ONLYIAS
BY PHYSICS WALLAH

UDAAN 3.0

Quick and Comprehensive Revision Series

For Prelims 2023



Environment & Ecology

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- Discussion of Highly Probable Topics for Prelims
- Updated Booklets with Latest Data and Facts
- Concise and Curated Content for Solving Objective Questions
- Inclusion of Tables, Flowcharts and Mindmaps for Easy Memorisation

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1 Basics of Ecology

1.1 IMPORTANT DEFINITIONS

Environment	The sum total of all biotic (related to living beings) and abiotic (related to non-living) factors, substances and conditions that surround and potentially influence organisms without becoming their constituent part.
Ecology	**Scientific study of the interactions** among organisms and between the organism and its physical (abiotic) environment. **'Ecology'** was coined by combining to two Greek words, **oikos** (house or dwelling place) and **logos** (study) by **Ernst Haeckel in 1869**.
Habitat	The **place of environmentally suitable conditions** where an organism can be found is called it's habitat. **All habitats are environments, but all environments are not habitats.**
Ecological Niche	**Grinnel (1917) first used the term 'Niche'** to explain microhabitats. Ecological niche of an organism includes the physical space occupied by it and its functional role in the habitat i.e. trophic position. **Gauss Law:** No two species have identical niche due to competition.
Ecotone	Ecotone is a **transitional area between two ecosystems**. It is an **overlapping region.** E.g. **Mangrove forest** represents an ecosystem between marine and terrestrial ecosystems.
Edge Effect	The **presence of a greater diversity of life** in the region where the edges of **two ecosystems overlap. Eg.** land/water, forest/ grassland. **Unique species are found** in the region of overlap which are not found in any of the neighbouring ecosystems.

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Ecocline	It is the **gradual continuous change in species composition** with change in climatic conditions between two neighboring ecosystems.
Ecotype	**Genetically distinct species found in the ecocline region**. Examples are Penguin, Polar Beer, Xerophytes, desert vegetation, asiatic lion etc.
Ecad	**Environmentally induced but reversible variations in habitat forms** gives population of individuals which although **belong to the same genetic stock, but differ** markedly in characters such as size, shape, number of leaves, reproductive capacity etc.

Population	A group of individual organisms of the same species in a given area.
Species	A uniform interbreeding population spread over time and space.
Community	A group of populations of different species in a given area. Thus, it includes all the populations in that area (all plants, animals and microorganisms).
Ecosystem	It is a structural and functional unit of biosphere consisting of living beings and their physical environment and the interaction among them. Term '**Ecosystem**' was coined by **A.G. Tansley** in 1935.
Biome	Biomes are bigger units than communities, constitute the great regions of the world in some climatic zone, distinguished on an ecological bias, such as tundra biomes, forest biomes, grasslands and deserts etc.
Biosphere	It is biological component (supporting life) of earth which includes the lithosphere, hydrosphere and atmosphere.

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Deep Ecology

An environmental philosophy that promotes the inherent worth of all living beings regardless of their instrumental utility to human needs, and the restructuring of modern human societies in accordance with such ideas. Tree planting and man-made forests are examples of deep.

Ecological Equivalents

These occupy the same or similar ecological niches in different geographical regions and are known as ecological equivalents ecology. E.g. Kangaroos of Australia are ecologically equivalent to the Bisons of North America.

Character Displacement

Term used to describe an evolutionary change that occurs when two similar species inhabit the same environment. Under such conditions, natural selection favors a divergence in the characters (morphology, ecology, behaviour, or physiology) of the organisms.

Indicator Species A species or group of species chosen as an indicator of, or proxy for, the state of an ecosystem or of a certain process within that ecosystem.	**Biological Spectrum** The relative numbers of plant species per biological type such as aerophytes, hygrophytes, phanerophytes etc. occurring in a particular ecosystem, each expressed as a percentage of the total.
Keystone Species A species that plays an essential role in the structure, functioning or productivity of a habitat or ecosystem. Disappearance of such species may lead to significant and disproportionate effects on the ecosystem as compared to other species.	**Ecological Efficiency** It is described as the efficiency with which energy is transferred from one trophic level to the next. The number of trophic levels in the grazing food chain is restricted as the transfer of energy follows 10 percent law – only 10 percent of the energy is transferred to the next trophic level.
Flora It is the species content of the region irrespective of the numerical strength of each species.	**Vegetation** The collective and continuous growth of plants in space/ region.

Detritivores vs Decomposers
Detritivores feed on animal or plant detritus. They initiate the transformation of dead organic matter.
Decomposers are **responsible for the second stage of degradation** of organic matter. **Mineralization** occurs by **aerobic or anaerobic processes (fermentation)** and organic molecules are broken into much smaller mineral molecules, the mineral salts.

Fig. 1.1: Important Definitions

1.2 COMPONENTS OF ECOSYSTEM

1.2.1 Major Abiotic Factors

- Abiotic factors are a nonliving part of an ecosystem that shapes its environment.

  In terrestrial ecosystem they include temperature, light and water.

  In marine ecosystems salinity and ocean currents are important.

1.2.1.1 Temperature and Associated Terminology

- Affects the kinetic of enzymes and through its basal metabolism, activity and other physiological functions of the organism.
- Level of thermal tolerance determines the geographical distribution of an organism.
- **Eurythermal**: Organism that can tolerate a wide range of temperatures.
- **Stenothermal**: Organisms that are restricted to a narrow range of temperature.

- High or low temperature causes inactivity and death of organisms. It is immediate in case of poikilothermic (**ectodermal** or cold blooded) animals and delayed in case of homeothermic (**endothermal** or warm blooded) animals.
- Growth, Metabolism, Reproduction, Sex ratio, Distribution, Colouration, Behaviour, Morphology are all affected by temperature.

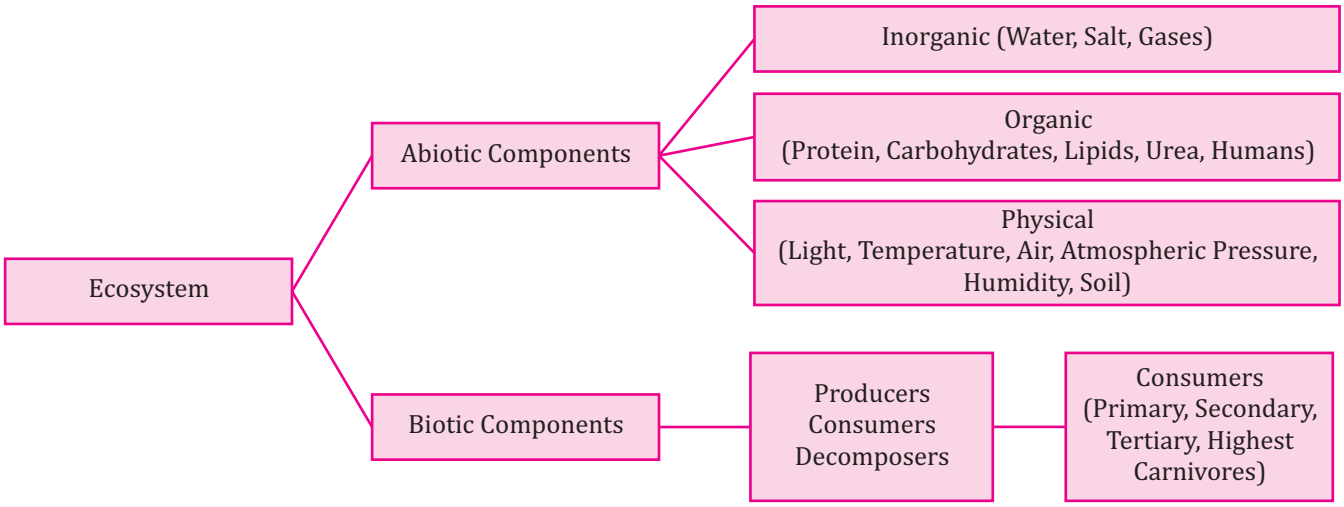


Fig. 1.2: Components of Ecosystem

1.2.1.2 Water and Associated Terminology

- **Hydrophytes**: Plants of aquatic habitats are called hydrophytes. They possess aerenchyma or air storing parenchyma to support themselves in water.
- **Mesophytes** are terrestrial plants which are neither adapted to particularly dry nor particularly wet environments.
- **Xerophytes** are plants of dry areas. They develop modifications to increase water absorption, reduce transpiration etc.
- **Halophytes** are salt tolerant plants that grow on soil or waters of high salinity such as **mangroves swamps, marshes, seashores and saline semi deserts.**
  - **Euryhaline** are organisms that can tolerate a wide **range of salinities.**
  - **Stenohaline** are organisms that are restricted to narrow **range of salinities**.
- **Pneumatophores** have lateral roots that extend out of the surface of the water and facilitate the exchange of oxygen and carbon dioxide for the roots submerged in water. They are specialised aerial root structures present in plants where the oxygen required for normal respiration of roots is inadequate.
- **Catadromous** species are born in **seawater**, spend most of their life in **freshwater** and then return to **seawater** to **spawn**.
- **Anadromous** species are born in **freshwater**, spend most of their life in **seawater** and then return to **freshwater** to spawn.
  - Certain animals of the dry areas do not drink water at all. E.g. **Kangaroo, Rat etc.**

1.2.1.3 Light

Regarding Animals
(Daily Rhythm, Breeding, Pigmentation, Reproduction)

Diurnal: Active during daytime
Nocturnal: Active during nighttime.
Auroral: Active at dawn or early morning
Vesperal: Active at the time of dusk or sunset.

Fig. 1.3

- Photosynthesis, Growth, Transpiration, Germination, Pigmentation, Movements, Photoperiodism are all light based.
- **Photoblastic seeds** are sensitive to light for germination. It can be positively photoblastic or negatively photoblastic.
- **Photonasty flowers** open or close in response to light and darkness.
- **Nyctinasty**: Folding of leaves in response to darkness.
- **Photomorphogenesis**: Differentiation of various tissues and organs in response to light.
- **Heliophytes**: Plants which are adapted to live under plenty of sunlight are called heliophytes. e.g. banyan. **Heliophytes** form the roof of a forest.

- **Sciophytes**: Plants which are adapted to live under low light conditions are called sciophytes, e.g herbs. Sciophytes form the understory of a forest.

Light Zones in Aquatic Habitat

- **Littoral zone:** It is the shallow coastal region where light can pass through shallow water and reach the bottom.
- **Limnetic zone:** Open water zone where the water is very deep. Amount of light and oxygen decreases with depth.
- **Profundal/Aphotic zone:** It is the zone of deep water below the photic zone and above the bottom to which light does not penetrate.
- **Benthic Zone**: It is the extreme bottom zone where light does not penetrate. Zone of extreme darkness.

1.3 IMPACTS OF ABIOTIC FACTORS

1.3.1 Regulation

- **Homeostasis:** Animal organs and organ systems constantly adjust to internal and external changes in order to maintain this steady state.
- **Osmoregulation**: Osmoregulation is the process of maintaining **salt and water balance (osmotic balance)** across membranes within the body.
- **Thermoregulation**: It is the ability of an organism to keep its body temperature within certain boundaries, even when the surrounding temperature is very different.

1.3.2 Migration

- **Drought Evaders:** Adoption of either a short annual life cycle or undergo aestivation or other dormant state.
- **Winter Migration:** Thousands of species of animals, birds, reptiles, and even insects participate in winter migration for the search for food or warmer temperatures.
- Animals that do not hibernate generally resort to migration.
- Keoladeo National Park (Bharatpur) Rajasthan, hosts thousands of migratory birds from Siberia during winter months.

1.3.3 Resistance

- **Dormancy**: Dormancy is a widely recognized behavioural and physiological state of both animals and plants generally involves inactivity and reduced metabolic rate.
- **Hibernation**: Animals conserve energy to survive adverse weather conditions or lack of food with Hibernation. It involves physiological changes such as a drop-in body temperature and slowed metabolism. Hibernation is a type of dormancy, but not all dormant animals hibernate. That's because **hibernation is a specific kind of dormancy.**
- **Diapause**: In animal dormancy, diapause is the delay in development in response to regularly and recurring periods of adverse environmental conditions.
- **Aestivation**: Animals aestivate to avoid desiccation, it is a lighter state of dormancy since they can reverse their physiological state rapidly and return to normal. The main concern of aestivating organisms is retaining water and conserving energy while stabilising their body organs and cells.
- **Brumation**: It is a state of dormancy in a reptile that resembles hibernation. Reptiles undergo brumation during the late stages of autumn, and they can wake up only to drink water and then go back to sleep.

1.4 IMPORTANT ECOLOGICAL PROCESSES

Evolution	Evolution is the change which gives rise to new species. It happens in order to make the organism better suitable to the present environment. Charles Darwin and Alfred Wallace propounded most acceptable theory of Evolution.
Adaptation	An adaptation is the mode of life of an organism that enables it to survive in a environment. Adaptations are inherited from one generation to another.
Variation	Variations are induced by changes in genetic makeup due to addition or deletion of certain genes. Mutations, change in climate, geographical barriers etc. induce variations over a period of time.

Speciation	Speciation is the process by which new species are formed, and evolution is the mechanism by which speciation is brought about. **Geographic isolation** leads to speciation. A species comprises of many populations. Often different populations of a species remain isolated due to some geographic barrier such as mountain, ocean, river, etc.
Mutation	Mutation (a change in genetic material that results from an error in replication of DNA) causes new genes to arise in a population. Members of the same species show 'variation' and are not identical.
Natural Selection	Natural Selection is the mechanism proposed by **Darwin and Wallace**. Natural selection is the process by which species adapt to their environment.
Extinction	Extinction is the termination of a kind of organism or of a group of kinds (taxon), usually a species. The moment of extinction is generally considered to be the **death of the last individual.**

Fig. 1.4

1.5 PRODUCTIVITY IN ECOSYSTEM

- The complexity and size of the food web is generally determined by the productivity of the ecosystem.
- Productivity of an ecosystem refers to the rate of production of biomass, i.e., the amount of organic matter accumulated in any unit time.
- It is usually expressed in units of mass per unit surface (or volume) per unit time. The mass unit may relate to dry matter or to the mass of carbon generated.

Points to Ponder

Terrestrial ecosystems have a higher productivity than aquatic ecosystems.

Tropical rainforests are the most productive terrestrial ecosystems.

Estuaries and coral reefs are most productive among aquatic ecosystems. Similarly, mangroves have high productivity like rainforests.

Open oceans and deserts have very low productivity but due to large size of open oceans, the total production is very high in open oceans.

Primary Productivity

It is defined as the rate of which radiant energy is stored by the producers, most of which are photosynthetic, and to a much lesser extent the chemosynthetic microorganisms.

Primary productivity is of two types: Gross Primary Productivity and Net Primary Productivity.

Secondary Productivity

It is the rate of energy storage at consumer's levels-herbivores, carnivores and decomposers.

Consumers tend to utilize already produced food materials in their respiration and also converts the food matter to different tissues by an overall process.

Net Productivity

It is the rate of storage of organic matter not used by the consumers.

It is equivalent to net primary production minus the consumption by consumers. Thus, it can be also referred to as the rate of increase of biomass of the primary producers which has been left over by consumers.

Fig. 1.5

1.6 ECOLOGICAL ADAPTATIONS

- Adaptation is any attribute of the organism (Morphological, Physiological, Behavioral) that enables organism to survive and reproduce in its habitat.

Morphological Adaptations	Desert plants have thick cuticle on their leaf surface and stomata arranged in deep pits to minimize water loss through transpiration. Mammals from colder climates have shorter ears and limbs to minimize heat loss. This is called Allen's Rule.
Physiological Adaptations	Mammals use evaporative cooling techniques to maintain a constant body temperature, while at the same time they use behavioral adaptations to reduce heat load and water loss. **Altitude Sickness:** Our body compensate low Oxygen availability by increasing red blood cell production, decreasing the binding affinity of hemoglobin and by increasing breathing rate.
Biochemical Adaptation	Examples of biochemical responses to temperature in endotherms involve metabolic uncoupling mechanisms that decrease metabolic efficiency with the outcome of producing heat. **Ectothermic adaptations** to temperature are best exemplified by the numerous mechanisms that allow for the tolerance or avoidance of ice crystal formation at temperatures below 0°C.
Behavioural Adaptations	Lizards bask in the sun when body temperature drops, but moves to shade when ambient temperature starts increasing.

Fig. 1.6

1.7 ECOLOGICAL ADAPTATIONS RULES

- **Gloger's rule** states that within a species of endotherms, more heavily pigmented forms tend to be found in more humid environments, e.g. near the equator.
- **Allen's rule** states that animals adapted to cold climates have shorter limbs and bodily appendages than animals adapted to warm climates. More specifically, it states that the body **surface-area-to-volume ratio** for homeothermic animals varies with the average temperature of the habitat to which they are adapted (i.e. the ratio is low in cold climates and high in hot climates).
- **Bergmann's rule:** states that within a broadly distributed taxonomic clade, populations and species of larger size are found in colder environments, while populations and species of smaller size are found in warmer regions. Bergman's rule only describes the overall size of the animals but does not include body parts like Allen's rule does.
- **Rensch's Rule:** a biological rule on allometrics, concerning the relationship between the extent of sexual size dimorphism and which sex is larger. Across species within a lineage, size dimorphism increases with increasing body size when the male is the larger sex, and decreases with increasing average body size when the female is the larger sex.
- **Hamilton's Rule:** It states that the more closely related two individuals are, the greater the potential genetic payoff. It supports the notion that natural selection favours genetic success, not reproductive success per se.
- **Shelford's Law of tolerance:** Stating that a certain organism's survival and existence depend upon the multifaceted set of conditions wherein each individual has definite minimum, maximum and optimum ecological factors to establish success.
- **Liebig's Law of Minimum:** Yield is proportional to the amount of the most limiting nutrient, whichever nutrient it may be.

Interaction Among Biotic Factors			
Interaction Type	**Species 1**	**Species 2**	**Detailed Effect(s)**
Neutralism	0	0	• Neither species affects the other. • True neutralism is extremely unlikely.
Competition	-	-	• Direct inhibition of each species by the other. • Competition is the struggle between two organisms for the same resources within an environment.
Amensalism	-	0	• Amensalism meaning, an ecological interaction between two species, but in this association among organisms of two different species, one is destroyed or inhibited, and other remains unaffected.
Parasitism	+	-	• Parasitism is a symbiotic relationship between species, where one organism, the parasite, lives on or inside another organism, the host, causing it some harm, and is adapted structurally to this way of life. • Many parasites have evolved to be host-specific (they can parasitize only a single species of host) in such a way that both host and the parasite tend to co-evolve.
Predation	+	-	• Predation is a biological interaction where one organism, the predator, kills and eats another organism, its prey. • Predators also help in maintaining species diversity in a community.
Commensalism	+	0	• Population 1, the commensal, benefits while the population 2. The host is not affected. • Commensalism is a long-term biological interaction in which members of one species gain benefits while those of the other species neither benefit nor are harmed.
Protocooperation	+	+	• Interaction favourable to both but not obligatory.
Mutualism	+	+	• Interaction favourable to both and obligatory.

1.8 ECOLOGICAL SUCCESSION

- Occurrence of relatively different sequences of communities over a period of time in the same area.
- Trends of ecological succession:
  - An orderly continuous change in the kind of plants and animals.
  - Tends to increase in diversity of species.
  - An increase in organic matter and biomass supported by the available energy flow (reverse in heterotrophic succession)
  - Decrease in net community productivity or annual yield.

