the project tiger. India has declared several national parks and wildlife sanctuaries as Tiger Reserves.

Aim and objectives of Project Tiger

1. To maintain a viable population of tigers in their natural habitats and save them from extinction to preserve its scientific, economic, ecological and cultural value.

2. To ensure conservation of other endangered species, and harmonise the rights of tribal people with conservation of wildlife in the tiger reserves and areas around it.

Tiger

Tiger Reserves

- Tiger Reserves – the areas for the protection of tigers and their prey; which are notified under the project tiger launched in 1973.
- The total number of Tiger reserves has increased from 9 in 1973 to around 50 presently.
- The state governments declare an area as a tiger reserve on the recommendations of national Tiger conservation authority.
- The Tiger Reserves are divided into core zone and buffer zone.

Core zone

- Core zone is the areas which are to be kept free of biotic disturbances and Forestry operations and are required to be kept inviolate to ensure Tiger conservation. The above objectives have to be achieved without affecting the lawful rights of Scheduled Tribes and other forest dwellers.

- The state governments, after consultation with an expert committee which is constituted for this purpose, notify the core areas and the Tiger Reserves.
- Activities such as Forestry operations, a collection of minor forest produce grazing of domestic animals and human disturbances etc are not allowed in core areas.

Buffer zone

- Buffer zone includes the area which is peripheral to the core area of Tiger Reserves. It aims at providing supplementary habitat for dispersing tigers along with allowing the coexistence of human activity.
- Buffer zone areas aim to promote coexistence of tigers and its prey species with the tribal population and ensure their livelihood, developmental, social and cultural rights.
- The gram sabha and expert committee constituted for this purpose determine the limitations of human activity in the buffer zone.
- The boundaries of tiger reserves cannot be changed without the recommendations of National tiger conservation authority and the approval of the national board for wildlife.
- The state governments, cannot de-notify any tiger reserve, except in public interest with the approval of and NTCA and the national board for wildlife.

Tiger task force

- To ensure the proper implementation of Project Tiger; it required the need for a statutory authority to ensure Tiger conservation. The Tiger task force was set up to look after the problems of Tiger conservation in India, on the recommendations of the national board for wildlife.
- The Tiger task force has given recommendations to strengthen the project tiger by providing it statutory and administrative powers.
- National board for wildlife → Tiger task force → NTCA.

National Tiger conservation authority (NTCA)

- In December 2005, after the recommendations of Tiger task force, the national Tiger conservation authority was established.
- The Wildlife Protection Amendment Act, 2006 provides for constitution of a Statutory authority, the national Tiger conservation authority. This was to help in the implementation of various Tiger conservation efforts and measures.

Members of NTCA

- The national Tiger conservation authority was set up under the chairmanship of the Minister for the Environment and Forest.
- The NTCA will have following members:
- Eight experts who have the qualifications in wildlife conservation and the Welfare of Scheduled Tribes and other forest dwellers.
- 3 member of parliaments (1 Rajya Sabha, 2 Lok Sabha).
- The ex officio member secretary of NTCA will be the inspector general of a forest, who is the in charge of Project Tiger.
- Other members.

Powers and functions of NTCA

- Its functions include the approval of Tiger conservation plans which have been prepared by the various state governments.

- Assessment and evaluation of different aspects of sustainable ecology and ecosystem and to disallow the ecological and sustainable land use practices which include mining, industrial development etc in the Tiger Reserves.
- For better implementation of Tiger conservation plans ensuring the provision of critical support which includes scientific, information technology and legal support.
- It has a responsibility to provide information about the protection and conservation plan of Tiger Reserves, estimation of the number of tigers and their natural prey species, surveillance of disease, mortality of tigers; and providing information about patrolling, and other management aspects which are necessary for the future plan of conservation of Tiger Reserves.
- It prescribes the normative standards and guidelines which are necessary for tourism activities in the tiger Reserves. It also ensures the implementation of its guidelines for tiger conservation in the buffer zone and core area of tiger reserves.
- It facilitates the tiger reserve management in the state for the protection and conservation of biodiversity initiatives through eco-development and people's as per the approved guidelines and management plans.
- It has the responsibility to ensure capacity building and skill development of staff and officers who are responsible for the management and protection of Tiger Reserves.

Estimation of Tiger population in India

- In India, Tiger census is carried out every four years, the last census was conducted in 2014 in which the total number of Tigers in India was 2226. Tiger census is conducted to know about the tiger population trend and estimates the number, density and change in tiger population indices – which is a measure of tiger occupancy in a particular area.
- It also helps to gather information about the density of tiger populations and their prey species.
- Pugmark census technique is one of the most commonly used methodologies to calculate the number of tigers. The imprints of the pugmark of tigers are recorded and used for the identification of individual tigers.

- New methods such as camera trapping, DNA fingerprinting, and mobile app are now being used to accurately calculate the total number of individual tigers.
- In-camera trapping, the photograph of different tigers are recorded and the individual tigers are differentiated by analysing the stripes of tigers which are different for different tigers. Indian DNA fingerprinting, tigers are identified by using their scats for DNA analysis.

Phase IV Monitoring Protocol

- For the proper monitoring of Tiger population, India has initiated the Phase IV of Tiger estimation program in November 2011.
- The methodology of phase IV estimation was developed by Wildlife Institute of India (WII) and national Tiger conservation authority NTCA after consultation with wildlife experts and conservationists. It uses statistically sound procedures and methodology to estimate the population of tigers and their prey species.
- It uses camera traps, at the density of 25 double-sided cameras as per hundred square kilometres and a minimum 1000 trap Nights per hundred square kilometres.
- Phase IV of Tiger monitoring programme provides an early indication of the status of Tiger population in the country. It is crucial for long-term management and conservation and protection of tigers in wild.
- It also monitors the population of prey species using distance sampling protocols.

Tiger population estimates

- Tiger census was carried out in 2006, 2010 and 2014. The next census is being carried out in 2018.
- According to Tiger census 2006, there were around 1411 Tigers in India. The Tiger population increased to 1706 in 2010 and 2226 in 2014.

Tiger Census 2018

- The Tiger census 2018 has begun and the new data about Tiger population is expected to be released in January 2019. The total number of tigers is estimated to cross 3000 marks as the surveys conducted by different states have reported notable increases in Tiger population.
- States with highest numbers of tiger populations such as Karnataka, Uttarakhand, Madhya Pradesh and Tamilnadu have reported about an increase in the numbers of Tiger population. Uttarakhand which had the second largest population of tigers in 2014 (340) has reported about the increase in Tiger population to at least 361.
- For the first time in the tiger census, neighbouring Nepal, Bangladesh and Bhutan are also being included in the tiger census as they constitute a larger Tiger range in the subcontinent. The officials of Nepal, Bhutan and Bangladesh are being trained in India to carry out the tiger census. Involving these countries in the tiger census would remove the chances of double counting of tigers as they move between the national borders.
- The all India tiger estimation, 2018 is expected to be more accurate and precise than earlier estimates as new technology is being adopted. An Android phone based application along with its desktop version, M-STrIPES (Monitoring System for Tigers-Intensive Protection and Ecological Status) is being used for collecting and analysing data about the Tiger population.
- This application automatically records the track log of service and authenticates the recorded data on signs and animal sightings with the geotagged photographs of tigers and other animals. Further, the camera density has been increased and the number of cameras to be used in 2018 is around 15000.
- The census also estimates the number of leopard population and prey species of tigers. In 2014, India's Leopard population was around 11000.

International Co-operation

- India has bilateral Memorandum of understanding with Nepal for controlling and preventing the transborder illegal trade in wild animal species and their conservation. Protocol for the conservation of tigers has been signed with China.
- A bilateral protocol has also been signed with Bangladesh for the conservation of a Royal Bengal Tiger, especially in the Sundarban area.
- India will also sign a tripartite protocol with Bhutan, Myanmar and Bangladesh for the conservation of tigers.
- An international forum called the Global Tiger forum of Tiger range countries has been created to ensure cooperation in international issues related to conservation of tigers. It has the target to double the number of tigers by 2022.
- In order to prevent the International trade of tigers and other wild animals, conventions such as CITES, of which India is a party is being used. In a landmark decision CITES, had stated that 'tigers should not be bred for trade in their parts and derivatives'.

Action and initiatives were taken by the government for Tiger conservation

The government of India has taken several steps which includes legal steps, administrative steps and financial steps to ensure and promote Tiger conservation in India.

Legal initiatives

- The Wildlife Protection Act 1972 was amended in 2006 to provide enabling provisions and constituting National Tiger conservation authority. Also, tiger and other endangered species crime control bureau were created through this amendment.
- The punishments for cases of offences related to the Tiger Reserves and its core area was increased.

Administrative Actions

- The government has taken steps for preventing poaching activities which includes a special strategy for monsoon patrolling etc.
- Under the chairmanship of respective Chief Ministers, state-level steering committees have been established along with the establishment of the Tiger Conservation Foundation.
- A special Tiger Protection Force was created by the Union budget 2008.

Financial initiatives

- The Government of India is providing financial and technical Support to the state governments under the centrally sponsored schemes such as Project Tiger, and integrated development of wildlife habitats etc.

Problems involved with Project Tiger

- The forest rights act 2006 passed by Indian Parliament recognises the historical rights of Scheduled Tribes and other forest-dwelling communities in the forested areas. This has created a controversy over its implications on the tiger reserves and tiger conservation.

- Further, there is lack of sufficient provisions in case of abuse of power by the authorities which can exaggerate the tiger crisis.

Why are tigers endangered?

The Tigers are facing threats mainly due to poaching, destruction of habitat, loss of prey species etc.

Man-animal conflict

- The man-animal conflict has been a major threat to the Tiger population. Human activities are leading to loss of habitat for the tigers and their prey species.
- Due to the expansion of Agricultural activities, the pressure in the buffer zone of Tiger reserves has increased. Tigers have started coming out to the villages in search of prey and have attacked domestic animals and human beings. This has resulted in man-animal conflict and many tigers have been killed in retaliation.

Hunting and illegal trade of tigers

- Hunting has been a major threat and has been responsible for the decline in the numbers of tigers in the past. The use of bones, teeth of the tiger for making medicines, jewellery etc has been responsible for the hunting and poaching of tigers.
- Also, hunting is seen as a symbol of status which has been a responsible for a decline of tiger population in the past, especially in the 20th century.

Anthropogenic Activities

- Anthropogenic activities such as mining, industrial activities, construction of roads and Highways etc have resulted in the destruction of Tiger habitat.
- Other activities such as the building of dam as in case of planned Ken Betwa river interlinking project which can negatively affect the nearby Panna Tiger Reserve.
- All these activities have led to a large loss of prey species population such as deer etc. which in turn affects the number of tigers.

Reasons for slightly increased Tiger population in the recent past

- Conservation efforts such as outstation patrolling, wireless communication systems etc have been responsible for a decline in poaching activities.
- Initiatives such as voluntary village relocation in many tiger reserves have reduced man-animal conflict in some areas.
- Control on grazing of livestock in tiger reserves has reduced man-animal conflict.
- Initiatives taken by tiger reserve authorities such as fire protection, improvement in vegetation have been responsible for an increase in the number of tigers and their prey species.
- Use of radio collars, GIS-based digitised database etc to evaluate Tiger population.
- Harsh punishments for violators and those involved in poaching activities etc.

Some important facts about tigers

- Panthera tigris is the scientific name of tiger species. There are five species of tigers which are present in wild, they are Bengal tigers, South China, Indo Chinese, Sumatran and Siberian tigers. Three species of tigers- Caspian, Bali and Javan are extinct.
- The stripes of tigers differ from each other and no two tigers have the same pattern of stripes.
- Nagpur is known as the tiger capital of India. Many tiger reserves are found in the areas around Nagpur such as Pench National Park, Melghat Tiger Reserve and Bor tiger reserve etc.

List of Tiger reserves in India

	STATE	TIGER RESERVE
1	**Andhra Pradesh**	Nagarjunsagar Srisailam
2	**Arunachal Pradesh**	Namdapha National Park

3	**Arunachal Pradesh**	Kamlang Tiger Reserve
4	**Arunachal Pradesh**	Pakke Tiger Reserve
5	**Assam**	Manas Tiger Reserve
6	**Assam**	Nameri National Park
7	**Assam**	Orang Tiger Reserve
8	**Assam**	Kaziranga National Park
9	**Bihar**	Valmiki National Park
10	**Chhattisgarh**	Udanti-Sitanadi Wildlife Sanctuary
11	**Chhattisgarh**	Achanakmar Wildlife Sanctuary
12	**Chhattisgarh**	Indravati Tiger Reserve
13	**Jharkhand**	Palamau Tiger Reserve
14	**Karnataka**	Bandipur Tiger Reserve
15	**Karnataka**	Bhadra Wildlife Sanctuary
16	**Karnataka**	Dandeli-Anshi Tiger Reserve
17	**Karnataka**	Nagarahole National Park
18	**Karnataka**	Biligiri Ranganatha Temple Tiger reserve
19	**Kerala**	Periyar Tiger reserve
20	**Kerala**	Parambikulam Tiger reserve
21	**Madhya Pradesh**	Kanha Tiger reserve
22	**Madhya Pradesh**	Pench Tiger reserve
23	**Madhya Pradesh**	Bandhavgarh Tiger reserve
24	**Madhya Pradesh**	Panna Tiger reserve
25	**Madhya Pradesh**	Satpura Tiger reserve

26	**Madhya Pradesh**	Sanjay-Dubri Tiger reserve
27	**Maharashtra**	Melghat Tiger reserve
28	**Maharashtra**	Tadoba-Andhari Tiger Reserve
29	**Maharashtra**	Pench Tiger Reserve
30	**Maharashtra**	Sahyadri Tiger Reserve
31	**Maharashtra**	Nagzira Tiger Reserve
32	**Maharashtra**	Bor Tiger Reserve
33	**Mizoram**	Dampa Tiger Reserve
34	**Odisha**	Similipal Tiger Reserve
35	**Odisha**	Satkosia Tiger Reserve
36	**Rajasthan**	Ranthambore Tiger Reserve
37	**Rajasthan**	Sariska Tiger Reserve
38	**Rajasthan**	Mukundra Hills Tiger Reserve
39	**Tamil Nadu**	Kalakad-Mundanthurai Tiger Reserve
40	**Tamil Nadu**	Anamalai Tiger Reserve
41	**Tamil Nadu**	Mudumalai Tiger Reserve
42	**Tamil Nadu**	Sathyamangalam Tiger Reserve
43	**Telangana**	Kawal Tiger Reserve
44	**Telangana**	Amrabad Tiger Reserve
45	**Uttar Pradesh**	Dudhwa Tiger Reserve
46	**Uttar Pradesh**	Pilibhit Tiger Reserve
47	**Uttar Pradesh**	Amangarh Tiger Reserve
48	**Uttarakhand**	Jim Corbett National Park

49	**Uttarakhand**	Rajaji Tiger Reserve
50	**West Bengal**	Sunderban National Park
51	**West Bengal**	Buxa Tiger Reserve

9.2 Project Elephant

Project Elephant- Conservation Strategy for Elephant

- Project elephant is a centrally sponsored scheme launched in February 1992. The scheme helps and assists in the management and protection of elephants to the States having free-ranging populations of wild elephants, in order to ensure the survival of elephant population in the wild and protection of elephant habitat and elephant corridor.
- Project elephant is mainly implemented in 16 States / UTs, which includes Andhra Pradesh, Arunachal Pradesh, Assam, Jharkhand, Kerala, Nagaland, Meghalaya, Karnataka, Tamil Nadu, Uttar Pradesh, Orissa, Uttaranchal West Bengal Maharashtra and Chhattisgarh.
- The union government provides financial and technical assistance to the states to achieve the goals of this project. Help is also provided for the purpose of the census, training of field officials and to ensure the mitigation and prevention of human-elephant conflict.
- There are around 32 elephant Reserves in India notified by the state governments. The first elephant reserve was the Singhbhum elephant Reserve of Jharkhand.

Objectives of project elephant

- Protection of elephants, their habitats and elephant corridors.
- Mitigation and prevention of man-elephant conflict.
- To ensure the Welfare of domesticated elephants.

The aim of this project

- To ensure the protection of elephants from hunters and poachers, and prevent illegal trade of ivory. It also includes the strategy to prevent unnatural causes of death of elephants in India.
- To develop and promote scientific and planned management strategies for the conservation of elephants.
- To mitigate and prevent the increasing conflict between humans and elephants in elephant habitats. It also aims to reduce and remove the pressure of human and domestic livestock grazing and other activities in important elephant habitat.

- To ensure ecological restoration of the natural elephant habitats and their migratory routes.
- To promote scientific research on issues related to conservation of elephants and promotion of public awareness and education on these issues.
- To ensure the proper health care and breeding of domesticated elephants. To facilitate veterinary care and Eco-development for the elephants.

Elephant Corridors in India

- Elephant corridor is the narrow strips of forested lands which connects larger elephant habitats with significant elephant populations. It acts as a conduit for the movement of elephants between the elephant habitat. It is necessary to enhance species survival and birth rate of the elephant population in the wild.
- There are around 88 elephant corridors in India out of which 20 are in South India, 12 in North Western India, 14 in North West Bengal, 20 in Central India and 22 in North Eastern India. About 77.3% of these corridors are regularly used by the elephants. One-third of these corridors are of high ecological priority and other two third are of medium priority.
- These elephant habitats are facing threats due to their fragmentation. This problem is severe in areas of Northern West Bengal followed by North Western India, North Eastern India and Central India. This fragmentation was least in South India.
- 65% of elephant corridor in South India fall under protected areas or reserved forests. But only 10% of elephant corridors in Central area are completely under forest area, while 90% of them are jointly under forest, agriculture and settlements. Overall, only 24% of elephant corridors in India are under complete forest cover.

Major threats to Elephant Corridors

- Problems such as elephant habitat loss which is leading to fragmentation and destruction primarily due to developmental activities such as the construction of roads, railways, buildings, holiday resorts and electric fencing etc.
- Mining activities such as coal mining and iron ore mining have been described as “single biggest threats” to elephant corridor in Central India. States like

Jharkhand, Chhattisgarh and Orissa are mineral rich but also have the highest number of elephant corridors which is leading to elephant man conflict.

- As elephants require extensive grazing ground for food, lack of such grazing grounds can force elephants to search for food elsewhere. Most of the elephant reserves unable to accommodate all the elephants, which results in man-elephant conflict due to the destruction of crops by elephants.

Mitigation Strategies

- Fusion of elephant corridors with the nearby protected areas and reserved forest wherever possible. In other areas, to provide protection to the elephant corridors, there is a need for the declaration of ecologically sensitive areas or conservation reserves.
- Securing the elephant corridors would require awareness generation and sensitizing the local population to promote voluntary relocation outside the conflict zones. This would prevent the problem of further fragmentation of continuous forest habitats from encroachment by human beings. It would also provide refuge for other wild animals such as tiger, Sambar, crocodile, bird species etc.
- During the process of securing the elephant corridor, there is a need to monitor the animal movements along with habitat restoration as per the requirements.

Elephant as the National Heritage Animal of India

- The elephant has been declared as the national heritage animal by the government of India in 2010 after the recommendations of the standing committee on national board for wildlife. This was to ensure sufficient protection for elephants before it's numbered fall to panic levels as it had happened in case of tigers.
- A proposed National elephant conservation authority (NECA) on the lines with NTCA has been proposed to be constituted by amending the Wildlife Protection Act 1972.

Monitoring of illegal killing of elephants (MIKE) Programme

- MIKE program was started in South Asia and in 2003 after the conference of parties a resolution of CITES. It aims to provide information which is required by the elephant range countries to make proper management and enforcement decisions and to promote institutional capacity in those States for long-term protection and management of their elephant populations.

Main objectives of MIKE Programme

1. To measure the levels and trends in the illegal poaching of elephants. To ensure changes in the trends for protection of elephant population.
2. To determine the factors which are responsible for such changes, and to assess in particular about the impact of decisions of the conference of parties to CITES responsible for such changes.
3. Under this programme, data are collected on a monthly basis from all the sites in specified MIKE patrol form and it is submitted to the sub-regional support office for South Asia programme located in Delhi.

Hathi Mere Sathi

- Ministry of environment and forests (MOEF) in partnership with Wildlife Trust of India (WTI) has launched a campaign called Hathi Mere Sathi. The campaign aims to improve the conservation, protection and welfare of elephants in India. It was launched at "Elephant- 8" ministerial meeting which was held in Delhi on 24th may 2011.
- The countries who are the part of the Elephant-8 ministerial meeting are Botswana, Kenya, Srilanka, Republic of Congo, Indonesia, Tanzania, Thailand and India.
- The Hathi Mere Sathi campaign aims at increasing public awareness and developing friendship and companionship between local population and elephants.

The campaign mascot Gaju

- The campaign Mascot Gaju focuses on various groups which include local people near elephant habitats, youth, policymakers and others. The scheme

envisions to set up elephant centres all over the country in the elephant landscapes. It aims to spread awareness about the plight of elephants and promote people's participation in addressing these issues.

- The campaign plans to ensure capacity building of law enforcement agencies at the ground level to enhance protection of elephants, and to advocate for the policies in favour of elephants.
- The elephant task force (ETF) which was constituted by the Ministry of Environment and Forest has recommended the campaign to "Take Gajah (the elephant) to the Prajah (the people)" in order to increase public awareness and their participation in the conservation and welfare of elephants.
- India has around 25000 – 29000 elephants in the wild. However, the tuskers (male) in India are as threatened as the Tigers as there are only around 1200 tusker elephants left in India.
- The Asian elephants are threatened by the habitat degradation, man-elephant conflict and poaching for the Ivory. This problem is more intense in India which has around 50% of the total population of world's Asian elephants.

Elephant – 8 ministerial meeting

- The Elephant- 8 ministerial meeting has the representation of all three species of elephants i.e. Asian elephant (Elephas maximus), African Bush elephant (Loxodonta africana), African forest elephant (Loxodonta cyclotis). The ministerial meeting has the participation of policymakers, wildlife conservationists, scientists, historians, experts from art and culture from the participating countries.
- The discussions in the ministerial meeting cover several issues under three basics themes which include science and conservation, management and conservation, and the cultural and ethical perspectives of conservation.
- The E-8 countries have agreed to take necessary steps for the protection and conservation of elephants. They have also decided to actively pursue a common agenda in order to ensure the long-term welfare, protection and survival of all the species of elephants in all the elephant range countries.
- The ministerial meeting has called all the E-8 countries for cooperation under the umbrella of elephant 50:50 forum. Elephant 50:50 forum is the shared

vision of 50 countries to promote conservation, protection, management and welfare of elephants and their habitats in the next 50 years.

Project elephant along the India Bangladesh border in Assam

- The India Bangladesh border in Assam is being completely fenced to prevent an illegal influx of migrants. However, this has created a problem for the movement of elephants who frequently travel through the borders of India and Bangladesh. Therefore in order to allow free movement of elephants, jumbo-sized gates would be constructed along the borders which have been the part of elephant corridors for several hundred years.
- These gates would be manned by the security forces guarding the borders. The forest department personnel would keep track of the movement of elephants and they would inform the border guards to open the gates for the herds to cross the border safely. There is a proposal of surveillance mechanism to keep track of the suspicious movements through these corridors.
- The elephants need a large Habitat for their survival and therefore they have been migrating in the neighbouring forests of Bangladesh from Assam and Meghalaya. Any obstruction on the seasonal migration routes of elephants has often lead to man-animal conflict leading to loss of lives and damages to crops and property.
- There are around 5000 elephants in Assam and another 1800 in Meghalaya. There are 6 elephant corridors along the India Bangladesh border in these northeastern states. The efforts of Wildlife Trust of India to restore the traditional migratory routes of elephants have been blocked by construction of boundary fences. Construction of Jumbo gates is seen as a solution to this problem. However, these gates should be long enough with sufficient cover for elephants to cross through them.
- Elephants use entire forest along the borders for their movement, but once they know about a safe route to pass through, then they are smart enough to use these gates as their corridors.

Elephant reserve in India

S.No	Zone	State	Elephant Reserve
1	North-Western Landscape	Uttarakhand	Shivalik Elephant Reserve
2	North-Western Landscape	Uttar Pradesh	Uttar Pradesh Elephant Reserve
3	East-Central Landscape	West Bengal	Mayurjharna Elephant Reserve
4	East-Central Landscape	Jharkhand	Singhbhum Elephant Reserve
5	East-Central Landscape	Orissa	Mayurbhanj Elephant Reserve
6	East-Central Landscape	Orissa	Mahanadi Elephant Reserve
7	East-Central Landscape	Orissa	Sambalpur Elephant Reserve
8	East-Central Landscape	Orissa	Baitami Elephant Reserve
9	East-Central Landscape	Orissa	South Orissa Elephant Reserve

S.No	Zone	State	Elephant Reserve
10	East-Central Landscape	Chhattisgarh	Lemru Elephant Reserve
11	East-Central Landscape	Chhattisgarh	Badalkhol – Tamor Pingla Elephant Reserve
12	Kameng- Sonitpur Landscape	Arunachal Pradesh	Kameng Elephant Reserve
13	Kameng- Sonitpur Landscape	Assam	Sonitpur Elephant Reserve
14	Eastern-South Bank Landscape	Assam	Dihing-Patkai Elephant Reserve
15	Eastern-South Bank Landscape	Arunachal Pradesh	South Arunachal Elephant Reserve
16	Kaziranga-Karbi Anglong-Intanki Landscape	Assam	Kaziranga-Karbi Anglong Elephant Reserve
17	Kaziranga-Karbi Anglong-Intanki Landscape	Assam	Kaziranga-Karbi Anglong Elephant Reserve
18	Kaziranga-Karbi Anglong-Intanki Landscape	Nagaland	Intanki Elephant Reserve
19	North Bengal- Greater Manas Landscape	Assam	Chirang-Ripu Elephant Reserve

S.No	Zone	State	Elephant Reserve
20	North Bengal- Greater Manas Landscape	West Bengal	Eastern Dooars Elephant Reserve
21	Meghalaya Landscape	Meghalaya	Garo Hills Elephant Reserve
22	Meghalaya Landscape	Meghalaya	Khasi-hills Elephant Reserve
23	Brahmagiri- Nilgiri-Eastern Ghats Landscape	Karnataka	Mysore Elephant Reserve
24	Brahmagiri- Nilgiri-Eastern Ghats Landscape	Kerala	Wayanad Elephant Reserve
25	Brahmagiri- Nilgiri-Eastern Ghats Landscape	Tamil Nadu	Nilgiri Elephant Reserve
26	Brahmagiri- Nilgiri-Eastern Ghats Landscape	Andhra	Rayala Elephant Reserve
27	Brahmagiri- Nilgiri-Eastern Ghats Landscape	Kerala	Nilambur Elephant Reserve
28	Brahmagiri- Nilgiri-Eastern Ghats Landscape	Tamil Nadu	Coimbatore Elephant Reserve

S.No	Zone	State	Elephant Reserve
29	Anamalai- Nelliampathy-High Range Landscape	Tamil Nadu	Anamalai Elephant Reserve
30	Anamalai- Nelliampathy-High Range Landscape	Kerala	Anamudi Elephant Reserve
31	Periyar- Agasthyamalai Landscape	Kerala	Periyar Elephant Reserve
32	Periyar- Agasthyamalai Landscape		Srivilliputhur Elephant Reserve

9.3 Project Snow Leopard

Snow leopards (Panthera uncial) belong to the family of cats called Felidae. Unlike other big cats such as lion and tiger and leopard, the snow leopard does not roar due to its different structure of vocal cords.

Project Snow Leopard

Snow leopard was once globally endangered species, but now its IUCN red list status has been changed from endangered to vulnerable. The snow leopard population is around 7500 surviving individuals in the world in the areas of Central Asian mountains, Himalayas and in Russia's remote Altai mountains. India has around 10% of the Global snow leopard population in less than the 5% of Global snow leopard habitat.

In India, snow leopards are found in the high altitude areas above the forested areas above 3000m. The states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh constitute snow leopard Habitat range in India. Most of the snow leopards are found in China, followed by Mongolia and India. India has an estimated snow leopard population of 400 to 700 snow in these five Himalayan States.

Threats to Snow Leopards

- **Loss of Habitat and species:** there have been concerns over loss of Habitat and prey species in the mountainous areas due to anthropogenic actions. Habitat degradation Habitat fragmentation and Habitat loss are caused due to human intrusion. Overgrazing has damaged the high altitude grasslands which have left less food for the Prey species of snow leopard such as wild goats and sheep. Further, hunting of Snow leopards natural prey for meat is also a major threat to the survival of snow leopards.
- **Retribution killings:** as the snow leopard Habitat lacks a sufficient number of prey species, snow leopard has increasingly being adapted to prey on domestic livestock. This has led to man-animal conflict. Loss of even a single sheep or goat causes great economic hardship for the herder communities. All these have led to retaliatory killings of the Snow Leopards.