1.8.1 Mechanism of Ecological Succession

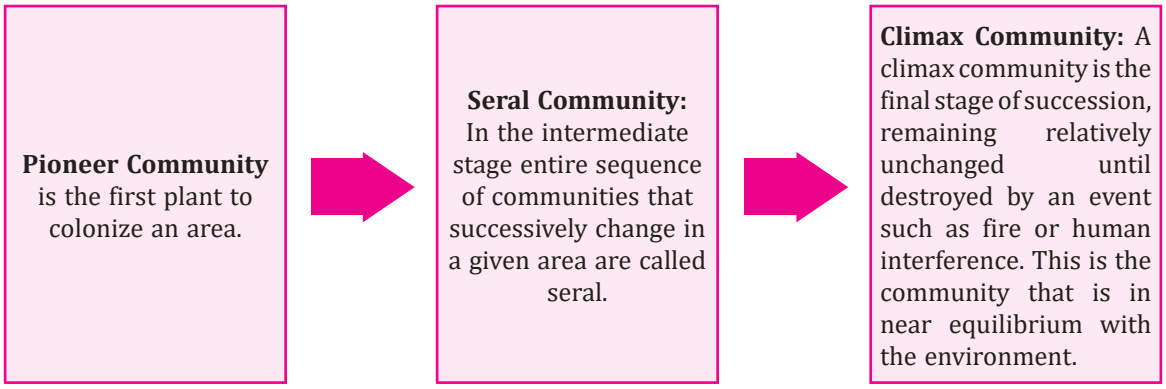


Fig. 1.7

1.8.2 Types of Ecological Succession

- **Autotrophic Succession:** Most of the organic matter is fixed by autotrophs and most living biomass is in plants.
- **Heterotrophic (Degradative) Succession:** Succession on a degradable source; most living biomass is animal, fungal or microbial material.
- **Primary succession:** Primary succession takes place over where no community has existed previously. E.g. rock outcrops, newly formed deltas and sand dunes, emerging volcano islands and lava flows, glacial moraines etc. In primary succession on a terrestrial site, the new site is first colonised by a few hardy pioneer species that are often microbes, lichens and mosses.
- **Secondary Succession:** Secondary succession begins in areas where natural biotic communities have been destroyed such as in abandoned farmlands, burned or cut forests, lands that have been flooded. Since some soil or sediment is present, succession is faster than primary succession.
- **Autogenic Succession:** Environment is modified by species of community itself such that conditions become favourable for that community and more favourable for upcoming communities.
- **Allogenic Succession:** Replacement of community is due to other external factors.

1.9 ECOLOGICAL PYRAMIDS

- The **pyramidal representation** of trophic levels of different organisms based on their ecological position (producer to final consumer) is called an **ecological pyramid.**
- The pyramid consists of a number of horizontal bars depicting specific trophic levels. The length of each bar represents the total number of individuals or biomass or energy at each trophic level in an ecosystem.

Pyramid of Numbers	Pyramid of Biomass	Pyramid of Energy
• Pyramid of numbers represents the total number of individuals of different species (population) at each trophic level.	• It arranges the biomass or weight of organisms in different trophic levels. Each trophic level has a certain mass of living material at a particular time called the standing crop.	• An energy pyramid represents the amount of energy at each trophic level. • As the usable energy decreases from sunlight to producer to herbivore to carnivore, the energy pyramid also narrows down at the top.
• Upright Pyramid of Numbers: In this pyramid, the number of individuals decrease from lower level to higher trophic level. This type of pyramid can be seen in the grassland ecosystem and pond ecosystem.	• **Upright Pyramid of Biomass:** For most ecosystems on land, the pyramid of biomass has a large base of primary producers with a smaller trophic level perched on top.	• Energy cannot be created or destroyed; it takes into account the loss of energy at each transfer to another trophic level. Hence the **pyramid is always upright,** with a large energy base at the bottom.
• Inverted Pyramid of Numbers: In this pyramid, the number of individuals is increased from lower level to higher trophic level. E.g., Tree ecosystem.	• **Inverted Pyramid of Biomass:** In many aquatic ecosystems, the pyramid of biomass may assume an inverted form. (In contrast, a pyramid of numbers for the aquatic ecosystem is upright).	• Not Applicable
• 10% Energy Rule: On average, only about 10 percent of energy stored as biomass in a trophic level is passed from one level to the next. This is known as the 10 percent rule, and it limits the number of trophic levels an ecosystem can support. • Consumption Efficiency: Measures the amount of energy transferred from one trophic level to the next.		

1.10 FOOD CHAIN AND FOOD WEB

1.10.1 Food Chain

- Sequence of transfers of matter and energy in the form of food from organism to organism. Food chains intertwine locally into a food web because most organisms consume more than one type of animal or plant.

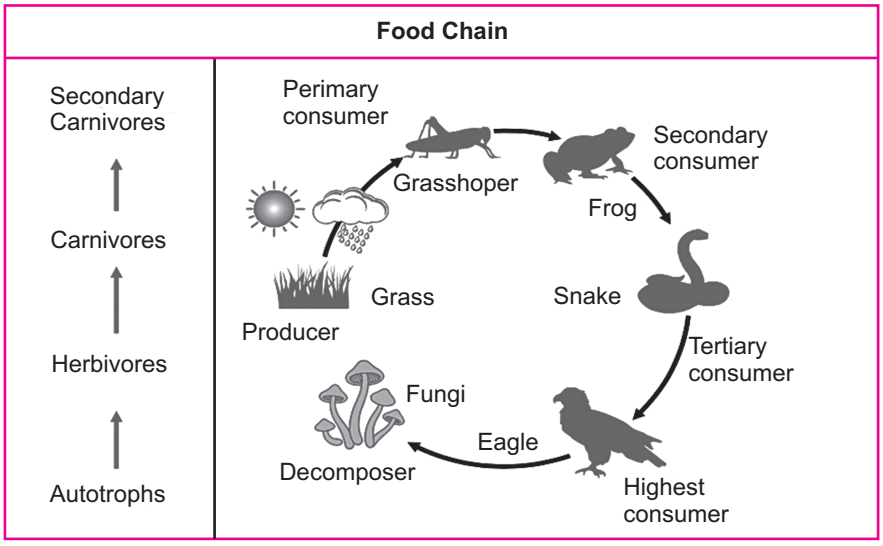


Fig. 1.8

1.10.2 Food Web

- A network of interconnecting food chains in a natural community of different organisms. The food web begins with plants and ends with the top carnivore.

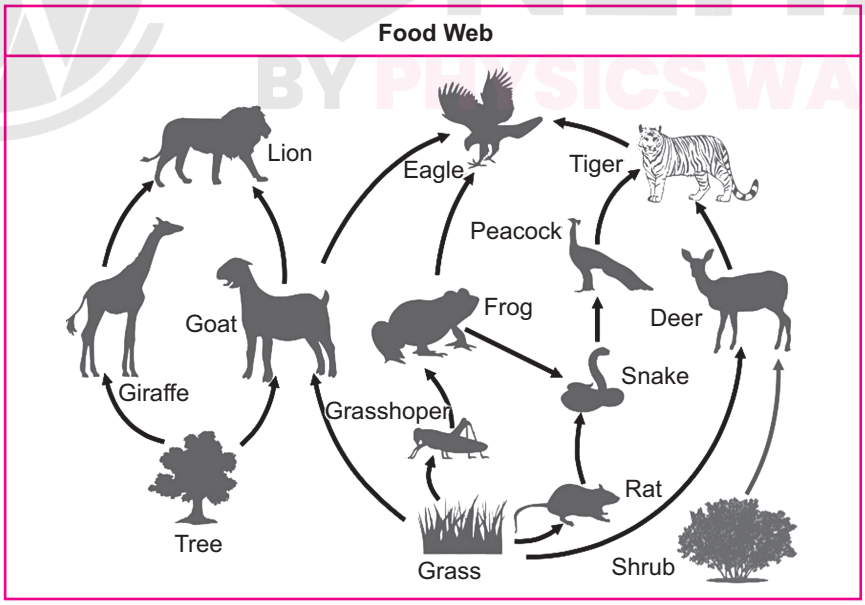


Fig. 1.9

Grazing Food Chain	Detritus Food Chain	Parasitic Food Chain
Directly dependent on an influx of solar radiation.	Depends chiefly on organic matter produced in another ecosystem.	Food energy transfers from larger organisms to smaller organisms, without killing in case of a predator.
Food chain starts from the **living green plants.** **Ex**: **Grass-Rabbit-Fox.**	Food chain goes **from dead organic matter into microorganisms** and then to organisms feeding on detritus. **Ex**: Mangrove leaves falling in shallow estuary water.	A parasitic food chain **starts with herbivores.** **Ex**: Tapeworms, fleas and barnacles deriving energy from other living organisms.

Ecological Debt is referred to as the level of resource consumption and waste discharge by a population in excess of locally sustainable natural production and assimilative capacity.	**Green GDP** is a monetization of the loss of biodiversity caused by climate change. It is calculated by subtracting resource depletion, environmental degradation from the traditional GDP figure.

1.11 POLLUTANTS AND TROPHIC LEVELS

- Non-degradable pollutants move between different trophic levels. Non-degradable (persistent) is one which cannot be metabolised by living organisms. **E.g. Chlorinated Hydrocarbons.**

Bioaccumulation:

It is the gradual accumulation of pollutants, chemicals (chronic poisoning) or other substances in an organism.

Bioaccumulation occurs when the rate of loss of the substance from the body of the organism through catabolism (breakdown of complex molecules in living organisms), or excretion is lower than the rate of accumulation of the substance.

Biomagnification:

Biomagnification refers to progressive bioaccumulation (increase in concentration) at each tropical level with the passage of time.

In order for biomagnification to occur, the pollutant must have a long biological half-life (long-lived) & must not be soluble in water but must be soluble in fats. E.g. DDT.

Fig. 1.10

1.12 BIOGEOCHEMICAL CYCLES

- More or less Circular pathways through which the chemical elements, including all the essential elements of the protoplasm, circulate in the biosphere from environment to organisms and back to the environment are known as **Biogeochemical Cycles**. These are categorised under following two types:
  - **Gaseous Cycle** wherein reservoirs of gaseous types of nutrients cycle (water, nitrogen, carbon) exist in the atmosphere.
  - **Sedimentary Cycles** have their reservoir located in the Earth's crust as in the case of Sulphur and Phosphorus.

1.12.1 Carbon Cycle

- **71 percent of Carbon** is dissolved in the oceans. This oceanic reservoir regulates the amount of carbon dioxide in the atmosphere. Atmosphere only contains about 1 percent of total global carbon.
- **Carbon cycling** occurs through the atmosphere, ocean and through living and dead organisms.
- A considerable amount of carbon returns to the atmosphere as CO_2 through respiratory activities of the producers and consumers.
- **Decomposers also contribute substantially** to CO_2 pool by their processing of waste materials and dead organic matter of land or oceans.

- **Human activities** have significantly influenced the carbon cycle. Rapid deforestation and massive burning of fossil fuel for energy and transport have significantly increased the rate of release of carbon dioxide into the atmosphere.

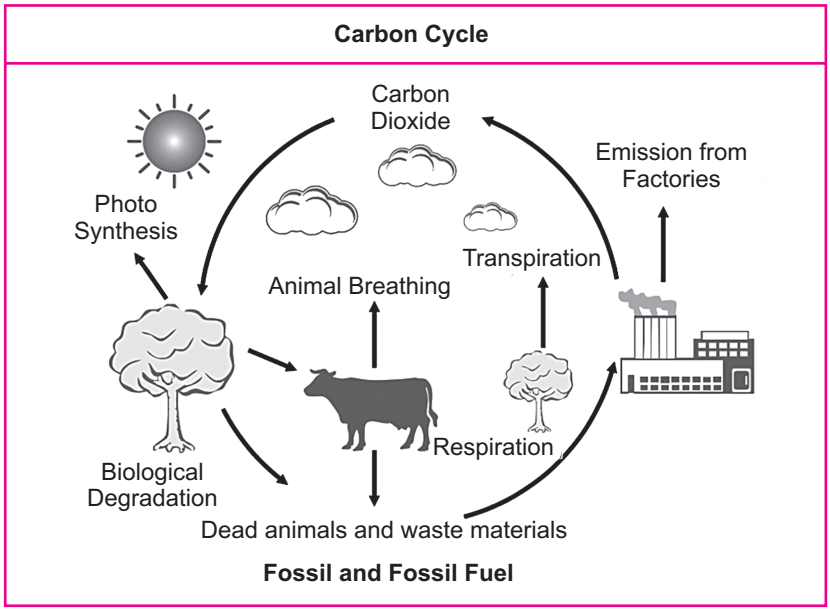


Fig. 1.11

- **Black Carbon** or **soot** is **part of fine particulate air pollution** (PM2.5) and contributes to climate change. Black carbon is formed by the incomplete combustion of fossil fuels, wood and other fuels. Black carbon is a **short-lived climate pollutant** with a lifetime of only days to weeks after release in the atmosphere.

Black carbon

- Carbon captured by the world's ocean and coastal ecosystems. Three types of coastal ecosystems — mangroves, seagrasses and tidal marshes — store half the blue carbon buried beneath the ocean floor.
- These areas absorb and store carbon at a much faster rate than other areas, such as forests, and can continue to do so for millions of years.
- The carbon found in coastal soil is often thousands of years old.
- **Blue Carbon Initiative** works to protect and restore coastal ecosystems for their role in reducing impacts of global climate change.
- Focuses on the coastal ecosystems - mangroves, tidal marshes and seagrasses, which are found on every continent except Antarctica.
- **Conservation International (CI), IUCN, and the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (IOC-UNESCO) jointly launched it**.

1.12.2 Nitrogen Cycle

- Nitrogen is a constituent of amino acids, proteins, hormones, chlorophylls and many of the vitamins.
- Plants compete with microbes for the limited nitrogen that is available in the soil. Thus, nitrogen is a limiting nutrient for both natural and agricultural ecosystems.
- In nature, **lightning and ultraviolet radiation** provide enough energy to convert nitrogen to nitrogen oxides (NO, NO_2, N_2O).
- Industrial combustions, forest fires, automobile exhausts and power-generating stations are also sources of atmospheric nitrogen oxides.
  - **Step 1:** N Fixing Nitrogen Ammonia or Ammonium
  - **Step 2:** Nitrification Ammonia or Ammonium Ions (bacteria: Nitrosomonas and/or Nitrococcus) Nitrite (Nitrobacter) Nitrate.
  - **Step 3:** Ammonification Dead Matter + Animal Waste (Urea, Uric Acid) Ammonia or Ammonium Ions.
  - **Step 4:** Denitrification Nitrate (bacteria: Pseudomonas and Thiobacillus) Nitrogen.

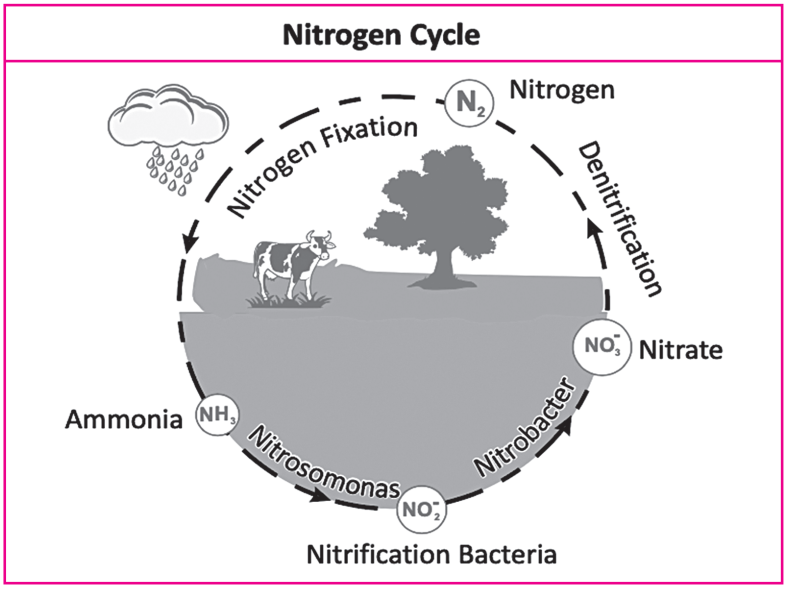


Fig. 1.12

1.12.3 Sulphur Cycle

- In the Sulphur cycle, there is a **circulation of sulphur in various forms** through nature. Sulphur occurs in all living matter as **a component of certain amino acids.**

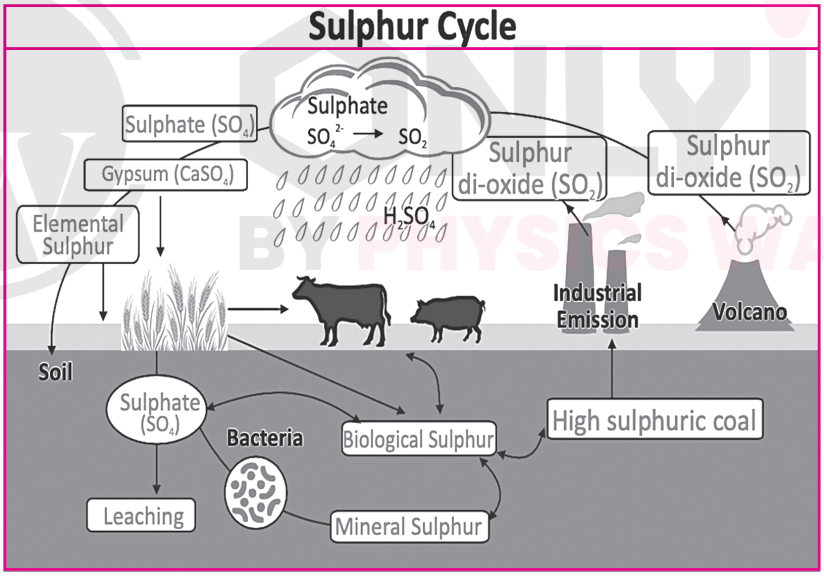


Fig. 1.13

- It is abundant in the soil in proteins and, through a series of microbial transformations, ends up as sulphates usable by plants.
- 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 cycle is mostly sedimentary except for two of its compounds,** hydrogen sulphide (H_2S) and Sulphur dioxide (SO_2), which add a gaseous component.
- Sulphur enters the atmosphere from several sources like **volcanic eruptions, combustion of fossil fuels (coal, diesel etc.),** from the surface of the ocean and gases released by decomposition.

1.12.4 Phosphorus Cycle

- Phosphorus is a major constituent of biological membranes, nucleic acids and cellular energy transfer systems.
- Many animals also need large quantities of this element to make shells, bones and teeth.
- The **natural reservoir of phosphorus is rock,** which contains phosphorus in the form of phosphates.
    - When rocks are weathered, minute amounts of these phosphates dissolve in soil solution and are absorbed by the roots of the plants.
- Herbivores and other animals obtain this element from plants. The waste products and the dead organisms are decomposed by phosphate-solubilizing bacteria releasing phosphorus.
- Unlike the carbon cycle, there is no respiratory release of phosphorus into the atmosphere.

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2 Terrestrial Ecosystem

2.1 INTRODUCTION

- A terrestrial ecosystem is a **land-based community of organisms and the interactions of biotic and abiotic components in a given area.** The terrestrial ecosystems can be found anywhere apart from heavily saturated places.

2.1.1 Types of Terrestrial Ecosystem

- The Terrestrial Ecosystem found in a particular place is dependent on its **topography** (valleys, mountains, plains and plateaus), **altitudinal and latitudinal** variations, quality of **soil**, amount of **light** and **precipitation** and **temperature range**.

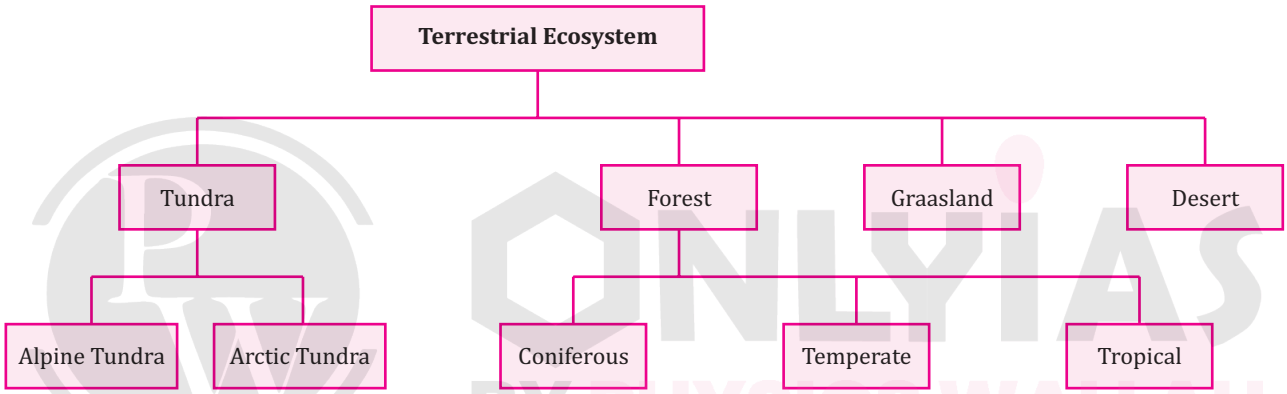


Fig. 2.1

2.2 TUNDRA

- Tundra means a **barren land**. Tundra ecosystems are treeless regions where environmental conditions are very severe.
- **Harsh climatic conditions** (cold and windy)**:** Winters are long and very severe; summers are cool and brief.
- **Precipitation**: Scanty rainfall, precipitation is mainly in the form of snow.
- **Soil:** Permafrost soil that remains frozen all year round and is also scarce of nutrients and low biotic diversity.

Types of Tundra	
Arctic Tundra	**Alpine Tundra**
• **Distribution**: It extends as a continuous belt below polar ice cap and above tree line in the northern hemisphere. • On the south pole, tundra is very small (limited to some parts of Antarctica and Falkland Islands) due to vast oceans. • **Regions**: Alaska, Canada, Russia, Greenland, Iceland, and Scandinavia. • **Flora**: Mosses, lichens, sedges, cotton grass, sedges, dwarf heath, willows, birches • **Fauna**: Arctic foxes, polar bears, caribou, muskox.	• **Distribution**: It is found at all latitudes in a high-altitude area. • **Regions**: The Himalayas, the Alps, Tibetan Plateau, The Caucasus Mountains, the American Cordillera etc. • **Flora**: Mosses, sedges, liverworts, grassy vegetation. • **Fauna**: Pikas, marmots, mountain goats, reindeer, musk ox, arctic hare, caribous, lemmings and squirrel.

2.3 FOREST

- Forests represent the **largest and most ecologically complex systems**. They contain a wide assortment of **trees**, **plants**, **mammals**, **reptiles**, **amphibians**, **invertebrates**, **insects** and **microorganisms** which vary depending on the zone's climate. Forest ecosystems are of three types.

	Coniferous Forest (Taiga/ Boreal Forest)	Temperate Forest (Temperate Deciduous/ Evergreen and Temperate Rainforest)	Tropical Rain Forest
Definition	It is sandwiched between the tundra to the north and the temperate forest to the south.	It is characterised by broad-leaved trees, which shed their leaves in autumn and grow new foliage in autumn.	It is characterised as the most luxuriant forest with a diverse array of communities and makes up one of the earth's largest biomes.
Distribution	It stretches in a great continuous belt across **North America**, **Europe** and **Asia**. Absent in the southern hemisphere because of the narrowness of the southern continents in the high latitudes.	Located in the mid-latitude areas, between polar regions (grade into boreal forest) and tropics (grade into Tropical rainforest). Found in both the northern and southern hemisphere.	Found in wet tropical uplands and lowlands around the Equator.
Abiotic Components	**Well defined seasons** with prolonged bitterly cold winter and short cool summer. Presence of local winds like blizzards of Canada and buran of Eurasia. **Precipitation** is well distributed throughout the year. **Soil type** is Podzolized soil (acidic, excessively leached and mineral deficient)·	Presence of distinct seasons. Moist, warm summer and frosty or rainy winter **Soil type:** Alfisol or brown forest soil.	High humidity and temperature (more or less uniform) **Precipitation**: exceeds 200cm, evenly distributed throughout the year **Soil type**: Red latosol (high rate of leaching makes it agriculturally useless, but can rejuvenate with nutrients when left undisturbed).
Biotic Components	**Natural vegetation/Flora**: Consists mostly of conifers-evergreen; conical in shape; thick, leathery and needle-shaped leaves. **E.g.:** Pine, Fir, Spruce, Larcho **Fauna**: Mink, Silver fox, Lynx, Wolf	**Flora**: Broadleaf trees (oaks, maples, beeches), shrubs, perennial herbs, and mosses **Fauna**: Squirrels, marsupials, brown bear, bats, rodents	**Flora**: Diverse Angiosperms and relatively few Gymnosperms. Besides, liverworts, creepers, ferns, mosses, lichens and algae are also found. Presence of dense upper canopy and thick undergrowth. **Fauna**: Monkeys, rhinos, large numbers of insects, birds.

2.3.1 Types of Indian Forest

2.3.1.1 Tropical Evergreen and Semi Evergreen Forests

- **Location**: Found in the western slope of the Western Ghats, hills of the northeastern region and the Andaman and Nicobar Islands in.
- **Climatic condition**: Warm and humid conditions with an annual precipitation of over **200 cm** and mean annual temperature above **22°C**.
- **Characteristics**: Stratified with layers closer to the ground and are covered with shrubs and creepers, with short-structured trees followed by a tall variety of trees. Trees reach great heights up to 60 m or above.

There is no definite time for trees to shed their leaves, flowering and fruition and these forests appear green all the year round.

- **Floral composition**: Rosewood, mahogany, ebony, etc. The under growing climbers provide an evergreen character to these forests. Main species are white cedar, and kail.
- **Faunal composition**: Elephants, monkey, lemur and deer, one-horned rhinoceros are found in jungles of **Assam** and **West Bengal** along with plenty of **birds**, **bats**, **sloth**, **scorpions** and **snails** etc.
- The semi evergreen forests are found in the less rainy parts of these regions. Such forests have a mixture of evergreen and moist deciduous trees.

2.3.1.2 Tropical Deciduous Forests

- Most widespread forests in India, also **called the monsoon forests.**
- **Climatic condition:** They spread over regions which receive rainfall between **70-200 cm**. Based on the availability of water and rainfall, they are divided into:
- **Tropical Moist Deciduous Forests:**
- **Location**: Northeastern states along the foothills of Himalayas, eastern slopes of the Western Ghats and Odisha.
- **Climatic condition**: Rainfall between 100-200 cm.
- **Floral Composition**: Teak, sal, shisham, hurra, mahua, amla, semul, kusum, and sandalwood etc·
- **Faunal Composition**: Mammals include the predators Indian tiger, wolf, dhole, and sloth bear, and the herbivores gaur, chousingha, blackbuck, and chinkara.

2.3.1.3 Dry Deciduous Forest

- **Location**: Rainier areas of the Peninsula and the plains of **Uttar Pradesh** and **Bihar**. In the higher rainfall regions of the **Peninsular plateau** and the **Northern Indian plain**.
- **Climatic Condition**: Rainfall ranges between 70 -100 cm.
- **Characteristics**: On the wetter margins, it has a transition to the moist deciduous, while on the drier margins to thorn forests. Forests have a parkland landscape with open stretches in which teak and other trees interspersed with patches of grass are common. As the dry season begins, the trees shed their leaves completely and the forest appears like a vast grassland with naked trees all around.
- **Floral Composition**: Tendu, palas, amaltas, bel, khair, axlewood, etc.

2.3.1.4 Tropical Thorn Forests

Location: It includes semi-arid areas of south west Punjab, Haryana, Rajasthan, Gujarat, Madhya Pradesh and Uttar Pradesh.

- **Climatic condition**: Tropical thorn forests occur in the areas which receive rainfall less than **50 cm**.
- **Characteristics**: Variety of grasses and shrub, plants remain leafless for most part of the year and give an expression of scrub vegetation.
- **Floral composition**: Babool, ber, and wild date palm, khair, neem, khejri, palas, etc.

2.3.1.5 Montane Forests

- In mountainous areas, decrease in temperature with increasing altitude leads to a corresponding change in natural vegetation. Mountain forests can be classified into two types, the northern mountain forests and the southern mountain forests.
- **Location:** The southern mountain forests include the forests found in three distinct areas of Peninsular India viz; the Western Ghats, the Vindhyas and the Nilgiris and northern montane forests include mountain ranges in Kashmir, Uttarakhand, Himachal Pradesh, Sikkim and Darjeeling are covered by Himalayan temperate forests.
- **Climatic condition:** The mean annual rainfall here is **150 cm to 300 cm**, the mean annual temperature is about **11°C to 14°C** and the average relative humidity is over **80 per cent**.
- **Characteristics:** Deciduous forests are found in the foothills of the Himalayas. It is succeeded by the wet temperate type of forests between an altitude of **1,000- 2,000 m**. The temperate forests are called **Sholas** in the Nilgiris, Anaimalai and Palani hills. Such forests are also found in the Satpura and the Maikal ranges.
- **Floral composition:** At higher altitudes, mosses and lichens form part of the tundra vegetation. Some of the other trees of this forest of economic significance include, Magnolia, Laurel, Cinchona and Wattle.
- **Faunal Composition:** Hangul or Kashmir Stag, Shou or Sikkim Stag, Red Panda, Elephants, Sambhar, Swamp deer etc.

2.3.1.6 Littoral and Swamp Forests

- **Littoral forests** are forests along the coast featuring salt-tolerant vegetation. They occur in patches and narrow strips along the mainland coast.
- **Swamp forests** are found on peat-poor soils that are permanently waterlogged. They may be created and maintained by land topography (**basin swamps**), hydrological barriers, and/or high-water tables. Aquatic habitats in swamp forests may be sporadic, seasonal, or permanent.
- **Location**: Along the coast and of the islands and to the deltas of the Ganga, the Mahanadi, the Godavari, the Krishna and the Cauvery.

- **Floral Composition**: Consists mostly of whistling pines, mangrove dates, palms, etc. They have roots that consist of spongy tissue so that the plant can respire in the water.
- **Faunal Composition**: Saltwater crocodiles, marine turtles, coconut crab, lizards, snakes (mainly reptiles and marine animals).

2.4 GRASSLAND ECOSYSTEM

Role of Fire

Fire plays an important role in the management of grasslands. Under moist conditions fire favours grass over trees, whereas in dry conditions fire is often necessary to maintain grasslands against the invasion of desert shrubs. Burning increases, the forage yields.

Impact of Grazing

Due to heavy grazing pressure, the quality of grasslands deteriorates rapidly, the mulch cover of the soil reduces, microclimate becomes drier and is readily invaded by xerophytic plants and borrowing animals.

- Grassland ecosystem is an area where the **vegetation is dominated by continuous cover of grasses and herbaceous** (non-woody) plants. It accounts for between **20 and 40% of the world's land area**.
- The grasslands are found where **rainfall is about 25-75 cm per year**, not enough to support a forest, but more than that of a true desert.
- Typical grasslands are vegetation formations that are generally found in temperate climates. In India, they are found mainly in the high Himalayas. The rest of India's grasslands are mainly **composed of steppes and savannas**.
- **Steppes viz-a-viz savannas**: all the forage in the steppe is provided only during the brief wet season whereas in the savannas forage is largely from grasses that not only grow during the wet season but also from the smaller amount of regrowth in the dry season.

2.4.1 Savanna/Tropical Grassland (Big Game Country)

- Savanna is distinguished by their warmer drier climates and their seasonal droughts. Savanna plant life is highly adapted to the hot and dry climate, with trunks that can store water for days or a special built in mechanism allowing the plant to lie dormant during periods of drought.
- Transitional between the equatorial forests and the trade wind hot deserts.
- E.g.: Savanna of Africa, Campos of Brazilian highland, Llanos of Orinoco basin.
- Characterised by an alternate hot, rainy season and cool, dry season and local wind Harmattan in Guinea coast. Soil types are **Alfisols and Ultisols**.
- **Flora:** tall, elephant grass and short trees that have long roots and water storing devices (e.g: baobabs and bottle trees).
- **Fauna:** Grass-eating Herbivores and flesh-eating Carnivores.

2.4.2 Steppe/Temperate Grassland (Granaries of the World)

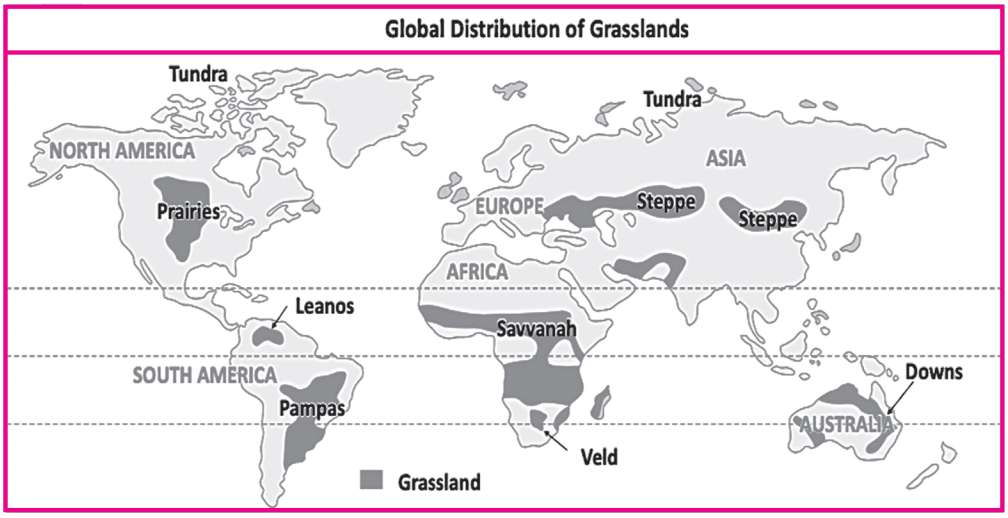


Fig. 2.2

- Found in the interiors of continents, away from maritime influence. E.g. **Prairies of North America, Pampas of Argentina, Downs of Australia, Velds of Africa, Steppes of Eurasia,** etc.
- Characterised by continental climate, not severe in the southern hemisphere local wind Chinook in Canada and America, Fohn in Switzerland and soil type is Chernozem soil.
- Flora: Short steppe type of grass, practically treeless (used for extensive wheat cultivation)
- Fauna: Mainly domesticated animals- cattle, sheep, pigs are found.

2.5 DESERT ECOSYSTEM

2.5.1 Introduction

- Desert ecosystem is a region of **scanty rainfall supporting a community of distinctive plants and animals** specially adapted to the harsh environment. Deserts are formed in regions with **less than 25 cm of annual rainfall**. Deserts cover about **one-fifth** of our planet.
- **Adaptations of Desert Vegetation**
  - **Extensive root system** to tap underground water and thick cuticle or sunken stomata to reduce transpiration.
  - Leaves- Absent or reduced in size or modified into either thorn, leathery, hard and waxy leaves.
  - **Large fleshy (succulent)** stems and leaves for water storage, **plants lie dormant for years** until rain falls.
- **Adaptations of Desert Animals**
  - **Nocturnal in habit to avoid the sun's heat**, store fat in their humps, thus they can live months without food.
  - Excreting concentrated urine to conserve water, **camels** (the ship of the desert) can travel several days without water (drink gallons of water at one go).
  - Can change body temperature to avoid losing water through sweating.

2.5.2 Types of Deserts

	Hot Deserts	Cold Deserts (Temperate/ Mid-Latitude)
Formation	• The hot deserts of the world are **caused by the presence of dry air and low precipitation** from subtropical high- pressure cells.	• Because of **their distance from moisture sources (oceans) or their location in the rain-shadow areas on the leeward side** of mountain ranges such as the Himalayas, Andes and Rockies.
Distribution	• Western coasts of continents between 15 and 30 N and S (lie in the region of **Horse latitudes**). E.g., Atacama (Chile), Western Sahara (Namibia), Arizona (USA).	• At **higher altitudes,** located in the interior of the continent, sheltered by the high mountains all around them. Examples are Gobi Desert of Mongolia, Ladakh in India, Patagonia etc.
Abiotic components	• Extreme diurnal range of temperature. Less than 25 cm of annual rainfall. • **Soil type**: saline, sandy soil with low water holding capacity.	• The annual range of temperature is much greater than that of the hot deserts. Continentality accounts for these extremes in temperature (Severe winter with cold wind).
Biotic components	• **Flora**: Xerophytic or drought resistant scrub, date palms, acacia etc. • **Fauna**: Diverse array of reptiles, marsupials, mammals (camels, hedgehog, hyenas).	• **Flora**: Alpine Mesophytic, Grasses, bushes, shrubs and even trees like junipers, birch. • **Fauna**: Bactrian camel, Asiatic ibex, snow leopard, Tibetan wolf, Tibetan wild ass (kiang).

2.6 DEFORESTATION

- It is an act of clearing or thinning forests to fulfil the varied purpose of humankind. Following are the prominent causes of deforestation:
- **Shifting cultivation**: It is a practice of clearing a patch of land by burning and left abandoned to recover its fertility.
- **Infrastructure expansion**: It can be for construction of highways, industries, real estates, communication lines, urban outgrowth.
- **Forest fire**: It can be of natural cause (high atmospheric pressure and low humidity) or man-made cause (deliberate firing by local inhabitants, discarded cigarettes, electric spark and mining).
- **Logging**: It is a process of cutting and processing trees in order to meet the requirements of fuel, fiber, timber, pulp, latex and rubber etc.
- **Large-scale agriculture and overgrazing**: Burgeoning population demands for more food (crops and livestock) which in turn encroaches forest land.

2.6.1 Effects of Deforestation

Aggravates Global warming

Through the released carbon dioxide.

- Forest is a great carbon sink which sequesters as much as 45% of carbon stored on land.
- Some 420 million hectares of world's forest have been lost since 1990 (The State of the World's Forests-FAO).

Disturbs Hydrological Cycle

Causes immediate lowering of ground water level and reduction of precipitation (may lead to drought).

- Rapid runoff (may lead to flood).

Biodiversity Loss

Eighty percent of the world's land-based species live in forests. Land degradation and soil erosion may lead to food insecurity. Reduces the ability of forests to provide essential services.

Livelihood Loss

Loss of livelihood of tribals and other forest dwellers

1.6 billion population has been affected due to forest degradation and deforestation (IUCN).

Fig. 2.3

2.7 DESERTIFICATION

- Under **23.7%** of the area undergoing desertification/ land degradation with respect to total geographic area of the country was contributed by **Rajasthan**, **Maharashtra**, **Gujarat**, **Karnataka**, **Ladakh**, **Jharkhand**, **Odisha**, **Madhya Pradesh** and **Telangana**.

2.7.1 Mitigation Measures

- **India is a signatory to the UNCCD**. India is working hard to achieve its national commitment on **Land Degradation Neutrality** (LDN) (SDG 15.3) and aims to restore 26 million hectares of degraded land by **2030**.
- **Delhi Declaration of 2019**: signed by **14th CoP** of the UNCCD, called for better access and stewardship over land, and emphasised gender-sensitive transformative projects.
- World Day to Combat Desertification and Drought was observed on **June 17th**. **Theme:** "Restoration. Land. Recovery. We build back better with healthy land".
- **ISRO (Indian Space Research Organization):** published Desertification and Land Degradation Atlas to provide information about the increasing Land Degradation and Desertification in recent years.

2.7.2 Land Degradation Neutrality (LDN)

- LDN is a condition where further land degradation (loss of productivity caused by environmental or human factors) is prevented and already degraded land can be restored.
- LDN has been defined by the Parties to the Convention as: A state whereby the amount and quality of land resources, necessary to support ecosystem functions and services and enhance food security, remains stable or increases within specified temporal and spatial scales and ecosystems.

2.7.3 The Bonn Challenge

- The Bonn Challenge is a global goal to bring **150 million hectares** of degraded and deforested landscapes into restoration by **2020** and **350 million hectares** by **2030**.
- Launched by **Germany** and **IUCN** in **2011**, the Challenge surpassed the **150-million-hectare milestone** for pledges in **2017**.

2.7.4 Great Green Wall

- Initiative by **Global Environment Facility** (GEF), where eleven countries in **Sahel-Saharan Africa** have focused efforts to fight against land degradation and revive native plant life to the landscape.