- **Poaching of snow leopards**: snow leopards are hunted for their fur and skin. The bones and other body parts of snow leopards are used in traditional Asian medicines, which has frequently led to poaching of snow leopards.
- **Other anthropogenic activities:** other activities such as tourism, construction of roads, human settlement in the snow leopard habitat also poses a great threat to the snow leopards.

Project snow leopard launched in January 2009

- Project snow leopard, launched in 2009 with the ultimate goal of safeguarding and conserving India's unique natural heritage of high altitude wildlife and their habitats by ensuring their conservation and welfare through the participation of local population and through supportive actions of government.

Aim and objectives of project snow leopard

- Promoting a knowledge-based adaptive conservation strategy which fully involves the participation of local communities who share the snow leopard habitat in the conservation and protection efforts under project snow leopard.
- Conserving India's unique natural heritage of high altitude wildlife by promoting conservation, protection and management through the participatory policies and actions.

Location

- It includes all the biologically important landscapes in the high altitude Himalayas in Jammu and Kashmir, Uttarakhand, Himachal Pradesh, Sikkim and Arunachal Pradesh. The project snow leopard includes all biologically important snow leopard habitats irrespective of its ownership, either protected areas or common land etc.
- The project snow leopard includes an estimated 1,29,000 km2 area in India, which comprises of non-forested or sparsely forested high altitude areas of the Himalayas and trans Himalayas above the altitude of 3000m in the Western Himalayas and 4000m in the Eastern Himalayas.

Project save our snow leopards (SOS)

- Project save our snow leopard SOS was launched in January 2014 by WWF India in partnership with Tata Housing Development company. The project Save Our snow Leopards (SOS) has been launched by unveiling the SOS online crowdfunding platform.
- Through this campaign, the WWF India and the Tata Housing Development company would build awareness about the conservation issues which the snow leopard are facing with the aim of raising at least 15,00,000 rupees through this platform. The funds would be used for WWF snow leopard conservation projects which includes setting up camera traps, construction of predator-proof livestock pens for local communities in the snow leopard habitat areas.
- Through this project, the WWF India and the Tata Housing Development would work with Central and state governments to assess the status and distribution of snow leopards and promote their conservation strategies. It would also encourage awareness generation among the local communities about wildlife conservation and build a positive attitude towards snow leopard and manage snow leopard- man conflicts.

Ladakh as a model for the protection of snow leopards

- The Ladakh region of India is setting an example for the protection of snow leopards. The estimated snow leopard population is around 400 in Ladakh. The wildlife department by taking the help of local communities and Non-governmental organisations (NGOs) have been successful in preventing the man-animal conflict and have discouraged the Killing of snow leopard in this region.

Protected areas for the Snow leopard

- Sacred Himalayan Landscape
- Kibber Wildlife Sanctuary at Lahaul Spiti, Himachal Pradesh
- Pin Valley National Park at Lahaul Spiti, Himachal Pradesh
- Great Himalayan National Park at Kullu, Himachal Pradesh
- Dibang Wildlife Sanctuary, near Anini, Arunachal Pradesh
- Hemis National Park, in Ladakh- Jammu and Kashmir

Other conservation efforts

- **Livestock insurance:** insurance cover is provided for the livestock in the snow leopard habitat to avoid retaliatory killings if the snow leopard attacks the domestic livestock.
- **Grazing set aside areas:** separate grazing areas have been created to keep away the livestock from the attack of Snow leopards.
- **Nature club and youth action Council** has been created to encourage community participation in the conservation of snow leopards.
- **Conservation education programs** have been carried out in the snow leopard habitat to create awareness and education about the conservation of biodiversity, especially the snow leopards.
- **Research camera programs** have been carried out, to keep track of snow leopards in their habitat.

Need for the conservation of high altitude ecosystem

- The high altitude zone which includes the Himalayas and trans-Himalayan biogeographic zone supports unique biodiversity and wildlife which is of global conservation importance.
- It includes various species of endangered and threatened populations such as snow leopard, 2 species of bears, wolf, Red Panda, and other mountain ungulates which includes Chiru, Tibetan gazelle, Ladakh urial, two species of Musk deer, wild yak, Hangul, 3 species of goral, serow, takin etc.
- For the conservation and protection of these high altitude wildlife species, India has ratified several International Agreements. Snow leopard was included in the convention on migratory species in 2003 as the concerted action species under appendix 1.
- The representatives of the Ministry of Environment and Forest played an important role in elevating the conservation and protection of snow leopard at international level.

The snow leopard is no longer an endangered species

- International Union for the conservation of nature IUCN on September 14, 2017, has changed the IUCN red list status of Snow leopards from endangered category to vulnerable category. This means that status of snow leopard has changed from “very high risk” too “high risk” of extinction in the wild.
- IUCN in 1972 for the first time had listed snow leopard in the endangered category. To be categorised as endangered species, the snow leopard population must be less than 2500 mature snow leopards in the wild and experiencing a high rate of decline. Vulnerable category means a species has less than 10,000 mature individuals left with a decline in the population of at least 10% over the three generations.

9.4 Project Hangul - A Conservation Strategy

In the 1970s, the Jammu Kashmir Government with the support of IUCN and World Wildlife Fund (WWF) prepared a project for the protection of the hangul and the Kashmir stag habitat. This project for the conservation and protection of Kashmir stag came to be known as project hangul and its population increased to 340 by 1980.

Project Hangul- Conservation of Kashmir red stag

- Hangul or kashmir red stag is a subspecies of the elk native to India. Earlier, kashmir stag was categorised as a subspecies of European red deer. Later kashmir red stag was categorised as the subspecies of elk after the mitochondrial DNA genetic study revealed that it belongs to the Asian family of elk. Kashmir stag is mainly found in the dense riverine forests of Kashmir Valley and the northern Chamba district of Himachal Pradesh.
- Hangul lives in the groups of around 2 to 18 individuals in the riverine forests, high valleys and mountains in Kashmir and the northern Chamba district of Himachal Pradesh. The Kashmir red stag is found in Dachigam National Park, Sindh Valley, Rajparian wildlife sanctuary, Overa Aru wildlife sanctuary and in forests of Kishtwar and bhaderwah.
- The Hangul is the only surviving species of the Asiatic member of the red deer family. The male members of this Kashmir red stag have beautiful antlers which can have around 11 to 16 points on it. The society of Kashmir stag is matriarchal.
- The Kashmir red stag is the state animal of Jammu Kashmir, and the Kashmir stag IUCN status is of a critically endangered species. Once, Kashmir stag habitat was distributed in the Northern India and Pakistan but now it has been restricted only to the Dachigam National Park in Kashmir.
- Since the 1950s, it has been considered as one of the rarest species of mammals in the Indian subcontinent. The Dachigam National Park has been affected by the intrusion of terrorists and the Kashmir stag are being killed just for their meat.

Threats to Hangul

- **Habitat destruction:** the intrusion of the human population in the Kashmir stag habitat, has been responsible for the declining population of Kashmir red Stag. Raising of domestic livestock such as sheep and goat in the Kashmir stag habitat has led to its fragmentation. The fragmentation of Kashmir stag habitat has hampered the genetic flow across its different populations. It has been also responsible for hangul population becoming locally scarce and even extinct.
- **Overgrazing** by the domestic livestock has caused stress situations which have affected the reproductive cycle of hangul. Infection to several diseases could have been responsible for its declining population.
- **Poaching** is another concern for the Kashmir red stag, and the situation gets deteriorated by the intrusion of terrorists in the Kashmir stag habitat.

Conservation of Kashmir red Stag

- At the beginning of 20th century, the Hangul numbered around 5000 individuals. However, due to massive poaching, the intrusion of domestic livestock in the Kashmir stag habitat etc. its numbers dwindled to around 150 by 1970s.

- In 1957, E. P. Gee published a report in which he considered the Kashmir stag along with the Asiatic lion and the one-horned Rhino as the most endangered species of India. However, the Kashmir stag could not get similar kind of conservation compared to the other two.
- Alarmed by the deteriorating situation, the Jammu Kashmir Government with the support of IUCN and World Wildlife Fund (WWF) prepared a project for the protection of this animal and the Kashmir stag habitat. This project came to be known as project hangul which brought good results and increased their numbers to over 340 by 1980.

Current protection status of Kashmir red Stag

- Hangul has been listed under the schedule 1 of Wildlife (Protection) Act 1972 and the Jammu and Kashmir Wildlife (Protection) Act 1978. It has been listed among the top 15 species which require high priority in conservation by the union government.
- The Kashmir stag IUCN status is critically endangered. Earlier the Kashmir stag IUCN status was the least concern as it was grouped under the European red deer family.
- A taxon is considered critically endangered if it meets any of the following criteria;

1. If its population has declined by greater than 80% in the last 10 years or in the three generations.
2. The species has been restricted to a geographical range.
3. If its population is less than 250 individuals and it is declining at 25% in 3 years or one generation.
4. If it has very small and restricted population with fewer than 50 mature individuals.
5. If the probability of extinction in wild is very high.

Wildlife conservation fund

- Wildlife conservation fund was founded in 2010 with the objective to save the wildlife and Wilderness in Jammu and Kashmir. It proposes to undertake the conservation and protection of wildlife in Jammu and Kashmir starting with the conservation of hangul.
- It aims to achieve this through community support, awareness and management of wildlife. It aims to change attitudes towards nature and promote harmony between the humans and wildlife.
- Wildlife conservation fund launched Hangul Conservation Project (HCP) which will try to resolve the various issues which are related to the threatened Hangul species in Kashmir, particularly in the Dachigam National Park.

Status of the population of Hangul

1. The Kashmir red stag population was reported to be 197 in 2007. It increased to 234 in 2009. However, after 2009 its population started decreasing and in 2011 it decreased to 218 and it further decreased to 186 in 2015. In the latest census of 2017, its numbers have fallen down to 182 individuals.
2. In 2013, the state wildlife department of Kashmir set up a captive breeding centre at Shikargarh on the Srinagar Anantnag highway. However, within days of shifting a fawn as the part of the breeding program, it fell prey to a leopard. Since then, the breeding centre has been dysfunctional and non-operative.
3. The falling sex ratio is another cause of worry. The male to female ratio ranged from 21 to 51 males per 100 females before the 1990s. However, the ratio has reduced to around 12 males per 100 females. This imbalance has led to a decline in birth rate which is a cause for concern. If the population of Kashmiri red stag has to be increased, the sex ratio has to be brought to the normal status within a specified period of time.

9.5 Indian Rhino Vision 2020

Assam celebrated 100 years of conservation of Indian Rhino species in the Kaziranga National Park in 2005. The state government and wildlife conservationist came up with a plan to change the status quo and promote conservation of rhinos. At that time the Kaziranga National Park had nearly 1,855 rhinos, Orang National Park had 68 and Pobitora wildlife sanctuary had around 81 Indian rhino.

Indian Rhino Vision 2020 (IRV 2020)

Wildlife experts believed that their numbers can be increased to 3000 in the next 15 years, and this idea gives birth to Indian rhino vision 2020 (IRV 2020).

Indian rhino vision 2020 is being implemented by the Department of Environment and Forest Assam, in partnership with Bodo Autonomous Council. It is supported by WWF India, WWF areas (Asian Rhino and Elephant action strategy) program, the international rhino foundation (IRF), US fish and wildlife service, save the rhino's campaign of zoological institutions worldwide, and several NGOs and local conservation groups.

IRV 2020 aims to increase the total rhino population in Assam to 3000 by 2020. The population of rhinos are to be distributed in various rhino habit in at least 7 protected areas in order to provide a long-term sustainable population of one-horned Indian rhino species.

Rhinoceros unicorns, Kaziranga

Indian Rhino and its role on ecosystem and biodiversity

- The scientific name of Indian rhino is Rhinoceros unicornis, and they can weight over 2000 kilograms. They are large herbivorous animals, and they shape the landscape and environment, and hence they are known as keystone species.
- By eating only certain kinds of grass and trampling on the dense vegetation the rhinos affect the smaller herbivorous of their area creating a cascading effect which in turn affects the other species.

Why there is a need for translocation of Indian rhino species

- Today, around 80% of Indian rhino population is concentrated in the most important rhino habitat – the Kaziranga National Park. Concentrating large number Indian rhino species in a single protected area exposes them to risks of epidemics, floods, poaching and other threats.

- Also, the rhinos in the Pobitora National Park have exceeded their carrying capacity and their numbers have to be reduced in order to avoid rhino human conflicts.

- Translocation of rhinos to new rhino habitat is the backbone of Indian rhino vision 2020 programme. The new potential rhino habitat which is identified is Manas National Park, Dibru Saikhowa wildlife sanctuary, Laokhowa- Bura Chapori wildlife sanctuary and Orang national park.

Translocation of Indian rhinos to new rhino habitat

- Manas National Park was selected as the first new rhino habitat for the translation of Indian rhino species. Rhinos were once common in this park, but violent civil conflicts beginning in 1989 caused damage to the park infrastructure and the destruction of anti-poaching camps, roads and the villages. The last Rhino which was seen in Manas National Park was in 1996.

- Under IRV 2020 Rhinos have been released in the Manas National Park. The Rhinos have been radio-collared for their tracking and anti-poaching camps have been set up in the park. However, despite efforts poaching has been a threat for Rhinos in the Manas National Park. Due to this reason, the translocation of new Rhinos in the park has been put on a moratorium.

- Bura chapori wildlife sanctuary was another site where the rhinos have been translocated from the Kaziranga National Park on 29th of March 2016. However, the death of two rhinos, probably due to some disease has been a cause for concern.

Threats for Indian rhino species

- The habitat of Indian Rhino once included the regions of Pakistan, Northern India, modern day Nepal, Bangladesh, Bhutan and Myanmar. However, loss of large tracts of rhino habitat and its large-scale poaching for its horn, which are believed to have medicinal properties has been responsible for its extinction in all other countries except in India and Nepal.

- By 1900 there were only 100 to 200 Indian rhinos in the world. However, with conservation efforts, the current Indian rhino population has reached 3500. However, threats against the rhinos have not vanished.

- For example, the Manas National Park where the rhinos where translocated have seen several instances of poaching. Due to this reason, the translocation of more rhinos has been on a moratorium.
- Diseases and natural disasters are other threats to the rhino population. The death of rhinos in the Bura Chapori wildlife sanctuary has been probably due to some disease which is a cause of concern for the rhino population.
- Man-animal conflict at the Pobitora national park and Kaziranga National Park can also become a major threat for the rhino population if it is not handled properly.

Problems with IRV 2020

- Trade of valuable parts along with the horn of Rhino in countries such as China and Vietnam is a major roadblock on IRV 2020. Further, the lack of space in the national parks such as Kaziranga and Pobitora is emerging as a big problem. This can increase the problems of man-animal conflict.
- Also, the import of drug etorphine, the tranquillizing drug of choice has been a big challenge. It is essential for the translocation of rhino population to other places.

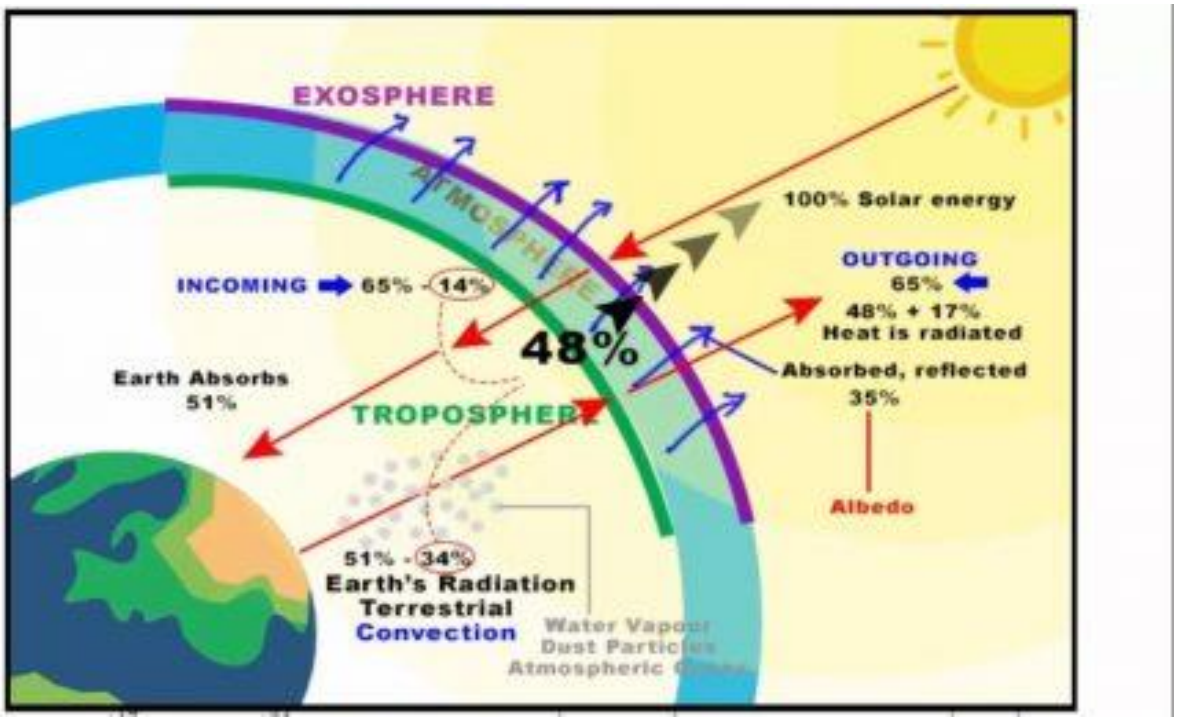
However, Zoos from Australia and other countries have donated around half a million dollars for the conservation of Indian rhino species under the Indian rhino vision 2020.

10- CLIMATE CHANGE

10.1 Global Warming and Green House Effect

Global Warming

Global warming is heating up of the globe when the accumulation of greenhouse gases in the atmosphere disturbs the heat budget (balance between incoming and outgoing heat) of the earth, which otherwise remains balanced. Since heat remains trapped within the earth's atmosphere, temperatures begin to rise. Both land and sea temperatures have witnessed a steady increase since 1880 when record-keeping began.



Evidence of Global warming

- Rise in average surface temperature by 0.95 degree Celsius as per NOAA (National Oceanic and Atmospheric Administration.
- Average Rate of temperature rise has been observed to be nearly 0.07 degree Celsius per decade.
- IPCC predicts the rise in temperature by the end of the 21st century could be up to 5.4 degree Celsius

- 16 of World's hottest years have occurred since 2000, as per NASA records.
- Melting of glaciers and polar ice caps and sea level rise are also evidence of global warming.

Causes of Global Warming

Accumulation of GHGs (Green House Gases) in Atmosphere

The increased volumes of carbon dioxide and other greenhouse gases. These gases collect in the atmosphere and prevent terrestrial radiations to escape the earth's atmosphere, thereby causing global temperatures to rise. Major This is caused by

- Burning of Fossil Fuels – for generation of electricity or transportation
- Forest fires, deliberate clearing of forests for plantation
- Agriculture and animal husbandry – a major source of methane.

Elimination of Carbon sinks from the atmosphere

Destruction of natural carbon sinks aids in the build-up of heat-trapping gases in the atmosphere. Major causes behind the removal of carbon sinks are

- Encroachment into wetlands
- Deforestation
- Eutrophication of lakes and water bodies resulting in 'dead zones.'

Variations in earth's orbit and changes in the solar cycle also attribute to global warming.

Deposition of soot, black carbon etc. act as positive radiative forcings and also contribute to the warming of temperatures.

Effects of Global Warming

- **On Climate**
    - The rise in extreme weather events like Hurricanes and cyclones.

- Researchers at MIT have observed that Atlantic exhibits high 'thermal potential' meaning water can rapidly evaporate into the atmosphere resulting in more favourable conditions for cyclone formation.
- A 10 fold increase in the frequency of hurricanes is predicted if the climate becomes 2 degrees C warmer.
- Increased frequency of tropical storms due to rise in sea surface temperatures.

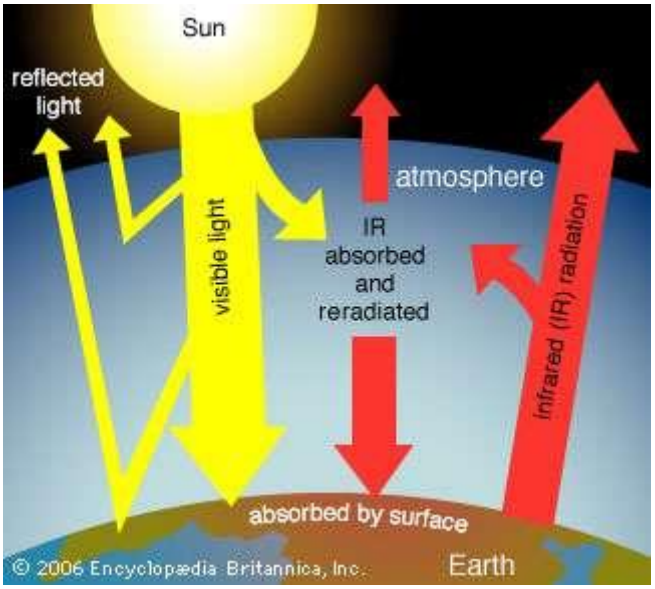
- **On Seas**
  - Melting of polar ice caps and receding of glaciers could cause nearly 4 – 8 inches of rising in sea levels and causes an increased risk of floods and submergence in low lying areas.
  - Sea levels are expected to witness a rise of up to 23 inches at the end of the 21st century
- **On Human Health**
  - Adverse impact on human health – due to the incidence of diseases such as heat stroke during heat waves (NCRB reported a 61% rise in deaths due to heat strokes in 2015 over previous years).
  - Increase in incidence of epidemics and communicable diseases.
- **On Agriculture**
  - Rising input costs due to water shortage
  - More losses due to pest attacks. On an average 5-10% of crops across the country are lost to pests. These are expected to rise as higher temperatures enable pest survival, and higher CO2 concentrations elevate sugar levels in leaves making attacks more severe.
  - Rising crop losses due to unpredictable weather events.
  - Farm indebtedness and agrarian distress
- **On Food Security**

- Global warming poses a serious threat to food security. Not only does it account for declining farm productions but also is responsible for disruptions seen in marine ecosystems.
- It also could push towards hunger, nearly 220 million Indians that depend on forests for food, nutrition and livelihood.

- **Socio-economic impact**
  - Global warming could push those employed in the primary sector into poverty.
  - It also makes those living in coastal regions and central India (exposed to heat waves and drought) more liable to future displacement.
  - As per UNDP, India will lose 3.6% of its daylight work by 2025 due to rising temperatures.
  - Apart from this, warming could also trigger conflicts over resources between people.
- **On Biodiversity and ecosystem**
  - Both terrestrial and marine ecosystems have come under stress due to temperature rise which has affected food chains. For instance, 25% of marine biodiversity that is concentrated in and around coral reefs is under direct stress due to rising incidents of mass coral bleaching.

Greenhouse effect

Greenhouse effect refers to the warming of the earth that occurs when CO2 and Greenhouse gases form a blanket around the earth's atmosphere allowing incident solar radiations of higher frequencies to penetrate but preventing outgoing terrestrial radiations from escaping. Joseph Fourier in 1824, calculated that earth would be 60 degrees Fahrenheit cooler if it had no atmosphere. The atmosphere thus works as a greenhouse and enables life on earth, but anthropogenic emissions of GHGs have caused heat build-up, threatening this very life.



Greenhouse Gases – what are these?

- Water vapour – causes 36–70% of the greenhouse effect
- Carbon dioxide (CO_2) – 9–26%
- Methane (CH_4) – 4–9%
- Ozone (O_3) – 3–7%
- Nitrous Oxides
- Chlorofluorocarbons (CFCs) and Hydrofluorocarbons (HFC and HCFCs)

Selected Greenhouse Gases				
Gas	Atmospheric Concentration		Atmo-spheric lifetime (Years)	100 Year Global Warming Potential (GWP)
	Pre-industrial (1000-1750)	Recent (1998)		
Carbon dioxide (CO_2)	280 ppm	365 ppm	50-200	1
Methane (CH_4)	0.7 ppm	1.745 ppm	12	23
Nitrous oxide (N_20)	0.270 ppm	0.314 ppm	114	296
Perfluoro-methane (CF_4)	40 ppt	80 ppt	>50,000	5700
Sulfur hexafluoride (SF_6)	0	4.2 ppt	3200	22,200

ppm = parts per million
ppt = parts per trillion

Source: U.S.Environmental Protection Agency website
Energy Information Agency (DOE): Emissions of Greenhouse Gases in the United States 2004, December 2005

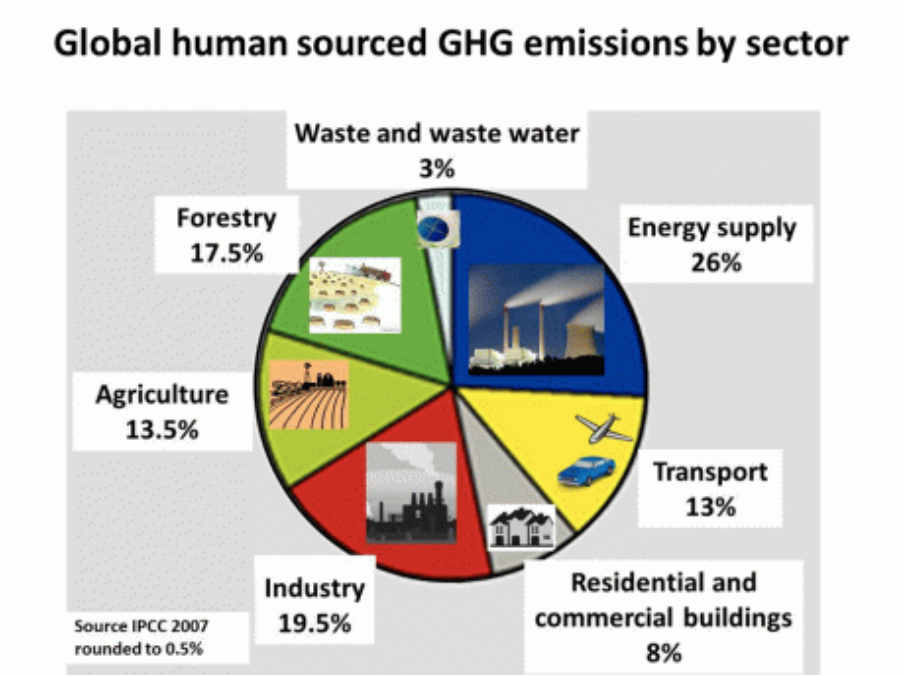
Major GHG Contributors

- China accounts for 26% of all GHG emissions, followed by US (14%) and the EU.
- America is the single biggest contributor to GHG emissions (cumulative)
- India accounts for 6% of total GHG emissions
- Per capita emissions from China stand at 6.5 mt, the US at 15 mt and India at 1.5 mt

What causes GHG emissions

- The burning of fossil fuels – for Industrial use, electricity generation and transportation

- Agriculture, Livestock and Animal Husbandry – Burning crop residues, Meat rich diets (more than 100g per day) contributes about 7.2 kg of CO2 per day against vegan diet contributing 2.9 kg CO2 per day.
- Landfill sites, garbage and sewage dumping sites.
- Forest clearing, shifting cultivation



What has been done to reduce GHG concentrations in the atmosphere?

In India

India is ranked 14th in this year's Climate Change Performance Index (CCPI) 2018 out of 56 nations. India aims to reduce greenhouse gas emissions by at least 40 per cent and increase energy efficiency and share of renewables by at least 27 per cent by 2030. Other measures taken include –

- Switch to cleaner fuels: Ujjwala Scheme helped women switch from chullha to LPG, Increasing share of renewable energy in energy mix (Solar mission)
- Energy efficiency initiatives – Ujala initiative, Transition to supercritical thermal power plants.
- The principle of polluter pay – Increase in coal cess to make it costlier.

- Arresting vehicular emissions – FAME Initiative planned the transition to BS VI fuels.
- Conserving forests – Compensatory afforestation, Joint Forest Management (under National forest policy).

What has the world done in recent years?