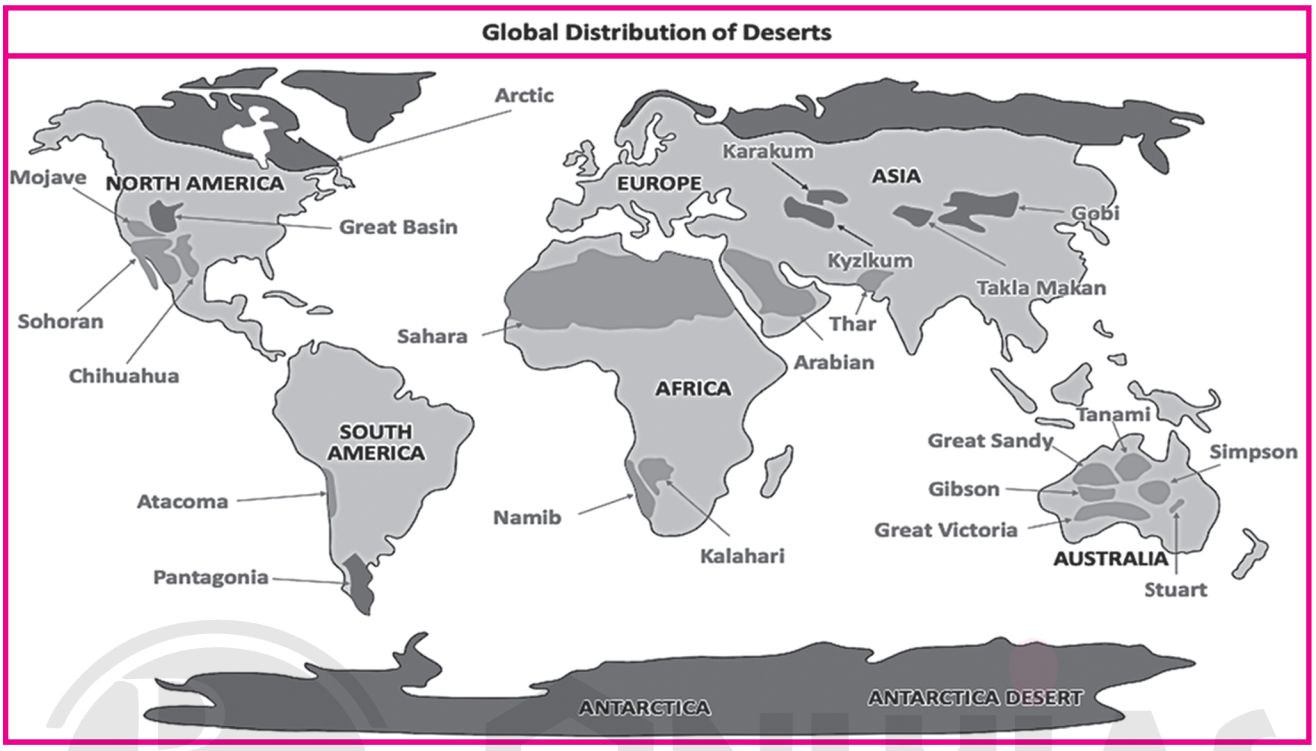


Fig. 2.4

Miscellaneous Information

Forest Survey of India was established in 1981 and functions under the aegis of Ministry of Environment, Forest and Climate Change. **HQ: Dehradun**, **Uttarakhand**.

The **biennial assessment of forest cover** was done from Indian Remote Sensing Satellite data (**Resourcesat**-II)

Establishment of **National Forest Inventory** for the first time on produce from forests.

FSI, in a first ever attempt, has carried out a rapid assessment of biodiversity for all the States and UTs (except two) and for all the **16 Forest Type Groups** as per **Champion** & **Seth Classification** (1968).

Forest Survey of India uses satellite **Moderate Resolution Imaging Spectroradiometer** (MODIS) for active forest fire detection.

FSI has **included a new chapter related to the assessment of forest cover in the Tiger Reserves**, **Corridors and Lion conservation area of India.**

❖ ❖ ❖

3 Aquatic Ecosystems

3.1 INTRODUCTION

- Ecosystems consisting of water as the main habitat are known as aquatic ecosystems. Based on their salt content, aquatic ecosystems are categorised into following three types:
  - **Freshwater Ecosystems** with less than 5 ppt (parts per thousands) such as lakes, ponds, springs, rivers etc.
  - **Marine Ecosystems** with 35 ppt or above such as Seas and Oceans.
  - **Brackish Water Ecosystems** with 5 to 35 ppt such as estuaries, mangroves.

3.2 FACTORS AFFECTING PRODUCTIVITY OF AQUATIC ECOSYSTEMS

3.2.1 Sunlight

- To sustain photosynthetic ability sunlight penetration is of utmost importance. The depth to which sunlight penetrates determines the extent of vegetation and its distribution. Based on the vertical penetration of sunlight, aquatic ecosystems are categorised into two zones:

3.2.1.1 Photic Zone

- It is the top layer, nearest to the surface of the ocean and is also called the sunlight layer. In this zone enough light penetrates the water to allow photosynthesis. **90 percent** of marine life lives in the photic zone, which is approximately two hundred metres deep.
- This includes **phytoplankton** (plants), including **dinoflagellates**, **diatoms**, **cyanobacteria**, **coccolithophorids** and **cryptomonads**.

3.2.1.2 Aphotic Zone

- Sunlight does not penetrate this region of ocean. Absence of photosynthetic activity and hence no plants are found, only respiration activity takes place. Most food in this zone comes from dead organisms sinking to the bottom of the lake or ocean from overlying waters.

3.2.2 Temperature and Oxygen Concentration

- Water temperature exerts a major influence on biological activity and growth, it influences water chemistry, can influence water quantity measurements, and **governs the kinds of organisms that live in water bodies.**
- **Warm water holds less dissolved oxygen** (than cold water) required for the survival of different species of aquatic life. Some compounds are also more toxic to aquatic life at higher temperatures.

3.2.3 Turbidity and Transparency

- **Turbidity** affects the **growth rate of algae (micro-aquatic plants)** and other aquatic plants in streams and lakes because increased turbidity causes a decrease in the amount of light for photosynthesis.
  - Turbidity **can also increase water temperature** because suspended particles absorb more heat.
- **Transparency** affects the extent of light penetration. Suspended particulate matters such as clay, silt, phytoplankton, etc. **make the water turbid.**
  - Consequently, it limits the extent of light penetration and the photosynthetic activity in a significant way.
- **Winterkill Phenomenon:** Ice cover on water bodies can effectively cut off light, plunging the waters into darkness. Hence **photosynthesis stops but respiration continues.** Thus, in shallow lakes, the oxygen gets depleted. **Fish die in large numbers** this phenomenon is known as **winterkill**.

3.3 FRESHWATER ECOSYSTEMS

- It emphasises mainly the study of the relationship between organisms and the freshwater environment.
  - **Limnology** is the study of all aspects (physical, chemical, geological and biological) of freshwater.
- Freshwater habitats occupy a relatively small portion of the earth's surface as compared to marine and terrestrial habitats.

- Following are two types of freshwater ecosystems:
  - **Standing water or Lentic**: Such as lakes, ponds, swamps, bog etc.
  - **Running water or Lotic:** Such as river, stream, spring etc.
- Temperature in freshwater ecosystems does not show a large range of variations, which is due to several unique properties of water. Although temperature in such habitats shows less variations, it is a major limiting factor in distribution of organisms, as aquatic organisms generally have **narrow tolerances** i.e., **stenothermal**.

3.3.1 Lake (Lentic) Ecosystem

- **Lake (hollow) is created from geological or geomorphic processes**. It then receives surface run-off water or ground discharge. In the next stage chemicals and minerals mix up and finally lake starts to age.
- Lake is **surrounded by land**. Algae, bacteria, fungi, aquatic phanerogams, crustaceans, aquatic insects, molluscs and fish make its flora and fauna.
- Extent to which and number of times the water is mixed during the year is known as **turn-over cycle of the lake**.
- Deep water abstraction, Flushing, Algae skimming, plants to suck nutrients, Harvest fish & macrophytes, Sludge removal, Filters for algae removal are different **mechanisms for cleaning lakes.**
- **Physiographic categorisation** gives 4 types of lakes namely, **Natural Lakes, Artificial Lakes, Oxbow Lake** (Formed by river deposits) and **Crater Lake** (due to volcanic activity).
- **Classification** based on **salt content** gives **Freshwater, Brackish, Saline Lakes.**

Lakes in India

Chilika Lake (Lagoon) in Odisha is Asia's largest brackish water lake, it was once part of the Bay of Bengal.

Ameenpur Lake: It is the **first Biodiversity Heritage Site** in the country under the Biodiversity Act, 2002. It is an **ancient man-made** lake in a western part of **Telangana**.

Largest Freshwater Lake in India is **Wular Lake** in Jammu and Kashmir.

Lake at maximum altitude in India is **Cholamu Lake**, Sikkim.

Longest Lake in India **Vembanad** Lake in Kerala.

Largest Artificial Lake in India is **Govind Vallabh Pant Sagar (Rihand Dam)** in Uttar Pradesh and Madhya Pradesh.

Dhebar Lake is India's second-largest artificial lake, after Govind Ballabh Pant Sagar. It is located in the Udaipur District of Rajasthan.

Comparing Lakes based on Nutritional (Trophic) Level

Parameter	Oligotrophic	Mesotrophic	Eutrophic
Aquatic plant production	Low	Moderate	Eliminated due to Eutrophication
Aquatic animal production	Low	Moderate	Eliminated due to Eutrophication
Aquatic plant nutrient flux	Low	Medium	High
Oxygen in the Hypolimnion	Present	Less	Absent
Depth	Deeper	Medium	Shallower
Water Quality (for domestic & industrial uses)	Good	Moderate	Poor
Total Salts or Conductance	Usually, lower	Growth in salinity	Sometimes higher
Plant and Animal species	Many	Few	Many

Neuston	Periphyton	Plankton	Nekton	Benthos
Unattached	Attached to stems	Locomotive power	Swimmers	Attached to bottom
Live at air-water interface	Live submerged in water	Live submerged in water	Live under water. Large & powerful	Live at bottom of water mass
E.g. Floating plants	**E.g.** Sessile algae	**E.g.** Algae, crustaceans	**E.g.** All sea animals	**E.g.** Sea stars, Sea urchins

3.4 EUTROPHICATION

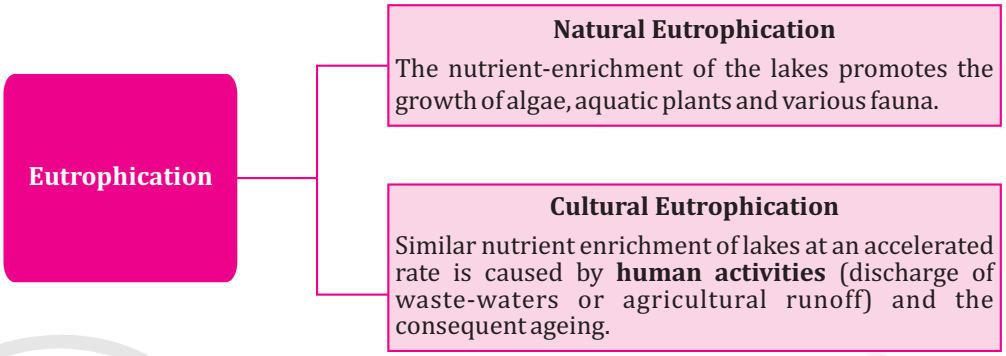


Fig. 3.1

- Due to addition of domestic waste (sewage), phosphates, nitrates etc, from wastes or their decomposition products in water bodies, **from point and nonpoint** sources, they become rich in nutrients, especially phosphate and nitrate ions.
  - **Point sources** are attributable to one influence, therefore easy to regulate.
  - **Non-point sources** having multiple unknown influences become **very difficult to regulate**.
- With the passage of these nutrients through such organic wastes, the **water bodies become highly productive or eutrophic.**
- Toxicity, new species invasion, decreased biodiversity, decrease in species richness and diversity, Toxic Aerosols in microenvironment are its **effects**.
- Restoration and preservation of ecosystems, create buffer zones for sediments to collect, **nitrogen testing**, **Industrial waste treatment** and efficiency, **reducing livestock densities** and **non-point pollution** are required for **effective mitigation.**

Biological Oxygen Demand (BOD)

It is the amount of water required for the biological oxidation by microbes in any unit volume of water.

BOD values generally approximate the amount of oxidizable organic matter and is therefore used as a measure of degree of water pollution and waste level.

Thus, mostly **BOD** value is proportional to the amount of organic waste present in water

Chemical Oxygen Demand (COD)

It is an indicator of water or effluent quality which measures **oxygen demand** by chemical (as distinct from biological) means using **potassium dichromate** as the **oxidizing agent**.

Oxidation takes **2 hours** and the method is thus much quicker than a **5- day** BOD assessment.

The **BOD**:**COD** ratio is fairly constant for a given effluent.

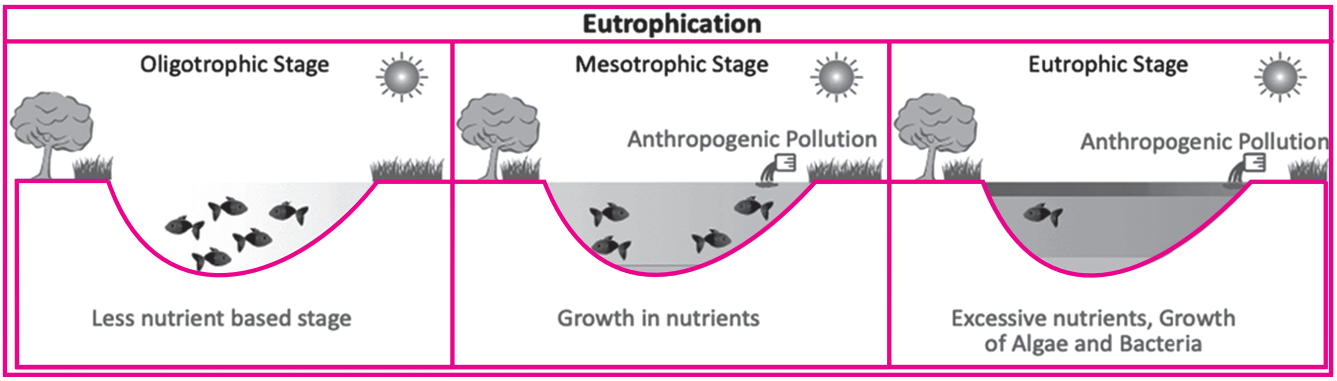


Fig. 3.2

3.5 ALGAL BLOOM

Dead Zones

Dead zones are areas of water bodies **where aquatic life cannot survive because of low oxygen levels**. Dead zones are generally **caused by significant nutrient pollution**, and are primarily a problem for bays, lakes and coastal waters since they receive excess nutrients from upstream sources.

The majority of the world's dead zones are along the eastern coast of the **US**, and the coastlines of the **Baltic States**, **Japan** and the **Korean Peninsula**. Notable examples include the **Gulf of Mexico** and the **Baltic Sea**.

- Algal bloom is rapid increase or accumulation in the population of algae in freshwater or marine water systems.
- Blooms can be due to a number of reasons. Two common causes are nutrient enrichment and warm waters.
- **Harmful Algal Blooms (HABs)** occur when colonies of algae i.e., simple plants that live in the sea and freshwater **grow out of control and produce toxic** or harmful effects on people, fish, shellfish, marine mammals and birds.
- Four regions of India have been identified as **bloom hotspots**, namely, North-eastern Arabian Sea, Coastal waters off Kerala, Gulf of Mannar and **C**oastal waters of Gopalpur.
- Negative Impacts
  - **Oxygen level** drops due to decomposition of dead algae and hence suffocates the living organisms around.
  - **Potent neurotoxins** are created that can enter the food web thus reaching animals, fish and even humans.
  - Some **toxins become airborne,** and people tend to breathe aerosolized **HAB** toxins near the beach.

National Plan for Conservation of Aquatic Ecosystem

NPCA is a single conservation programme for **both wetlands and lakes**.

Centrally sponsored scheme, currently being implemented by the **MoEFCC**.

NPCA seeks to promote better synergy and avoid overlap of administrative functions.

Formulated in **2015** by merging of the **National Lake Conservation Plan** and the **National Wetlands Conservation Programme**.

3.6 WETLAND ECOSYSTEM

- Areas of marsh, 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, depth of which at low tides, does **not exceed 6 metres** are included under wetlands **according to Ramsar Convention on Wetlands**.
- Wetlands are **intermediate** areas between **deep-water and terrestrial habitats**, also transitional in nature, and often located between them.
- India became a party to the 'Convention on Wetlands', also known as the **Ramsar Convention** on **1st February 1982** and has since then designated about **75 wetlands** under the **List of Wetlands of International Importance.** World Wetland Day is observed on **2nd February**.

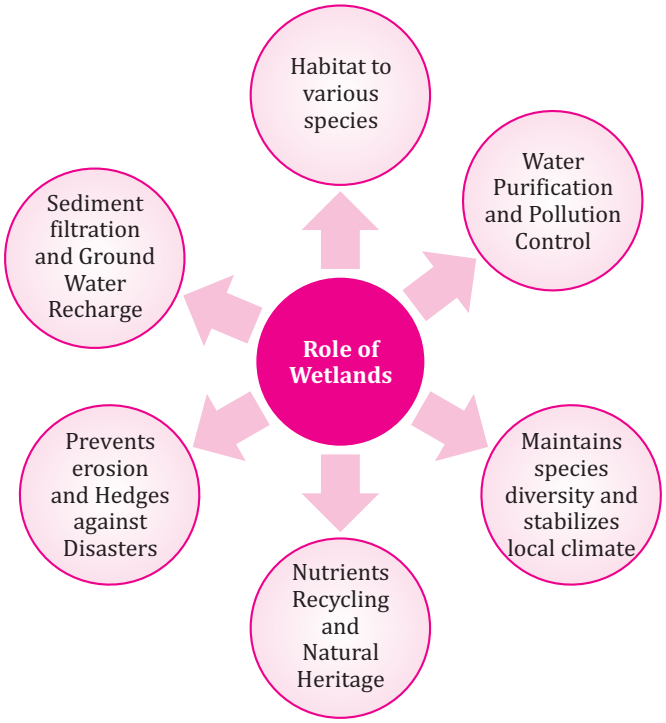


Fig. 3.3

3.6.1 Causes of Loss

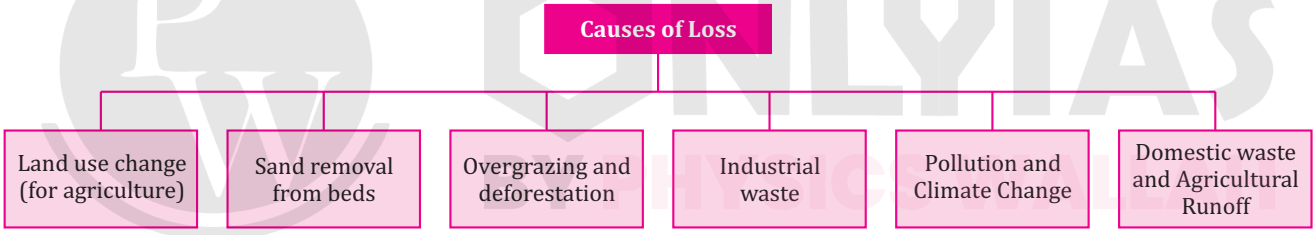


Fig. 3.4

3.6.2 Mitigation

- Eutrophication abatement, environmental awareness, afforestation, soil conservation, weed control, artificial regeneration, wildlife conservation, heritage management.

3.6.3 Ramsar Criteria for Wetland Identification

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

- Ramsar Convention works with the collaboration of International Union for Conservation of Nature (IUCN), Birdlife International, International Water Management Institute (IWMI), Wetlands International, Wildfowl & Wetlands Trust (WWT), WWF International.

Lakes Vs Wetlands	
Lakes	**Wetlands**
• Minimum depth 3 metres	• Minimum depth under 3 meters
• Origin from multiple sources	• Geomorphic Origin
• Minor water level changes	• Major water level changes
• Small pelagial ratio	• Large pelagial ratio
• No waste treatment occurs	• Waste treatment occurs
• Low productivity	• High productivity
• Low biodiversity	• High biodiversity
• Oligotrophic status	• Eutrophic status
• No major role in flood control	• Significant role in floods control
• Thermal stratification	• No thermal stratification
• **Management Objectives**-Control of Eutrophication and High-Water quality	• **Specific Functions-** Biodiversity conservation

3.6.4 Important Facts about Ramsar Sites in India

- **Sunderban** is the **largest** while **Renuka** is the **smallest** Ramsar site in India.
- **Vembanad Kol Wetland** is the **second largest Ramsar Site** in India after Sundarbans.
- **Chilika lake** is the oldest Ramsar site in India. Irrawaddy dolphin (Endangered) is the flagship species of Chilika lake.
- **National Waterway 3** passes through **Ashtamudi Wetland**.
- **Beas Reserve** hosts the only known population of the endangered **Indus River Dolphin** in India.
- Recently, the colour of **Lonar lake** water had turned pink due to a large presence of the **salt-loving haloarchaea** microbes.
- **Wular lake** is the **largest freshwater** lake in India.
- **Loktak Lake** is the **largest freshwater** lake in the north- eastern region of the country and **Keibul Lamjao National Park** (**only floating national park in the world**) floats over it.
- **Nalsarovar Bird Sanctuary** hosts a significant population of Indian Wild Ass (Near Threatened).
- The **Sambhar Salt Lake** is India's largest inland saltwater lake.

Montreux Record

- A register of wetland sites on the **List of Wetlands of International Importance** where **changes in ecological character have occurred, or are occurring, or are likely to occur** as a result of technological developments, pollution or other human interference.
- It is maintained as part of the Ramsar List.
- **Montreux Record Sites in India:**
  - **Chilika Lake, Orissa:** Placed in 1993 due to choking at mouth. Removed in 2002. Won Ramsar Wetland Conservation Award for 2002.
  - **Loktak Lake, Manipur:** Places in 1993 due to deforestation in area & pollution.
  - **Keoladeo National Park, Rajasthan:** Placed in 1990 due to water shortage and Unbalanced grazing around.
  - **Cities for Forests Global Campaign** works closely with cities around the world to connect with forests, emphasises the importance of wetlands and their multiple benefits to help combat climate change and protect biodiversity in cities.

- Not to confuse with **Montreal Protocol** which is an **international treaty designed to protect the ozone layer** by phasing out the production of numerous substances that are responsible for ozone depletion.

3.6.5 Wetlands (Conservation and Management) Rules, 2017

Nodal Authority	Wetlands Authority within a state is the nodal authority for all wetland-specific authorities in a state/UT for the enforcement of the rules.
Prohibited Activities	Setting up any industry and expansion of existing industries, dumping solid waste or discharge of untreated wastes and effluents from industries and any human settlements. Encroachment or conversion for non-wetlands uses.
Integrated Management Plan	The guidelines recommend that the state/UT administration prepare a plan for the management of each notified wetland by the respective governments.
Penalties	As per the Environment (Protection) Act, 1986.

Fig. 3.5

3.7 MARINE (OCEAN) ECOSYSTEM

- Marine environments as compared with fresh water, **appear to be more stable in their chemical composition** due to being saline and moreover other such physio-chemical aspects such as dissolved oxygen content, light and temperature are also different. The biotic components of an ocean ecosystem are of the following orders:
- Producers
  - Autotrophs responsible for trapping radiant energy of the sun with the help of their pigments.
  - They show distinct zonation at different depths of water in the sea.
  - Examples are mainly **phytoplankton** and **macroscopic** sea weeds such as **brown** and **red algae**.
- Consumers
  - All heterotrophic macroconsumers being dependent for their nutrition on the producers.
  - **Primary consumers**: Herbivores that feed directly on producers and are chiefly crustaceans, molluscs, fish etc.
  - **Secondary consumers**: These are carnivorous fishes feeding on herbivores.
  - **Tertiary consumers**: Carnivorous fishes that feed on other carnivores or secondary consumers.
- Decomposers
  - The microbes active in the decay of dead organic matter of producers and macroconsumers are chiefly bacteria and some fungi.

3.8 ESTUARINE ECOSYSTEM

- **Areas where the river meets the sea** (exhibiting gradient in salinity), resulting in mixture of fresh river water with salty ocean water, subject to tidal variations.
- **Examples of Estuaries include** river mouths, coastal bays, tidal marshes and water bodies behind barrier beaches. Thus, estuaries are also considered as ecotones between the freshwater and marine habitats.
- **Four major types of estuaries classified by their geology**: drowned river valley, bar-built, tectonic, and fjords.

Conditions for Estuary Formation

- Rising sea level.
- Movement of sand and sandbars.
- Glacial processes.
- Tectonic processes.

- **Characteristics:** Filter for river water, Traps mud & sands, Semi-enclosed coastal body, Connection with open sea, Salinity range - **0 to 35 ppt**, heavily populated, little wave action.
- **Benefits of Estuarine ecosystems**: Commercial fishing, Ports and harbours, Travel and tourism, Economic and social benefits, Water purification, Breeding hotspot, Recreational and community benefits, Erosion protection, Stores and recycles nutrients.
- **Biologically most productive region** receives a high amount of nutrients from fresh and marine water.
- **Lagoons Viz-a-Viz estuaries**: In estuaries, the water flows fast and strong, while in lagoons the water is shallower and flows sluggishly. Estuaries are usually deeper than lagoons.
- Communities of estuaries are a **mixture of endemic species and those which come from the sea**. An estuary consists of several basic subsystems linked together by the ebb and flow of water that is driven by the hydrological cycle and the tidal cycle.
- **Estuaries In India:** India has **14 major**, **44 medium** and **162 minor rivers**. Major estuaries occur in the **Bay of Bengal region**. West- flowing rivers are generally fast-moving ones giving rise to formation of estuaries.
- **India's major estuaries occur on the east coast** (for example Hooghly estuary). 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.
- **Issues relating to Indian Estuarine Ecosystems:** Modification of catchment areas, Pollution, Recreation & unsustainable tourism, Increased dredging and shipping, unstainable Land-use pattern, Fishing & aquaculture, Climate change.

3.9 MANGROVES ECOSYSTEM

- Mangroves are **tropical trees or shrubs that grow in swampy areas and have tangled roots located above ground**, **or a tidal swamp** with a number of these types of trees and shrubs.
- **High adaptation to salinity** (Halophytic adaptability) and water logging.
- Most of them produce **special type of branched,** negatively geotropic roots that comes out of the mud surface to encourage the entry of oxygen gas- such roots are called **pneumatophores**.
- Some of the mangrove species show the phenomenon of **vivipary** i.e., germination of seeds before they are shed from the parent plant.
- Adventitious roots, also called **stilt roots.**
- **Rhizophora, Sonneratia, Avicennia, Heritiera** (its common names include sunder, sundri,), etc. are **examples of mangroves**.
- **Benefits of Mangroves**: Reduce inundation, moderate monsoonal tidal floods, prevent coastal soil erosion, enhance nutrient recycling, Source of firewood, medicinal plants, edible plants to locals.

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3.9.1 Advantages of Mangrove Ecosystem

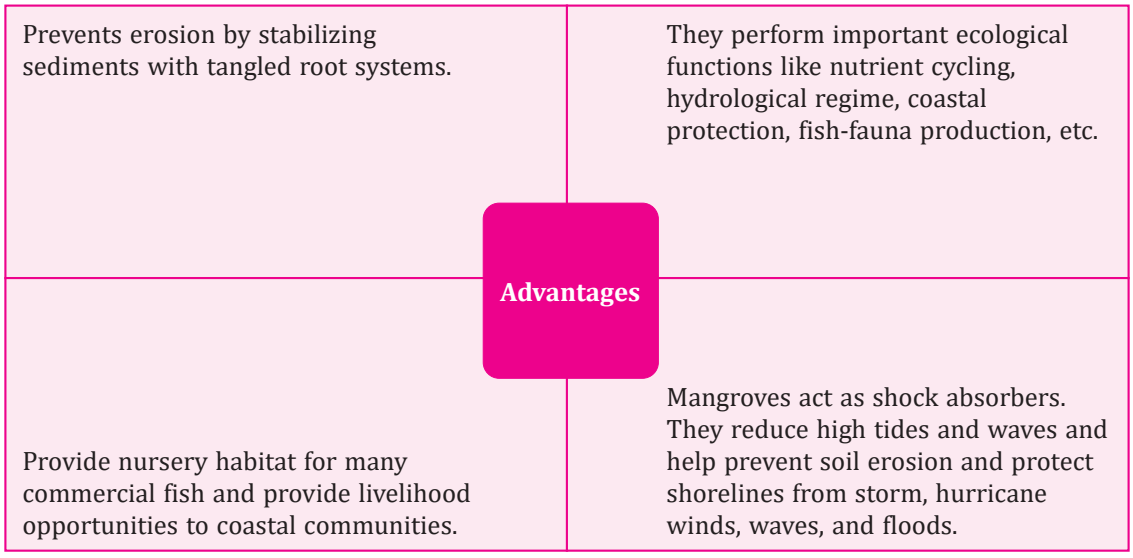


Fig. 3.6

3.9.2 Mangroves in India

- **India houses the largest mangroves of the world** i.e., Sunderbans. It is home to the Royal Bengal Tiger and crocodiles.
- **Odisha's Bhitarkanika** mangroves are the **2nd largest** in the Indian subcontinent.
- **Mangroves of Godavari-Krishna** deltaic regions of Andhra Pradesh in the eastern coast of India, extend from Odisha to Tamil Nadu.
- The forest is under protection for Calimere Wildlife and Pulicat Lake.
- In **Gujarat** they are found in the Gulf of Kachchh and Kori creek.
- **Andaman & Nicobar Islands** possess diverse undisturbed mangrove flora in Andaman's Baratang Island.
- Mangrove cover in the country has **increased by 54 sq. km (1.10%)** as compared to the previous assessment.
- Current assessment shows that mangrove cover in the country is **4,975 sq. km**, which is **0.15% of the country's total geographical area.**
- **West Bengal** has **42.45%** of **India's largest mangrove cover**, followed by **Gujarat 23.66%** and **A&N Islands 12.39%**.
  - **South 24 Parganas** district of **West Bengal** alone accounts for **41.85%** mangrove cover of the country.
- **Gujarat** shows a maximum increase of **37 sq. km** in mangrove cover.
- **Mangroves for the Future (MFF)**
  - **MFF** is a unique partner-led initiative to promote investment in coastal ecosystem conservation for sustainable development. Co-chaired by **IUCN** and **UNDP**, **MFF** provides a platform for collaboration among the many different agencies, sectors and countries which are addressing challenges to coastal ecosystem and livelihood issues
  - The goal is to promote an integrated ocean-wide approach to coastal management and to building the resilience of ecosystem-dependent coastal communities.
  - Mangroves are the flagship of the initiative, but MFF is inclusive of all types of coastal ecosystem, such as **coral reefs**, **estuaries**, **lagoons**, **sandy beaches**, **seagrass** and **wetlands.**

3.10 CORAL REEFS

- Corals are living animals, which live in a Symbiotic relationship with **'zooxanthellae'**. Both have a mutual type of relation.
- There are **2 types of corals**: **Hard** and **soft** - only hard corals build reefs.
- Majority coral reefs are **found in tropical and subtropical water**, however there are exceptions of deep-water corals in colder regions.
- Unsustainable fishing, Water Pollution, Marine Debris, and Habitat Destruction are the Global Warming induced threats to Corals.
- **Coral Reefs in India** are found at Andaman Nicobar Islands, Gulf of Kutch, Gulf of Mannar, Palk Bay, Lakshadweep, Vijay Fort (Maharashtra), Netrani Island (Karnataka) etc.

Zooxanthellae
• Assist coral in nutrient production through photosynthetic activities. • Provide fixed carbon compounds, enhance calcification, mediate elemental nutrient flux.
Coloration
• Tissues of corals are clear white. • Corals receive coloration from zooxanthellae living within tissues.
Coral Polyp
• Protects zooxanthellae and supplies carbon-dioxide for photosynthesis.

3.10.1 Advantages of Coral Reefs

- Natural protective barriers against storms and soil erosion, Food, Tourism, Capture nutrients and plankton from water, Largest biogenic calcium carbonate producer, Home to variety of animals and plants.
- Sources of new medicines being developed to treat cancer, arthritis, human bacterial infections, Alzheimer's disease, heart disease, viruses, and other diseases.
- More than **1 billion** people depend on food from **coral reefs**.

3.10.2 Coral Bleaching

- Without algae, coral loses its major source of food, turns white or pale and is more susceptible to diseases and eventually starves to death.
- Bleaching of corals occur when densities of zooxanthellae decline and/or concentration of photosynthetic pigments within zooxanthellae fall.
- Presently, over **4000 miles of coral reefs in Fiji,** Corals of Great barrier reef and of
- Port Douglas (severe) are undergoing bleaching

3.10.3 Ecological Causes of Coral Bleaching

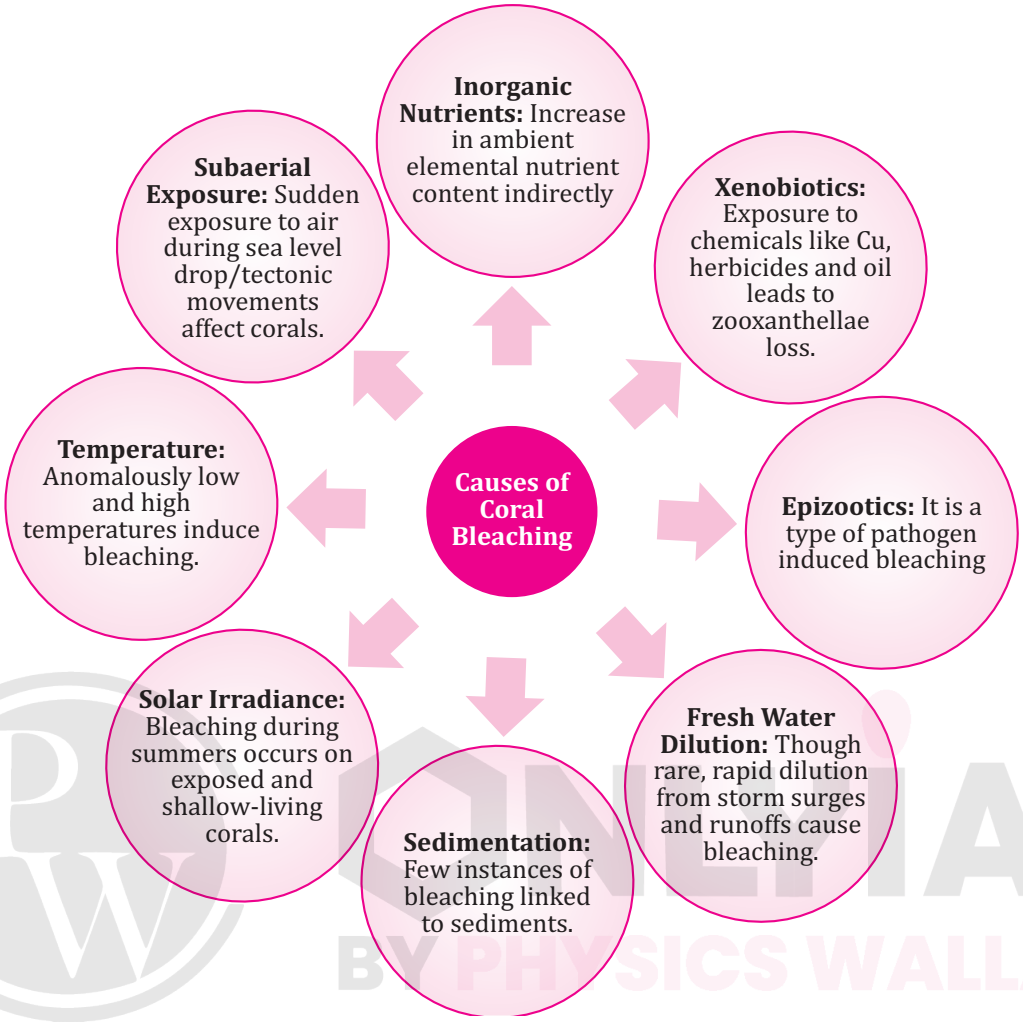


Fig. 3.7

Location And Classification			
Fringe Reefs	**Patch Reefs**	**Barrier Reefs**	**Atoll**
• Most common, contiguous with shore • Seen in Andamans	• Isolated and discontinuous lying shoreward of offshore reef • Seen in Palk Bay, Gulf of Mannar & Kachchh	• Linear offshore structures. Run parallel to the coastline. • Water body between reef & shore is called **lagoon** • Seen in Nicobar and Lakshadweep	• Circular or semi-circular reefs, arise from subsiding sea floor platform • Seen in Nicobar and Lakshadweep

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4 Biodiversity

4.1 INTRODUCTION

- Biodiversity is defined as 'the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems (**United Nations Earth Summit (1992)**).

> State of a species being native to a single defined geographic location, such as an island, state, nation, country or other defined zone is called **Endemism**.

- **More than 70 per cent of all the species recorded are animals**, while plants (including algae, fungi, bryophytes, gymnosperms and angiosperms) comprise no more than **22 percent** of the total.
  - Among animals, **insects are the most species-rich taxonomic group**, making up **more than 70 per cent** of the total.
- **Maximum biodiversity** on earth is observed in the Amazon rainforest. **India** accounts for **nearly 7% of recorded species**.

4.1.1 Factors Responsible for Biodiversity Loss

- **Natural Causes** are floods, earthquakes, landslides, rivalry among species, lack of pollination and diseases.
- Habitat destruction, Uncontrolled commercial exploitation, Hunting & poaching, Conversion of rich biodiversity sites for human settlement and industrial development, Extension of agriculture, Pollution, filling up of wetlands, Destruction of coastal areas **are the man-made factors responsible for loss of biodiversity**.

4.2 PATTERNS OF BIODIVERSITY

- **Latitudinal Gradients**: Diversity of plants and animals is not uniform throughout the world. Species diversity decreases as we move away from the equator towards the pole. **Tropics harbour more species than temperate or polar areas.**

> **Ecosystem Services**
>
> Protection of water resources, Soils formation and protection, Nutrient storage and recycling, Pollution breakdown and absorption, Contribution to climate stability, Maintenance of ecosystems, Recovery from unpredictable events.

- **Speciation,** which is a function of time, unlike temperate regions subjected to frequent glaciations in the past, tropical latitudes have remained relatively undisturbed for millions of years.
- **Relatively constant and predictable** nature of temperate environments **promotes niche specialisation** and leads to a greater species diversity. Tropical environments experience more **seasonal variations.**
- **More solar energy available in the tropics**, which contributes to higher productivity; this in turn might contribute indirectly to greater diversity.

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4.3 LEVELS OF BIODIVERSITY

Levels of Biodiversity

Genetic Diversity

It is concerned with the variation in genes within a particular species. Genetic diversity allows species to adapt to changing environments. This diversity aims to ensure that some species survive drastic changes and thus carry-on desirable genes.

Genetic diversity gives us beautiful butterflies, roses, parakeets or coral in a myriad hues, shapes and sizes.

Species Diversity

It refers to the variety of living organisms on earth. Species differ from one another, markedly in their genetic makeup, do not inter-breed in nature. Closely related species however have in common much of their hereditary characteristics.

It is the ratio of one species population over total number of organisms across all species in the given biome. Zero would be infinite diversity, and one represents only one species present.

Ecosystem/ Community Diversity

Community diversity refers to the different types of habitats. A habitat is the cumulative factor of the climate, vegetation and geography of a region.

There are several kinds of habitats around the world. Corals, grasslands, wetland, desert, mangrove and tropical rain forests are examples of ecosystems.

Pattern Diversity

Diversity resulting from the differences due to zonation, periodicity, stratification, food webs, patchiness and habitat condition is referred to as pattern diversity .