- Under UNFCCC, countries signed the Kyoto protocol which came into effect in 2005. Developed countries, hereby accepted legally binding targets to curb their carbon emissions
- At the United Nations Conference on Climate Change held in Paris in 2016, 195 nations agreed to prevent temperature rise beyond 1.5 degree Celsius above average temperature during preindustrial times.
- In Kigali, an amendment to Montreal protocol was signed between countries to gradually phase out HFCs that have high global warming potential.

What needs to be done?

- GHG concentration in the atmosphere needs to be capped at 450 – 550 ppm (Currently it is 380 ppm)
- As per IPCC, global GHG emissions must be reduced by 50 – 80% of their current values.
- Focus on energy conservation and energy efficiency.
- Technological advancements to be made in the field of GHG sequestration (Capturing gases in the atmosphere and storing them underground)
- Creating and Protecting Carbon Sinks – forests and wetlands.

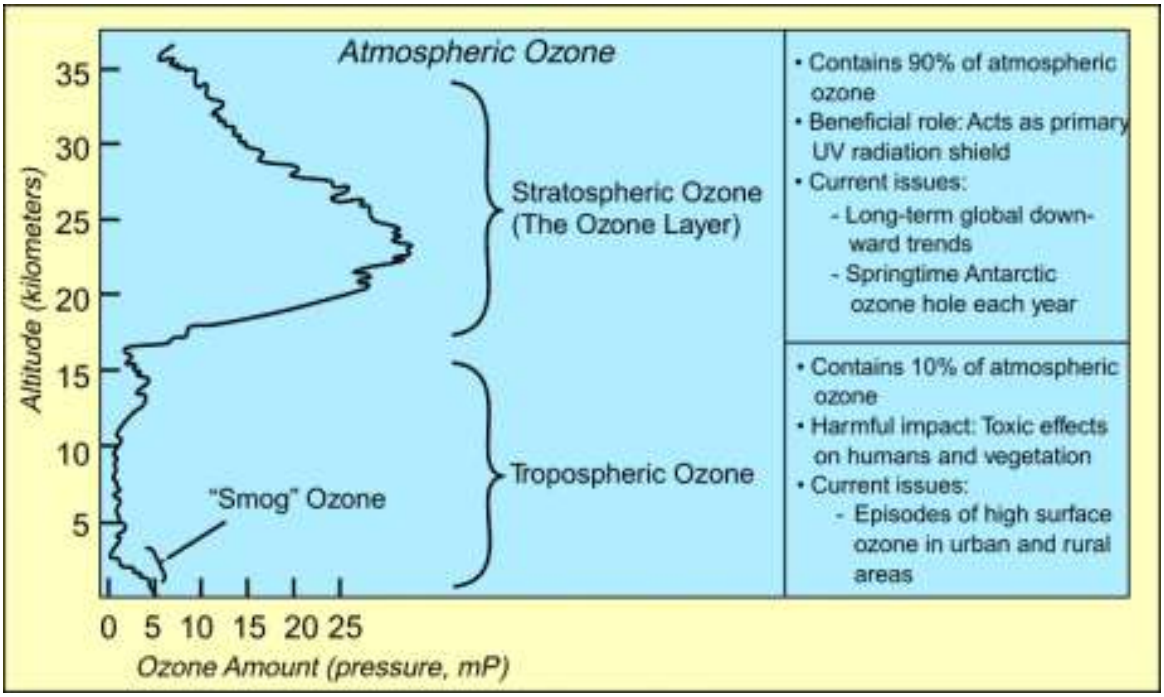
10.2 Ozone Depletion

Ozone or trioxygen is an unstable molecule, an allotrope (different physical forms in which an element exists) of oxygen with molecular formula O_3. **Christian Friedrich Schönbein** discovered the gas. It forms when Oxygen molecules react with ultraviolet rays. In the presence of UV, light Oxygen molecules split into atoms which recombine to form Ozone. The Ozone layer, in the stratospheric region, therefore, absorbs these radiations and blocks UV rays from entering the earth's atmosphere and is hence of immense importance. Contrary to this, ground ozone could be very damaging as it is a powerful oxidizing agent and damages respiratory tissues in animals and humans.

One may also note that during the Ozone – Oxygen cycle, absorbed radiation energy is dissipated as heat. As a result, the region also witnesses temperature inversion (Temperature increasing with the rise in altitude).

Ozone Layer

The ozone layer was discovered in 1913 by the French physicists Charles Fabry and Henri Buisson. The thickness of the ozone layer is about 3 to 5 mm with Ozone concentration nearing 10 ppm. This layer sits at an altitude of 15 – 30 km above mean sea level, in the stratosphere and acts as a UV shield thereby enabling life to exist on earth.



Ozone Depletion

Ozone and free oxygen atoms are highly unstable and they react readily with nitrogen, hydrogen, chlorine, and bromine compounds that are found naturally in Earth's atmosphere (released from both land and ocean sources). Sometimes, materials injected into the atmosphere during volcanic eruptions reacted with stratospheric Ozone and converted it to oxygen. But the disruption Ozone-Oxygen balance is largely human-induced.

During 1970s scientists began to notice Ozone layer depletion prominent in the Polar Regions commonly referred to as the Ozone hole, which became a cause for worry. This was found to be due to increase in the presence of ozone-depleting substances – chlorine, bromine and fluorides in the upper stratospheric region. Nearly 80% of depletion was caused by CFCs (Chlorofluorocarbons) that are commonly used as a refrigerant.

Mechanism of Depletion

- CFCs rise up to the stratosphere without breaking down due to their high stability.
- There they react with UV rays giving rise to free radicals.

$$\mathbf{CFCl_3 + electromagnetic\ radiation \rightarrow Cl\cdot + \cdot CFCl_2}$$

- Ozone depletion is brought about by the presence of free radicals such as chlorine radical (Cl·) and bromine radical (Br·) in the stratosphere. (Free

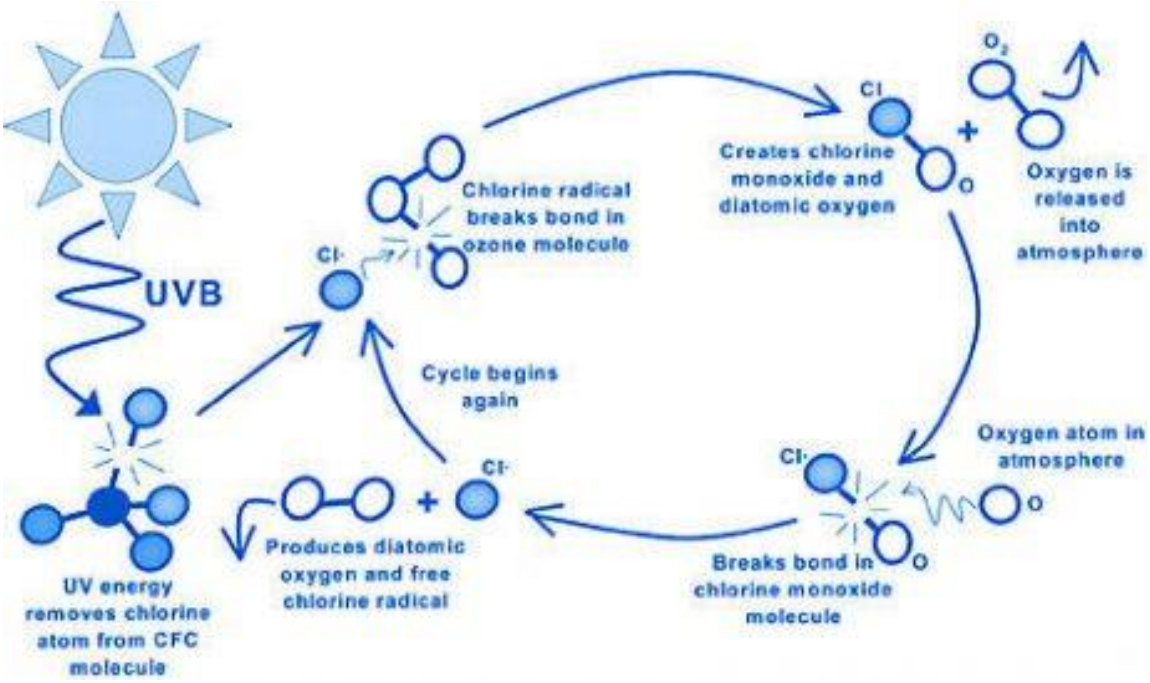
radicals are elements or molecules having an unpaired electron in the outermost shell. They are highly reactive).

$Cl\cdot + O_3 \rightarrow ClO + O_2$

- At the end of the cycle Chlorine free radical is again generated, thereby making it a chain reaction which perpetuates Ozone depletion

$ClO + O_3 \rightarrow Cl\cdot + 2\ O_2$

A Single chlorine atom can, therefore, deplete Ozone for 2 years continuously.



Polar Stratospheric clouds

Also called Nacreous clouds, these are formed at very high altitudes, between 15 and 25 km and at very cold temperatures often in winter near the North or South Pole. Their surfaces act as a catalyst which converts chlorine molecules into free radicals and therefore speeds up ozone depletion. It was due to the presence of PSCs that Ozone holes were seen over Antarctica and Arctic regions. In winter, the air mass over the Antarctic called Polar vortex freezes the chemicals present in stratosphere resulting in formation PSCs. In spring when there is sunlight, PSCs catalyze ozone depletion by absorbing UV rays and hence the Antarctic ozone hole is produced every spring over the earth's south pole.

Ozone Depleting Substances (ODS)

- Chlorofluorocarbons (CFCs)
- Halons

- Carbon tetrachloride (CCl4), Methyl chloroform (CH3CCl3)
- Hydro-bromofluorocarbons (HBFCs)
- Hydro-chlorofluorocarbons (HCFCs)
- Methyl bromide (CH3Br)
- Bromochloromethane (CH2BrCl)

Uses of ODS

- CFCs are used as refrigerants, as aerosol or propellant in manufacturing Scents, perfumes, Paints, Pesticides etc. and as foam blowing agent.
- Methyl Bromide is used as a pesticide
- Carbon tetrachloride and Methyl Bromide are used as cleaning agents.
- Halons are used as fire protection chemicals.

Importance of Ozone and Challenges posed by Ozone depletion

- Penetration of UV rays into earth's atmosphere increased with Ozone depletion and the UV Index climbed to levels much higher than WHOs safe limits in 2008.
- Higher UV rays reaching the ground led to rising in ground level Ozone, which is a respiratory hazard.
- No planktons could survive or produce food in the presence of high UV radiation. UV destroys fish egg and amphibian eggs and larva. Thereby food chains of the Oceans are affected adversely by Ozone depletion.
- By destroying phytoplanktons that also absorb CO2, Ozone depletion also causes global warming.
- Ozone depletion would make humans more susceptible to skin cancer, cataracts, and impaired immune systems. It is estimated that 1% decrease in Ozone layer results in a 2-5 percent increase in the occurrence of skin cancer.
- Genes are UV sensitive and thereby it can cause mutation leading to cancer.
- CFCs are power greenhouses gases with very high global warming potential and contribute to melting of glaciers and polar ice caps, sea level rise and changes in global and local weather patterns.

Global Action against Ozone Depletion: What did the world do?

- To arrest Ozone depletion, 20 nations, including most of the major CFC producers, signed the **Vienna Convention** in 1985. The convention laid a framework for global cooperation on arresting ozone depletion. It was not legally binding.

- Then in 1987, 43 nations signed the **Montreal Protocol**. The protocol is today ratified by 197 parties.
- The UNGA designated September 16 as World Ozone Day, to commemorate the signing of the **Montreal Protocol**.

Montreal Protocol

With the adoption of Montreal Protocol, CFC concentrations in the atmosphere have witnessed a gradual decline since they peaked in 1994. Effective Equivalent Chlorine (EECl) level in the atmosphere had dropped about 10 percent by 2008. Ozone concentrations in the lower stratosphere over Antarctica are expected to return to pre-1980 levels by about 2060–2075. Under the protocol –

- Ozone-depleting substances (stated above) were identified for phase-out and were to be replaced by HFCs (Hydrofluorocarbons).
- the participants agreed to freeze production of CFCs at 1986 levels and to reduce production by 50 percent by 1999.
- In 1990, The participants agreed to phase out CFCs and halons entirely by 2000 in developed countries and by 2010 in developing countries. The phase-out was later advanced to 1996.
- Phase out in LDCs was to be supported by transfers of expertise, technology, and money. For this purpose Multilateral Fund for the Implementation of the Montreal Protocol was established.
- In 2016 at Kigali, the Parties to the Montreal Protocol adopted the Kigali Amendment whereby the Parties agreed to phasedown HFCs under the Montreal Protocol due to their high global warming potential (14,800 times that of CO_2. As per the amendment, industrialised countries are to bring down their HFC usage by 85% of usage in 2011-2013, developing countries including China, Brazil and South Africa are mandated to reduce their HFC use by 85% value in 2020-22 by the year 2045. India and some other developing countries — Iran, Iraq, Pakistan, and some oil economies like Saudi Arabia and Kuwait — will cut down their HFCs by 85% of their values in 2024-26 by the year 2047.

Conclusion

The Montreal Protocol is one of the most successful global agreements that is universally accepted and has also shown promising results. While much has been achieved on this front, there is a need for the world to come together and enable an advanced ozone hole recovery given its correlation with global warming, the formation of ground ozone and severe health risks. To achieve this, technology sharing, financial support for developing and least developed countries are extremely important.

10.3 Impact of Climate Change

What is Climate Change?

Climate change refers to changes in average weather conditions of a given area observed over an extended period of time. The term 'Climate change' was used by World Meteorological Organization in the 1960s to refer to climate variability observed on a time scale of over 10 years irrespective of causes, but in later years the term became associated with human-induced changes in weather patterns. Climate Change, which is today a cause for worry, has been evidenced by rising temperatures since the mid-20th century, retreating glaciers and melting of polar ice caps, increased frequency of extreme weather events such as droughts, heavy rainfall, cyclones, heat waves etc.

Causes

Factors that shape climate are called 'climate forcing'. These could be grouped into natural and anthropogenic

Natural Causes

- **Biotic processes:** Processes pertaining to living beings shape and influence water cycle and nutrient cycles (Carbon, nitrogen etc.) and thereby shape climate. For instance glaciation in the past occurred on earth with the evolution of plants that depleted atmosphere of Carbon dioxide (using it in photosynthesis)
- **Variations in solar radiation received by Earth:** Sunspot cycle (periodic variation in the number of sunspots) amounts to changes in incoming solar radiation that have a bearing on climate.
- **Plate tectonics:** The location of continents and seas across the globe has a bearing on ocean circulation and atmospheric circulation which brings about the meridional transfer of heat. Changes in these dynamics can induce climate changes
- **Volcanic eruptions:** These inject sulfate aerosols into the atmosphere which induce cooling by reflecting solar radiations.
- **Variations in the Earth's orbit:** Changes in earth's axial tilt cause changes in incident solar radiation and result in climate change.

- **Changes in the albedo or reflectivity of the continents, atmosphere, and oceans**

Anthropogenic causes

- **Emissions of Greenhouse gases:** Build-up of heat-trapping gases such as CO2, Water vapour, HFCs, Nitrous oxides etc in the atmosphere is a major factor behind rising global temperatures and consequent climate variability. CO2 concentration in the atmosphere has increased from 288 ppm in 1870 to 404 ppm (2016).
- The World Resource Institute (WRI) in its report estimates that the world produces 31,000 million tonnes of Carbon dioxide every year and the earth naturally assimilates 17,500 mt of CO2 annually, leaving a substantial amount of CO2 to accumulate in the atmosphere.
- **Ozone depletion:** Caused by the release of ODS (Ozone depleting substances) used in refrigerants, coolants, sprays, dyes and paints etc
- **Agriculture and Animal Husbandry**
- **Deforestation:** Clearing of forests has removed natural carbon sinks and facilitated an increase in CO2 concentration in the atmosphere. Deforestation has also adversely impacted rainfall patterns in monsoon regions.

Impact of Climate Change

Global Warming

Average surface temperature has risen by 0.95 degree Celsius since 1880 (as per NOAA). NASA records show that the world witnessed 16 of its hottest years post year 2000. Current levels of Emissions, global temperatures are predicted to rise by up to 5.4%. Scientists have also observed that spring seasons now begin early and last longer causing disruptions in ecology and economy (agriculture, fisheries etc.).

Sea Level Rise and Glacier Retreat

Each ton of CO2 emitted is known to melt 32 square feet of arctic ice. Globally sea levels have risen by 8 to 9 inches since 19th Century. Arctic ice caps have reduced from nearly 3 million square miles to less than 2 million square miles. Further ice melts could raise sea levels to dangerous degrees leading to coastal

submergence and displacements. In addition to this, Himalayan glaciers have lost 21-30% of their cover in the last 40 years (CSE).

Climate-related disasters

Average number of climate-related disasters such as droughts, floods, cyclones and heat waves etc. has tripled since 1980 from an average of 218 to 700 in 2016. Researchers have observed that warming of 0.85 degree Celsius in the present day is responsible for 75% of daily heat extremes and 18% of precipitation extremes. If global temperature rises by 2 degree Celsius, 40 percent of rainfall extremes would then be a result of anthropogenic climate disruptions.

Impact on Biosphere

47 percent of species are reported to have gone extinct due to human-induced climate change and many have come under stress. Rising temperatures have caused a reduction in plant and animal populations, distress migrations, coral bleaching and die-offs.

Self-reinforcing

Increasing temperatures have caused an increase in demand for cooling appliances – refrigerants, air conditioners etc. Energy use for cooling is predicted to witness a 90% jump on 2017 levels which is likely to reinforce global warming by raising CO2 concentrations in the atmosphere by nearly 2.5 Gt by 2050.

On civilization

A renowned epidemiologist, McMichael in his book 'Climate Change and health of nations' observes that novel infectious disease could appear in future due to cross-species microbial traffic in response to climate change. He cites Kawasaki disease occurring in Japan as an example and states that change in wind patterns could widen the geographical range of the disease affecting greater number of people in near future, thus threatening human civilization. One may note here that collapse of Mesopotamian and Harappan Civilizations is also often associated with climate change.

Impact on India

Climate

- Warming of Tibetan plateau is associated with the instability of western winds resulting in variability in western Disturbances. This changes the pattern of winter rainfall witnessed in northern and north-western India.
- The Indian Ocean is showing signs of large warming as compared to suppressed warming of the Indian subcontinental landmass. This will result in weakening of summer monsoons.
- By 2100, the temperature in tropics might rise by more than 4 degree Celsius.
- IMD study shows a rise of about 1 degree Celsius in mean temperatures in the Himalayan cold arid zone since 1950.

Agriculture and Food security

- Temperature rise beyond the biological limit for food crops could spell agrarian crisis and jeopardize food security in the country.
- Declining yield: By 2030, a 10 percent drop in rice yield is expected in South Asia. By 2050, this will impact wheat and maize
- Fish catch is expected to reduce by 60 percent owing to habitat destruction and fish migrations

Economy

- Agriculture is the mainstay of economy employing nearly 50% of the population, the country's economy will come under stress due to climate change. The Economic Survey points out that climate change could cause a 25% drop in agricultural incomes in the next 7 decades.
- Fiscals will come under stress due to rising spate of disasters and disease burden.

Others

- The rise in water stress
- Resource conflicts

- Displacements
- Impoverishment
- The rise in disease burden

Climate change negotiations and Action – History

- Climate change drew the attention of scientists in 1980 when Ozone hole was discovered and glacier melt and sea level rise was also noticed.
- In 1988, IPCC (Intergovernmental Panel on Climate change) was established by WMO and UNEP.
- In 1992, Earth Summit at Rio, an agreement to combat climate change was mooted in the form of UN Framework Convention for Climate Change (UNFCCC). This came into force in 1994. It was aimed at stabilizing GHG emissions and to ensure sustainable economic development. The principle of Equity and CBDR also found mention in the framework.
    - UNFCCC recognized that the largest share of global GHG emissions came from the developed world
    - It mandated developed countries to assist developing world through finance and technology in transitioning to low carbon economies.
    - The convention, however, did not institute timelines and binding targets. This was corrected in Kyoto Protocol
- The Kyoto Protocol was signed to provide a framework of action for reducing emissions.
    - Kyoto introduced the model of burden-sharing based on the concept of 'Polluter pays'.
    - It instituted a target of 5% reduction in GHG emissions against 1990 levels, during the first commitment period (2008-12)
    - These targets were legally binding for developed countries (Annex –I) only.

    - The protocol couldn't achieve the desired outcomes as the US, Canada pulled out of it calling it unfair.

- In 2010, at Cancun countries pledged to reduce their emissions in the pre-2020 period. Green Climate Fund was launched with mandated contribution from developed countries to the tune of $100 bn by 2020.
- Doha Amendment to this protocol instituted targets for 2nd commitment period under Kyoto (2012 – 2020) in terms of emission reduction. This is yet to come into force.
- Paris agreement was signed in 2015 by the conference of parties to UNFCCC, to determine action against climate change post-2020. (the US pulled out of Paris deal in 2017)
    - To cap global temperature rise below 2 degree Celsius.
    - Countries were free to decide on the extent of actions they were to undertake in the form of INDCs (Intended Nationally Determined Contributions). This was aligned with the concept of Common but differentiated responsibilities.
    - Loss and Damage finds mention in the agreement but is not subject to liability and compensation by the developed world
- At the 23rd Session of COP in Bonn, Germany, a section on the pre-2020 action with two stock takes in 2018 and 2019, was introduced. Discussions on this aspect are to be held in this year's Talanoa Dialogue.

Conclusion

Last year alone witnessed a 3ppm rise in atmospheric CO2 concentrations (WMO report), the largest increase ever seen. At the end of 2017, GHG emissions stood at 60% higher mark above 1990 levels signalling their continued rise as opposed to intended stabilization. This calls for a stronger collective action against climate change and global warming as the current climate agreements agreed in Paris are grossly inadequate to address this looming threat.

11- INDIA'S EFFORTS TOWARDS MITIGATION OF CLIMATE CHANGE IMPACT

11.1 8 Missions of India's National Action Plan on Climate Change

Acknowledging the potential impact of climate change on India, which could indeed be severe as India is an economy closely tied to natural resource base and has a skewed dependence on climate-sensitive areas such as agriculture, forestry etc.

National Action Plan on Climate Change

India devised a strategy to help the country adapt to climate change, to transition into a development pathway that is sustainable and to make a contribution towards the global challenge as a responsible member of the international community. This was encapsulated into the National Action Plan on Climate Change, released in the year 2008, which comes under the charge of the Prime Minister's Council on Climate Change.

Principles underlying NAPCC

- An inclusive and sustainable development strategy that protects the poor and vulnerable sections of society
- Balancing growth objectives with ecological sustainability.
- Devising strategies for end use Demand-side Management
- Accelerated adoption of technologies for mitigating GHG emissions
- Promoting sustainable development through a new market, regulatory and voluntary mechanisms
- Achieving Implementation efficiency through engagements with civil society.
- Collaborating internationally for research and development, sharing and transfer of technology

Eight National Missions form the core of Climate Action Plan which hinge on technology adoption, implementation through an institutional mechanism,

improved understanding of climate change, adaptation and mitigation, conservation and improved efficiency.

EIGHT MISSIONS UNDER NAPCC

National Solar Mission

The Mission was launched with the objective of increasing the share of solar energy in the total energy mix, utilizing the existing solar energy potential in India given its tropical location. Most parts of India experience clear sunny weather for 250 – 300 days a year. Average solar radiation incident over India is 5.5 KWh/$m^{2.}$ Solar energy also has the potential to empower people at the grassroots level since it permits decentralized generation. The mission seeks to create policy conditions to facilitate diffusion of solar technologies throughout the country. For this, it adopts a three-phased approach to secure its twin objectives – a. Long-term Energy security and b. Ecological Security.

Mission Targets include

- Enabling deployment of 20,000 MW of solar power capacity by 2022. This target was later revised upwards to 1,00,000 MW or 100GW with 40 GW of solar rooftop and 60 GW of grid-connected solar power projects. The new target will help in abating over 170 mt of CO2.
- Facilitating the creation of solar manufacturing capability
- Promotion of off-grid solar applications, expansion of solar collector area and deployment of solar lighting systems in rural areas.

National Mission on Enhanced Energy Efficiency

NMEEE sought to establish a policy regime that facilitates energy efficiency through innovative models, the creation of a market for energy efficient systems, financial mechanisms etc. It must be noted that the legal framework for adoption of energy efficiency measures was provided in the Energy Conservation Act 2001, which institutionalized adoption of efficient energy systems under Bureau of Energy Efficiency.

Four Initiatives under this mission were

- Perform Achieve Trade (PAT) – Provided for certification of energy savings for energy-intensive industries, which could be traded. This was thus a market mechanism to promote energy efficiency
- Market Transformation for Energy Efficiency – Sought to facilitate the adoption of energy efficient appliances by making them affordable.
- Energy Efficiency Financing Platform – Aimed at financing demand side management programs by capturing future energy savings
- Framework for Energy Efficient Economic development – Developing fiscal tools for promoting energy efficiency.

National Mission on Sustainable Habitat

This was aimed at making the habitat more sustainable by making sustainability and energy efficiency an integral part of urban planning. This was to be done by –

- Promoting energy efficient buildings
- Improving waste management
- Transiting to public transports
- Improving the resilience of infrastructure to climate change, facilitating community-based disaster management, improved disaster warning systems.

Three major initiatives under NMSA include

- Energy Conservation Building Code – for optimal energy utilization in commercial buildings.
- Recycling of urban waste – developing technologies to enable conversion of waste to energy, reuse of wastewater etc.
- Better urban planning and modal shift to public transport.

National Water Mission

The mission sought to enable integrated water resource management with a view to conserve water, minimize wastage and ensure equitable distribution across and within states.

- It sought to improve water use efficiency by 20 %.
- It mooted the concept of differential entitlements and pricing.
- Urban water demand was to be met through wastewater recycling to a considerable extent.
- For coastal areas, adoption of technologies like low-temperature desalination was to be promoted for meeting water demand
- To meet the challenge of climate change and ensuing water stress, the mission stressed on enhancing storage capacity, rainwater harvesting and promotion of drip and sprinkler irrigation.

National Mission for Sustaining the Himalayan Ecosystem

The mission sought to address the glacier retreat in the Himalayan region, acknowledging its importance for India as a source of its perennial rivers. An observation and monitoring network was to be established for continuous assessment of the health of the Himalayan ecosystem.

Major Objectives of the mission include

- Building Human and institutional capacities to understand and address climate change
- Developing a database with the cooperation of neighbouring countries and networking knowledge on Himalayan ecosystem
- Detecting environmental changes and projecting their future impact
- Designing appropriate growth strategies for the Himalayan region
- Incorporating traditional knowledge systems
- Creating awareness among stakeholders.

National Mission for a Green India

The mission sought to create additional carbon sinks by increasing forest cover. The national target of the area under forest cover is 33% while currently, the area under forest is 23%. The mission sought to enhance this area.

Major Objectives and Targets under the Mission are:

- Increased forest cover and improved quality of forest cover on a total land area of 10 million hectare
- Enhanced annual CO2 sequestration by 50-60 mt in 2020.
- Restoration of cold deserts, mangroves, wetlands, ravines and abandoned mines
- Improved tree cover in urban and peri-urban areas, on marginal agricultural and non-forest areas through social forestry, agroforestry
- Community-based forest management
- Promoting adoption of alternative fuels and improving fuel-wood use efficiency
- Diversification of forest-based livelihood of people dwelling around forests.

National Mission For Sustainable Agriculture

The mission aims at making Agriculture in India climate resilient by developing new crop varieties, integration of traditional knowledge, geospatial technology and biotechnology, improving the productivity of rainfed areas through an ecologically sustainable green revolution.

Ten Key Dimensions identified under NMSA for adaptation and mitigation include

1. Improved crop seeds, livestock and fish culture
2. Water Efficiency
3. Pest Management
4. Improved Farm practices

5. Nutrient management
6. Agricultural Insurance
7. Credit support
8. Markets
9. Access to Information
10. Livelihood diversification

National Mission on Strategic Knowledge for Climate Change

In order to identify the challenges of climate change and responses thereto, the Strategic Knowledge mission seeks to enlist global collaboration through the mechanism of open source platforms. The mission will focus research on the socio-economic impact of climate change including the impact on health, demography, migration patterns etc. It sought to support the creation of dedicated institutions for studying climate change. A Climate Science Research Fund was to be created under the mission to finance research.