It is environmentally induced diversity.

Fig. 4.1

4.4 MEASUREMENT OF BIODIVERSITY

Alpha Diversity

Diversity within a particular area or ecosystem is represented by alpha diversity. It is usually expressed by the number of species (i.e., species richness) in that ecosystem.

Beta Diversity

It is a comparison of diversity between ecosystems, usually measured as the change in amount of species between the ecosystems.

Gamma diversity

It is a measure of the overall diversity for the different ecosystems within a region.

Fig. 4.2

4.5 SPECIES-RELATED TERMINOLOGIES

4.5.1 Flagship Species

- A species selected to act as an ambassador, icon or symbol for a defined habitat, issue, campaign or environmental cause.
- Flagship species may or may not be keystone species and may or may not be good indicators of biological process.
- Indian tiger, Giant panda, Golden lion, African elephant, Asian elephant, etc. are examples.

4.5.2 Keystone Species

- Species whose addition to or subtraction from an ecosystem leads to major changes in abundance or occurrence of at least one other species.
- Plays role in structure, functioning or productivity of a habitat or ecosystem.

- All top predators like Lion, Tiger, Crocodile, Elephant come under this category.

4.5.3 Priority Species

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

4.5.4 Indicator Species

Die-back
Phenomena in which **progressive dying** of plants happens, microorganisms, animals, etc., that can be developed usually backwards from the tip of any portion of plant. This further for commercialization and overall benefits of the is one of the **adaptive mechanisms** to avoid adverse conditions.

- Species or group of species chosen as an indicator of, or proxy for, the state of an ecosystem or of a certain process within that ecosystem.
  - **Lichens** are indicators of air quality (sensitive to sulphur dioxide).
  - **Crayfish** as indicators of freshwater quality.
  - **Corals** as indicators of marine processes such as siltation, unpredictable events. seawater rise and sea temperature fluctuation.
  - **Amphibians** (e.g. Frog) indicates global warming and air pollution.

4.5.5 Foundation Species

- Dominant primary producer in an ecosystem both in terms of abundance and influence. Corals are example.

4.5.6 Charismatic Species

- Large animal species with widespread popular appeal that environmental activists use to achieve conservation goals well beyond those species.
- Barasingha (Bhoorsingh from Kanha National Park), Giant panda ,The Bengal Tiger and Blue Whale are examples.

4.5.7 Umbrella Species

- It acts as an umbrella for conservation attempts and programs. Conservation of umbrella species would extend protection to other species as well.
- **Conservation of Tiger**, efforts have been made to save the populations of **wild Tigers** in order to save other species that are present in the same ecosystems such as **Leopards**, **Monkey**, **Hares**, **Boars**, etc.

4.5.8 Invasive/Alien Species

- Species that occur outside their natural range and threaten native plants and animals or other aspects of biodiversity by altering and utilising the components of the ecosystem in which they are introduced.
- Goat weed, Prickly poppy, Palmyra, Toddy palm, Calotropis/Madar, Swallow wort, Water Hyacinth, Alternanthera paronychioides are examples.

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Species Richness	Species Evenness
• **Species Richness** is the number of different species represented in an ecological community, landscape or region. Species richness is simply a count of species, and it does not take into account the abundances of the species or their relative abundance distributions. • It is a measurement of the relative frequency of each species.	• Species evenness refers to how close in numbers each species in an environment is. Mathematically it is defined as a diversity index, a measure of biodiversity which quantifies how equal the community is numerically. • So, if there are **40 foxes** and **1000 dogs**, the community is not very even. • It is a number of species found in said environment.
Species diversity of an environment is essentially a combined measurement of richness and evenness. Sometimes, it is called the **Shannon Diversity Index.**	

Important Terms Related to Ecosystem

Biopiracy: Practice in which indigenous knowledge of nature, originating with indigenous peoples, is used by others for profit, without authorization or compensation to the indigenous people themselves.

Bioprospecting: Systematic and organized search for useful products derived from bioresources including plants, microorganisms, animals, etc., that can be developed further for commercialization and overall benefits of the society.

Biomining: Process of using microorganisms (microbes) to extract metals of economic interest from rock ores or mine waste. Biomining techniques may also be used to clean up sites that have been polluted with metals.

Bioassay: A test in which organisms are used to detect the presence or the effects of any other physical factor, chemical factor or any other type of ecological disturbance. It is very common in pollution studies; the aim is to detect lethal concentration or effective concentration causing mortality or other effects.

4.6 BIODIVERSITY CONSERVATION

4.6.1 Ex-situ conservation

- Conserving biodiversity outside the areas where they naturally occur is known as ex-situ conservation.
- Here, animals are reared, or plants are cultivated like **zoological parks** or **botanical gardens**. Reintroduction of an animal or plant into the habitat from where it has become extinct is another form of **ex situ conservation**.
- Gangetic gharial has been reintroduced in the rivers of **Uttar Pradesh**, **Madhya Pradesh** and **Rajasthan** where it has become extinct.
- **Seed banks**, **botanical**, **horticultural** and recreational gardens are important centres for **ex-situ conservation**.

Botanical Garden

Botanical garden refers to the scientifically planned collection of living trees, shrubs, herbs, climbers and other plants from various parts of the world.

Zoological Park

Zoo is an establishment, whether stationary or mobile, where captive animals are kept for exhibition to the public and includes a circus and rescue centers but does not include an establishment of a licensed dealer in captive animals.

Fig. 4.3

4.6.2 In-situ Conservation

- Conserving the animals and plants in their natural habitats is known as in-situ conservation. The established natural habitats are: **National Park**, **Sanctuaries**, **Biosphere Reserves** and **Reserved Forests**, **Protected Forests**.

4.7 BIODIVERSITY IN INDIA

- India, a mega diverse country with **only 2.4% of the world's land area, accounts for 7-8% of all recorded species**, including **over 45,000 species of plants and 91,000 species of animals.**
- The most biodiversity rich regions are the **Western Ghats** (4 % area) and **North East** (5.2% area).
- The country's diverse physical features and climatic conditions have resulted in a variety of ecosystems such as forests, wetlands, grasslands, desert, coastal and marine ecosystems.

- Four of 34 globally identified biodiversity hotspots are in India, namely, **The Himalayas, the Western Ghats, the North-East, and the Nicobar Islands.**
- In terms of species richness, India ranks **7th** in mammals, **9th** in birds and **5th** in reptiles.
- **World Conservation Monitoring Centre (WCMC)** of the **United Nations Environment Program (UNEP)** has identified a total of **17 megadiverse countries**: **India**, Australia, DRC, Madagascar, Philippines, Brazil, Ecuador, Malaysia, Peru, China, USA, Papua New, South Africa, Colombia, Indonesia, Guinea, Venezuela.
- The national gene bank at **National Bureau of Plant Genetic Resources** (NBPGR), Delhi is primarily responsible for conservation of unique accessions on long-term basis, as base collections for posterity, predominantly in the form of seeds.

4.7.1 Biomes of India

- The term biome means the main groups of plants and animals living in areas of certain climate patterns. It includes the way in which animals, vegetation and soil interact together. The plants and animals living in the area are adapted to that environment. The **five Biomes of India** are as under:
  - Tropical Humid Forests
  - Tropical Dry or Deciduous Forests (including Monsoon Forests)
  - Warm deserts and semi-deserts
  - Coniferous forests
  - Alpine meadows.

9 Botanical (Floristic) Regions of India

Western Himalayas,
Eastern Himalayas,
West Indian Desert,
Gangetic Plains,
Assam,
Central India,
Malabar,
The Deccan,
Andamans.

4.7.2 Biogeography

- It is the aspect of geography which deals with the correlation among the animals, plants and their geography. It is studied under following 2 heads:
  - **Phyto-geography (plant geography)** deals with origin, distribution and environmental interrelationships of plants.
  - **Zoogeography** deals with the migration and distribution of animals.

Biogeographic Zones and Provinces in India

Trans Himalayan Zone	• An extension of the Tibetan plateau, harbouring high-altitude cold desert in **Ladakh** (J&K) and **Lahaul Spiti** (H.P) comprising **5.7%** of the country's landmass. • This region consists of **Karakoram**, **Ladakh**, **Zaskar** and **Kailash mountain ranges** (5.6%).	• **Himalaya** - Ladakh Mountains • **Himalaya** - Tibetan Plateau • **Trans Himalaya** - Sikkim
Himalayan Zone	• This region extends from east to west upto **2400 kms** from **Kashmir** to **Arunachal Pradesh**. • The entire mountain chain runs from north-western to northeastern India, comprising a diverse range of biotic provinces and biomes, **7.2%** of the country's landmass.	• **Himalaya** - North West Himalaya • **Himalaya** - West Himalaya • **Himalaya** - Central Himalaya • **Himalaya** - East Himalaya
Desert Zone	• This region lies mostly in the **Rajasthan** state of India and extends into some parts of **Haryana**, **Punjab** and **Gujarat**. • The desert region extends from the Aravalli hills in the north-east to the **Rann of Kutch** along the coast and the alluvial plains of the **Indus River** in the **West** and **North-West** (6.6%).	• **Desert** – Thar • **Desert** – Kachchh

Biogeographic Zones and Provinces in India		
Semi-Arid Zone	• A transition zone between the desert and the dense forest of Western Ghats. The Indian semi-arid region mainly lies in the states of Gujarat, Punjab, Haryana and western parts of Rajasthan. • The zone between the desert and the Deccan plateau, including the Aravalli hill range. • **15.6 %** of the country's landmass.	• **Semi - Arid** - Punjab Plains • **Semi - Arid** - Gujarat Rajputana
Western Ghats	• The hill ranges and plains run along the western coastline, south of the Tapti river, covering an extremely diverse range of Mountains, biotic provinces and biomes. • **5.8%** of the country's landmass.	• **Western Ghats** - Malabar Plains • **Western Ghats** - Western Ghats
Deccan Plateau	• The largest of the zones, covering much of the southern and south central plateau with predominantly deciduous vegetation. • **4.3 %** of the country's landmass.	• **Deccan Peninsular**-Central Highlands • **Deccan Peninsula-Chota** Nagpur • **Deccan Peninsular** - Eastern Highlands • **Deccan Peninsular**-Central Plateau • **Deccan Peninsular** - Deccan South
Gangetic plain Zone	• Defined by the Ganges River system, these plains are relatively homogenous. • **11%** of the country's landmass. • The great plains of India stretch from Delhi to Kolkata covering the states of Uttar Pradesh, Bihar and West Bengal.	• **Gangetic Plain**- Upper Gangetic Plains • **Gangetic Plain** - Lower Gangetic Plains
North East Zone	• The plains and non-Himalayan hill ranges of northeastern India, with a wide variation of vegetation. • **5.2%** of the country's landmass. • Region represents the transition zone between Indian, Indo-Malayan and Indo-Chinese biogeographical regions as well as • being a meeting point of the Himalayan Mountains and Peninsular India.	• **North - East** - Brahmaputra Valley • **North - East** – North East Hills
Islands	• The Andaman and Nicobar Islands in the Bay of Bengal, with a highly diverse set of biomes. • **0.03%** of the country's landmass.	• **Islands** – Andamans • **Islands** – Nicobars
Coasts	• A large coastline distributed both to the west and east, with distinct differences between the two; Lakshadweep islands are included in this with the percent area being negligible.	• **Coasts** - West Coast • **Coasts** - East Coast • **Coasts** – Lakshadweep

4.8 PLANT DIVERSITY OF INDIA

4.8.1 Insectivorous Plants

- These plants are specialised in trapping insects.
- Insectivorous plants can broadly be divided into **active** and **passive types** based on their method of trapping their prey - active ones can close their leaf traps the moment insects land on them and passive plants have a 'pitfall' mechanism, having some kind of jar or pitcher-like structure into which the insect slips and falls, to eventually be digested.
- **Drosera or Sundew, Aldrovanda, Nepenthes, Utricularia or Bladderworts, Pinguicula or Butterwort** are insectivorous plants found in India.

Floral Diversity of India

Peninsular India including western and Eastern Ghats (about 2,600 species)

Eastern Himalaya and north-eastern region (about 2,500 species)

North-western Himalaya (about 800 species).

Andaman & Nicobar Islands (about 250 species).

4.8.2 Invasive Alien Species

- Aliens are species that occur outside their natural range. Alien species that threaten native plants and animals or other aspects of biodiversity are called alien invasive species.
- They cause loss of biodiversity, **decline of native species (Endemics),** habitat loss, introduction of pathogens and reduction of crop and stock yields, degradation of marine and freshwater ecosystems.
- **Invasive Alien Flora of India**: Needle Bush, Black Wattle, Goat weed, Prickly Poppy, Palmyra, Toddy Palm, Water Hyacinth, Balsam, Parthenium/Congress grass, Prosopis juliflora, Lantana camara, Sleeping Grass.
- **Medicinal Plants**: Beddomes Cycad, Pooshkarmoola, Blue vanda, Ladies Slipper Orchid, Red vanda, Sarpagandha, Indian Podophyllum, Tree Ferns, Cycads, Elephant's foot.

Algae	The green non-differentiated plants (non-differentiated into organs like root, stem and leaf) possessing chlorophyll.
Fungi	Non-green non-differentiated plants characterized by total absence of chlorophyll are called Fungi.
Bacteria	Non-chlorophyllous micro-organisms which lead saprophytic or parasitic existence. Many of them are pathogenic; Saprophytic bacteria are rather beneficial.
Lichens	A lichen is a peculiar combination of an alga and a fungus–the two live deriving mutual benefit.
Bryophytes	The plant body is differentiated into a small stem and simple leaves, but true roots are absent.
Pteridophytes	The pteridophytes have well-differentiated plant bodies, consisting of roots, stems and leaves. Moreover, they possess vascular bundles.
Gymnosperms	Gymnosperms (Gymnos naked; Sperma seed) are the naked-seeded plants.
Angiosperms	Angiosperms (Angeion a case) are the closed-seeded plants.
Insectivorous Plants	Plants are specialized in trapping insects.This is an adaptability mechanism of plant in nutrient poor soil.

Fig. 4.4

4.9 WILDLIFE DIVERSITY OF INDIA

4.9.1

4.9.1.1 Himalayan Foothills

- **Flora**: Natural monsoon evergreen and semi-evergreen forests; Species like **Sal, giant bamboos, silk cotton trees; tall grassy meadows** with savannahs in terai are dominant.
- **Fauna**: Elephant, sambar, swamp deer, cheetal, hog deer, barking deer, wild boar tiger, panther, hyena, black bear, sloth bear, Great Indian one-horned rhinoceros, wild buffalo, Gangetic gharial, golden langur.

4.9.1.2 Western Himalayas (High altitude region)

- **Flora**: Natural monsoon evergreen and semi-evergreen forests; rhododendrons; dwarf hill bamboo and birch forests mixed with alpine pastures.
- **Fauna**: Tibetan wild ass (kiang), wild goats (thar, ibex) and blue sheep; antelopes (Chiru and Tibetan gazelle), deers (hangul of Kashmir stag and Sikkim stag, musk deer); golden eagle, snow cocks, snow partridges; snow leopard, black and brown bears; birds like Griffon vultures.

4.9.1.3 Eastern Himalayas

- **Flora**: The Eastern Himalayas can be divided into the following climatic regions: arctic, subarctic, temperate, subtropical, and warm tropical. The forest region is very humid. Sal forests and evergreen trees are found extensively all along the foothills of the Eastern Himalayas.
    - Subtropical forests cover the hills up to an elevation of about 2000 m. Oaks, magnolias, laurels and birches covered with moss and ferns; coniferous forests of pine, fir, yew and junipers with an undergrowth of scrubby rhododendrons and dwarf bamboos; lichens, mosses, orchids, and other epiphytes dominant.
- **Fauna**: Red panda, hog badgers, forest badgers, crestless porcupines, Great one-horned rhinoceros Asian elephant, Takin ,Wild water buffalo, Swamp Deer, Tiger Snow leopard, Clouded leopard.

4.9.1.4 Peninsula India

- **Flora**: Sal in north and east extensions (higher rainfall) and teak in southern plateau are dominant trees. Western Ghats have evergreen vegetation (flora and fauna similar to evergreen rainforests of north-eastern of India. In dry areas of Rajasthan and Aravalli hills, trees are scattered, and thorny scrub species predominate.
- **Fauna**: Elephant, wild boar, deers (cheetal or axis deer), hog deer swamp deer or barasinga, sambar, muntjac or barking deer, antelopes (four-horned antelope, Nilgiri, blackbuck, chinkara gazelle), wild dog or dhole, tiger, leopard, cheetah, lion, wild pig, monkey, striped hyena, jackal, gaur.

4.9.1.5 Indian Desert

- **Flora**: Thorny trees with reduced leaves like babool, ber, khejri tree; cactus, other succulents are the main plants.
- **Fauna**: Its diverse fauna includes the great Indian bustard, blackbuck, chinkara, fox, Bengal fox, wolf, caracal, rodents, Asiatic wild ass, desert cat, red fox; reptiles (snakes, lizards and tortoise) well represented. Desert lizards include geckos.

4.9.1.6 Tropical Rain Forest Region

- Distributed in areas of Western Ghats and northeast India.
- **Flora**: Extensive grasslands interspersed with densely forested gorges of evergreen vegetation known as shoals occur in the Nilgiris (an offshoot of Western Ghats). The rain forests of the Western Ghats have dense and lofty trees with much species diversity. Mosses, ferns, epiphytes, orchids, lianas and vines, herbs, shrubs make diverse habitats. Ebony Indian rosewood, Malabar Kino, teak and Indian laurel trees predominate in these forests.
- **Fauna**: Wild elephants, gaur and other larger animals. The most prominent are hoolock gibbon (only ape found in India), golden langur, capped langur or leaf monkey, Assam macaque and the pig-tailed macaque, lion-tailed macaque, Nilgiri langur, slender loris, bats, giant squirrel, civets, flying squirrels, Nilgiri mongoose, spiny mouse.

4.9.1.7 Mangrove Swamps of Sundarbans

- **Flora**: Various species of mangroves
- **Fauna**: In the higher regions of mangroves, there are spotted deer, pigs, monitor lizard, monkey, Royal Bengal Tiger.

4.9.2 Important Animals in India

Animal (IUCN Status)	Habitat and Distribution
Pygmy Hog (Critically Endangered)	• Relatively undisturbed, tall **'terai' grasslands.** • Formerly, the species was more widely distributed along the southern Himalayan foothills but now is restricted to only a single remnant population in Manas Wildlife Sanctuary and its buffer reserves. • In 1996, a captive-breeding programme of the species was initiated in Assam, and some hogs were reintroduced in Sonai Rupai area in 2009. • World's smallest wild pig, with adults weighing only 8 kgs. This species constructs a nest throughout the year. • It is one of the most useful indicators of the management status of grassland habitats. The grasslands where the pygmy hog resides are crucial for the survival of other endangered species such as Indian Rhinoceros, Swamp Deer, Wild Buffalo, Hispid Hare, Bengal Florican and Swamp Francolin.
Malabar Civet (Critically Endangered)	• It is endemic to India and was first reported from Travancore, Kerala. • It is nocturnal in nature and found exclusively in the Western Ghats. • Wooded plains and hill slopes of evergreen rainforests, Western Ghats. • It is considered to be one of the world's rarest mammals.
Sumatran Rhinoceros (Critically Endangered)	• It is now thought to be regionally extinct in India, though it once occurred in the foothills of the Himalayas and north-east India. • It is the smallest and most endangered of the five Rhinoceros species. • The Javan Rhinoceros (Rhinoceros sondaicus) is also believed to be extinct in India and only a small number survive in Java and Vietnam.
Kashmir Stag/ Hangul (Critically Endangered)	• Found in dense riverine forests, high valleys, and mountains of the Kashmir valley and northern Chamba in Himachal Pradesh. • Its subspecies of Red Deer which is native to India. • State animal of Jammu & Kashmir. • It is facing threats like habitat destruction, overgrazing by domestic livestock, and poaching.
Dugong (Vulnerable)	• Coastal Island water belt East Africa & Vanuate belt latitude **27° N** - South of Equator (India - Andaman & Nicobar, Laccadives). • Coastal water, wide shallow mangrove & sizeable seagrass bed. • Occurs in near shore waters of Gulf of Mannar, Gulf of Kachchh and Andaman and Nicobar Islands. • Dugong is also called as **sea cow**.
Ganges River Dolphin (Endangered)	• Indus-Ganges-Brahmaputra, Megna, Karnaphuli-Sangu river system of south. • Ganges and Brahmaputra Rivers and their tributaries in Bangladesh, India and Nepal. • Ganges river dolphin has been recognized by the govt. of India as its **National Aquatic Animal**.
Indus River Dolphin (Endangered)	• Indus River in Pakistan and its Beas and Sutlej tributaries.
Bengal Florican (Critically Endangered)	• Habitat is Grasslands occasionally interspersed with scrublands. • Native to only 3 countries in the world - Cambodia, India and Nepal. In India, it occurs in 3 states, namely Uttar Pradesh, Assam and Arunachal Pradesh. • A rare bustard species that is very well known for its mating dance. Among the tall grasslands, secretive males advertise their territories by springing from the ground and flitting to and from in the air.

Animal (IUCN Status)	Habitat and Distribution
White-Bellied Heron (Critically Endangered)	• Rivers with sand or gravel bars or inland lakes are its habitat. • Bhutan and north-east India to the hills of Bangladesh and north Myanmar. • Extremely rare bird found in five or six sites in Assam and • Arunachal Pradesh, one or two sites in Bhutan, and a few in Myanmar.
Pink- Headed Duck (Critically Endangered)	• Habitat are overgrown still-water pools, marshes and swamps in lowland forests and tall grasslands. • Recorded in India, Bangladesh and Myanmar. Maximum records are from north-east India. • It has not been conclusively recorded in India since 1949. Males have a deep pink head and neck from which the bird derives its name.
Siberian Crane (Critically Endangered)	• Habitat are Wetland areas, mainly Keoladeo National Park in Rajasthan. • It is a large, strikingly majestic migratory bird that breeds and winters in wetlands. They are known to winter at **Keoladeo National Park, Rajasthan**. However, the last documented sighting of the bird was in **2002**.
Chinese Pangolin (Critically Endangered)	• Primary & Secondary tropical forest, limestone forest, bamboo forest, grassland & agricultural field. • Occurs in Himalayan foothills in Eastern Nepal, Bhutan, Northern India, North East Bangladesh (India - Sikkim). • It is a nocturnal animal.
Indian Gazelle (Chinkara) (Least Concern)	• Inhabits arid area, Sand deserts, Flat plains & hills, dry scrub & light forest. • Western & Central India through Pakistan, South-West Afghan. (Thar desert remains strong hold)
Clouded Leopard (Vulnerable)	• Arboreal, forest habitat (Primary evergreen tropical rainforest, also in dry deciduous forest Himalaya **(2500 m).** • Himalayan foothill in Nepal through mainland South East Asia - China
India Gaur (Vulnerable)	• Habitat is from sea level upto least 2800m. (hill & low-lying area.) undisturbed forest tact, hilly terrain, availability of water, availability of coarse grasses. • Gaur historically occurred throughout mainland South East Asia, Sri Lanka.
Golden Langur (Endangered)	• Habitat is moist evergreen, dipterocarp, riverine & moist deciduous forest. • Bhutan and North- east India (Assam). Forest belt of west Assam between Manas River in East, Sankosh - Brahmaputra
Himalayan Ibex (Least Concerned)	• Mountain, open alpine meadow & crags (not in forest zone). • Central & Northeast Afghanistan, China, North (India) - Himalayas of Jammu and Kashmir & Himachal Pradesh Hindu Kush range (Karakoram, Trans-Himalayan).
Hoolock Gibbon (Endangered)	• Forest dweller, locale, inhabit tropical evergreen (Tree to tree more); Hill forest, Mountainous, etc. • Not found in India except Eastern Arunachal Pradesh and Assam.
Leopard (Near Threatened)	• Rainforest to desert. India - all forest type-tropical rainforest to temp deciduous and alpine coniferous. • Southwest Asia, Himalayan foothills, India, China, Jawa, Sri Lanka • Leopards occur widely in forest of Indian Sub-continent.
Red Panda (Vulnerable)	• Temperate Forest having bamboo and thickest under stories. • Nepal, India (Meghalaya Plateau), Bhutan, Myanmar, Southern China.

Animal (IUCN Status)	Habitat and Distribution
Lion Tailed Macaque (Endangered)	• Upper canopy of primary tropical evergreen rainforest, Monsoon forest in hilly countries. • Endemic to Western Ghats hills range in South Western India (Karnataka, Kerala, Tamil Nadu).
Nilgiri Tahr (Endangered)	• High elevation, grass covered hills, open terrain · Nilgiri Tahr is the **state animal of Tamil Nadu.** • 5% of Western Ghats in South India (Kerala & Tamil Nadu)
Himalayan Musk Deer (Endangered)	• Alpine environment, barren plateaus at high altitude meadows, fell fields, shrublands forest. • Himalayan of Bhutan, North India (Sikkim), Nepal & China.
Greater One Horned Rhino (Vulnerable)	• Riverine grassland - Terai. Alluvial grass land - swamps & forest. • Northern part - India along Indus, Ganga, Brahmaputra basin includes Nepal, Bhutan, Bangladesh, Pakistan.
Swamp Deer (Vulnerable)	• Open Sal, with grass understorey and grassland forms, true swamp deer, Mangroves of Sundarbans. • Northern & Central India, Southwestern Nepal, Assam, Sundarbans, Indo - Gangetic.
Tibetan Gazelle (Near Threatened)	• High altitude plains, hills also grass in wetland margin. • Tibet Plateau, India (Ladakh, Sikkim).
Tiger (Endangered)	• Forest of tropical Asia. • Southwest Asia, Central Asia, (Java & Bali) - disappeared. • Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Russia, Thailand & Vietnam.
Snow Leopard (Vulnerable)	• High mountain of C.A, Pamir, Karakorum, Hindu Kush and Himalayan Range. India - J and K, Himachal Pradesh, Sikkim, Uttarakhand. • Alpine & Sub-Alpine ecological zone favouring steep terrain.
Gharial (Critically Endangered)	• India - Chambal River, Girwa river, Son River. • Terrestrial, Fresh Water.
Olive Ridley Turtle (Vulnerable)	• Multiple habitat, migration less compared to others, it is usually carried by major currents. • Throughout tropical water (Except Mexico).
Nilgai (Least Concern)	• Arid areas, scrub, dry deciduous, agricultural areas. Avoids Dense Forest, deserts. • Widely distributed in India. lowland of Nepal & border areas of Pakistan extinct in Bangladesh.

4.10 BIRD'S MIGRATION

- Migration refers to the regular, recurrent and cyclical seasonal movement of birds from one place to another.
- The distance of migration ranges from a short distance to thousands of kilometres. But at the end of the period, birds will eventually return to their original place.
- **Reasons for Migration**
  - To avoid extreme climatic condition,
  - To manage food shortage,
  - To manage shortage of water,
  - To have a better breeding condition,
  - Less competition for safe nesting places.



Fig. 4.5

4.11 WILDLIFE PROTECTION ACT (WPA) (1972)

- Wildlife Protection Act (WPA), 1972 **consists of 6 schedule lists**, which give varying degrees of protection to animals listed in these schedules.
- Poaching, smuggling and illegal trade of animals listed Schedule 1 to schedule 4 are prohibited.
- **THE WILD LIFE (PROTECTION) AMENDMENT ACT, 2022** has reduced the number of schedules from Six (previously) to Four now.
- The Amendment has the provisions for the implementation of the **CITES**.
- The Amendment has delegated **much more power to the Central Government.**
  - The central government can **designate a Management Authority**, which grants export or import **permits** for the trade of specimens.
- **Central Government can regulate or prohibit the import, trade, possession or proliferation of invasive alien species** (plant or animal species which are not native to India and whose introduction may adversely impact wildlife or its habitat)
  - The central government may also notify a **conservation reserve** (typically act as buffer zones to or connectors and migration corridors between established national parks, and wildlife sanctuaries)
- The Amendment empowers the **Chief Wildlife Warden to control, manage and maintain all sanctuaries in a state.**
  - The Chief Wildlife Warden is **appointed** by the **State Government.**
- As per the Amendment, people possessing live specimens of scheduled animals must obtain a **registration certificate from the Management Authority.**
- The Amendment has an exception for 'live elephant' i.e. Commercial Trade In Live Elephants has been permitted.
  - The **(Wildlife (Protection) Act, 1972)** specifically prohibited trade in Wild Animals including captive and wild elephants.
- **For sanctuaries falling under Scheduled Areas** (where FRA 2006 is applicable and comes under the 5th Schedule), the management plan must be prepared after due consultation with the **Gram Sabha concerned**
- **States can declare areas adjacent** to National parks and Sanctuaries as **Conservation Reserve**, for protecting flora and fauna, and their habitat.
- The amendment has **increased the quantum of the penalty fee.**

Schedules	Information
Schedule I	Animal Species enjoying the highest level of protection
Schedule II	Animal species subject to a lesser degree of protection
Schedule III	Protected Plant species
Schedule IV	Specimens listed in the Appendices under CITES (scheduled specimens)

Pink pages
Include the critically endangered species. As the status of the species changes, new pages are sent to the subscribers.
Green pages
Used for those species that were formerly endangered but have now recovered to a point where they are no longer threatened.

- Animals listed in **schedule 5 are called "vermin"** which can be hunted. Mice, Rat, Common Crow and Flying Fox (Fruit Eating Bats) are included in schedule 5 (i.e., vermin).
- Cultivation, Collection, extraction, trade, etc. of Plants and its derivatives **listed in schedule 6 are prohibited.** Red Vanda, Blue Vanda, Kuth, Pitcher Plant, Beddomes Cycad and Ladies Slipper Orchid are the plants listed in this schedule.

4.12 INTERNATIONAL UNION FOR CONSERVATION OF NATURE (IUCN)

- IUCN is a membership union uniquely composed of both government and civil society organisations.
- Created in **1948,** it is the global authority on the status of the natural world and the measures needed to safeguard it.
- It's headquarter is in **Switzerland**.
- **The Red Data Book** was **first issued in 1966 by the IUCN's Species Survival Commission** as a guide for formulation, preservation and management of species listed.

4.12.1 Conservation Priorities

Data Deficient (DD)

A taxon 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 taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking.

Data Deficient is therefore **not a category of threat**.

Not Evaluated (NE)

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

Least Concern (LC)	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.
Near Threatened (NT)	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future
Vulnerable (VU)	A taxon is Vulnerable when the best available evidence indicates that it meets any of the following criteria: Reduction in population (> 50% over the last 10 years) Population size estimated to number fewer than 10,000 mature individuals, Probability of extinction in wild is at least 10% within 100 years, and Considered to be facing a high risk of extinction in the wild.
Endangered (EN)	A taxon is Endangered when the best available evidence indicates that it meets any of the following criteria: Reduction in population size (70% over the last 10 years), Population size estimated to number fewer than 250 mature individuals, Quantitative analysis showing the probability of extinction in wild in at least 20% within 20 years. Considered to be facing a very high risk of extinction in the wild
Critically Endangered (CR)	A taxon is Critically Endangered when the best available evidence indicates that it meets any of the following criteria: Reduction in population (> 90% over the last 10 years), Population size (number less than 50 mature individuals), Quantitative analysis showing the probability of extinction in wild in at least 50% in their 10 years) Considered to be facing an extremely high risk of extinction in the wild.
Extinct in the Wild (EW)	A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range.
Extinct (EX)	A taxon is Extinct when there is no reasonable doubt that the last individual has died.

Fig. 4.6

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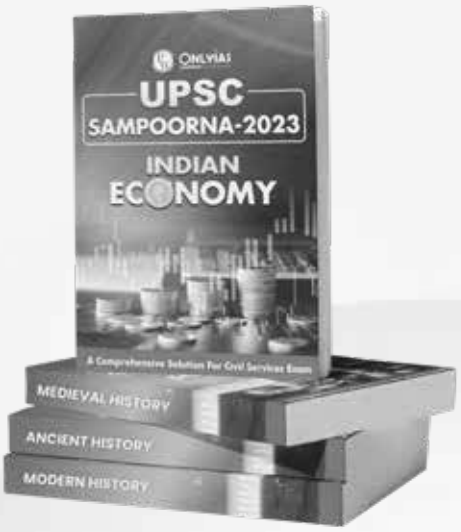
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5 Protected Areas

5.1 INTRODUCTION

- Conservation is the **planned management of natural resources to retain the balance in nature** and diversity. It emphasises the use of natural resources by accepting the idea of **sustainable development**. Conservation of biological diversity leads to conservation of essential ecological diversity to preserve the continuity of food chains.

> Recent surveys by **WWF** and **TRAFFIC** have identified 10 of the most widely trafficked animals in the Golden Triangle. These top 10 animals are: Tiger, Elephant, Pangolin, Bear, Rhinoceros, Serow, Helmeted Hornbill, Gaur, Leopard, and Turtles.

- **First serious attempt to protect wildlife and biodiversity at international level** was made in the year **1992** at the first Earth Summit, known as **Rio Summit**, held in **Rio de Janeiro (Brazil)** under the aegis of UN for the protection of Earth and its environment, maintenance of ecological balance and to enrich biodiversity.
- **Term "protected area"** includes marine protected areas, the boundaries of which will include some areas of ocean, and **Transboundary Protected Areas** that overlap multiple countries which remove the borders inside the area for conservation and economic purposes.

5.1.1 Reserved and Protected Forests

- Reserved forests and protected forests differ in one important way i.e.,
  - Rights to all activities like hunting, grazing, etc. in reserved forests are banned unless specific orders are issued otherwise.
  - In protected areas, rights to activities like hunting and grazing are sometimes given to communities living on the fringes of the forest, who sustain their livelihood from forest resources or products.
- **Satpura National Park in Madhya Pradesh** was the **country's first reserve forest.**
- Typically, reserved forests are often upgraded to the status of wildlife sanctuaries, which in turn may be upgraded to the status of national parks, with each category receiving a higher degree of protection and government funding.

5.1.2 Wildlife Sanctuaries

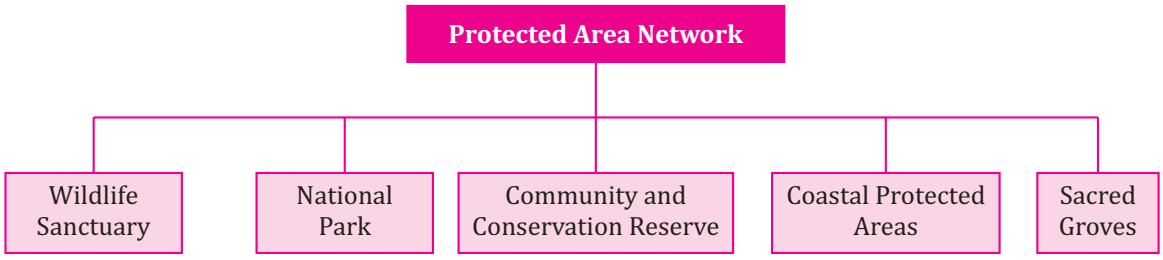


Fig. 5.1

- The **Wildlife (Protection) Act of 1972** provided for the declaration of certain areas by the **State Government** as **wildlife sanctuaries** if the area was thought to be of adequate ecological, geomorphological and natural significance.
- Some restricted human activities are allowed inside the Sanctuary area.
- It can be any area other than area within reserve forest or the territorial waters.

- As of December 2020, UT of **Andaman & Nicobar Islands (96) has the highest** number of Wildlife Sanctuary, followed by Maharashtra (48) and Karnataka (35).
- **Asola Bhatti Wildlife Sanctuary** is the only sanctuary situated in **Delhi**.
- Among the North-eastern states, **Assam** has the highest number of Wildlife sanctuaries.

5.1.3 National Park

- An area, whether within a sanctuary or not, can be **notified by the state government** to be constituted as a National Park, by reason of its ecological, faunal, floral, geomorphological, or zoological association or importance, needed to for the purpose of protecting & propagating or developing wildlife therein or its environment.
- **No human activity is permitted** inside the national park except for the ones permitted by the Chief Wildlife Warden of the state under the conditions given in WPA 1972.
- Both the Central and State governments can declare any area within or outside any reserve forest as a WL sanctuary or national park (under the provisions of Wildlife Protection Act 1972).
- **No alteration** of boundaries of a sanctuary/National Park shall be made **except on recommendation of the National Board for Wildlife.**
- **First NP in India** was established in 1936 at the Jim Corbett NP (Uttarakhand).
- **Hemis National Park in Ladakh** is the **largest** national park in India followed by Desert National Park in Rajasthan.

Basis of Comparison	National Park	Wildlife Sanctuary
Degree of Protection	Greater	Lesser
Statute	WPA 1972	WPA 1972
Boundaries	circumscribed by legislation.	Boundaries are sacrosanct
Activities like grazing of livestock, hunting, forestry etc.	Prohibited	Allowed
Established for a Particular Species	No (habitat specific conservation)	Yes (species specific conservation)
Protected area management under IUCN	Category II	Category IV

Protected Areas as Provided Under WPA 1972					
Parameter	**Wildlife Sanctuary**	**National Park**	**Conservation Reserve**	**Community Reserve**	**Tiger Reserve**
Year of formation	Wildlife Protection Act (1972)	Wildlife Protection Act (1972)	Amendment to the Wildlife Protection Act in 2003	Amendment to the Wildlife Protection Act in 2003	Amendment to WPA in 2006 provides for statutory authority known as NTCA.
Declared by	State government by notification	State government by notification	State govt after having consultations with local communities	State govt after having consultations with local communities	State government on recommendation of NTCA

Protected Areas as Provided Under WPA 1972					
Parameter	**Wildlife Sanctuary**	**National Park**	**Conservation Reserve**	**Community Reserve**	**Tiger Reserve**
Area	Areas that are considered to be of adequate ecological, geomorphological and natural significance	Areas that are considered to be of adequate ecological, geomorphological and natural significance	These are areas owned by the state government adjacent to national parks and sanctuaries for protecting the landscape, seascape and habitats.	Any community or private land provided members are agreeable to offer the land, it aims to improve socio economic conditions of the people living in such areas.	Area if critical tiger habitat and peripheral area for the purpose of tiger conservation without affecting the rights of STs or other forest dwellers.
Boundary Alteration	No alteration of boundaries in Wildlife Sanctuaries can be done without approval of the NBWL.	No alteration of boundaries in National Park can be done without approval of the NBWL.	—	—	No alteration of boundaries in Tiger reserve can be done without approval of the NTCA.
Management	Chief Wildlife Warden	Chief Wildlife Warden	Conservation Reserve Management Committee	Conservation Reserve Management Committee	NTCA
State boards for wildlife at the state level					
Advice the state governments in selection and management of protected areas and other matters connected with the protection of wildlife. It is headed by Chief Minister, with the Forest Minister of the State as the Vice Chair.					

5.1.4 Conservation Reserves

- It is an **area owned by the State Government adjacent to National Parks and Sanctuaries** for protecting landscape, seascape and habitat of fauna and flora.
- They typically **act as buffer zones to or connectors and migration corridors** between established national parks, wildlife sanctuaries and reserved and protected forests of India.
- Such areas are **designated as conservation areas if they are uninhabited and completely owned by the GOI** but used for subsistence by communities and community areas if part of the lands are privately owned.

Chief Wildlife Warden

A statutory authority under Wildlife (Protection) Act, 1972 (WPA) that heads Wildlife Wing of Forest Department.

The authority shall control, manage and maintain all Protected Areas.

It may grant permit to enter or reside in a sanctuary/ national park for all or any of the following purposes:

Investigation or study of wildlife,

Photography,

Scientific research,

Tourism,

Transaction of lawful business,

Residing in the protected areas.