Mission objectives include

- Formation of knowledge networks among existing institutions
- Establishing technology watch groups to help in the selection of technologies for sustainable development
- Developing National capacity for assessing climate change impact locally
- Promoting research in the field of climate change impact
- Creating institutional capacity for climate change research
- Fostering global collaboration in the field of climate change research and technology development.

The missions were institutionalized by respective ministries. The missions were planned, monitored and evaluated by the Prime Minister's Council on Climate Change. Together, these Eight Missions aimed to prepare India for bracing the climate change challenge.

11.2 Intended Nationally Determined Contributions (INDC)

INDC is a term used to refer to **emission reduction targets voluntarily declared by countries in the Conference of Parties** meet held in Paris in the year 2015. (Conference of Parties(COP) refers to the annual meeting of UNFCCC signatories).

Intended Nationally Determined Contributions

INDCs enable countries to determine their contributions in the context of their national priorities, circumstances and capabilities. This takes into account the contention of the developed world that emission targets be made applicable to developing countries which were exempt from binding emission reduction targets under Kyoto Protocol, while also factoring the principle of Common but Differentiated Responsibility (CBDR) in holding developed and developing countries responsible, by varying degrees, for climate change. Countries will submit INDCs every five years, each submission being more ambitious than the last. These will also be subject to review.

INDCs communicated by countries include

- A reference point (for instance, the base year from which emissions will be reduced)
- Timeframe
- Scope and coverage
- The methodological approach towards calculating emissions
- How the contribution is fair and ambitious
- How it contributes towards achieving the objective of the UN's climate convention

Emission reductions achieved by way of INDCs are aimed at capping global temperature rise to less than 2 degree Celsius (as per the Paris Agreement)

INDCs submitted by countries

- Switzerland, the first country to submit its INDCs seeks to reduce greenhouse gas emissions by 50-60% by 2030.
- China, which contributes to 20% of the global GHG emissions, decided to reduce emissions by 60-65% by 2030.
- European Union targets a 40 % reduction from 1990 levels by 2030.
- The US targeted a 26-28 % reduction by 2025 but eventually withdrew from Paris Agreement.

INDCs submitted by India

- To further a sustainable way of living based on traditions and values of conservation and moderation
- To adopt a cleaner development path as compared to the path taken by those at a similar level of economic development
- Reduce emission intensity of GDP by 33 to 35 % by 2030 from 2005 levels
- Achieve 40 % of non-fossil fuel based installed power capacity by 2030.
- Create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent by 2030 through additional forest and tree cover.
- Mobilizing funds for adaptation and mitigation both domestically and from developed countries
- Build capacity for research in cutting-edge climate technology.

National Circumstances

India faces the daunting task of addressing Infrastructure deficit and fast-tracking development on the one hand and managing emerging climate risks on the other.

- Where per capita emissions of developed countries vary between 7 and 15 metric tonnes, India's per capita emissions stand at 1.56 metric tonne (2010)
- India's emission intensity (volume of emissions per unit GDP) is also much lower than that of developed countries.

- 24% of global population without access to energy is in India. Per Capita energy consumption in India is barely one-third of the global average.
- Energy demand in the country is slated to rise as India is rapidly urbanizing, with expected levels of urbanization reaching 40% by 2030.
- With nearly 21% of people living below poverty line, India is more vulnerable to climate-related hazards.

India's success in meeting its targets is contingent upon support regarding finances and technology transfer from developed countries.

It is estimated that India will need around 205 billion US$ for implementing its adaptation plans and another 834 billion US$ for mitigation by 2030. For meeting India's climate change actions, a total of about 2.5 trillion USD will be required till 2030.

Apart from this, India also seeks access to clean energy technologies free of IPR costs which could be met separately through the Green Climate Fund (financial mechanism under UNFCCC established to fund investment in climate-friendly technologies in developing countries. It is headquartered in Songdo, South Korea).

Assessing India's INDCs

- Accounting for only 3 % of cumulative global emissions, India's action on climate front may be of limited global impact but is indeed quite ambitious.
- This will create a substantial financial burden on India
- India will also have to brace the challenge of achieving faster growth on the one hand and reducing emission intensity of its GDP on the other.

Action Taken so Far

- India declared a voluntary emission reduction target of 20-25% over 2005 levels by 2020 (Kyoto period) and achieved a 12% emission intensity reduction by 2010.
- India also instituted the **National Action Plan on Climate Change** with Eight Missions to direct the country towards a sustainable development pathway.

- India seeks to increase the share of renewable energy in its energy mix with the target of 175 GW of installed renewable capacity by 2022. Renewable energy accounts for 18% of total energy, today.
- Introduction of Ultra-supercritical technologies in thermal power plants to make them more efficient.
- **Green Energy Corridor** for evacuation from renewable energy plants.
- **National Smart grid mission** was launched to bring efficiency in power supply.
- Under NMEEE (Mission on energy efficiency), 19,000 MW of avoided capacity addition was targeted, of which 10,000 MW was achieved by 2012.
- Nation-wide Energy conservation campaign so as to bring down 10% reduction in energy consumption by 2018-19.
- **Zero Effect Zero Defect Scheme** seeks to promote energy efficiency among MSMEs.
- **HRIDAY, AMRUT and Smart cities mission** – to make cities greener.
- **FAME** – Faster Adoption and Manufacturing of Hybrid and electric vehicles for cleaner transports
- **Climate Finance** – In order to fund Climate action, Coal cess at the rate of Rs 200 per tonne is being imposed. It flows into the National Clean Environment Fund. India also set up the National Adaptation fund with a corpus of Rs 3500 million to fund adaptation programs.
- **Adaptation Programs** – Soil Health Card, PM Krishi Sinchayee Yojana, Paramparagat Krishi Vikas Yojana etc

Assessing INDCs and the Paris Agreement

- There is no official mechanism to hold countries accountable in case they fall short of their INDC targets
- If INDCs proposed by countries so far, amounting to 80% of global GHG emissions are met, then the rate of increase in emissions would come down from 24 % between 1990- 2010 to 11-23% between 2010 and 2030. This, however, is not enough to cap global temperature rise at 2 degree Celsius.

- Despite the INDCs, the world will reach 75% of emission limits, consistent with the goal of limiting temperature rise, by 2030 itself.

The Paris Agreement marks a Landmark in the history of Climate change negotiations as it brings significant global cooperation in the area of climate change. It is not enough, and with US withdrawal, its effectiveness has further come into question. In this background, India's efforts deserve praise. India must continue its efforts towards a sustainable future and also undertake diplomatic initiatives to deepen global cooperation on climate change.

11.3 GRIHA

In the various ways that human habitats interact with their environments throughout their life cycles, from construction to operation and then demolition, they consume resources and emit wastes. GRIHA, meaning 'Abode' in Sanskrit attempts to economize the resource consumption, reduce waste generation, promote renewable energy adoption and bring down the ecological impact of a building to sustainable levels. The rating tool helps in assessing building performance against nationally accepted benchmarks. This instrument is of immense significance in the current scenario, where growing demand for buildings is creating a pressure on resources on one hand and rapidly changing climate is altering the resource geography of the country on the other hand.

GRIHA – Green Ratings for Integrated Habitat Assessment

In 2007, GRIHA was adopted as the national rating system for green buildings. It was developed by TERI with support from Ministry of New and Renewable Energy (MNRE).

Issuance of GRIHA ratings is done by GRIHA Council which is an independent platform for the interaction on scientific and administrative issues related to sustainable habitats

The Energy and Resources Institute (TERI): Established in 1974 as Tata Energy and Resource Institute, TERI is an independent research institute, headquartered in Delhi, that conducts research work in the fields of energy, environment and sustainable development.

More About GRIHA

- It incorporates a holistic, life-cycle approach to buildings
- The framework applies to commercial, institutional and residential buildings.
- Eliminates implementation challenges that arise from institutions working in silos towards improving waste management, energy conservation etc.
- It comprehensively approaches the goal of sustainable habitat creation through its overall objective that includes
- Reduction in resource consumption

- Reduction in greenhouse gas emissions
- Enhanced use of renewable and recycled resources by the building sector
- It quantifies building's performance in terms of energy utilization, waste generation and renewable energy adoption so as to help in management and control of these aspects
- It standardizes the definition for 'green building' and helps in evaluation of environmental impact of a building
- The ratings are periodically revised under the supervision of GRIHA Technical Advisory Committee.

GRIHA VARIANTS

GRIHA V 2015

The latest GRIHA ratings GRIHA V 2015 consist of 31 criteria categorized under sections such as

- Site Planning
- Construction Management
- Occupant Comfort and Wellbeing
- Sustainable Building Materials
- Performance Monitoring and Validation

Buildings are awarded points for compliance across these categories and on this basis, their performance is assessed.

SVA-GRIHA

Small Versatile Affordable GRIHA or SVA-GRIHA guidelines were formulated for small buildings by GRIHA Council and TERI. It applies to buildings, excluding factory buildings, with a built-up area less than 2500 square metre. This has 14 criteria.

GRIHA – LD

GRIHA – Large Developments was meant for large projects such as campuses, housing complexes, townships etc. with a total site area greater than or equal

to fifty hectares. The ratings were developed by GRIHA Council, TERI and MNRE jointly.

GRIHA AH

This rating has been developed for Affordable Housing projects. Projects under Pradhan Mantri Awas Yojana are eligible for these ratings

GRIHA for Existing Buildings

It applies to operational buildings such as offices, retail spaces, institutional buildings, hotels, hospital buildings, healthcare facilities, residences having a built-up area greater than 2,500. It lists 12 criteria for assessing building's performance.

Basic features of GRIHA

The system has been developed to help 'design and evaluate' new buildings at the inception stages based on its predicted performance over its entire life cycle – inception through operation. The stages of the life cycle that have been identified for evaluation are:

- Pre-construction stage: Here following parameters relating to the site and its location are taken into account –
- proximity to public transport
- type of soil
- kind of land
- where the property is located
- flora and fauna on the land before construction activity start
- the natural landscape and land features
- Building planning and construction stages: This stage involves performance monitoring over the following aspects
- Resource (land, water, air, energy and green cover) conservation
- reduction in resource demand
- resource utilization efficiency

- resource recovery and reuse
- occupant health and well-being
- Building operation and maintenance stage: This looks at the aspects of a building that relates to its operation and maintenance such as
- monitoring and recording of energy consumption,
- occupant health and well-being
- and also issues that affect the global and local environment).

Benefits offered by the rating tool

GRIHA seeks to benefit the community at large by bringing improvement in the environment by reducing GHG (greenhouse gas) emissions, reducing energy consumption and the stress on natural resources. The benefits it offers include –

- Lower energy consumption without compromising the comfort level
- Minimizing destruction of the Natural environment
- Lowering Environmental Pollution
- Reduced water consumption
- Limited waste generation due to recycling and reuse
- Reduced pollution loads
- Increased user productivity
- Enhanced image and marketability

Challenges in implementation of GRIHA

- Decentralized nature of the industry – Design, construction, installation etc. is carried out in a fragmented manner as the industry lacks integration. This gives rise to difficulties in making holistic interventions for a building to ensure that it remains environment-friendly.

- Limited awareness about GRIHA initiative results in the meagre number of applications for GRIHA certification requests.
- High costs of climate-friendly technologies is another barrier that restricts people from adopting green building norms.
- Lack of stakeholder involvement, particularly Urban Local Bodies makes the ground level assessment and monitoring of building performance extremely difficult.

Conclusion

GRIHA is an extremely important rating tool that could help in ushering sustainable habitat. It is crucial, particularly in a rapidly urbanizing India where urbanization is expected to double by 2050 thus creating a huge pressure on resources. India needs to mobilize its efforts towards faster adoption of GRIHA standards by households as well as institutional and commercial buildings.

11.4 National Initiative on Climate Resilient Agriculture (NICRA)

National Initiative on Climate Resilient Agriculture was launched in the year 2011 by Indian Council on Agricultural Research (ICAR) (an autonomous body responsible for coordinating agricultural education and research in India that reports to the Department of Agriculture and Research (DARE) in the Ministry of Agriculture and is presided over by the Union Minister of Agriculture).

National Initiative on Climate Resilient Agriculture

The initiative recognizes India's vulnerability to climate change with nearly half of its population dependent on agriculture. It is estimated that by 2039, climate change could cause a drop in production by 4 to 9 % which could, in turn, cost up to 1.5 % of GDP as Agriculture makes nearly 16% of India's GDP. To address this emerging challenge, NICRA was launched with the following objectives.

Objectives of NICRA

1. **Research** to improve production and risk management so as to enhance climate resilience of Indian agriculture.
2. **Technology demonstration** to enable vulnerable districts in coping with climate change through demonstration of site specific technologies on farmer's fields.
3. **Capacity building** of scientists and other stakeholders in climate resilient research

Salient Features

- Assessment of Crop Zones and their Climate Vulnerability
- Measuring GHG emissions
- Screening of crop germplasm to promote drought resistant varieties
- Evaluation and adoption of new technologies of paddy cultivation
- Special attention to livestock and fishery sectors

- understanding of crop-pest/pathogen relationship under changing the climate
- Facilitating wider adoption by farmers through KVKs and NMSA

Components of NICRA

With the aim of improving varieties of crops, livestock breeds and management practices, mainstreaming climate resilience in agricultural planning and assisting in adaptation and mitigation, NICRA was designed to have the following components –

- Strategic research on adaptation and mitigation
- Technology demonstration on farmers' fields to cope with current climate variability
- Sponsored and competitive research grants to fill critical research gaps
- Capacity building of different stake holders

Strategic Research

Research on climate resilient technologies was planned at research institutes of ICAR such as IARI (Delhi), NDRI (Karnal) etc. in a network mode.

Scope of research extended to crops, horticulture, livestock, natural resource management and fisheries sectors. Initial focus of the project was on crops like wheat, rice, maize, pigeonpea, groundnut, tomato, mango and banana; cattle, buffalo and small ruminants among livestock and both marine and freshwater fish species of economic importance.

Research Theme Include

Crops

- Assessing Climate-related vulnerabilities of major production zones
- Linking weather based agro-advisories to contingency planning for improved risk management. This will help in averting climate-related disasters
- Assessing the impacts and evolving varieties tolerant to key climatic stresses (drought, heat, frost, flooding, etc.) in major food and horticulture crops
- Continuous monitoring of greenhouse gases in open field conditions

- Evolving adaptation and mitigation strategies through enhancing water and nutrient use efficiency and conservation agriculture
- Studying changes in pest dynamics, pest/pathogen-crop relationships and emergence of new pests and pathogens under changing climate

Livestock

- Understanding the unique traits in indigenous livestock which make them resilient to climate change and development of database
- Adaptation strategies in livestock through nutritional and environmental manipulations

Fisheries

- Assessment of spawning behaviour of major fish species in marine and inland environments with a view to harnessing the beneficial effects of temperature

Technology Demonstration

This includes a demonstration of proven technologies in village panchayats in select districts to assist crop and livestock systems to adapt to climate change. These interventions will depend on climate vulnerabilities faced by the region and technologies available from the concerned zonal agricultural research institutes. Interventions planned to span across four modules

Modules

1. **Natural resources:** Interventions under this module include –
   - In-situ moisture conservation
   - water harvesting and recycling
   - improved drainage in flood-prone areas
   - artificial groundwater recharge
   - water saving irrigation methods
2. **Crop Production:** This module includes –
   - Introduction of drought-tolerant varieties

- Advanced planting of rabi crops in areas with terminal heat stress
- Adoption of water saving paddy cultivation methods (SRI, aerobic, direct seeding)
- Frost management in horticulture through fumigation (filling with gas)
- community nurseries
- Adoption of location-specific intercropping systems

3. **Livestock and Fisheries:** Methods in this module are –

- Use of community lands for fodder production
- Improved fodder storage methods
- Promoting preventive vaccination
- Developing improved shelters for reducing heat stress in livestock
- Management of fish ponds during water scarcity and excess water

4. **Institutional Interventions:** This includes

- strengthening of existing and creation of new institutions such as –
- Seed banks and fodder banks
- commodity groups
- custom hiring centres
- facilitation of collective marketing
- Introduction of weather index-based insurance
- Fostering climate literacy through a village level weather station.

Sponsored and Competitive Grants

Under this component, research grants are provided to institutions on the competitive basis to address critical gaps in research in priority areas such as

- Adaptation strategies including carbon sequestration for climate resilient agriculture in arid, hill and mountain, coastal and Island ecosystems
- Germplasm collection and characterization from climate hot spots
- Impact of climate change on pollinators
- Nutrient management and physiological adaptations for enhanced tolerance to climate variability in livestock
- Methane mitigation strategies in livestock
- Socio-economic impact assessment of Climate Change
- Fisheries and aquaculture related aspects with a focus on climate variability
- Management of extreme weather events

Projects are approved by an Expert Committee constituted by Director General, ICAR with the secretariat located in CRIDA, Hyderabad

Capacity Building

This involves measures taken for upgrading the knowledge base of different stakeholders in order to prepare them for changing climates. Programs planned include –

Scientists	On tools and methodologies in climate change research at advanced research institutes in India and abroad Short term visit of senior officers to advanced countries Inviting foreign experts to conduct hands-on training to Indian scientists and setting up and calibration of state of the art facilities up to the state

Central/ State line department officers	On implications of climate variability in crop management and contingency planning during droughts and floods
Farmers, NGOs, Self Help Groups (SHGs) and etc.	To create awareness on climate change and simple adaptation measures farmers can follow to cope with climate variability The NGOs would be trained as trainers who in turn will train community-based organizations (CBOs) and farmers
Development Banks, Co-operative Societies and Insurance Companies	On climate risk assessment and modelling Methods for crop loss assessment due to climatic events and weather insurance products
Policymakers	On general awareness on climate change impact on agriculture and need for a policy framework for the prudent use of energy and natural resources

11.5 BSE-GREENEX

Launched in 2012 by Bombay Stock Exchange, BSE GREENEX or 'Green Index' is India's first carbon-efficient live index. The index has been developed by the BSE in collaboration with IIM Ahmedabad with the purpose of measuring performances of companies in terms of carbon emissions. g-Trade Carbon Ex Ratings Services Private Limited has co-developed the BSE-GREENEX Index with BSE.

BSE GREENEX

The index acts as a market-based solution for industries, investors and governments aimed at the promotion of energy efficient practices and at encouraging investments in sustainable businesses.

Bombay Stock Exchange – Established in 1875 by Premchand Roychand (Founder), BSE is world's twelfth largest stock exchange that provides a platform for exchange or trade of stocks and securities.

Feature of BSE- GREENEX

- The index consists of top-ranking companies from each sector like power, steel, cement etc. It enlists 25 stocks (earlier the list had 20 stocks) from the list of BSE 100 based on –
- **Minimum carbon footprint or emission intensity** – this refers to the amount of carbon dioxide or its equivalents released into the atmosphere as a result of the organization's activities
- **market capitalization** – that is the value of a company measured in terms of the number of shares traded on the stock market and their prices.
- **Turnover** – Stands for annual sales volume net of all taxes and discounts
- If a company is removed from the list of BSE 100, then it is taken off the BSE GREENEX list as well
- Some of the major constituents of the Index include Tata Steel, ICICI Bank, SBI, HDFC, Sun Pharma and BHEL
- The index seeks to assess and quantify the energy efficiency of firms, based on energy and financial data.

- The index carries weight for two major criteria that together indicate long-term sustainability of businesses
- **Energy efficiency** – measured by gauging reduction in the amount of energy consumed, reduced wastage, renewable energy adoption and costs incurred on energy.

Profitability

- BSE GREENEX is a Cap Weighted Free-Float Market Capitalization-weighted Index, where constituents are weighted in accordance with the market value of their shares.
- Individual stocks are capped at 6 per cent
- ITC Ltd has the biggest weight in the index, followed by Infosys Ltd, ICICI Bank Ltd and Housing Development Finance Corp. Reliance Infrastructure Ltd has the lowest weight.
- Assessment is made on the basis of actual performance and not on that of future stated goals.
- The index follows a bi-annual review process implying that it is reviewed twice a year, once in March and then in September.
- The index gives representation to firms from all sectors.
- It follows a sector-specific algorithm whereby a firm's performance is measured in comparison to others in the same sector.

The significance of BSE- GREENEX

- This index is of importance to both businesses and investors in raising finance and in benchmarking against best carbon performers respectively.
- It helps investors in the identification of 'green investments' and companies with a strong social responsibility and thereby help investors to make better-informed investment decisions on companies in the energy-intensive sectors.
- The index is a tool for 'Green finance' and of use to both individual or retail investors and institutional investors such as asset management companies,

pension funds, and insurance companies looking for investments in companies with strong long-term prospects.

- Mutual funds investing in sustainable businesses may also evaluate companies for their performance by means of this index. The index, therefore, helps in screening climate sensitive businesses.

Factors that may undermine the relevance of the index

- Climate consciousness among businesses and investors remains low
- High costs involved in the deployment of green technologies impact their profitability and hence they do not find much favour among businesses.
- The indices have so far not developed a method that takes into account the positive externalities generated by sustainable business practices and green technologies.
- Green finance is not often forthcoming as returns from such investments are slow and also carry greater risk. Investors, therefore, remain wary of investing in this area.

Other sustainability Indices

BSE CARBONEX

- Launched in 2012, BSE's CARBONEX is a carbon-based thematic index which ascertains an organisation's commitment to climate change mitigation.
- CARBONEX assesses the performance of BSE 100 companies on the basis of the following parameters –
- reporting and disclosure
- strategy and governance
- performance and achievement
- ecosystem action
- ITC and Reliance Industries Ltd carry the highest weight in this index.
- CARBONEX is also reviewed bi-annually like BSE- GREENEX

- It seeks to promote active disclosure of non-financial information pertaining to their strategies for climate risk mitigation.
- The index also is useful in providing investors with a reliable benchmark for the low carbon strategies of their companies.

Conclusion

Both BSE GREENEX and BSE CARBONEX seek to facilitate access to finance for climate-sensitive businesses. They create awareness among investors about green technologies, provide a tool for assessing and benchmarking the climate impact of companies' strategies and in this way are futuristic and progressive instruments in the present scenario of rapidly changing climate.

12- INTERNATIONALORGANISATIONS AND CONVENTIONS

12.1 UNFCC

Climate change has emerged as one of the serious challenges for mankind and this threat was realised during the latter half of the 20th century. The establishment of the United Nations Framework Convention on Climate Change (UNFCCC) can be traced back to the Stockholm conference of 1972.

United Nations Framework Convention On Climate Change (UNFCCC)

The 'United Nations Conference on the Human Environment' was held for the first time in 1972, Stockholm, Sweden. The conference established environment as the permanent agenda of the world and it eventually led to the establishment of United Nations environment programme (UNEP). It introduced the idea of a proper relationship between development and the protection of the natural environment of earth.

Rio Earth Summit 1992

In 1992, on the 20th anniversary of Stockholm conference, the representatives of 178 Nations, Non-governmental organisations (NGOs) and other parties met in Rio de Janeiro Brazil for the discussion on global environmental issues for the purpose of environmental policy implementation. The conference focused on the state of the global environment along with the relationship between economic development, science and the natural environment of an Earth in a political context.

This was the first United Nations Conference on Environment and Development (UNCED), which was also known as the Earth Summit. It addressed environmental issues such as protection of air, land and water along with the protection and conservation of biodiversity, forest and natural resources of Earth.

UNFCCC

- The United Nations Framework Convention on climate change (UNFCCC) is an international environment treaty which was signed under the UNCED, Earth Summit held in Rio de Janeiro. UNFCCC was adopted by consensus as the first multilateral legal instrument on climate change.

- The countries joined UNFCCC for cooperation to limit the average global temperature increase, which was responsible for climate change and to cope up and mitigate its impacts. As of now, there are 197 parties (196 States and one regional economic integration organisation) to the UNFCCC.
- UNFCCC entered into force on 21st March 1994. The main objective of this treaty is to stabilize and control the greenhouse gas concentration in the earth's atmosphere at a level which could prevent dangerous anthropogenic interference with the climate system.
- The treaty does not put any binding limits on the greenhouse gas emissions for the individual states and does not have any enforcement mechanisms.
- The treaty is considered legally non-binding, and it actually provides a framework for negotiating different International treaties and protocols which can set binding limits on greenhouse gas emissions.
- The secretariat of UNFCCC supports the institutions involved in the negotiations of international climate change which includes Conference Of Parties (COP), the subsidiary bodies (which advises COP), and the COP Bureau which deals with procedural and organisational issues of COP along with some technical functions.
- All the different multilateral discussions on different issues of Climate Change including adaptation and mitigation are held on the principles and objectives set up by the UNFCCC.

Classification of UNFCCC parties and their commitments

There are now around 197 parties (196 States and one regional economic integration organisation). The parties of UNFCCC are classified as follows

- **Annex I Parties:** Annex I parties are the industrialized and developed countries and the Economies in transition (EIT). There are 43 parties listed under the Annex I of UNFCCC convention which includes the European Union. There are 14 Economies in transition (EIT) which includes the former centrally planned Soviet countries of Russia and Eastern Europe.
- **Annex II Parties:** the Annex II parties include the members of the Organisation for Economic Cooperation and Development (OECD). There are 24 parties under the Annex II list of UNFCCC convention. The Annex II parties provide

financial and technical support for the Economies in transition (EIT) and developing countries in order to help them for reducing greenhouse gas emissions, climate change mitigation and adaptation, and for reducing the negative impacts of climate change.

- **Annexe B Parties:** the countries with first or second round Kyoto Protocol greenhouse gas emissions targets are listed under the Annexe B of Kyoto protocol under COP of UNFCCC.
- **Least-developed countries (LDCs):** there are 49 countries which are given the special status of least developed countries LDC. It is given in the view of their limited capacity to adapt and take steps to mitigate the effects of climate change.
- Non-Annex I Parties: the non-Annex I parties are mostly the low-income group of developing countries which are not listed in the Annex I list. However, the developing countries can volunteer to become Annex I parties after they are sufficiently developed.

Conference of Parties (COP)

- The Conference of Parties (COP) is the supreme decision-making body under the UNFCCC convention. All the different parties are represented at the COP, where the review and implementation of the UNFCCC convention and decisions which are necessary to promote the effective implementation of the convention including the institutional and administrative arrangements are taken.
- The main function of the Conference of parties to review the national communications and the emission inventories submitted by the states. Based on this information the conference of parties assesses the effects of the actions taken by the parties and the progress made towards the ultimate goal of this convention.
- The first COP was held in Berlin, Germany in 1995, and since then COP meets almost every year. The most recent COP, COP23 was held in Germany in November 2017.

List of UNFCCC Summits (Conference of Parties)

1. 1995: COP 1, Berlin, Germany

2. 1996: COP 2, Geneva, Switzerland
3. 1997: COP 3, Kyoto, Japan
4. 1998: COP 4, Buenos Aires, Argentina
5. 1999: COP 5, Bonn, Germany
6. 2000: COP 6, The Hague, Netherlands
7. 2001: COP 6, Bonn, Germany
8. 2001: COP 7, Marrakech, Morocco
9. 2002: COP 8, New Delhi, India
10. 2003: COP 9, Milan, Italy
11. 2004: COP 10, Buenos Aires, Argentina
12. 2005: COP 11/CMP 1, Montreal, Canada
13. 2006: COP 12/CMP 2, Nairobi, Kenya
14. 2007: COP 13/CMP 3, Bali, Indonesia
15. 2008: COP 14/CMP 4, Poznań, Poland
16. 2009: COP 15/CMP 5, Copenhagen, Denmark
17. 2010: COP 16/CMP 6, Cancún, Mexico
18. 2011: COP 17/CMP 7, Durban, South Africa
19. 2012: COP 18/CMP 8, Doha, Qatar
20. 2013: COP 19/CMP 9, Warsaw, Poland
21. 2014: COP 20/CMP 10, Lima, Peru
22. 2015: COP 21/CMP 11, Paris, France
23. 2016: COP 22/CMP 12/CMA 1-1, Marrakech, Morocco
24. 2017: COP 23/CMP 13/CMA 1-2, Bonn, Germany

25. 2018: COP 24/CMP 14/CMA 1-3, Katowice, Poland (Scheduled in December 2018)

Note:

- **CMP-** Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol.
- **CMA-** Conference of the Parties serving as the meeting of the Parties to the Paris Agreement

Important summits of Conference of Parties (COP)

Kyoto Protocol

- After the UNFCCC treaty in the first conference of parties, the decision was taken that the Annex I parties would take the initiative to stabilize their greenhouse gas emissions at 1990 levels by the year 2000. The Kyoto Protocol is an international treaty linked to UNFCCC adopted in Kyoto Japan on 11 December 1997 which entered into force on 16 February 2015.
- The Kyoto Protocol puts a heavier burden on the developed countries under the principle of common but differentiated responsibilities. It has two commitment periods, the first 2008 – 2012, and second 2013 – 2020.
- During the first commitment period, the industrialized nations, including 37 countries and the European Union had to reduce the greenhouse gas emissions to an average of 5% against 1990 levels. In the second commitment period, they had to reduce the greenhouse gas emissions by at least 18% below the 1990 levels between 2013 to 2020.

Bali Meet, 2007

- At the Bali Summit, 2007 (COP 13, CMP 3) the Bali roadmap was adopted. The Bali roadmap had the following features:

1. The Bali Action Plan (BAP) was to launch a comprehensive process for the implementation of the convention for a long-term Cooperative action up to the year 2012 and beyond.

2. Decisions were taken for technology transfer to the developing and underdeveloped countries. Decisions were also taken to reduce the greenhouse gas emissions from deforestation.

3. The adaptation fund was launched at the Bali Summit.

- The developed countries had agreed to "quantified emission limitation taking into account differences in their national circumstances". Also, the developed countries stressed that the developing countries like China and India should also undertake some kind of emission cuts as they grow economically.

Copenhagen Summit, 2009

- The COP 15, CMP 5 was held at Copenhagen, Denmark. The Copenhagen Accord was produced at the Summit which was an agreement between the BASIC nations (Brazil, South Africa, India and China).

- The Accord is based on the pledge to put voluntary limits to reduce the greenhouse gas emissions. The binding obligations were not possible due to differences between the developed countries and developing countries.

- The accord agreed on a goal for the world for raising $100 billion per year by 2020. It also had the provision for funding for adaptation which would be delivered with a governance structure. The accord aimed to limit the global temperature rise to below 2 °C to the pre-industrial level.

COP 16, Cancun Summit, 2010

- At Cancun Summit, an agreement was adopted which called for a Green Climate Fund and an Adaptation committee for supporting the developing countries in mitigating and reducing their Greenhouse gas emissions.

- The summit looked forward to the second commitment period of the Kyoto Protocol. According to the Cancun agreement, all the parties agreed to report their voluntary goals of mitigation and adaptation and their implementation.

- It recognised the need for the establishment of a mechanism (including REDD+) for the mobilization of financial resources by developed countries.

COP 17, Durban Summit, 2011

- The Durban Summit led to the adoption of "Durban platform for enhanced action". The parties agreed to "develop a protocol, another legal instrument or an agreed outcome with legal force". This was to be adopted at the 21st conference of parties, and to be implemented in 2020.
- The Summit secured the second phase of the Kyoto protocol. The principle of common but differentiated responsibility was retained on the insistence of India.
- The Summit also approved the governing instrument for the Green Climate Fund (GCF).

COP 18, Doha Summit, 2012

- The Doha Summit established the second commitment period 2013 to 2020 of Kyoto Protocol. However, Japan, Russia and Canada did not join this second commitment period.
- The Summit also finalized the host for the Green Climate Fund (GCF).

COP 19, Warsaw Summit, 2013

- The developing and developed countries demanded $100 billion annually by 2020 from the developed countries.
- For reducing emissions from deforestation, the Warsaw framework for REDD+ was agreed.
- The Climate Technology Centre Networks (CTCN) established in Canton 2010, was now ready to respond to the requests of developing countries on issues related to transfer of Technology.

COP 20, Lima, 2014

- At the Lima Summit, pledges were made by both the developed and developing countries for the capitalisation target of $10 billion for the Green Climate Fund (GCF).

- There was progress on elevating the adaptation to the same level as curbing and cutting greenhouse gas emissions through National adaptation plans (NAPs).
- The conference agreed to the 'Lima Work Programme on Gender' for advancing the gender balance and gender sensitivity in the development and implementation of climate policy.

COP 21, Paris, 2015

- The Paris agreement facilitates enforcement of global GHG reduction measures for post-Kyoto protocol period (after 2020). It is based on the principle of voluntary 'Intended Nationally Determined Contributions (INDCs)' of respective parties.
- Its objective is to limit the rise of global temperature below 2 °C above the pre-industrial levels. Efforts will be made to limit this increase to 1.5 °C above pre-industrial levels.
- The developed countries would raise finances of 100 billion US Dollars per year by 2020. However, after the exit of the USA from the Paris agreement, achieving this target seems difficult.
- It has provisions for adaptation, mitigation, capacity building and technology transfer for achieving the target.

COP 22, Marrakech, 2016

- The conference ended with underwhelming and disappointment due to lack of fertilizing of political pioneers of significant forces.
- However, some progress was made on the international solar Alliance (ISA), Adaptation of African Agriculture (AAA), Mission Innovation, 2050 Pathway Platform and Climate Vulnerable Forum.
- All the participating member Nations collectively reaffirmed their commitment to the Paris agreement of November 2015. The Marrakech action proclamation highlighted the need to support the efforts aimed at improving the adaptive capacity to reduce the vulnerability of most vulnerable countries etc.

COP 23 Bonn, Germany

- This was the first conference after the withdrawal of the USA from the Paris agreement. At this conference, a blueprint for Talanoa Dialogue was framed.
- Talanoa is a traditional approach which is used in Fiji and the Pacific to engage in an inclusive, participatory and transparent dialogue to resolve the differences. The dialogue will consider the efforts of different parties on the mitigation action, financial and technical support in the pre-2020 period under the Kyoto protocol.

Green Climate Fund of UNFCCC

- The Green Climate Fund (GCF) was established at COP 16 as an operating entity of financial mechanism of UNFCCC. At the Cop 17, Durban, the governing instrument for the GCF was given legal approval.
- At the COP 18, a consensus decision was taken for the GCF board to select Songdo, Incheon, and Republic of Korea as the host of GCF. The fund became operational in 2013.
- GCF is a mechanism to redistribute funds from the developed countries to the developing countries for mitigation efforts aimed at reducing GHG emissions. This will help developing countries in adapting and mitigating to the negative effects of climate change.
- GCF is intended to be the centrepiece of efforts with the aim of raising $100 billion by 2020.

Adaptation fund

- It was established for financing the adaptation projects and programs in the developing countries that are particularly vulnerable to the negative effects of climate change. It is financed from the share of proceeds on the Clean Development Mechanism projects etc.
- The fund is supervised and managed by the Adaptation Fund Board (AFB) which is composed of 16 members and 16 alternates.
- The Global Environment Facility(GEF) provides Secretariat Services, while the World Bank serve as its trustee, on an interim basis.

Other mechanisms of UNFCCC

- **Special climate change fund (SCCF)-** it was established in 2001 for the financing of projects related to adaptation and mitigation; technology transfer and capacity building; energy, transport, agriculture, forestry and waste management, industry and economic diversification etc. The Global Environment Facility (GEF) has been entrusted with the responsibility to operate as an entity of financial mechanism of SCCF.
- **Fast start Finance**– at COP15, Copenhagen, the developed countries pledged to provide additional resources including forestry and Investments of around USD 30 billion for the period of 2010 to 2012; this came to be known as Fast Start Finance.

Criticisms of UNFCCC

- Except for the Kyoto protocol, all other initiatives did not put any binding limits on the greenhouse gas emissions on the parties.
- It could never achieve its stated goals of reducing the greenhouse gas emissions.
- The discussions are governed by the principle of consensus due to which often the small group of countries are able to block it.
- It has become easier for the developed countries to escape from their responsibilities. The United States never ratified the Kyoto protocol, and it even came out of the Paris agreement. Canada came out of the Kyoto Protocol, while Japan and Russia did not sign the second term of the Kyoto Protocol.

12.2 Kyoto Protocol

The UNFCCC convention was signed in 1992 with the aim to limit the global temperature rise and the resulting climate change and to cope up with its negative impacts. However, by 1995 the countries realised that the UNFCCC convention was inadequate for the realization of emission reduction goals. Thus negotiations were launched to strengthen the global response to global warming and climate change, and after two years the Kyoto Protocol was adopted.

Kyoto Protocol

On 11 December 1997, Japan, the Kyoto Protocol was adopted. But due to the complex ratification process, it came into force in 2005. India had already ratified the Kyoto Protocol in 2002. The main objective of the Kyoto Protocol is to reduce and control the greenhouse concentration in the atmosphere to "a level that would prevent dangerous anthropogenic interference with the climate system." The main distinction between the Kyoto protocol and the UNFCCC convention is that the convention encourages the developed countries to reduce greenhouse gas emissions, while the Kyoto Protocol binds them to do so. It is the only global treaty which has binding limits on greenhouse gas emissions. The protocol fulfils the principle of common but differentiated responsibilities.

The principle of common but differentiated responsibilities under Kyoto Protocol

- It is based on the principle of historical responsibility and puts the obligation to reduce emissions in industrialized countries on the basis of their contribution to the current levels of greenhouse gas emissions.
- Common but differentiated responsibility divides the countries into two groups. The historically largest polluting industrialized nations like the USA, UK, France, Russia etc. who have been responsible for greenhouse gas emissions since the industrial revolution. The second group consists of developing countries like China, India, Brazil etc. who have been contributing to the recent greenhouse gas emissions since the 1950s.
- The word common ensures that every country including developing and developed must take part in the action for reducing greenhouse gas emissions

and in the fight against climate change. However, the differentiated responsibilities put more responsibilities on the historically biggest polluters.

- Under the CBDR principle, that developed countries like USA, UK, France etc. have to take more responsibilities for reducing greenhouse gas emissions. Therefore, certain binding limits for reducing GHG emissions have been put for them. They also have to financially contribute to the reduction of GHG emissions in the developing and least developing countries.
- The developing and least developing countries have to take every possible action for reducing their greenhouse gas emissions. However, their actions are voluntary in nature, and there are no binding targets for them.

Classification of parties and their commitments under Kyoto Protocol

- **Annex I Parties:** it includes the developed economies of industrialized nations and the Economies in transition (EIT). There are 43 parties listed in Annex I of the convention which also includes the European Union (EU).
- **Annex II Parties:** it includes the members of the Organisation for Economic Cooperation and Development (OECD). There are 24 parties in the Annex II list of the convention. The Annex II parties have to provide financial and technical support to the Economies in transition (EIT), developing countries and least developed countries.
- **Annex B Parties:** the countries with first or second round Kyoto Protocol greenhouse gas emissions targets are listed under the Annexe B of Kyoto protocol under COP of UNFCCC.
- **Least-developed countries (LDCs):** it includes 49 countries who have been given the status of least developed countries due to their limited capacity to take mitigative steps against the negative effects of climate change.
- **Non-Annex I Parties:** these are mostly the developing countries which are not listed in the Annex I list.

The position of United States of America

- USA was a party in the UNFCCC convention but it did not ratify the Kyoto Protocol. USA was responsible for 36.1% of the 1990 greenhouse gas emission

levels of the Annex I countries, and it had to reduce its emissions by an average 7% below the 1990 levels.

- The protocol was rejected by the George W. Bush Administration in 2001, and he criticized it as economically irresponsible For USA.

The position of India, China, Brazil

- India, China and Brazil are regarded as the most advanced developing nations. However, they are in the non-Annex group of parties, and thus they do not have any binding obligations under the Kyoto Protocol for reducing their greenhouse gas emissions.

Commitment period under the Kyoto Protocol

- There are two commitment periods under the Kyoto Protocol. The first commitment period was from 2008 – 2012, and the second commitment period is from 2013 – 2020.
- The second commitment period which was agreed in 2012 came to be known as **Doha amendment** to the Kyoto Protocol.
- These commitment periods had set its own targets for the industrialized economies for reducing the greenhouse gas emissions. Those parties who missed the 2012 target of Kyoto Protocol had to incur a penalty of an additional third added do whatever cut they had agreed under the Copenhagen treaty.
- The first commitment period (2008 – 2012) had more than 35 countries with binding targets. Canada withdrew from the treaty after the first commitment period in 2012. Japan, New Zealand and Russia participated in the first commitment period but they did not take targets in the second commitment period of Kyoto Protocol.
- In the second commitment period, China, India and the USA who are the three major greenhouse gas emitters of the world have refused to ratify any treaty with binding targets for GHG emission reductions.
- India ratified the **Doha amendment** to Kyoto protocol in 2017.

Kyoto Protocol emission reduction gases

- Carbon dioxide (CO2),
- Methane (CH4), Nitrous oxide (N2O),
- Sulfur hexafluoride (SF6),
- Hydrofluorocarbons (HFCs) groups and
- Perfluorocarbons (PFCs) groups.

The benchmark of 1990 emission levels was accepted in the COP 3 based on the values of 'Global Warming Potential' which was calculated for the second assessment report of IPCC

Flexible market mechanisms

- The parties under Kyoto protocol who have binding targets have to meet them largely through domestic action by reducing greenhouse gas emissions onshore. However, they can meet a part of their GHG emission reduction targets through three market-based mechanisms.

1. Clean development mechanism CDM
2. Emission trading, and
3. Joint implementation (JI)

Clean development mechanism (CDM) under Kyoto Protocol

- The clean development mechanism (CDM) of Kyoto Protocol allows any developed country (Annex B Party) with emission reduction targets, to implement any greenhouse gas emission reduction projects in the developing and least developed countries.
- These kinds of projects in the developing countries can earn Certified Emission Reduction (CER) credits, each equivalent to 1 tonne of CO2 which can be counted for achieving the Kyoto Protocol targets.
- Most developed countries which emit more GHG gases and loose carbon credits can provide financial support to the developing and least developed countries for clean energy projects such as (solar energy, wind energy etc) and

can gain Carbon credits for it. They can use these Carbon credits for meeting their Kyoto Protocol emission reduction targets.

- For example, if any developed country emits 10 tonnes of more CO2 than its Kyoto targets, it loses 10 Carbon credits. The country has to make up for this lost carbon credit in order to avoid penalty. So it can provide financial support for the Clean Energy projects such as solar plants, wind power projects etc in the developing and least developed countries, and can gain its 10 Carbon credits to avoid penalty.
- Major parts of clean development mechanism projects have been implemented in China and India as these countries have a favorable climate in different sectors such as agriculture, waste handling, afforestation, solar energy etc.

The carbon credits trading mechanism under Kyoto protocol

- **Carbon credit-** A carbon credit is a tradable certificate with each carbon credit equivalent to 1 tonne of carbon dioxide emissions. Carbon credits can be acquired through afforestation, Clean energy projects, carbon dioxide sequestration, Methane capture, buying Carbon credits etc.
- **Carbon trading** refers to the exchange of emission permits. It can take place within the economy or through an international transaction.
- Under this mechanism, the developed countries that emit more carbon dioxide than their allotted quota can buy Carbon credits from those countries who emit less.
- More carbon emitting countries are able to achieve their carbon emission targets through this carbon trading mechanism. The developing countries such as India, China are able to sell such Carbon credits which provides them monetary benefits.
- These carbon credits are traded at different exchanges of the world. The multi-commodity Exchange of India (MCX) in 2009 had launched futures trading and carbon credit.

There are two types of carbon trading

1. Emission trading

2. Offset trading

Emission trading/ 'cap-and-trade'

- Emission trading permits countries that have carbon emission units to spare (carbon emissions quota permitted to them but not used) to sell to other countries that have overshot their carbon emission targets.
- The Carbon credits are traded like a commodity in the carbon market.

Other trading units in the carbon markets

- Removal unit (RMU) by reforestation.
- Emission reduction unit (ERU) by a joint implementation project.
- The certified emission reduction (CER) which are generated from the clean development mechanism projects.

Offset Trading/ 'baseline-and credit' trading

- This is another variant of carbon credit which is earned by a country by investing in the Clean energy projects which emit lower emissions in the atmosphere.
- For example, suppose a country wants to set up 10,000 megawatt capacity of a thermal power plant which emits GHG emissions equal to 500 Carbon credits. But the country builds a 10,000-megawatt solar power project which does not cause any GHG emissions as an alternative. The country gains 500 Carbon credits from this project.

Joint implementation

- The joint implementation mechanism allows a party with emission reduction commitment under Kyoto Protocol (Annex B Party) to earn the Emission reduction units (ERUs) from the emission reduction projects implemented in another Annex B Party, which could be counted towards meeting their binding commitments under Kyoto protocol.
- The joint implementation mechanism provides the parties with a flexible and cost-efficient means to fulfill their Kyoto Targets. The host country gets the benefit of technology transfer along with foreign investment.

Benefits of Flexible Market Mechanisms

- Increase in investment in green projects in the Developing Countries. It allows the involvement of private sector in the mission of reducing the GHG emissions at a safe level.
- It allows the developing countries to skip the older and polluting technologies for newer, more advanced and cleaner infrastructure and technologies having long-term benefits.
- It also improves the Kyoto protocols environmental integrity, and support to the carbon markets credibility which ensures transparency and accountability.

Non-compliance of Kyoto Protocol and penalties

- If a party does not meet the requirements for measurements and reporting of GHG emissions, the country loses its privilege of gaining Carbon credits through the joint implementation projects.
- If a party overshoots its emission cap and does not make up the difference through any of the available mechanisms, then the party has to make up the difference plus an additional 30% in the next commitment period. There is also the provision for banning the country from participating in the cap and trade program in future.

Criticism of Kyoto Protocol

- The provision of meeting the emission targets through Carbon credits and carbon trading from other countries ignores its long-term social and economic costs.
- Kyoto Protocol has been criticized for Common but differentiated responsibilities (CBDR) approach as it allows many developing and least developed countries to increase their greenhouse gas emissions.
- The protocol excludes countries like India, China from binding targets who have become the leading emitters of greenhouse gases.

After the Kyoto Protocol, the parties held discussions and commitments under Bali Action Plan (2007), the Copenhagen Accord (2009), the Cancun agreement 2010, the Durban platform for enhanced action (2011), the amendment to Kyoto

Protocol under Doha summit (2012), the Warsaw Summit (2013), the Lima Summit (2014) etc.

12.3 UNCED

United Nations Conference on environment and development (UNCED) also known as Rio Summit, Earth Summit signalled at Rio de Janeiro, Brazil in June 1992.

United Nations Conference on Environment and Development (UNCED)

The major issues discussed in the Summit are:

- Systematic scrutiny of the patterns of production especially about the production of toxic components such as radioactive chemicals, poisonous wastes, pollutants such as lead in gasoline etc.
- Finding alternative environment-friendly and clean sources of energy with the aim to reduce and replace the use of fossil fuels which have been responsible for the global climate change.
- Increasing the reliance on public transport systems with the main objective of reducing congestion in cities, and removing the negative impacts of polluted air and smog on human health.
- To address the problem of the growing scarcity of water.

The Rio Summit resulted in the following documents

- Rio declaration on environment and development
- Forest principles
- Agenda 21

Three important legally binding agreements (Rio conventions) were opened for signature

- Convention on biological diversity (CBD)
- United Nations convention to combat desertification (UNCCD)
- United Nations Framework Convention on climate change (UNFCCC)

Rio declaration on environment and development

- The Rio declaration on the environment and development was a short document which was produced at the United Nations Conference on environment and development (UNCED), Earth Summit.
- The declaration consisted of 27 principles which were intended to be the main guiding principles for the purpose of future sustainable development in the world.

Agenda 21

- Agenda 21 is a United Nations Action Plan which is related to Sustainable Development. It is an outcome of United Nations Conference on environment and development (UNCED) which was held in 1992 in Rio de Janeiro Brazil.
- It is a blueprint for the actions to be taken globally, nationally and locally by the organisations of United Nations, National governments, and major groups in all the areas where humans directly affect the earth's environment.
- The number 21 in the Agenda 21 refers to the agenda for the 21st century.

Local agenda 21

- Agenda 21 was intended to be implemented by involving necessary actions and steps at the international, national, regional and local levels. Many of the national governments and the state governments have legislated and advised the local administrative authorities to take proper actions for the implementation of agenda 21 plan locally as per the recommendations in chapter 28 of agenda 21 document. These types of programs are referred to as 'local agenda 21' or 'LA21'.

Agenda 21 for culture

- At the first world public meeting on culture, which was held in 2002 at Porto Alegre, Brazil, the idea for drawing up the document guidelines for the local cultural policies, a document which was comparable to the Agenda 21 of 1992 came up.
- It is the first document having a worldwide mission which advocates for establishing the groundwork, an undertaking by the cities and the local governments for the purpose of cultural development.

Rio+5, 1997

- A special session of united nations was held to appraise the five years of progress about the implementation of agenda 21 (Rio+5) in 1997.
- It recognised the progress as uneven, and it also identified the key trends which included increasing globalization, widening of inequalities in the income levels and the continued deterioration of the global natural environment.

Johannesburg Summit, (Earth Summit 2002)

- The Johannesburg plan of implementation at the World Summit on Sustainable Development (the Earth Summit 2002) affirmed about the United Nations commitment for the full implementation of the Agenda 21, along with the achievements of Millennium development goals and other Global treaties and conventions.

Rio+20, Brazil 2012

- Rio+20 refers to the United Nations Conference on Sustainable development held at Rio de Janeiro Brazil in June 2012. It was held after 20 years of the landmark Earth summit of 1992 held in Rio de Janeiro, Brazil.
- In this conference, the participants included world leaders, participants from the private sector, Non-governmental organisations and other groups. All of them came together to shape how we can reduce poverty, improve social equity and promote the protection of the environment on this planet Earth. It focused on the following themes.

1. Discussions about building the green economy for achieving sustainable development and lifting people out of poverty.
2. Discussions for ways for improving the International coordination for the purpose of achieving sustainable development.

- Around $513 billion was pledged at this Summit for building a sustainable future. It signalled as a major step for achieving the future goal of sustainable development.

12.4 Convention on Biological Diversity

Convention on biological diversity is a legally binding convention which for the first time recognised that the conservation and protection of biodiversity is a "common concern of humankind" and the integral part of sustainable development process.

Convention on Biological Diversity

CBD is an outcome of the Earth Summit held in Rio de Janeiro, Brazil on 5 June 1992, which entered into force on 29th December 1993. The convention covers all the ecosystems, species, important biodiversity areas and genetic resources. The convention is commonly known as "biodiversity convention".

Convention on Biological Diversity Objectives

- Conservation of biodiversity and the sustainable use of its components.
- Fair and equitable sharing of benefits arising from the use of genetic resources. It includes appropriate access to the genetic resources by transfer of relevant technologies, and taking in the account about all the rights over those genetic resources and technologies, and also by funding.
- The main idea is the development of national strategies for the conservation, protection and sustainable use of biodiversity resources.

Parties of Convention on biological diversity

- There are 198 countries/territories who are parties of Convention on biological diversity.
- India is also a part of this convention.
- The USA has signed this convention but has not ratified it.

Reason for non-ratification of Convention on biological diversity by the USA

- USA, Somalia and Andorra are the only countries who have not signed/ratified the convention on biological diversity.

- The USA has given its concerns about CBD provisions such as transfer of technology to developing and least developed countries, which could threaten US intellectual property interests.
- Further, the obligation of financial aid under CBD is also a reason. However, other developed countries have signed the convention, despite the above concerns.

Important provisions of Convention on biological diversity

- Conservation of the intrinsic value of biological diversity.
- The convention recognises the conservation of biological diversity as the common concern of humankind.
- It recognises the rights of sovereign States over their biological resources.
- CBD puts the responsibility to conserve and promote the sustainable use of biodiversity on the state parties.
- It also recognises the important role of local communities and women in the protection, conservation and sustainable use of biodiversity resources.
- It recognises the need for the provision of new and additional funding, and access to new technologies in the developing and least developed countries to address the loss of biodiversity.
- Article 6 of CBD talks about developing National strategies, plans or programs for conservation and sustainable use of biodiversity, or adapt for this purpose existing Strategies and plans.
- Article 8 and 9 of CBD refers to the biological techniques for the success of the objectives of CBD which includes in-situ and ex-situ conservation measures.

Funding for the Convention on biological diversity (CBD)

- The implementations of the provisions of CBD and its projects require a large number of financial resources. The financial resources for this purpose come through an organisation named as Global Environment Facility (GEF).
- GEF gets its money from the World Bank, United Nations, financial help from developed countries, trust organisations, private companies etc.

- GEF provides financial support to many environment-related activities including the Convention on biological diversity (CBD), United Nations Framework Convention on climate change (UNFCCC) etc.

Convention on biological diversity India

- The Biodiversity Act, 2002 has been enacted for the protection and conservation of biological diversity of India.
- The national biodiversity authority (NBA) ensures the fair and equitable sharing of benefits arising from the utilisation of Genetic Resources. It is mandatory to get the approval of the NBA for the use of benefits arising from the research for commercial purposes etc.

Protocols under Convention on biological diversity (CBD)

- The Cartagena protocol and Nagoya protocol have been adopted by the Conference of parties (Cop) under the Convention on biological diversity (CBD).
- The Cartagena protocol on biosafety addresses issues related to the benefit-sharing and biosafety issues. It seeks to protect the biodiversity from the potential risks posed by the living modified organisms (LMOs).
- Nagoya protocol is about one of the objectives of CBD, the “access to genetic resources fair and equitable sharing of benefits arising from utilisation”.

12.5 Cartegena Protocol

Biosafety is the need to protect the human health, biodiversity and environment from the possible negative effects from the products of modern biotechnology (Living modified organisms (LMOs)). The Cartagena protocol recognises the following aspects of modern biotechnology.

1. The access and transfer of Technologies to different parties.
2. The proper procedure to improve the safety of biotechnology-related Technologies.

Cartagena Protocol on Biosafety

- Cartagena protocol on biosafety aims to ensure a sufficient level of protection in the safe transfer, handling and the use of Living modified organisms (LMOs) resulting from modern biotechnology which can have negative impacts on the sustainable use of biodiversity, taking into account the risk to the human health, and a special focus on the transboundary movements of living modified organisms (LMOs).
- It is an additional agreement to the convention on biological diversity CBD. The protocol establishes the procedure for regulation of import and export of living modified organisms (LMOs) from one country to another country.
- The Cartagena protocol on biosafety also requires the parties to ensure that living modified organisms (LMOs) being shipped from one country to another country are handled, packaged and transported with proper safety measures.
- Such kind of shipments must be obtained by the documentation which clearly identifies the living modified organisms (LMOs), and specifies the requirements for safe handling, transport, storage and the use of LMOs and also provides the contact details for further information.
- Two main sets of procedures, one for the living modified organisms which are intended for direct introduction to the environment, known as advanced information agreement (AIA). The other one is for living modified organisms (LMOs) intended for the direct use as the food or feed, or for their further processing (LMOs – FFP).

What are Living Modified Organisms (LMOs)

- According to the Cartagena protocol, living modified organism (LMO) is any living organism that possesses a combination of genetic material obtained through the use of modern biotechnology, and living organism. It means any biological entity which is capable of transferring or replicating genetic material, which includes sterile organisms, viruses, and viroids.
- But the living modified organism is equivalent to the 'genetically modified organisms' and the protocol does not make any distinction between these two terms.

Advanced information agreement

- Under the advanced information agreement procedure, any country intending to export a living modified organism for releasing it in the earth's natural environment has to notify in writing to the party of import before the first proposed export.
- The party of import has to acknowledge the receipt of such notification within 90 days. The party of import has to inform about its decision on whether or not it intends to import the living modified organism within the 270 days.
- The parties have to ensure that their decisions are based on the risk assessment of the living modified organism intended to be exported or imported. The risk assessment has to be scientifically sound and transparent.
- After a decision has been taken by a party on the living modified organism, it is required to communicate the decision and the summary of risk assessment to the central information system, Biosafety Clearing House.

Living Modified Organisms (LMOs) – food or feed, or for processing

- Under the LMOs- FFP procedure, those parties who decide to approve and place such living modified organisms on the market have to make their decision based on relevant information, which includes the risk assessment reports, publicly available through the Biosafety clearing house (BCH).

The Nagoya – Kuala Lumpur supplementary protocol

- Through the Nagoya- Kuala Lumpur supplementary protocol on Liability and Redress, the objectives of Cartagena protocol have been reinforced.

- The Nagoya- Kuala Lumpur supplementary protocol specifies the response measures which has to be taken in the event of any damage to the biological diversity due to the living modified organisms.
- The competent authority in the party to the Nagoya- Kuala Lumpur supplementary protocol requires the person in control of living modified organisms (operator) to take the response actions and measures. It can implement the measures and actions itself and can also recover the costs incurred by that operator.

12.6 Nagoya Protocol

Nagoya Protocol

- Nagoya protocol on the access to genetic resources and the fair and equitable sharing of benefits arising from their utilisation to the Convention of Biological Diversity (CBD) is a 2010 supplementary agreement to the 1992 Convention on Biological Diversity. It is also known as Nagoya Protocol on Access and Benefit Sharing (ABS).
- Nagoya protocol provides a transparent legal framework for effectively implementing the one of the three objectives of Convention on Biological Diversity. It was adopted on 29th October 2010 in Nagoya, Japan and entered into force on 12th October 2014.
- Nagoya protocol has been ratified by 97 parties which includes the European Union and 96 member states of United Nations. It is the second protocol the Convention on Biological Diversity, the first is the Cartagena Protocol on Biosafety.

Objectives of Nagoya Protocol

- The objective of this protocol is the fair and equitable sharing of benefits arising from the utilisation of the genetic resources and contribute to the conservation and sustainable use of the resources from the biological diversity.

Obligations under Nagoya Protocol

- This protocol sets out some core obligations for the contracting parties to take measures in relation to the access and benefit sharing from the utilisation of genetic resources and their compliance.

Access obligations

The domestic level access measures are:

- To create legal certainty, transparency and clarity.
- To ensure fair and non-arbitrary rules, regulations and procedures.

- To establish clear rules and procedures to ensure prior informed consent on the mutually agreed terms.
- To provide for the issuance of a permit or its equivalent when the access is granted.
- To create conditions for promoting and encouraging research to contribute to the conservation and sustainable use of resources of the biological diversity.
- To pay proper attention to the cases of the present or eminent emergencies which can threaten the human, animal or the plant health.
- To consider and understand the importance of genetic resources for Food and Agriculture to ensure food security.

Benefit sharing obligations under Nagoya Protocol

- The domestic level benefit sharing measures and steps are to ensure the fair and equitable sharing of the benefits arising from the utilisation of the genetic resources with the contracting party who is providing the genetic resources.
- The utilisation of genetic resources includes research and development on the genetic or the biochemical composition of genetic resources along with its subsequent application and their commercialization.
- The sharing of benefits arising from the utilisation of genetic resources is subject to the mutually agreed terms and conditions.
- The benefits arising from the utilisation of genetic resources can either be monetary or nonmonetary such as royalties and the sharing of the research results etc.

Compliance obligations under Nagoya Protocol

There are specific obligations for supporting the compliance with the domestic legislation and the regulatory requirements of the contracting parties providing the genetic resources, and the contractual obligations reflected in the mutually agreed terms, are important innovation of the Nagoya Protocol. The contracting parties are to:

- To take proper measures for ensuring that the utilisation of genetic resources within their jurisdiction have been accessed according to the prior informed

consent. Also, the mutually agreed terms should have been established as required by the another contracting party.

- To ensure cooperation in cases of alleged violation of the requirements of another contracting party.
- To provide for the opportunity to seek recourse under their legal systems when any dispute arises from the mutually agreed terms.
- To take measures for ensuring the access to justice.
- To take measures for monitoring the utilisation of the genetic resources after they leave a Country. It should include the designation of effective checkpoints at any stage of the value chain: research, innovation, development, pre-commercialisation or during commercialization.

Traditional knowledge

- The Nagoya Protocol addresses the traditional knowledge which is associated with the genetic resources with provisions on access, benefit sharing and their compliance.
- The Nagoya Protocol also addresses the genetic resources where the indigenous and local communities have the established right to grant access to them.
- The contracting parties have to take sufficient measures and actions to ensure these communities' prior consent. They also have to ensure fair and equitable benefits sharing, keeping in mind the community laws and procedures as well as their customary use and exchange.

Tools and mechanisms to assist the implementation of Nagoya Protocol

The success of Nagoya Protocol will require its implementation at the domestic level. A number of tools and procedures have been provided by the Nagoya Protocol which assists the contracting parties including:

- Establishment of National focal points (NFPs) and the competent national authorities (CNAs) for serving as the contact points for information, granting access or cooperating on the issues of compliance.

- Access and benefit sharing clearing house for sharing information, such as the domestic regulatory Access and Benefit Sharing requirements or the information on National focal points and Competent national authorities.
- Capacity building for supporting key aspects of implementation. Based on any country's self-assessment of the national priorities and needs, it can include capacity to
    - Develop the domestic ABS legislation for implementing the nagoya protocol.
    - Negotiate mutually agreed terms.
    - To develop the in country research and development capabilities and institutions.
- Raising awareness.
- Technology transfer to the developing and least developed countries.
- To provide for the targeted monetary support for capacity building and development through the Nagoya Protocol's financial mechanism, Global environment facility (GEF).

Nagoya's outcome: Aichi target

The "Aichi target" is the strategic plan which is an outcome of the Nagoya Protocol. It includes the 20 headline targets organised under the five strategic goals to address the underlying causes of biological diversity loss, reduce the pressure on biological diversity, safeguard biological diversity at all the levels, enhance the benefits provided by the resources of biological diversity and to ensure capacity building.

The important agreements under this are:

- To reduce the rate of loss of natural habitats including forests to at least half and wherever possible bring it close to zero.
- It established a target of 17% of the terrestrial and inland water areas and 10% of the Marine and coastal areas.
- The governments would raise store at least 15% of the degraded areas through conservation and restoration.

- The parties will make special efforts for reducing the pressure faced by the coral reefs.
- The parties would also increase the level of financial resources for supporting the implementation of the convention.

Importance of Nagoya Protocol

- The Nagoya Protocol creates a greater legal certainty and transparency for both the providers of genetic resources and its uses by:
  - Creating more predictable conditions for accessing the genetic resources.
  - Ensuring benefit sharing when the genetic resources obtained from biodiversity leave the contracting party providing the genetic resources.
- By ensuring benefit sharing, the nagoya protocol creates incentives for conservation and sustainable use of genetic resources, and enhances the contribution of biological diversity to the development and the human well being.

Criticism

- Many scientists have raised their concern over the nagoya protocol, fearing the increased red tape which could hamper the disease prevention and conservation efforts. The threats of possible imprisonment of scientists can have negative impacts on research.
- The non-commercial biodiversity researchers and Institutions such as the Natural History Museums fear that maintaining the biological reference collections and exchanging material between institutions can become difficult.

12.7 Aichi Biodiversity Targets

The 'Aichi Targets' was adopted at the Nagoya conference of the Convention on Biological Diversity (CBD). In the conference of parties (COP-10), the parties agreed to come up with new plans and targets as the previous targets on biodiversity protection were not achieved. The short-term plan which consists of 20 ambitious targets is collectively known as Aichi targets.

Aichi Biodiversity Targets

Strategic Goal A

The strategic goal A of Aichi Biodiversity Targets was to address the underlying causes of the loss of biodiversity across government and Society.

1. By 2020, at the latest, making the people aware of the values of biodiversity and the steps they can take to ensure conservation and sustainable use of the resources of biodiversity.

2. By 2020, at the latest integrating the biodiversity values in the national and local level development and poverty reduction plans and strategies, and the planning process to be incorporated in the national accounting, as appropriate and reporting systems.

3. By 2020, at the latest, the incentives including subsidies which are harmful to the biological diversity are eliminated, phased out or reformed to minimise or remove its negative impacts on biodiversity. Also, positive incentives to ensure the conservation and sustainable use of the resources of biological diversity are developed and applied which are consistent and in harmony with the CBD, and other international obligations and treaties, taking into account the national socio-economic conditions.

4. By 2020, at the latest, the governments, businesses and other stakeholders at all the levels should have taken steps to achieve or have implemented plans and strategies to ensure sustainable production and consumption to keep the impacts of natural resources within the safe ecological limits.

Strategic Goal B

The strategic goal B of Aichi Targets aims to reduce the direct pressure on the resources of biological diversity and promote its sustainable use.

1. By 2020, the rate of loss of forests and all other natural habitats is at least halved and wherever possible brought close to zero, and the degradation and fragmentation of habitats are reduced significantly.

2. By 2020 all the fish and invertebrates stocks and the aquatic plants are harvested and managed sustainably, legally and by applying ecosystem-based approach. This is to avoid overfishing, the recovery plans and measures are in place for all the depleted species, and the fisheries have no significant negative impacts on the threatened species. The vulnerable ecosystems and the impacts of fisheries on the stocks, species and the ecosystems are well within the safe ecological limits.

3. By 2020, the areas under agriculture, forestry and aquaculture are managed sustainably to ensure the conservation of biodiversity.

4. By 2020, the pollution levels, including from the excess of nutrients, are brought to the levels which are not detrimental to the functioning of ecosystem and biodiversity.

5. By 2020, the invasive alien species and their pathways are identified and prioritized. The priority species are either controlled or eradicated, and measures are taken to manage the pathways to prevent their introduction and establishment.

6. By 2015, the multiple sources of anthropogenic pressures on the coral reefs, and all other vulnerable ecosystems which are highly impacted by the climate change or by the ocean acidification are minimised to ensure their integrity and proper functioning.

Strategic Goal C

The strategic goal C of Aichi Biodiversity Targets aims to improve the status of biological diversity by safeguarding the ecosystems, species and the genetic diversity.

1. By 2020, at least 17% of the terrestrial and the inland water, and 10% of the coastal and marine areas, especially the areas which are important for biodiversity and ecosystem services are conserved. This is to be achieved through effectively and equitably managed, ecologically representative and well-connected ecosystems of the protected areas and other area-based

conservation measures and strategies, and are integrated into the wider landscapes and the seascapes.

2. By 2020, the extinction of the threatened species are to be prevented and their conservation and protection status, especially of those which are most in decline, has been improved and sustained.

3. By 2020, genetic diversity of the cultivated plants and domestic animals and their wild relatives, including other socially, economically and culturally valuable species has been maintained. Also, strategies had been developed and implemented to reduce and minimise the genetic erosion and for safeguarding their genetic diversity.

Strategic Goal D

The strategic goal D of Aichi Biodiversity Targets aims to enhance the benefits from biodiversity and ecosystem services to all.

1. By 2020, ecosystems which provide essential services, including the services related to water, and contribute to the health, well being, and livelihoods are to be restored and safeguarded. It will also take into account the needs of women, local and Indigenous communities and that of the poor and vulnerable sections.

2. By 2020, the ecosystem resilience and contribution of biological diversity to the carbon stocks are to be enhanced and increased through conservation and restoration. It includes the restoration of at least 15% of the degraded ecosystems, thereby contributing to the mitigation and adaptation of climate change and to combat desertification.

3. By 2015, the Nagoya protocol and the access to genetic resources and fair and equitable sharing of benefits arising from its utilisation are in force and operational, and it is also consistent with the national legislation.

Strategic Goal E

The strategic goal E of Aichi Biodiversity Targets aims to enhance the implementation by adopting participatory planning, knowledge management and capacity building.

1. By 2015, each party has developed and adopted a policy instrument and has also commenced the implementation of an effective, updated and participatory national biological diversity strategy and action plan.

2. By 2020, the traditional knowledge, practices and innovations of the local indigenous communities which are relevant to the conservation and the sustainable use of biological diversity, and their customary use of biodiversity resources are respected subject to the national legislation and international treaties and applications. Also, it has to be fully integrated and reflected in the implementation of this convention with effective participation of the local and indigenous communities at all the relevant levels.

3. By 2020, the knowledge, scientific base and the technologies related to the biological diversity, its values, status, trends and the functioning and the consequences of its loss and degradation, are improved, widely shared and transferred, and are applied.

4. By 2020, the mobilization of financial resources for effective implementation of the strategic plans and measures for biodiversity 2011 – 2020 from all the different sources, in accordance with the consolidated and an agreed process for resource mobilization should increase to a significant extent from the current levels. The target will be subject to the different changes contingent on the resource needs assessments which are to be developed and reported by the parties.

12.8 Ramsar Convention on Wetlands

The Ramsar convention on wetlands is an international treaty which provides the framework for the National action plan and international cooperation for the conservation, protection and wise use of the wetland and its resources.

The Ramsar convention uses a broad definition for the identification of wetlands in the Ramsar list. The wetlands according to the Ramsar convention includes all lakes and rivers, underground aquifers, wet grasslands, peatland, swamps and marshes, oases, deltas and tidal flats, estuaries, mangroves and other coastal areas, coral reefs and all the human-made sites such as the reservoirs, dams, fishponds, rice paddies and the salt pans.

Ramsar Convention on Wetlands

Ramsar convention was adopted at Ramsar, Iran in 1971 and it came into force in 1975. Ramsar convention is the only global environmental treaty that deals with a particular ecosystem.

Ramsar convention is not affiliated with the United Nations systems of environmental agreements, but it works closely with the other multilateral environmental agreements (MEAs). It is a full partner among the "biodiversity-related cluster" of treaties and agreements.

The mission of Ramsar convention

- The mission of Ramsar convention is the conservation and wise use of all the wetlands and its resources through local, regional and national action plans and strategies and international cooperation. It aims to contribute towards achieving sustainable development throughout the world.

Three pillars of the Ramsar Convention

The signatory parties of Ramsar convention have committed themselves to:

- Working towards wise use of all their wetlands and its resources through National land use planning, proper policies and legislation, management actions and by educating the public.
- Designation of suitable wetlands for the list of wetlands of international importance under the Ramsar list and ensure their appropriate management.

- International cooperation for transboundary wetlands included in the Ramsar list, shared wetland systems, shared species and the development projects which can affect the wetlands.

The Ramsar list

- When a party joins the Ramsar convention, it has to designate at least one site for inclusion in the Ramsar list (list of wetlands of international importance).
- The addition of any site in the Ramsar list of wetlands of international importance confirms it the prestige of international recognition. It expresses the government's commitments to take all the necessary steps to ensure the ecological character of the designated wetland.

Transboundary Ramsar sites

- Transboundary Ramsar sites are ecologically coherent wetlands that extend across the national borders. The Ramsar authorities on both sides or all sides of the border formerly agree to cooperate and collaborate in the management of the wetland and have notified the Secretariat of this decision.
- It is a cooperative management arrangement procedure, and it has not been given a distinct legal status for these Ramsar sites.

Conference of Parties (COP)

- Conference of parties is the governing body of the Ramsar convention which consists of all the governments that have ratified the Ramsar Treaty.
- The representatives of the contracting parties meet at the conference of Parties (COP) in every 3 years.
- COP is the policy-making body of the Ramsar convention which adopts the resolutions and recommendations to administer the work of the Ramsar convention. The COP13 will be held in October 2018 in Dubai, United Arab Emirates.

Criteria for the identification of wetlands Under Ramsar convention

- If the wetland represents a rare, or unique example of any natural or near-natural wetland type.

- If the wetland supports vulnerable endangered or critically endangered species or any of the threatened ecological communities.
- If the wetland supports the population of plants or animals important for maintaining the biodiversity of any particular biogeographic region.
- If the wetland supports any plant or animal species at any critical stage in their life cycles, or if it provides refuge to any plant or animal species during adverse conditions.
- If the wetland supports at least 20000 or a number of water birds.
- If the wetland regularly supports around 1% of individuals of any one species or subspecies of the water birds.
- If the wetland provides a major source of food for fishes, spawning ground, nursery or the migration path.
- If it supports a significant proportion of indigenous species or subspecies of fish.
- If the wetland provides an important source of food and water and has increased possibilities for eco-tourism, recreation etc.

Key facts about Ramsar Convention

- The number of contracting parties in the Ramsar convention is 170.
- World wetlands day is celebrated on 2nd February every year, marking the date of adoption of the convention of wetlands on 2nd February 1971.
- There are six Ramsar regions in the world.
- The Ramsar Convention works closely with six other International Organisation Partners (IOPs).
    - Birdlife International.
    - Wetlands International
    - WWF International.
    - International Union for conservation of nature (IUCN).

- International water management institute (IWMI).
- Wildfowl and wetland trust (WWT).

The Montreux record

- The Montreux record was adopted by the conference of contracting parties in Brisbane in 1996. It accompanies the guidelines for the operation of Montreux report.
- The Montreux Record is a register of wetland sites where changes in ecological character have occurred, are occurring or can occur in future as a result of pollution, technological development or any other anthropogenic activities.
- The Montreux record is the principal tool of the Ramsar convention, and it is maintained as a part of the Ramsar list.

Indian wetland and the Montreux record

- Keoladeo National Park, Rajasthan was included in the Montreux record in 1990 and the Loktak Lake, Manipur was added in 1993.
- Chilika Lake, Odisha was included in the Montreux record in 1993 and was removed In 2002. It was placed in the Montreux record due to the problems of siltation and sedimentation which was choking the mouth of the Chilika Lake. It was removed from the Montreux record in 2002 after the rehabilitation efforts for which the Chilika Lake Development Authority was awarded the Ramsar Wetland Conservation Award in 2002.

The Changwon Declaration on human well being and wetlands

- The Changwon declaration highlights the positive actions to ensure the human well being and security in future under the themes – water, climate change, people's health and livelihood, changes in land use and biological diversity.

Wetlands International

- Wetlands International is a global NGO that works to sustain and restore the wetlands and their resources for the benefit of people and biological diversity. It is a not for profit organisation which is supported by the government and the NGO membership from all around the world.

- Its works include research, advocacy and engagement with National governments, corporate and international policy fora and conventions and agreements.

India and Wetland Conservation

- India joined the Ramsar convention in 1981. India has implemented several conservation programmes and schemes for wetlands, mangroves and coral reefs.
- India has designated 26 wetlands in the Ramsar list of wetlands of international importance.
- The implementing units of Ramsar and the Convention on Biological Diversity, work in close coordination at the national level. India has taken a leading role in the formulation of Ramsar convention guidelines on integrating the wetlands into river basin management.
- The National Conservation strategy and policy statements on environment and development (1992), and the National Water Policy (2002) highlights the importance of conservation and sustainable development and use of wetlands and its resources.

National Wetland Conservation Plan (NWCP)

- The National Wetland Conservation program was implemented in the year 1985- 86. Under the National Wetland Conservation program, 115 wetlands have been identified by the Ministry of Environment and Forests, which require urgent conservation and management efforts.
- The criteria for identifying the wetlands of national importance under this program are same as that of the Ramsar convention.
- The central government has the responsibility of overall coordination of wetland conservation efforts and programmes. The central government also provides guidelines, financial and technical assistance and support to the state governments.
- As the land resources belong to the state governments, the state/union territory administration has the responsibility of the management of wetlands.

Objectives

- To make policy guidelines and rules for the conservation and management of wetlands in India.
- To provide financial support for undertaking conservation measures and strategies.
- To monitor the implementation of the NWCP programme.
- To prepare the Inventory of wetlands in India.

Ramsar list of wetlands in India

Andhra Pradesh – Kolleru Lake

Assam – Deepor Beel

Gujarat - Nalsarovar Bird Sanctuary

Himachal Pradesh - Chandertal Wetland, Pong Dam Lake, Renuka Wetland (smallest wetland of India)

Jammu & Kashmir - Hokera Wetland, Surinsar-Mansar Lakes, Tsomoriri Lake, Wular Lake

Kerala - Ashtamudi Wetland, Sasthamkotta Lake, Vembanad Kol Wetland (Largest Wetland of India)

Madhya Pradesh - Bhoj Wetland

Manipur - Loktak Lake (part of Montreux Record)

Odisha - Bhitarkanika Mangroves, Chilika Lake

Punjab - Harike Wetland, Kanjli Wetland, Ropar Wetland,

Rajasthan - Keoladeo National Park (part of Montreux Record), Sambhar Lake

Tamil Nadu - Point Calimere Wildlife and Bird Sanctuary

Tripura - Rudrasagar Lake

Uttar Pradesh - Upper Ganga River (from Brijghat to Narora Stretch)

West Bengal - East Calcutta Wetlands

Gujarat - Nalsarovar Bird Sanctuary (the latest wetland added to Ramsar List)

12.9 TRAFFIC-Wildlife Trade Monitoring Network

Traffic is a joint conservation program of WWF and International Union for Conservation of Nature (IUCN). Traffic was established in 1976 by the species survival commission of the IUCN. It was set up principally as a response to the entry into force during the former year of Convention on International Trade in Endangered Species of wild flora and fauna (CITES).

TRAFFIC: The Wildlife Trade Monitoring Network

- TRAFFIC is a leading NGO working globally on the trade of wild animals and plants for ensuring biological diversity and sustainable development. It consists of TRAFFIC International, based in Cambridge, UK and it has its officers on five continents.
- It has become the world's largest wildlife trafficking and wildlife trade monitoring program since its establishment, and today it is a global expert on wildlife trade-related issues.
- TRAFFIC undertakes its various activities related to wildlife trafficking in close collaboration with the national governments and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Secretariat.
- In 1991, it came to India as a division of WWF – India. It has worked closely with the central and state governments and various other agencies to study, monitor and influence the actions in order to prohibit the illegal trade of Wildlife.

The vision of TRAFFIC Initiative

- Its vision is to create a world in which trade in wild animals and plants should be managed at sustainable levels without causing any harm to the integrity of ecological systems. It aims to achieve this in a manner that it makes a significant contribution to the human well being, supporting local and national economies and promoting commitments to the conservation of wild species and their habitats.

Objectives of TRAFFIC

- TRAFFIC aims to ensure that trade in wild animals and plants and wildlife trafficking do not cause a threat to the conservation of nature.
- Prohibit and avoid the trafficking of protected and endangered wildlife species.
- Identification and prohibition of illegal wildlife trade of both animals and plants.
- Gathering and maintaining the data of wildlife to ensure conservation of endangered species due to the wildlife trafficking. It aims to ensure sustainable wildlife population and combat with the wildlife trafficking.

Goal of TRAFFIC

- The ultimate goal of TRAFFIC is to ensure that the trade in wild plants and animals do not threaten the conservation of nature. The TRAFFIC 2020 goal is to help to reduce the pressure of illegal and unsustainable wildlife trade on biodiversity. It is to enhance the benefits to Wildlife Protection and conservation along with human well being from the trade at the sustainable levels.

TRAFFIC specialises in

- Investigation and analysis of the wildlife trade, trends, patterns, impacts and drivers to provide data and knowledge base on the trade in plants and wild animals.
- To inform, support and encourage the actions taken by National governments, through their intergovernmental cooperation to implement and enforce the effective policies and legislation.
- To provide information, advice and encouragement to the private sector to provide an effective approach to ensure that the sourcing of wildlife uses sustainable standards and best practices.
- To develop insights about the customer attitudes and purchasing motivation, and to design effective communication interventions to discourage the purchase of illicit wildlife products.

Major achievements of TRAFFIC

- Traffic started a program USAID 2017, working in Asia and Africa to create Global hubs for the protection of wildlife from illegal trade.
- The ROUTES partnership initiative of TRAFFIC to create hurdles in the illegal trade and transportation of wildlife through Airways.
- It helped in the establishment of SAWEN (South Asian wildlife enforcement network), launched in 2012 by Bhutan for carrying illegal trade in wildlife and bringing eight Asian countries together.
- ETIS (Elephant Trade Information System) was a successful information system managed by TRAFFIC on behalf of CITES to track the illegal trade of elephants for ivory.
- Traffic successfully influenced the European Union and its wildlife trade regulations and helped EU in drafting its wildlife policies and regulations which came into force in 1997.
- It has established partnerships and has worked with various groups like CITES, World customs organisation, World Bank, Wildlife justice Commission, FairWild Foundation, GEF and other NGOs and organisations.
- TRAFFIC in 1999 worked with WWF to curb the illegal trade of Shahtoosh wool and for raising awareness about reducing the demand for Shahtoosh which comes from the wool of the endangered Tibetan antelope.
- It has continually worked on tracking the trade of endangered tiger products, who are frequently killed for their pelts and bones used in traditional Asian medicines etc.
- It pushed UN to come up with a resolution for the protection of wildlife and to make all the countries a part of curbing wildlife crime and illegal trade of wild animals and plants.
- It has exposed the illegal trade which was in many countries and has helped to strengthen the Wildlife Protection initiatives.

12.10 Convention on Conservation of Migratory Species

The Bonn Convention or the Convention on the Conservation of Migratory Species (CMS) aims to conserve the terrestrial, aquatic and avian migratory species throughout their habitat range.

Convention On Conservation of Migratory Species

CMS is an intergovernmental treaty which was concluded under the United Nations Environment Programme (UNEP), which deals with the protection and conservation of wildlife and their habitats throughout the world.

There are 126 parties to the Bonn convention and has membership from Africa, Central America, South America, Europe, and Oceania. The CMS convention was signed in Bonn, Germany in 1979, it and came into force in 1983.

Bonn Convention is the only Global convention which specializes in the conservation of migratory species and their habitats and migration routes. It compliments and cooperates with several International organisations, NGOs, media and private sector members etc.

Appendix I

- The migratory species which are facing the threat of extinction are listed in Appendix I of CMS convention.
- The parties have to strictly protect these animals, and they have to conserve and restore the places where they live, and mitigate the factors causing obstacles to their migration and have to control other factors which can endanger them.
- The convention promotes concerted measures and actions among the range states of these species.

Appendix II

- The migratory species which need or can benefit significantly from International cooperation are listed under Appendix II of CMS convention.

To ensure conservation of migratory species, the parties will take the following steps:

- They will promote, cooperate and support research activities related to the migratory species.
- They would provide immediate protection and conservation to the species which are included in Appendix I.
- They would conclude agreements which cover the conservation and management of various migratory species included in Appendix II.

CMS as a Framework convention

- Agreements can range from legally binding treaties to less formal Memorandum of understandings, as per the requirements of any particular region.
- Development of models as per the conservation requirements throughout the migratory range is unique to the Convention on Conservation of Migratory Species.

The organisational structure of CMS

Conference of Parties (COP)

- The conference of parties (COP) is the decision making body of the CMS convention. COP meets every 3 years and decides about its policies and programmes. The functions of COP are described under Article VII of the CMS convention.
- The functions of the conference of parties include the review of the implementation of the convention, adoption of budgets, giving resolutions and recommendations on various issues, amendment of Appendix I and Appendix II, and takes decisions about the future priorities of CMS activities.

The Standing Committee (STC)

- The standing committee provides the guidance for policy formulation and administrative actions during the regular meetings of COP on general policy issues as well as on operational and financial matters.

- The standing committee consists of the representatives of the parties particularly from each of the CMS region.
- A delegate represents the country which plans to host the next meeting of the Conference of Parties. The standing committee meets at least annually.

Scientific Council

- The scientific council advises the conference of parties and Secretariat on the scientific issues and it prioritises the research and conservation measures. The functions of the scientific council are mentioned in Article VIII of the Bonn Convention. The members of the scientific council consist of the experts who are appointed by the CMS parties.

Steps Taken by India

- India has signed a 'Raptor MoU' on the conservation of birds of prey in Africa and Eurasia. India became the 56th member to sign the Raptor MoU under the Convention on Conservation of Migratory Species (CMS).

Raptor MoU

- Raptor MoU is a multilateral agreement under Article IV, paragraph 4 of the CMS Convention. It is a non-binding initiative, signed in October 2008, which came into effect on November 1, 2008.
- The MoU aims to ensure the working of members States for the conservation of Raptor species and their habitats. The MoU covers 76 species of birds of prey and has formulated an action plan for conservation action for the Raptor species.

Benefits for India from Raptor MoU

- It will help in gaining knowledge for the effective management of the habitats of 76 migratory species of birds under its ambit.
- The initiative is in conformity with the provisions of Wildlife Protection Act 1972, which provides protection to various bird species in India.
- It would ensure transboundary efforts for the conservation and protection of migratory birds through cooperation with other signatory parties of MOU with the CMS convention.

12.11 The Stockholm Convention on POP

The Stockholm Convention on Persistent Organic Pollutants was adopted by the Conference of Parties at Stockholm in 2001. The treaty entered into force in 2004.

The Stockholm Convention on POP

It is a multilateral convention under the United Nations Environment Programme (UNEP) which seeks to protect human health and environment from the harmful effects of certain chemicals which are classified as persistent organic pollutants (POPs).

Persistent Organic Pollutants (POPs)

They are organic chemical substances which possess a set of physical and chemical properties such that when they are released into the atmosphere/environment, they:

- Remain intact, without getting degraded, for exceptionally long periods of time (several years)
- Become widely distributed throughout the environment as a result of natural processes involving soil, water and, most notably, air
- Accumulate in the fatty tissues of living organisms including humans, and are found at higher concentrations at higher levels in the food chain

They are highly toxic to both humans and wildlife. They are known to cause serious damage to human health including birth defects, cancers, dysfunctional immune and reproductive systems, weakening of the immune system leading to a greater susceptibility to diseases, and damage to the central and peripheral nervous systems. Some of them are considered to be endocrine disrupters, which can damage the reproductive and immune systems by altering the hormonal balance of the exposed individuals as well as their offspring. They are also known to cause developmental defects

Human activities of the past several decades have led to the release of POPs into the environment. These chemicals are now found all around the globe, distributed over large regions including those regions where POPs have never been used. The extensive contamination of the environment and living

organisms, including many foodstuffs, with these chemicals, has resulted in a sustained exposure of many species, including humans, for time periods spanning generations which led to both acute as well as chronic health effects.

POPs tend to concentrate in living organisms through a process known as bioaccumulation. Though most of them are not soluble in water, they are readily soluble in fatty tissues where their concentrations can become magnified by up to 70,000 times the background levels

Owing to their ability to travel longer distances, no government acting alone can protect its citizens and/or its environment from the harmful effects of POPs.

The initial 12 POPs

Initially, 12 POPs have been recognized as causing adverse effects on humans and the ecosystem. They were placed in 3 categories as:

- Pesticides: aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, toxaphene;
- Industrial chemicals: hexachlorobenzene, polychlorinated biphenyls (PCBs); and
- By-products: hexachlorobenzene, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans (PCDD/PCDF), and PCBs.

List of New POPs

Nine new POPs have been added to the list of POPs under Stockholm Convention at the CoP held in 2009. Annexures A, B, and C were amended to include the following chemicals as POPs

- Pesticides: chlordecone, Alpha Hexachlorocyclohexane, Beta Hexachlorocyclohexane, lindane, Pentachlorobenzene;
- Industrial chemicals: Hexabromobiphenyl, Hexabromodiphenyl Ether and Heptabromodiphenyl Ether, Pentachlorobenzene, Perfluorooctane Sulphonic Acid, its salts and Perfluorooctane Sulphonyl Fluoride, Tetrabromodiphenyl Ether and Pentabromodiphenyl ether; and
- By-products: Alpha Hexachlorocyclohexane, Beta hexachlorocyclohexane, and Pentachlorobenzene.

At its fifth meeting held in 2011, the CoP adopted an amendment to the Annex A to the Stockholm Convention to include technical endosulfan and its isomers in the list of POPs with a specific exemption.

12.12 Basel Convention

The Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal was adopted in 1989 by the Conference of Plenipotentiaries in Basel, Switzerland. It came as a response to a public outcry following the discovery in Africa and other parts of the developing world in the 1980s of deposits of toxic wastes imported from abroad. The Convention is placed under the United Nations Environment Programme. It came into effect from 1992.

Basel Convention

With rising environmental awareness in the industrialized countries, there was a tightening of environmental regulations which escalated the costs of disposing of hazardous wastes. This led to the growth of not in my backyard (NIMBY) syndrome whereby the developed country operators found it cheaper to dispose of such wastes in developing countries and Eastern European nations where the levels of environmental awareness are not as high as in the developed countries. Laxity in environmental laws, regulations and their enforcement in these countries is also a reason for the rise in the movement of such wastes from the developed countries into the developing countries.

Objective

The prime objective of the Convention is to protect human health and the environment against the adverse effects of hazardous wastes. The Convention covers a wide range of wastes defined as “hazardous wastes” based on their origin and/or composition and their characteristics. In addition, two types of wastes defined as “other wastes” viz., household waste and incinerator ash are also brought under the scope of the Convention.

Principal Aims

The Convention aims at:

- Reducing the generation of hazardous wastes and promotion of environmentally sound management of hazardous wastes, irrespective of the place of disposal.

- Restricting the transboundary movement of hazardous wastes except in those cases where it is perceived to be in compliance with the principles of environmentally sound management.
- Putting in place a regulatory system which is applicable to cases where transboundary movements are permitted.

Wastes under the Basel Convention

Wastes are substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law.

Annex:

Annex I of the Convention, as further clarified in Annexes VIII and IX lists those wastes that are classified as hazardous and subject to the control procedures under the Convention. Annex II of the Convention identifies those wastes that require special consideration (known as “other wastes”, and which primarily refer to household wastes).

Examples of wastes regulated by the Basel Convention:

- Biomedical and healthcare wastes.
- Used oils.
- Used lead acid batteries.
- Persistent Organic Pollutant (POP) wastes.
- Polychlorinated Biphenyls (PCBs).
- Thousands of chemical wastes generated by industries and other consumers.

However, the Convention is not legally binding on the member countries.

12.13 Rotterdam Convention

The Rotterdam Convention was adopted in 1998 by a Conference of Plenipotentiaries in Rotterdam, the Netherlands and entered into force from 2004.

Rotterdam Convention

The Convention imposes legally binding obligations upon the member nations for implementing the Prior Informed Consent (PIC) procedure. It expanded the voluntary PIC procedure initiated by the United Nations Environment Programme (UNEP) and the Food and Agriculture Organization (FAO).

The Convention includes pesticides and industrial chemicals which either have been banned or are severely restricted for health or environmental reasons by Parties and which have been notified for inclusion in the PIC procedure by the Parties to the Convention.

Objectives of Convention

- To promote cooperative efforts and shared responsibility among the Parties in the international trade of certain hazardous chemicals with the aim of protecting human health and environment from potential harm.
- To ensure environmentally sound use of those hazardous chemicals, by facilitating information exchange regarding their characteristics, by also providing for a national decision-making process on their export and import and by disseminating these decisions to Parties.

Annex III Chemicals

The chemicals listed in this annexe include pesticides and industrial chemicals which either have been banned or are severely restricted for health and/or environmental reasons by two or more Parties. These chemicals must have been decided by the Conference of the Parties subject to the PIC procedure. At present, there are 43 chemicals listed in Annex III of which 32 are pesticides and 11 industrial chemicals.

One notification from each of the two specified reasons triggers the consideration for the addition of a chemical to the Annex III of the Convention.

Certain chemical formulations considered to be severely hazardous, which present a risk under conditions of use in developing countries or those countries with economies in transition may also be proposed for their inclusion in Annex III.

12.14 United Nation Convention to Combat Desertification

The United Nations Convention to Combat Desertification (UNCCD) was established in 1994. It was an outcome of the Earth Summit of 1992 held in Rio de Janeiro.

UN Convention to Combat Desertification

It is the sole legally binding international agreement which links development and environment with sustainable land management. The Convention strives to ensure the participation of local people in combating desertification and land degradation and adopts a bottom-up approach.

Objective

The Convention focuses its attention on arid, semi-arid, and dry sub-humid areas, collectively known as “dry lands”, which are home to some of the most vulnerable ecosystems and populations. Its main areas of work include desertification, land degradation, and drought (DLDD).

According to the Convention, ‘Desertification’ refers to land degradation in the drylands (arid, semi-arid, and dry sub-humid regions) which can be a result of various factors and does not connote the expansion or spread of deserts. Land degradation refers to a long-term loss of ecosystem functions and productivity caused by certain disturbances from which the land cannot recover without an external aid.

Land Degradation Neutrality

The Convention comprises of 196 parties which are committed to improving the living conditions of people in drylands, maintaining and restoring land productivity, and mitigating the effects of drought. It promotes sustainable land management (SLM) as a solution to global environmental challenges. The new UNCCD Strategy Framework 2018-30 is a comprehensive global commitment to achieve Land Degradation Neutrality (LDN) in order to improve the livelihoods of over 1.3 billion people by restoring the productivity of degraded lands and reducing the impacts of drought on vulnerable populations.

The achievement of land degradation neutrality is essential to meet the targets set out in the 2030 Agenda for Sustainable Development, which includes various Sustainable Development Goals (SDGs). Since the dynamics of land, biodiversity, and climate are closely connected, the Convention works in collaboration with the other two Rio Conventions viz., The United Nations Convention on Biological Diversity (UNCBD) and the United Nations Framework Convention on Climate Change (UNFCCC) by adopting an integrated approach to make the best possible use of natural resources and also meet these complex challenges.

12.15 International Whaling Commission

The International Whaling Commission is the global intergovernmental body charged with the conservation of whales and the management of whaling with headquarters in Cambridge, United Kingdom. It was set up under the International Convention for the Regulation of Whaling which was signed in Washington DC in 1946.

The preamble of the Commission mentions its duties:

- To provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry.
- To keep under review and revise as necessary the measures laid down in the Schedule to the Convention which governs the conduct of whaling throughout the world.

These measures, among other things,

- provide for the complete protection of certain species;
- designate specified areas as whale sanctuaries;
- set limits on the numbers and size of whales which may be taken;
- prescribe open and closed seasons and areas of whaling; and
- prohibit the capture of suckling calves and female whales accompanied by calves

The compilation of catch reports and other statistical and biological records is also required. In 1986 the Commission introduced zero catch limits for commercial whaling. This provision is still in place today, although the Commission continues to set catch limits for aboriginal subsistence whaling.

Apart from keeping whale catch limits under review, the Commission works to promote the recovery of depleted whale populations by addressing a range of specific issues. These include ship strikes, entanglement events, environmental concerns and establishing protocols for whale watching.

12.16 Vienna Convention

The Vienna Convention for the Protection of Ozone Layer was adopted in the year 1985 and entered into force in 1988. It acts as a framework for the international efforts to protect the ozone layer. However, it does not include legally binding reduction goal for the use of ozone-depleting substances (ODS).

Vienna Convention

The Vienna Convention and its Montreal Protocol are the most widely ratified treaties in the history of United Nations, with 197 parties. United Nations Environment Programme (UNEP) provides secretarial assistance to the Convention.

Montreal Protocol

The Montreal Protocol on Substances that Deplete the Ozone Layer was designed to reduce the production and consumption of ozone-depleting substances in order to reduce their abundance in the atmosphere and thereby protect the earth's fragile ozone layer. The treaty was opened for signature in 1987 and entered into force in 1989. The first follow up meeting under the protocol was held in Helsinki in 1989. Since then, it has undergone multiple revisions:

- London, 1990
- Nairobi, 1991
- Copenhagen, 1992
- Bangkok, 1993
- Vienna, 1995
- Montreal, 1997
- Beijing, 1999
- Kigali, 2016

The protocol sets a mandatory timetable for the phase-out of ozone-depleting substances which was reviewed periodically. The developed, as well as

developing countries, come under binding progressive phase-out obligations for all the major ozone-depleting substances, including chlorofluorocarbons (CFCs), halons, and the less damaging transitional chemicals such as hydrochlorofluorocarbons (HCFCs). The Multilateral Fund was the first international treaty-based finance mechanism designed to help the developing countries achieve their phase-out obligations by providing them with financial assistance.

The protocol targets 96 chemicals which are used in over 240 industrial processes/sectors. Under the Multilateral Fund, more than $2.5 billion was provided as financial assistance to help developing countries phase-out the production and consumption of ozone-depleting substances. The protocol is considered to be one of the most successful environmental treaties because it has helped in not only stopping the depletion of ozone layer but also in reversing the damage which was reflected in the shrinking of the ozone hole that was formed over Antarctica. Other significant environmental benefits of the protocol include the delay of climate forcing by up to 12 years.

Ozone depleting substances	Developed countries	Developing countries
Chlorofluorocarbons (CFCs)	Phased out end of 1995[a]	Total phase out by 2010
Halons	Phased out end of 1993	Total phase out by 2010
CCl_4(Carbon tetrachloride)	Phased out end of 1995[a]	Total phase out by 2010
CH_3CCl_3 (Methyl chloroform)	Phased out end of 1995[a]	Total phase out by 2015
Hydrochlorofluorocarbons (HCFCs)	Freeze from beginning of 1996[b] 35% reduction by 2004 75% reduction by 2010 90% reduction by 2015 Total phase out by 2020[c]	Freeze in 2013 at a base level calculated as the average of 2009 and 2010 consumption levels 10% reduction by 2015 35% reduction by 2020 67.5% reduction by 2025 Total phase out by 2030[d]
Hydrobromofluorocarbons (HBFCs)	Phased out end of 1995	Phased out end of 1995
Methyl bromide (CH_3Br) (horticultural uses)	Freeze in 1995 at 1991 base level[e] 25% reduction by 1999 50% reduction by 2001 70% reduction by 2003 Total phase out by 2005	Freeze in 2002 at average 1995-1998 base level[e] 20% reduction by 2005 Total phase out by 2015
Bromochloromethane (CH_2BrCl)	Phase out by 2002	Phase out by 2002
Hydrofluorocarbons (HFCs)	10% reduction by 2019[f] 30% reduction by 2024 70% reduction by 2029 80% reduction by 2034 85% reduction by 2036	Freeze in 2024[g] 10% reduction by 2029 30% reduction by 2035 50% reduction by 2040 80% reduction by 2045

12.17 Kigali Agreement

Kigali Agreement, formally known as the Kigali Amendment to Montreal Protocol was adopted at the 28th Meeting of Parties to the Montreal Protocol on Substances that Deplete Ozone Layer (MOP28) at Kigali, Rwanda in October 2016. The agreement lays down a framework for the reduction, and finally phasing out, of the production and use of hydrofluorocarbons (HFCs). Under the Kigali Agreement, all the 197 countries have agreed to reduce the usage of HFCs by 85 percent of their respective baselines by 2045.

Kigali Agreement

Kigali Agreement, being a part of Montreal Protocol, is legally binding on all the countries. It includes provisions for penalties which can be imposed on member nations for non-compliance to their respective targets. As part of this agreement, developed countries are to provide additional funding support, worth billions of dollars, to developing countries in order to help them transition away from HFCs. The assistance will be channelled through the Multilateral Fund created under the Montreal Protocol.

Developed countries have historically been the highest emitters of HFCs but their emissions from the developing countries have been rising at faster rates because of their increasing use for refrigeration and air-conditioning purposes.

HFCs – uses and implications

Hydrofluorocarbons were introduced as replacements for chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), which were sought to be eliminated under the Montreal Protocol because they were ozone-depleting substances, in refrigeration and air-conditioning systems, aerosol sprays etc. HFCs do not have chlorine atom in them and hence do not deplete the ozone layer unlike the other two class of refrigerants.

However, HFCs were a family of greenhouse gases (GHGs) whose global warming potential (GWP) i.e., their ability to absorb and retain the longwave radiation reflected by the earth, is several times higher than that of carbon dioxide. At present, HFCs have been identified as the world's fastest rising GHG emissions, with their emissions increasing at a rate of around 10 % every year. Thus, HFCs may have helped in reducing the ozone hole over Antarctica but have contributed to an increase in global temperatures.

HFC phase-out timelines

Under the Agreement, all the countries have been categorized into three groups and are assigned different timelines, based on their respective capabilities under the principle of common but different responsibilities (CBDR of UNFCCC), for the phase-out of HFCs.

- First Group – includes the industrialized nations such as countries of the European Union, the United States etc. They have to freeze the production and consumption of HFCs by 2018 and reduce their use to around 15 % of 2012 levels by 2036.
- Second Group – includes developing countries such as China, Brazil, the whole of Africa etc. They have to freeze the production and consumption of HFCs by 2024 and reduce their use to around 20 % of 2021 levels by 2045.
- Third Group – includes developing countries such as India, Pakistan, Iran, Saudi Arabia etc. They have to freeze the production and consumption of HFCs by 2028 and reduce their use to 15 % of 2025 levels by 2047.

The significance of the Agreement

Though the HFCs are not ozone-depleting substances they have been included under the Montreal Protocol since they were introduced as substitutes for CFCs and HCFCs. By achieving the phase-out of HFCs within the targets set under the Kigali Agreement, a potential 0.5 degrees Celsius increase in global temperatures can be averted by the end of this century.

Paris Climate Agreement will come into force from 2020. It has set a target of limiting the rise in global temperatures by 2 degrees Celsius until the end of this century, and possibly limit the rise to 1.5 degrees Celsius. However, unlike the Kigali Agreement, the Paris Agreement is not legally binding on the members. Hence, Kigali Agreement becomes absolutely essential to help achieve the targets set under the Paris Agreement.

India's role

Under the Kigali Agreement, India will have multiple baseline years – 2024, 2025, 2026. While the freeze year is set at 2028, a technology review is to be conducted in 2024-25 and if the growth in sectors using these refrigerants is found to be higher than a certain threshold, its freeze year can be pushed to 2030. India has agreed to complete its phase-out in four steps beginning in 2032

and achieving a cumulative reduction of 10 % in 2032, 20 % in 2037, 30 % in 2042, and finally 85 % reduction in 2047.

At the 28th MOP to Montreal Protocol in Kigali, India had announced that it will eliminate the use of HFC-23 by 2030. HFC-23 is a by-product of HCFC-22 (a common refrigerant) and has a global warming potential which is 14,800 times that of carbon dioxide. With this move, India can potentially check the emission of around 100 million tonnes of carbon dioxide equivalent over the next 15 years.

12.18 Globally Important Agriculture Heritage System

According to the Food and Agriculture Organization (FAO), Globally Important Agriculture Heritage Systems (GIAHS) are "outstanding landscapes of aesthetic beauty that combine agricultural biodiversity, resilient ecosystems, and a cultural heritage". GIAHS programme was started by FAO in 2002 when it began awarding such designations to selected sites across the world.

Globally Important Agricultural Heritage Systems

The idea behind identifying GIAHS is to increase understanding and awareness among the public regarding sustainable agricultural practices and to conserve the economic, environmental, and socio-cultural goods and services these systems provide to communities dependent on them, particularly the small and marginal farmers, indigenous populations etc.

Objectives

- To identify the eco-friendly agricultural practices followed by local communities and to provide institutional support to such systems.
- To undertake capacity building of local communities in the conservation and management of such agricultural systems.
- Documentation and cataloguing of indigenous knowledge in agricultural systems.
- To harness such systems for poverty alleviation and food security.
- To incentivize the local population towards conserving such systems by measures such as eco-tourism, eco-labelling etc.
- To mitigate the risks to biodiversity and traditional knowledge from climate change, land degradation, and other associated threats.
- To promote the conservation and sustainable use of biodiversity and local resources.

Components of GIAHS

GIAHS programme includes interventions and institutional support at three levels:

- **Local level** – it supports the conservation and management of agricultural systems through the active involvement of local communities by undertaking sensitization programmes.
- **National level** – it helps in streamlining and achieving convergence of various policies, schemes, and programmes which are aimed at conserving the agricultural systems and providing support to the local communities.
- **Global level** – it provides a platform for the consolidation and dissemination of agro-biodiversity related knowledge across the world for effective conservation.

GIAHS sites in India

Koraput (Odisha)

- It's famous for the cultivation of traditional varieties of paddy, pulses, millets, oilseeds, and vegetables.
- The region is inhabited by several tribal groups such as Khonds and Bondas who practice poddhu (shifting) cultivation.
- The region faces challenges such as loss of biodiversity due to shifting cultivation, soil erosion, and loss of habitat.
- The communities living in this region face abject poverty and backwardness with low levels of literacy, a small size of landholdings, and large families.

Pampore (Kashmir Valley)

- It's a prominent Saffron Heritage Site in India which also cultivates crops such as maize, pulses, lentils, fruits, and vegetables.
- The communities here follow low-tillage agriculture and during the fallow season, fodder, fruit, and mulberry trees are grown along the edges of farmland which helps in the conservation of agro-biodiversity.

- Water scarcity, climate change, the younger generation losing interest in agriculture etc., are some of the challenges faced by this region.

Kuttanad (Kerala)

- It's a deltaic region with an area of around 900 sq.km., where lowland rice cultivation is practised.
- Rice cultivation takes place below the sea level, the only such site in India.
- This unique technique was evolved by farmers here over 150 years ago.
- It contributes towards biodiversity conservation and the ecosystem services generated provide livelihood security to the local communities.

Potential GIAHS sites in India

- **Ladakh** – situated on the high altitude Tibet plateau, cultivation here takes place on four types of land viz., Zhing (cultivated land), Zhing Zhang (fertilized land), Rizhing (stony land), Thang Zhing (pasture land). Fruits such as apples, apricots, and walnuts are cultivated using an indigenous organic composting technique.
- **Raikas** – a pastoral Camel herding community of Rajasthan. They combine crop cultivation during the rainy season with pastoralism during the dry season.
- **Korangadu** – it's a silvopastoral system practised in the semiarid tracts of Tamil Nadu, including areas like Erode, Coimbatore, Karur, and Dindigul. The land is fenced with the help of a thorny, drought-resistant shrub known as "mullkiluvai". Without using chemical fertilizers, crop nutrients are supplied with the help of animal droppings and crops (such as Phaseolus Trilobus) which have high nutrient content.
- **Catamaran fishing** by the local fishing communities of coastal Tamil Nadu. It provides a sustainable alternative to the commercial, exploitative, overfishing done by mechanized trawlers.
- **Soppina betta system** is found in the Western Ghats of Karnataka. It's a self-sustaining system with rice cultivation which uses foliage and leaf litter as a natural fertilizer. The Soppina beta systems provide ecosystem services such as fuelwood, fodder, medicinal plants etc., to local communities.

12.19 REDD and REDD+

According to UN-REDD Programme, deforestation and forest degradation account for close to 20 % of global greenhouse gas emissions. Hence, it becomes imperative to conserve our forests to prevent the release of stored carbon into the atmosphere.

REDD and REDD+

REDD stands for Reducing Emissions from Deforestation and Forest Degradation. It is a global initiative negotiated under the United Nations Framework Convention on Climate Change (UNFCCC) in 2005. The objective of the REDD initiative was to mitigate climate change by reducing the net emission of greenhouse gases from forests (through their degradation) by the means of better forest management, particularly in the developing countries. REDD involves a provision of incentives to the developing countries to encourage them to “protect, better manage, and save their forest resources”.

REDD+ is an extension of the REDD initiative. The “+” here includes, “sustainable management of forests, conservation, and enhancement of forest carbon stocks”. REDD+ is a more comprehensive forest management initiative which includes incentives for conservation and sustainable management of forests, beyond a mere reduction in deforestation.

History

REDD was first proposed by the Coalition for Rainforest Nations (CfRN) at the 11th Conference of Parties (CoP) to the UNFCCC at Montreal in 2005. It was then termed as Reducing Emissions from Deforestation in Developing Countries. At the 13th CoP at Bali in 2007, the Bali Action Plan was adopted which included the REDD+ initiative.

The Warsaw Framework on REDD-plus was adopted at the CoP 19 at Warsaw in 2013. It included,

- a work programme for results-based finance to developing countries
- the modalities for national forest monitoring systems
- a technical assessment of emission levels

- the modalities for measuring, reporting, and verifying (MRV)

The UNFCCC rulebook on REDD+ was completed at the CoP21 at Paris in 2015 where all the outstanding decisions related to REDD+ were taken.

The significance of REDD+

- REDD+ provides positive incentives for not just reduction in deforestation but also for enhancement of forest cover, including its quality and the expanse.
- The incentives are based on the financial value that is attached to the carbon stored and enhanced in the soil and biomass of standing forests.
- This initiative also gives importance to livelihood improvement, biodiversity conservation, and food security services for communities dependent on forests.
- Countries which undertake sustainable management of forest resources, going beyond a reduction in deforestation, will be entitled to receive funds and resources as incentives.

India and REDD+

India is going to benefit from the REDD+ initiative in the following manner:

- India's sustained pro-conservation efforts and sustainable management of forests which have increased the forest cover and enhanced the carbon stack stand to be rewarded for its contribution towards providing carbon services to the international community as well as for providing the local communities access to traditional goods and services.
- India's domestic acts, policies, and regulations have been framed in such a way that the benefits deriving from the REDD+ initiative shall accrue to the local communities. This shall further strengthen the community efforts towards forest conservation and management.
- All REDD+ deliberations at the international level recognize, respect, an encourage the participation of local communities in the implementation and monitoring of REDD+ initiative.

India's position on REDD and REDD+ has been that the two initiatives should not be viewed in isolation. It had stressed that forest conservation and their

sustainable management must go hand-in-hand with the efforts to reduce deforestation. India's stand was accepted at the 13th CoP at Bali and got incorporated in the Bali Action Plan. Since then, REDD has come to be viewed under the broader framework of REDD+.

India's efforts under REDD+

- A National Green India Mission was started under the National Action Plan on Climate Change. It aims to increase the forest and tree cover by 5 million hectares and to improve the quality of existing forests in another 5 million hectares. It also aims to improve the ecosystem services obtained from 10 million hectares of land to increase the flow of forest-based services and income to around 3 million households dependent on forests.
- It has established a National REDD+ Coordinating Agency. It has also set up a Technical Group to develop procedures and methodologies to monitor and assess contributions of REDD+ actions.

13- ACTS AND POLICIES (INDIA)

13.1 Wildlife Protection Act, 1972

India is the first country in the world to have made provisions for the protection and conservation of the environment in its constitution.

Wildlife Protection Act, 1972

On 5th June 1972, the environment was first discussed as an item of international agenda at the UN Conference on Human Environment in Stockholm and thereafter 5th June came to be celebrated all over the world as World Environment Day. Soon after the Stockholm Conference, India took substantive legislative steps for the protection of the environment. The Wildlife (Protection) Act was passed in 1972,

Constitutional Provisions

The provisions for the environmental protection in the constitution were made within four years of Stockholm Conference, in 1976, through the 42nd Amendment Act as follows:

- Article 48-A of the Constitution provides: “The State shall endeavour to protect and improve the environment and to safeguard forest and wildlife of the country”.
- Article 51-A(g) provides:”It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers, and wildlife and to have compassion for living creatures”.

Thus our constitution includes environment protection and conservation as one of our fundamental duties.

The Importance of the Act

The passing of Wildlife (Protection) Act, 1972 constitutes an important landmark in the history of wildlife legislation in the country. This is because of the fact that “forest”, including “wildlife” was then a State subject and Parliament had no power to make a law on the same except under special circumstances (such as those mentioned under Articles 249, 250, 252 etc.)

Having regard to the importance of the matter, the Act has been adopted by all the States except Jammu and Kashmir which has a similar law enacted for the purpose of wildlife protection. The Act is applicable for Union Territories as

well. The Wildlife (Protection) Act 1972 provides the basic framework to ensure the protection and management of wildlife. The Act was amended subsequently in 1982, 1986, 1991, 1993 etc., to accommodate various provisions for its effective implementation.

The rationale for the passing of the Act

- A rapid decline in the populations of wild animals and birds, one of the richest and most varied wildlife resources of the country is a cause of grave concern.
- Areas which were once teaming with wildlife have become devoid of it and even in the sanctuaries and national parks, the protection accorded to wildlife needed to be enhanced.
- The Wild Birds and Animals Protection Act, 1935 had become outdated completely. It provided for punishments which were not commensurate with the offence, vis-a-vis the financial benefits that occur due to poaching and trade in wildlife products.

Salient Features of the Act

- The Act symbolized the efforts at wildlife protection which began in 1887 for the protection of wild birds.
- With its amendments in 1912, wild animals were added under the purview of the Act. The amendment in 1991 included certain specified plants which made the Act cover approximately the entire wildlife resources which are in need of protection and management.
- The Act consists of 6 schedules. Schedules I to V include species based on their risks of survival. Schedule I animals are accorded the highest protection, and their hunting, trade and commerce are strictly regulated. Schedule VI was added by the amendment of 1991 to include certainly specified plants.
- An expert committee, constituted by the National Wildlife Board, considers amendments to the Act as and when necessary.
- The amendment of 1991 took away the powers of the State Governments to declare any wild animal as vermin.

- Immunization of livestock within a radius of 5km from a national park or a sanctuary has been made mandatory.

13.2 EPA, 1986

As compared to all other previous laws on environment protection, the Environment (Protection) Act, 1986 is a more effective and bold measure to fight the problem of pollution.

Environment Protection Act, 1986

The genesis of the Environment (Protection) Act, 1986 is in Article 48-A (Directive Principle of State Policy) and Article 51-A(g) (Fundamental Duty) of the Indian Constitution. Soon after the United Nations Conference on the Human Environment held in Stockholm in 1972, the Water (Prevention and Control of Pollution) Act, 1974 was enacted. Then came the Air (Prevention and Control of Pollution) Act 1981 and finally the Environment (Protection) Act, 1986.

The Environment (Protection) Act (EPA) contains 26 sections which are divided into four chapters relating to

- preliminary
- general powers of the Central Government
- prevention, abatement, and control of environmental pollution and
- miscellaneous provisions

Provisions of the Act

The Act consists of and deals with more stringent penal provisions. The minimum punishment for contravention or violation of any provision in the Act is imprisonment for a term which may extend up five years or a fine of up to one lakh rupees or both. The Act also provides for further punishment if the contravention or violation continues after the date of conviction, which is Rs. 5000 per day. If the violation extends for a period beyond one year, the offender is punished with imprisonment for a term which may extend up to seven years.

The Act empowers the Central Government to take all appropriate measures to prevent and control pollution and to establish effective machinery for the purpose of protecting and improving the quality of the environment and preventing, abating and controlling environmental pollution.

The Central Government or any authorized person is empowered to collect samples or air, water, soil or any other substance as evidence for the offences under the Act. It prescribes the procedure for handling hazardous substances, and the concerned person has to handle such substances in accordance with the procedure established by the Act.

The Act has relaxed the provision of “Locus Standi” which has enabled even a common citizen to approach the Court provided he/she has given a notice of sixty days of the alleged offense and his/her intention to make a complaint to the Central Government or any other competent authority.

In case the offense under the Act has been committed by a government department, the head of the department is held responsible unless he/she provides evidence that the offense was committed without his/her knowledge or that he/she has exercised due diligence to prevent the commission of such offense.

The Act also empowers and authorizes the Central Government to issue directions for the operation or process, prohibition, closure, regulation of any industry. The Central Government is also authorized to stop or regulate the supply of electricity, water, or any other utility services directly, without obtaining a Court order for this purpose.

The Act grants immunity to officers of the Government for acts done under the provisions of this Act or under the powers vested in them or functions assigned to them under this Act. The Central Government is also empowered to enter and inspect any place through any person or through any agency authorized by the Central Government.

The Act debars a civil court from having any jurisdiction to entertain any suit or proceeding in respect of any action, order, or direction issued by the Central Government or any other statutory authority under this Act.

The Act contains a supremacy provision. This means that the provisions of this Act and the rules made thereunder, or the orders issued under this Act shall exercise supremacy over any provision under any enactment which is inconsistent with those under this Act.

13.3 National Forest Policy 1988

The National Forest Policy of 1988 was launched with the principal aim of ensuring environmental stability and maintenance of ecological balance, including atmospheric equilibrium which is essential for the sustenance of all life forms – plant, animal, and human.

National Forest Policy 1988

The objectives of the National Forest Policy 1988

- Maintenance and restoration of the ecological balance which has been adversely disturbed by a serious depletion of the forests.
- Conservation of the natural heritage and protection of remaining flora and fauna, representing the genetic diversity in the country.
- Checking soil erosion and denudation in the catchment areas of rivers, lakes, reservoirs in the interest of soil and water conservation.
- Checking the extension of sand-dunes in the desert areas of Rajasthan and along the coastal tracts.
- Increasing substantially the forest/tree cover in the country through massive afforestation and social forestry programmes, especially on all denuded, degraded and unproductive lands.
- Meeting the requirements of fuel-wood, fodder, minor forest produce, and small timber of rural and tribal populations.
- Increasing the productivity of forests to meet the essential national needs.
- Encouraging the efficient utilization of forest produce and maximizing the substitution of wood.
- Creating a massive people's movement with the involvement of women in achieving these objectives and to minimize the pressure of population on existing forests.

Strategy to implement the provisions of the policy

- About one-third of the total geographical area of the country to be brought under forest cover. In hills and mountainous regions, about two-thirds of the total area must be kept under forest cover to prevent soil erosion and land degradation and to preserve the stability of the fragile ecosystems.
- To encourage the planting of trees along roads, railway lines, canals and streams, and over the unutilized lands of State entities, lands under institutional or private ownership.
- Formation of Green belts in and urban areas, industrial zones etc., to check soil erosion and desertification as well as to improve the micro-climate of the region.
- Village and community lands must be encouraged to grow tree crops and fodder resources. The revenue generated from such resources must be shared with the panchayats and local communities.
- Land laws should be modified to encourage individuals and institutions to take up tree-fanning and grow fodder plants, legumes, etc., on their lands. Appropriate regulations must be put in place to oversee the felling of trees in private lands

The major achievements of the National Forest Policy, 1988 include

- Increase in the forest and tree cover.
- Involvement of local communities in the protection, conservation, and management of the forests through Joint Forest Management Programme.
- Conservation of biological diversity and genetic resources of the country through in-situ and ex-situ conservation efforts.
- A significant contribution towards the maintenance of ecological balance and environmental stability in the country.

Joint Forest Management Programme

- Under JFM programme both the State forest department, as well as the local communities, are involved in the conservation, protection, and management of forest lands under their jurisdiction.

- The local communities enter into a JFM agreement with the forest department under which they assist the forest department in the protection of forests from the illegal felling of trees, excessive grazing, fires, etc., in return for rights over the minor forest produce and a share of revenue generated from the sale of timber products.

13.4 Biological Diversity ACT 2002

The Biological Diversity Act, 2002 was legislated to fulfill India's commitment towards protection of Biological Diversity.

Biological Diversity Act, 2002

The act provides a legal framework to realize the objectives of UN Convention on Biological Diversity 1992.

Objectives of the Act

- Conservation of biological diversity
- sustainable use of its components
- fair and equitable sharing of the benefits arising from the utilization of genetic resources

Structure of the Administrative Mechanism

The Act envisages a three-tier structure to regulate the access to biological resources, comprising of

- National Biodiversity Authority (NBA) at the central level. A foreign national or a foreign company needs to take the permission from the NBA for utilizing the biological resources or accessing the knowledge thereof, for a survey, research, and commercial purposes. In case a company applies for a patent over the biological resources or the knowledge associated with them, it needs to take the permission from NBA which can order for benefit sharing or payment of royalties for the protection of such intellectual property
- State Biodiversity Boards (SBB) at the level of the States. Indian nationals and companies need to take the permission from SBBs to utilize the country's biological resources.
- Biodiversity Management Committees at the local level. These committees are tasked with preserving and protecting the local biodiversity. They are mandated to prepare a Peoples' Biodiversity Register (PBR) which includes the information about all the locally available biological resources, prepared in consultation with the local communities. They also have the right to levy fees

on any individual or company for accessing and utilizing the local biodiversity or the knowledge thereof.

13.5 Scheduled tribe and Forest Dwellers Act 2006

The forest rights Act, FRA 2006 aims to restore the deprived forest rights of the scheduled tribes and other traditional forest dwellers across India, including the individual rights to cultivate land in the forested area, and community rights over the community forest resources in the forest land.

Forest Right Act 2006

The forest right act provides scope and historic opportunity for integrating the conservation of forest and wildlife with the livelihood rights of the Scheduled Tribes and other traditional forest dwellers.

Objectives of the Forest rights act, FRA 2006

- To strengthen and empower the local self-government for Scheduled Tribes and other traditional forest dwellers.
- To address the problem of livelihood security of Scheduled Tribes and other traditional forest dwellers.
- To deal with the issues related to conservation and management of natural resources and their conservation.

FRA, 2006 recognises and secures the following rights

- Individual rights and community rights over the forest land and common property resources.
- The rights to protect, regenerate, conserve and manage the community forest resources which have been traditionally protected and conserved by the communities.
- Rights related to the intellectual property rights and traditional knowledge related to biological diversity and the cultural diversity.
- Recognition and restoration of the rights of displaced communities and their rights over the various developmental activities of that area.

- The FRA 2006 provides the rights of ownership, use, access to collect and dispose of the minor forest produce. It includes the non-timber forest produce.

Eligibility criteria under the Forest rights act (FRA), 2006

- It is applicable to those communities who primarily reside in the forest and depend on forest and forest land for their livelihood.
- The FRA 2006 is applicable for the tribal and other traditional forest dweller communities who have been residing in the forest land for three generations (75 years).

The process of recognition of rights under FRA, 2006

- As per this act, the gram sabha, or the village assembly has been designated as the competent authority to pass the resolution for determining the nature and extent of individual or the community forest rights or both to be recognised.
- Afterwards, the resolution is screened and approved at the subdivision level, and then subsequently at the district level.
- The screening committee includes the three government officials related to the departments of forest, revenue and tribal welfare, and the 3 elected members of the local body. The screening committee also hears the appeals related to disputes over the claims.

Other important features of the FRA 2006

- The nodal agency for implementation of this right is the Ministry of Tribal Affairs.
- The maximum limit of land to be recognised as rights is 4 hectares.
- The forests for recognition of rights also includes the national parks, sanctuaries, reserve forests, and protected forests.
- The act includes the forest rights related to the government providing for the diversion of land for schools, hospitals, anganwadis, drinking water supply etc.

- The rights provided under the Forest rights act (FRA), 2006 shall be heritable but not alienable or transferable.
- According to this act, no member of a forest dwelling scheduled tribes and other forest dwellers shall be evicted from the forested land until the recognition and verification procedure has been completed.

Issues and challenges related to the implementation of FRA, 2006

- The cap of maximum of 4 hectares of land entitlement hurts the families of Scheduled Tribes who have ancestral land more than 4 hectares.
- The inclusion of "Other Traditional Forest Dwellers" has been blamed to dilute the law by taking away the focus from the scheduled tribes who have a symbiotic relationship with the forest.
- There have been issues of rejecting the claims which have been authorised by the gram sabha. Dilution of such claims without substantive reason dilutes the very objective of this act.
- Further, the forest Bureaucracy has been reluctant to give up control. They have misinterpreted the FRA 2006 as an instrument to regularise illegal Encroachment. This is clear from the fact that, the forest Bureaucracy has put more emphasis on recognising the individual rights while ignoring the collective claims over community forest resources.
- Further, the role of environment ministry has also been seen as a roadblock in the process of forest clearances.

Way forward

- The government should confront and clarify the forest bureaucracy that the obstruction over the implementation of FRA act is unacceptable. The attitude of Bureaucracy must be changed to provide real benefits of the FRA act to the scheduled tribes and other traditional forest dwellers.
- There is a need to strengthen the nodal tribal departments, and providing proper instructions to the state and district administration for implementation of this act.

- The misuse of this law cannot be, and should not be a reason to dilute or repeal it. The government must fulfil its obligations under this act.

13.6 National Green Tribunal

The National green tribunal (NGT) came into existence in 2010 under the National Green Tribunal act 2010. The NGT act provides for the establishment of the National green tribunal for the purpose of effective and quick disposal of various cases related to the protection and conservation of forests, environment and other natural resources including the enforcement of any legal right related to the environment.

National green tribunal (NGT)

- NGT has replaced the 'National environment appellate authority'. It has provisions for giving relief and compensation for damages to persons and property.
- After the establishment of the National green tribunal, India has joined the league of countries that have a dedicated adjudicatory forum for disposing of cases related to environmental disputes.
- After the establishment of NGT in 2010, India became the third country to have a full-fledged green tribunal followed by New Zealand and Australia.
- The national green tribunal will facilitate fast-track resolutions of the cases related to environmental disputes, and help in the implementation of many sustainable development measures.
- The National green tribunal is mandated to dispose of the cases related to environmental disputes within 6 months.

Members of the National green tribunal (NGT)

- **Chairperson and members:** It has the provision of a full-time chairperson and at least 10 and maximum 20 full-time judicial members. It also has the provision for minimum 10 and maximum of 20 full-time expert members.
- **Qualification of chairperson-** the person should have been a judge of Supreme Court or the chief justice of any High Court.
- **Qualification of judicial members-** the judicial members should either be a judge of Supreme Court, Chief Justice of High Court or a judge of the high court.

- **Qualification for expert members-** the person should have a degree in the Master of Science in the physical sciences or the life sciences with a doctorate degree or should have a degree in master of engineering or the master of technology. A person having 15 years experience in the relevant field, and administrative experience of 15 years in either Central or state government can also be the member.

- After retirement, the chairman and the judicial members cannot take any job related to the matters of NGT for 2 years.

- The chairperson of the National green tribunal is appointed by the union government after consulting with the Chief Justice of India. The judicial and export members of NGT are appointed on the recommendations of a selection committee.

- The members including the chairperson can hold the office for 5 years. Maximum age limit for the chairman is 70 years if he has been the judge of Supreme Court, while the maximum age is 67 years, for the judge of the high court.

- The Chairperson can be removed by the union government after enquiry made by the judge of Supreme Court. The chairperson or the judicial members have to be informed about the charges against them and should be given a reasonable opportunity of being heard in defence of those charges.

Jurisdiction of the National green tribunal (NGT)

The jurisdiction of NGT extends over all the civil cases where there is a substantial question of environment, and such questions arising out of the implementation of enactments under schedule 1 of NGT act 2010. The schedule 1 of NGT includes the following acts.

1. The water (prevention and control of pollution) act, 1974.
2. The water (prevention and control of pollution) Cess act, 1977.
3. The forest (conservation) act, 1980.
4. The air (prevention and control of pollution) act, 1981.
5. The environment (Protection) Act, 1986.

6. The public liability insurance act, 1991.
7. The biological diversity Act, 2002.

Principles adopted by NGT

- The National green tribunal is guided by the principles of natural justice and is not bound by the procedure laid down by the code of civil procedure 1908. It is also not bound by the rules under the Indian Evidence Act 1872.
- As per the section 20 of NGT act, while passing any decision or award, the tribunal applies the principles of sustainable development, the precautionary principle along with the polluter pays principle.

Who can apply a case to the NGT?

- The person who has sustained an injury. The owner of the property who has suffered any damage. Any representative authorised by such person or by the owner of the property.
- In cases in which the environmental problems have resulted in death, the legal representatives of the deceased can apply to the tribunal.
- The state government, union government, state pollution board, Environmental authorities etc can also apply before the tribunal.
- Any party who has suffered any damage has to apply before the court within 6 months of the date of cause of action. This can further be extended to 60 days if there is sufficient cause before the court.
- Any person can appeal to the supreme court if the concerned person is not satisfied with the judgement of NGT within 6 months.

Important orders of the National green tribunal (NGT)

- In 2017, the NGT banned all the diesel vehicles over 10 years old in Delhi national capital region.
- The National green tribunal had put a fine on the 'Art of Living Foundation' as compensation for damage caused during World cultural festival on the floodplains of river Yamuna.

- The National green tribunal bench has imposed a no construction zone of 75 M around the lakes and Stormwater drains in Bengaluru.
- The Kochi bench of National green tribunal banned the diesel vehicles more than 10 years old in 6 cities of Kerala.

Critical issues related to the National green tribunal (NGT)

- The NGT act has limited jurisdiction to "substantial question of the environment" where the 'damage to public health' is broadly measurable or where it relates to 'point source of pollution'. This leads to a subjective assessment of environmental damage, which may not be a good practice.
- The qualifications for technical members of the National green tribunal are more favourable for bureaucrats. The act allows participation of Science, Technology and administrative experience but it does not ensure the participation of ecologist, sociologist, environmentalist, NGOs etc.
- The National green tribunal act does not provide the NGT jurisdiction over all the laws related to the environment; for example Wildlife Protection Act 1972, Scheduled Tribes (Recognition of forest rights Act) 2005 etc.
- The higher number of backlog cases in the NGT is also a cause of concern.

The overall work of National green tribunal (NGT) has been satisfactory. But the above-mentioned shortcomings need to be resolved to make the environmental dispute resolution under NGT accessible, speedy and effective.

13.7 Coastal Regulation Zone

The coastal areas of seas, bays, creeks, river, and backwaters which get influenced by tides up to 500 m from the high tide line and the land between the low tide line and the high tide line have been declared as coastal regulation zone (CRZ) in 1991. A new notification CRZ 2011 was brought later with amendments.

Coastal Regulation Zone (CRZ)

The coastal regulation zone has been declared by the Ministry of Environment, Forest and Climate change under the Environment Protection Act 1986.

The 1991 notification of the coastal regulation zone had several shortcomings. It had uniform regulations for the coastlines all over India and it did not take into account the diversity in terms of biological diversity, natural resources, population etc.

It lacked the proper procedure for obtaining CRZ clearance. It also had the problems of proper enforcement mechanism.

Coastal regulation zone amendment - CRZ 2011 and CRZ 2018

- Several amendments were made in the CRZ 1991 notification which was consolidated and issued in the CRZ 2011 notification. The CRZ 2011 notification took into account the issues of CRZ 1991.
- The Ministry of Environment, forest and climate change has now brought a draft coastal regulation zone CRZ, 2018 which has the potential to change the Governance of coastal structures of India. It will amend the regulations of CRZ 2011.

Classification criteria and regulatory norms

Coastal regulation zone CRZ 1

This coastal regulation zone is the environmentally most critical area. It has been further classified as CRZ – 1A and CRZ – 1B.

CRZ -I A

- It includes the ecologically most sensitive areas such as mangroves, corals and coral reefs, sand dunes, biologically active mudflats, national parks, Marine Park, centuries, reserve forest and other protected areas under the Wildlife Protection Act, forest conservation act or Environment Protection Act etc.
- These are ecologically most sensitive areas, and no activity shall be permitted except the following:
    - Ecotourism activities such as mangrove walks, nature trails etc.
    - Laying of pipelines, transmission lines etc. for public utilities.
    - Construction of roads on stilts, by way of reclamation, shall be permitted in exceptional cases for defence, strategic purposes, public utilities etc.

CRZ -I B

It includes the area lying between low tide line and the high tide line. The activities shall be regulated / permissible as follows.

- Land reclamation and bunding shall be permitted only for sure facilities like seaports projects for defence and security purposes, measures to control erosion, clearing waterways etc.
- Activities related to ports and harbours, non-conventional energy sources, facilities for receipt and storage of Petroleum products, treatment of waste and effluents etc. shall be regulated in this zone.

Coastal Regulation Zone – II

1. Coastal regulation zone II includes the areas developed up to the shoreline which fall within the Municipal limits.
2. The activities which are permissible in the coastal regulation zone II includes construction of buildings on the landward side of the existing road, or on the landward side of existing authorised fixed structures. Other permissible activities include desalination plants, temporary tourism facilities etc. as per the guidelines of notification.
3. According to the CRZ 2011, the Coastal regulation zone II areas, floor space index (FSI) or the floor area ratio (FAR) was frozen at the 1991 development

control regulations levels. The new CRZ 2018 has proposed to de-freeze them and permit FSI for the construction projects.

Coastal Regulation Zone – III

- CRZ- III has been divided into CRZ- IIIA and CRZ- III B as per the new draft regulation of coastal regulation zone 2018 by Ministry of Environment, forest and climate change.
- **CRZ – III A –** it Includes those areas where population density is more than 2161 per sq km as per the 2011 census. In this zone, the area of 50 m from the high tide line on the landward side shall be the no development zone.
- **CRZ – III B –** it includes all the other areas of CRZ- III where population density is below 2161 per sq km as per the 2011 census. In this area, the area up to 200 meters from the high tide line on the landward side shall be declared as the no development zone.
- Only a few activities such as agriculture, forestry projects related to atomic energy, mining of rare Earth minerals, manufacture of salt non-conventional energy resources, regasification of Petroleum products and some public facilities are allowed in this zone.
- In the area between 200 – 500 m all the activities which are permitted between zero to 200 m will be allowed. The construction of homes for the local communities and the tourism project are allowed.

Coastal Regulation Zone – IV

The coastal regulation zone IV has been further classified as CRZ – IVA and CRZ – IV B.

- **CRZ – IV A-** it constitutes the water area and the seabed area between the low tide line up to 12 nautical miles on the seaward side.
- **CRZ – IV B-** it includes the water area and the seabed area between the low tide line on the banks of the tidal influenced water body to the low tide line on the opposite side of the bank of the water body.
- CRZ – IV does not put restrictions on the traditional fishing by local communities. But dumping of untreated sewage or solid waste is not permissible in this zone.

- Land reclamation and bonding are permitted for some activities like ports, harbours defence and strategic purpose etc. as per the notification.
- Projects related to Department of Atomic Energy, strategic and defence related projects etc. are allowed as per the notification.

Ecologically sensitive areas in the coastal regulation zone

- The Sundarbans, Gulf of Kutch Gulf of Khambhat, Malvan, Achara Ratnagiri in Maharashtra, Karwar and Coondapur in Karnataka, Bhitarkanika in Orissa, Coringa in East Godavari, Krishna in Andhra Pradesh and Vembanad in Kerala constitutes the Critical Vulnerable Coastal Areas (CVCA).
- No construction activities are allowed in these areas.

Shailesh Nayak committee report on coastal regulation zone

- Shailesh Nayak committee was constituted on June 2014, and it submitted its report in January 2015.
- The committee recommended relaxation on the terms set up by the CRZ 2011 notification. The major objective behind the recommendations was to boost tourism, port construction and real estate.
- The committee suggested diluting the regulatory powers of Central Government in the coastal areas. Except for those activities which require environmental clearances all other activity should fall under the ambit of state and local planning bodies.
- Based on the recommendations of Shailesh Nayak committee, and the suggestions given by the coastal states and union territories, the CRZ 2011 shall be replaced by the draft coastal regulation zone notification, 2018.\

Important features of the Draft coastal regulation zone 2018

- The high tide line the marked by the National Centre for sustainable coastal management will be the universal standard for high tide line (HTL) for all the regulatory purposes.
- The hazard line mapping has been carried out by the survey of India. It has been de-linked from the coastal regulation zone regulatory regime. This

hazard line mapping should be used only as the tool for disaster management and planning.

- The No Development Zone of 20 meters has been proposed for all the Islands close to the mainland coast. It also includes the backwater Islands in the mainland.
- Wherever there are national or state level Highways passing through the no development zone and the coastal regulation zone III areas, the temporary tourism facilities have been proposed on the seaward side of the roads subject to the regulations of the concerned state.
- The new notification has also proposed to permit regulated limestone mining in the areas adequately above the height of high tide line based on the recommendations of National Institutes in the mining field, subject to environmental safeguards.
- The new amendment shall come into effect after the respective coastal zone management plans that were framed under the previous CRZ 2011 notification shall be revised and updated by the states and union territories. It also requires the approval of the ministry of environment, forest and climate change.
- The proposed changes will empower the coastal zone management authority (CZMAs) at the state level, who have the responsibility for the coastal zone management plans (CZMPs). This will promote the process of making plans in consultation with the coastal communities.
- **Projects that require the approval of the Ministry of Environment, Forest and Climate change** It includes only those projects which are located in the Coastal regulation zone – I and coastal regulation zone IV areas. The coastal zone management authority in the states and the union territories shall consider all other projects.

Benefits of the new draft coastal regulation zone

- The new guidelines proposed under the CRZ draft 2018 will make the coasts of India more accessible for tourism and industrial infrastructure. This will boost the economic growth and development.

- The CRZ draft 2018 will also give states the authority to decide their developmental plans in their region as per their regional requirements.

Criticism of new amendments to the Coastal Regulation Zone

- The new CRZ 2018 draft will lead to commercialization in most of the protected areas. This step of government can prove disastrous for the biodiversity and environment, and for the coastal communities.
- It has been around 7 years since the deadline set by the CRZ 2011 notification to submit the coastal zone management plans to the ministry of environment forest and climate change. The fact has also been noted by the National green tribunal. This dilutes the objectives of the coastal regulation zone.
- Coastal areas are fluid and the models pertaining to the inland areas should not be implemented in the coastal areas. Implementing the models of Inland areas to the coasts can prove problematic and disastrous.

Way forward

The new amendment is intended to benefit the local coastal communities. However, the changes which are being called as Pro-poor and Pro-tourism can override the concerns and their negative impacts on the Coastal Communities. Therefore, there is a need to ensure that the activities intended to promote economic growth must be sustainable and environment-friendly.

13.8 Wetlands Rule 2010

Wetlands refer to the transitional areas between the terrestrial and aquatic ecosystems. In the wetlands, land may be covered by shallow water or the water table is usually at or near the surface. It is an area of marsh, peatland or water, permanent or temporary with water which is either static or flowing, fresh or brackish in the inland and coastal areas. It includes lakes, reservoirs, lagoons, creeks, backwaters, and man-made wetlands

Wetland Rules 2010

The central government has officially identified 115 wetlands in India. In India, there are around 26 wetlands identified under the Ramsar convention of 1971.

Ramsar convention is an international Treaty signed in Ramsar, Iran in 1971 to ensure wetland protection, wetland conservation, and wetland management. The Ashtamudi wetland in Kerala, Bhitarkanika and Chilika Lake in Odisha, Kolleru Lake in Andhra Pradesh are famous wetlands of India.

Functions of wetland

- Wetlands preserve water and biodiversity and help in water supply and purification.
- Wetlands act as the buffer against natural disasters such as floods, storms cyclones etc.
- Wetlands are helpful in waste assimilation, groundwater recharge and controlling soil erosion.
- The wetlands also support recreational activities, social and cultural activities. They are rich in biodiversity with a range of floral and faunal diversity.
- Wetlands can help in mitigating and adapting to climate change as they can act as carbon sinks and can also provide a habitat to the biodiversity.

Threats to wetlands

- Several activities have been identified which are threatening the sustainability of wetlands.
- Activities such as drainage and landfills, disposal of domestic and industrial waste in the wetlands etc. are threatening their sustainability.

Wetland conservation and Management rules 2010

- The wetlands conservation and management rule 2010 was notified by the Ministry of Environment and Forest to reduce and prohibit the degradation of wetlands in India. Its objectives were wetland conservation, wetland protection, and wetland management to ensure that no further degradation of wetlands takes place in India.
- The wetland conservation and management rule 2010 specifies the activities which are harmful to the wetlands. It includes activities such as industrialization, construction activities, dumping of untreated sewage and solid waste, reclamation etc. The wetland rules prohibit these activities in the wetlands.
- The activities such as harvesting and dredging can be carried out with prior permission from the concerned authorities.
- The rules have classified the wetlands to ensure wetland protection, its easier identification and management.
- To ensure proper implementation of these rules, the central wetland regulatory authority has been set up. It also performs all the functions related to the management of wetlands.
- The central wetland regulatory authority had representatives from government, and a number of expert members to ensure wetland protection and wetland conservation in the best possible manner.
- The wetland conservation and management rules, 2010 was a necessary step to promote wetland protection and conservation in India.

Amendments in the Wetlands rule 2010

The wetlands rule 2010 has been amended in 2016 and again in 2017. The new Wetland (Conservation And Management) rules, 2017 will replace the Wetlands rule, 2010. It will prohibit a range of activities in the wetlands of India.

Salient features of Wetlands (Conservation and Management) Rules, 2017

State wetland Authority (SWA)

- The wetlands conservation and management rules, 2017 stipulates to set up State Wetland Authority in every state and union territory. It would be headed by the state's environment minister and would include other government officials.
- Experts in the field of wetland ecology, fisheries, hydrology, landscape planning and social economics would be appointed by the state government.

Functions of State Wetlands Authority (SWA)

- The functions of state wetland authorities include developing a comprehensive list of activities which would be regulated and permitted in the wetlands in their zone of influence.
- State Wetland Authorities would also recommend various additional prohibited activities for specific wetlands. It will also define strategies, wise use of the wetlands and would undertake conservation measures through enhanced awareness of stakeholders and local communities.
- The wise use of wetlands refers to the principle of Sustainable use of the resources of wetlands which is compatible with wetland conservation, wetland protection, and wetland management.

Prohibited activities in the Wetlands

- The prohibited activities in the wetlands include conversion of wetlands for non-wetland uses such as encroachment of any kind, setting up new industries or expansion of old industries, dumping of waste and discharge of untreated sewage from factories, cities, villages and other human settlements.

Digital inventory of all wetlands

- The new wetland conservation and management rules, 2017 makes it mandatory for the state authorities to prepare the list of all the wetlands in the state. The list of wetlands has to be notified within 6 months.
- Based on this data, a comprehensive digital inventory of all the wetlands will be prepared, and this inventory would be updated in every 10 years.

National Wetlands Committee (NWC)

- The wetlands conservation and management rules, 2017 stipulates for setting up national wetland authority (NWC) to be headed by the secretary of the ministry of environment, forest and climate change. The functions of NWC would be to monitor the implementation of these rules and oversee various works carried out by the state governments.
- The NWC will also give advice to the union government on various policies and action programs for wetland conservation, wetland protection and wise use of wetlands. It would recommend the designation of wetlands of international importance under the Ramsar convention.
- It would also advise the government in collaboration with the International organizations on various issues related to wetland conservation and wetland protection etc.

Comparison of Wetlands Conservation and Management Rules 2010 and 2017

- Both the Wetland Conservation and Management Rules, 2010 and 2017, emphasizes maintaining the ecological character of wetlands for their conservation and management.
- Ecological characters are the processes and components which make the wetland a unique ecosystem. For example the Chilka lake Orissa is a lagoon characterized by a mix of saline and freshwater flows and the flow of each type has to be maintained.
- The 2010 rules had made some related criteria explicit such as ecological sensitivity, historical value, natural beauty etc which have been omitted in the Wetland conservation and management, 2017 rules.

- The restriction of activities on the wetlands would be determined by the State Wetland Authority on the principle of 'wise use'. However, there are concerns that whether the wise use would be able to maintain the ecological character of wetlands or not.
- In the new rules, the salt pans have been omitted as wetlands. Earlier as per the 2010 rules, the salt pans were identified as wetlands as they are important sites of migratory birds and other forms of biological diversity.