- **The State Government** may, after having **consultations with the local communities**, declare any area owned by the Government as a conservation reserve.
- It is managed through a **Conservation Reserve Management Committee**.
- The **rights of people living inside a Conservation Reserve are not affected**.
- These protected area categories were **first introduced in the Wildlife (Protection) Amendment Act of 2003.**
  - The amendment provided for a **mechanism to provide recognition and legal backing** to the **community-initiated efforts in wild-life protection** without compromising the community's needs**.**
- In 2005, **Tiruppadaimarathur Conservation Reserve in Tamil Nadu** was declared country' first conservation reserve.

5.1.5 Community Reserves

- **State Government may notify** any community land or private land as a community reserve, provided that the members of the community or individuals concerned are agreeable to offer such areas for protecting the fauna and flora, as well as their traditions, cultures and practices.
- The Reserve is managed through a **Community Reserve Management Committee**.
  - Without a resolution passed by the Management Committee and approval of the same by the State Government **no change in land use pattern** can be made.
- The **rights of people living inside a Community Reserve are not affected**.
- **Kokkare-Bellur (2007) in Karnataka** was declared India's first Community Reserve**.**
- As per the National Wildlife Database, Jan. 2023, there are **220 existing Community Reserves in India** covering an area of 1455.16 km^2, which is **0.04% of the geographical area of the country**.
- **Nagaland has the most number (114)** of community reserves in India.

5.1.6 Eco Sensitive Zones

- Eco-Sensitive Zones or Ecologically Fragile Areas are **areas within 10 kms around Protected Areas, National Parks and Wildlife Sanctuaries.**
- ESZs are **notified by MoEF&CC**, Union Government, **under Environment Protection Act of 1986**.
- In case of places with sensitive corridors, connectivity and ecologically important patches, **even area beyond 10 km width can also be included** in the eco-sensitive zone.
- The aim of notifying an area as ESZ is **to regulate certain activities around National Parks and Wildlife Sanctuaries** for minimising the **negative impacts** of such activities on the fragile ecosystem encompassing the protected areas.

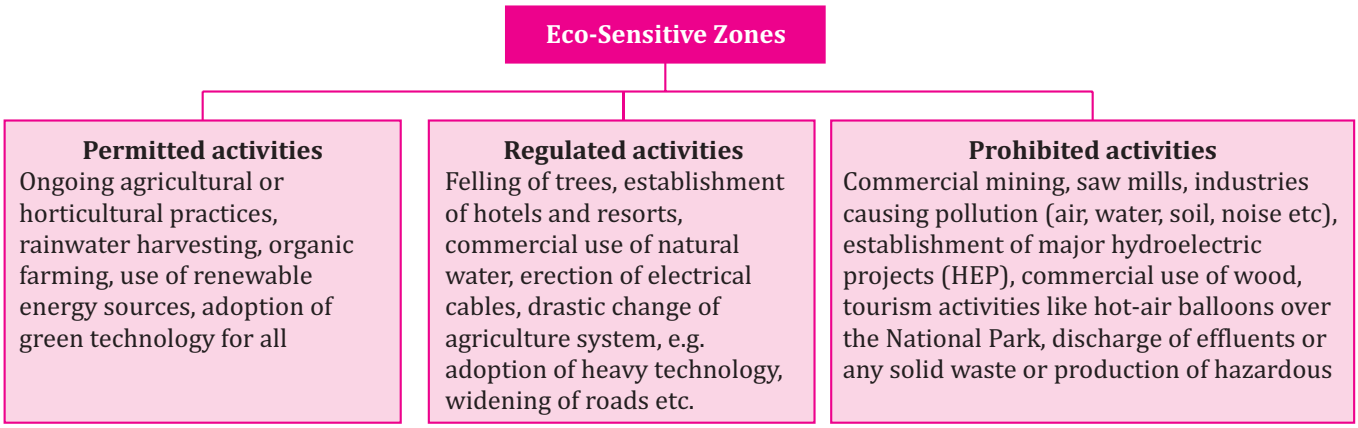


Fig. 5.2

5.1.7 Marine Protected Area (MPA)

- MPAs are defined as "any area of **intertidal or subtidal terrain**, together with its overlaying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment".
- MPAs were notified under **Wildlife (Protection), Amendment Act of 2002.**
- These places are **given special protections for natural or historic marine resources** by local, state, territorial, native, regional, or national authorities.
- To achieve **National Biodiversity Target 2** and **Aichi Biodiversity Target 11**, India has identified and prioritized 106 coastal and marine sites as Important Coastal and Marine Areas (ICMBAs) by the Wildlife Institute of India.
- Marine Protected Areas are primarily classified into following three categories:
  - **Category I:** Covers National Parks and Sanctuaries having entire areas in intertidal/sub-tidal or mangroves, coral reefs, creeks, seagrass beds, algal beds, estuaries, lagoons.
  - **Category II:** includes Islands, which have major parts in marine ecosystem and some part in terrestrial ecosystem.
  - **Category III has two sub-categories of which IIIA** includes sandy beaches beyond intertidal line but occasionally interacting with the seawater and **IIIB** includes evergreen or semi evergreen forests of islands.
- **A Marine Protected Area can be:**
  - **National Park:** Gulf of Kachchh- Marine in Gujarat, Gulf of Mannar- Marine in Tamil Nadu.
  - **Community Reserve**: Kadalundi Vallikkunnu in Kerala.
  - **Wildlife Sanctuary**: West Sundarbans in West Bengal, Gahirmatha in Odisha, Pulicat Lake in Andhra Pradesh.
  - **Conservation Reserve**: A. Attakoya Thangal Marine, Dr. K.K. Mohammed Koya Sea Cucumber, P.M. Sayeed Marine Birds in Lakshadweep.

5.1.8 Sacred Groves

- Sacred Groves were notified under **Wildlife (Protection), Amendment Act, 2002** as patches of forests or natural vegetation, few trees or forests of several acres that are usually **dedicated to local folk deities** (protected by local communities).

Local Names for Sacred Groves

Kaavu in Malayalam
Koyil kaadu in Tamil
Orans in Rajasthan
Devara Kaadu in Karnataka
Sernas in Madhya Pradesh
Devarai in Maharashtra

- The degree of sanctity of the sacred forests varies from one grove to another. People believe any kind of disturbances would offend the local deity and thereby causing natural calamities, diseases of crops.
- **Traditional Grove** - The grove where a village deity resides, who is represented by an elementary symbol.
- **Temple Grove** - The grove which is created around a temple Groves around the burial or cremation grounds.
- Sacred groves are ecologically significant as they help in **conservation of biodiversity, recharge of aquifers, soil conservation through vegetation cover**.
- Diminishing traditional belief systems, rapid urbanisation and development, Sanskritization, Invasion by exotic weeds (such as Lantana camara, Prosopis juliflora), Increasing livestock and fuelwood collection are serious threats that Sacred Groves face today.

Trans-Boundary Protected Areas		
India has identified **12 protected areas as trans-boundary protected areas** under the framework of the **IUCN Transboundary Protected Area programme.** Two of these sites are **MPAs** i.e., **Sundarbans National Park and Gulf of Mannar Biosphere Reserve.**		
Type 1	**Type 2**	**Type 3**
Transboundary Protected Area is a clearly defined geographical space that consists of protected areas that are ecologically connected across one or more international boundaries and involves some form of cooperation.	**Transboundary Conservation Landscape and/ or Seascape** is an ecologically connected area that sustains ecological processes and crosses one or more international boundaries, and which includes both protected areas and multiple resource use areas and involves some form of cooperation.	**Transboundary Migration Conservation Areas** are Wildlife habitats in two or more countries that are necessary to sustain populations of migratory species and involve some form of cooperation.
Park for Peace: A Park for Peace is a special designation that may be applied to any of the three types of Transboundary Conservation Areas, and is dedicated to the promotion, celebration and/or commemoration of peace and cooperation.		

5.2 BIOSPHERE RESERVE

- **The International Coordinating Council** (ICC) of **UNESCO**, **in 1971**, introduced the designation **'Biosphere Reserve'** for natural and cultural landscapes extending over a large area of terrestrial or coastal/marine ecosystems or a combination thereof.

Man & Biosphere Programme

An intergovernmental scientific programme, launched in 1971 by UNESCO, that aims to establish a scientific basis for the improvement of relationships between people and their environments.

The first biosphere reserve of the world was established in 1979, since then the network of biosphere reserves has increased to 738 biosphere reserves in 134 countries.

- Biosphere reserves are **learning places for sustainable development**. They are sites for testing interdisciplinary approaches for understanding and managing changes and interactions between social and ecological systems, including conflict prevention and management of biodiversity.
- Biosphere reserves are **large areas of protected land for conservation of wildlife, plant and animal resources and traditional life of the tribes living in the area.**
- Biosphere reserves are **sites established by countries and recognized under UNESCO's Man and the Biosphere (MAB) Programme (since 1971)** to promote sustainable development based on local community efforts and sound science.
- **The Government of India** also initiated this in **1986** to ensure participation of local inhabitants in conservation of the ecosystem without compromising their livelihood.
    - While Nilgiri Biosphere Reserve (Est. 1986) was the country's **first** Biosphere Reserve, Gulf of Mannar is the **largest** and Panna is the **smallest.**
- Biosphere Reserve (BR) **is not intended to replace existing protected areas,** but it widens the scope of 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 BR **without any change in their legal status**.
- 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.

5.2.1 Criteria for Selection of Biosphere Reserves

- **Primary Criteria**
    - Protected and minimally disturbed core area.
    - Ability to sustain viable populations representing all trophic levels, in core area.
    - Involvement of local communities to link biodiversity conservation and socio-economic development.
- **Secondary Criteria**
    - Presence of rare and endangered species.
    - Presence of micro-climatic conditions, diverse soil and indigenous varieties of biota
    - Preservation of traditional tribal or rural modes of living for harmonious use of environment

5.2.2 Functions of Biosphere Reserve

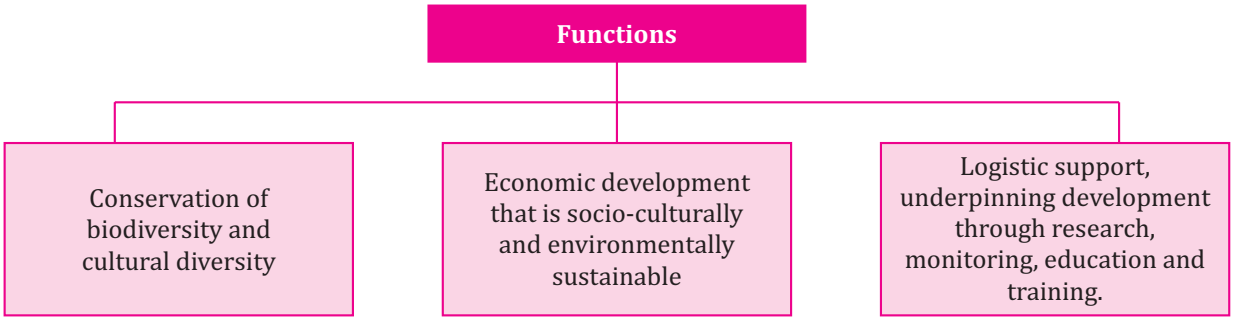


Fig. 5.3

5.2.3 Zonation of BR

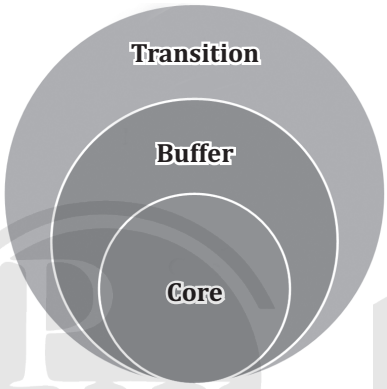


Fig. 5.4

- **Transition Area:** Outermost region where community's foster socio-culturally and ecologically sustainable economic and human activities.
- **Buffer Zones:** Adjoining region around the core area(s), may also accommodate education, training, tourism, and recreation facilities. In many biospheres reserves the buffer zone is regarded as an area in which human use is less intensive than what might be found in the transition zone and is used for scientific research.
- **Core Areas:** The core areas of biosphere reserves are strictly protected zones which are often public lands with legal protection, such as a previously designated national park, wilderness area or wildlife refuge. However, the core area may be privately owned or belong to non-governmental organisations.

Biosphere Reserves in India (18)		
Sr.	**Name and Year**	**Details**
1.	**Nilgiri*** 1986	• World Natural Heritage Site • Nilgiri Biosphere Reserve is the **first to be designated** as a Biosphere Reserve in India. • **Fauna**: Nilgiri Tahr, Lion-tailed Macaque, Malabar Pied Hornbill, Elephant, Tiger. • **Location**: Part of Wayanad, Nagarhole, Bandipur and Mudumalai, Nilambur, Silent Valley and Siruvani hills (**Tamil Nadu, Kerala and Karnataka**).
2.	**Nanda Devi*** 1988	• Declared World Natural Heritage Site • **Fauna**: Snow Leopard, Musk deer, Himalayan black bear, Brown Bear. • **Location**: Part of Chamoli, Pithoragarh, and Bageshwar districts, **Uttarakhand**.
3.	**Nokrek*** 1988	• **Fauna**: Hoolock Gibbons, Clouded Leopard, Elephant, Barking Deer. • **Location**: Part of Garo hills, **Meghalaya.**
4.	**Gulf of Mannar*** 1989	• First marine Biosphere Reserve in India. Falls within the Indo-Malayan realm • **Fauna**: Dugong, Whale Shark, Hawksbill sea turtle. • **Location**: Indian part of Gulf of Mannar between **India** and **Sri Lanka (Tamil Nadu).**
5.	**Sundarbans*** 1989	• World Natural Heritage site • **Fauna**: Royal Bengal Tiger, Ganges and Irrawaddy Dolphins, Terrapin, Estuarine crocodiles. • **Location**: Part of delta of Ganges and Brahmaputra river system, **West Bengal**.

Biosphere Reserves in India (18)		
Sr.	**Name and Year**	**Details**
6.	**Manas** 1989	• World Natural Heritage site • **Fauna**: Pygmy hog, Golden Langur, Hispid hare, Bengal Florican. • **Location**: Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamprup and Darang districts, **Assam.**
7.	**Great Nicobar*** 1989	• **Fauna**: Nicobar tree shrew, Nicobar crab-eating macaque, Dugong, saltwater crocodile. • **Location**: Southernmost islands of Andaman And Nicobar (**A&N Islands**).
8.	**Simlipal*** 1994	• The biosphere reserve has the largest zone of Sal in all of India. • **Fauna**: Royal Bengal Tiger, Asiatic Elephant, Leopard. • **Location**: Part of Mayurbhanj district, **Orissa**.
9.	**Dibru-Saikhowa** 1997	• Smallest Biosphere Reserve in India is Dibru-Saikhowa in **Assam**. • **Fauna**: Tiger, Elephant, Assamese Macaque, Sambar, Barking Deer, Water Buffaloes. • **Location**: Part of Dibrugarh and Tinsukia Districts, **Assam.**
10.	**Dehang-Dibang** 1998	• **Fauna**: Leopard-Clouded, Common, Spotted, Himalayan Black Deer, Indian Wild Dog. • **Location**: Part of Siang and Dibang Valley in **Arunachal Pradesh**.
11.	**Pachmarhi*** 1999	• **Fauna**: Indian Giant Squirrels, Flying Squirrels, Gaur, tiger, Nilgai • **Note**: Pachmarhi BR area is often recognized as **"Genetic Express Highway"** linking two biological hotspots of the country viz. Eastern Himalayas and Western Ghats, also as confluence of northern and southern type of vegetation. • **Location**: Parts of Betul, Hoshangabad and Chhindwara districts of **Madhya Pradesh.**
12.	**Khangchend-zonga*** 2000	• India's **first Mixed Heritage Site.** • **Fauna**: Himalayan- Tahr, Black Bear, Blue Sheep, Red panda, Snow Leopard. • **Location**: Parts of Khangchendzonga hills and **Sikkim**.
13.	**Agasthyamalai*** 2001	• Part of **"Hottest biodiversity hotspots"** • World Natural Heritage Site. • **Fauna**: Bengal Tiger, Asiatic Elephant, Nilgiri Tahr. • **Location**: Neyyar, Peppara and Shendurney Wildlife Sanctuaries and their adjoining areas in **Kerala**.
14.	**Achanakmar -Amarkantak*** 2005	• **Fauna**: Indian Wild Dog, Sarus Crane, White-backed Vulture, Sacred grove Bush frog. • **Location**: Covers parts of Anuppur and Dindori districts of **M.P**. and parts of Bilaspur districts of **Chhattisgarh State**.
15.	**Great Rann of Kutch** 2008	• The **largest Biosphere reserve in India** is the Gulf of Kachchh, Gujarat. • **Fauna**: Indian Wild Ass, Great Indian Bustard • **Location**: Part of Kachchh, Rajkot, Surendra Nagar and Patan Civil Districts of **Gujarat.**
16.	**Cold Desert** 2009	• **Fauna**: Tibetan Gazelle, Snow Leopard, Himalayan Ibex, Red fox • **Location**: Pin Valley National Park and surroundings; Chandratal and Sarchu & Kibber Wildlife Sanctuary in **Himachal Pradesh.**
17.	**Seshachalam Hills** 2010	• **Fauna**: Golden Gecko, Slender Loris • **Location**: Seshachalam Hill Ranges covering parts of Chittoor and Kadapa districts of **Andhra Pradesh.**
18.	**Panna*** 2011	• **Fauna**: Bengal Tiger, Nilgai, Leopard, Chinkara, Chital • **Location**: Part of Panna and Chhatarpur districts in **Madhya Pradesh.**
Note: * marked BRs of India are included in **World Network of Biosphere Reserve - UNESCO'S MAB programme.**		

5.2.4 World Network of Biosphere Reserve

- In order to facilitate cooperation, BRs are admitted into international networks by **International Coordinating Council** (ICC) of the **Man and Biosphere** (MAB) **Programme of UNESCO** on the request of the participating country subject to their fulfilment of prescribed criteria.
- The **BRs remain under the sole sovereignty of the concerned country/state** where it is situated, and **participation in the World Network is voluntary.**
- **Exit Strategy:** The **MAB Council** can decide to withdraw sites from the **World Network of Biosphere Reserves** if such sites do not, or no longer, function as a Biosphere Reserve due to non- compliance with the new strategy by the state. **Bulgaria** asked for the withdrawal of four sites: **Ali Botouch**, **Dupki- Djindjic Itza**, **Mantaritza** and **Parangalitsa**.

5.3 BIODIVERSITY HOTSPOTS

- British biologist **Norman Myers coined the term "biodiversity hotspot" in 1988** as a biogeographic region characterised both by exceptional levels of plant endemism and by serious levels of habitat loss.
- **Conservation International** (CI) **adopted Myers' hotspots** and in 1996, the organisation made the decision to undertake a reassessment of the hotspots concept.
- According to CI, to qualify as a hotspot a region must meet two strict criteria:
  - at least **1,500 species** of vascular plants (> 0.5% of the world's total) as endemics.
  - lost at least **70%** of its original habitat (It must have 30% or less of its original natural vegetation).
- Biodiversity hotspots cover only **2.3% of the Earth's land surface**. Madagascar, Philippines, Sundaland, Brazil's Atlantic Forest, Caribbean, Indo-Burma, Western Ghats and Sri Lanka, Eastern Arc & Coastal Forests of Tanzania/Kenya **eight Hottest Hot Spots.**
  - **Five key factors have been considered for defining the above 8 hot spots:** Endemic plants, Endemic vertebrates**,** Endemic plants/area ratio**,** Endemic vertebrates/area ratio**,** Remaining primary vegetation as % of original extent.

Biodiversity Cold Spots

Areas that have relatively low biological diversity but are also experiencing a high rate of habitat loss.

Although a biodiversity cold spot is low in species richness, it can also be important to conserve, as it may be the only location where a rare species is found.

Extreme physical environments (low or high temperatures or pressures, or unusual chemical composition) inhabited by just one or two specially adapted species are cold spots that warrant conservation because they represent unique environments that are biologically and physically interesting.

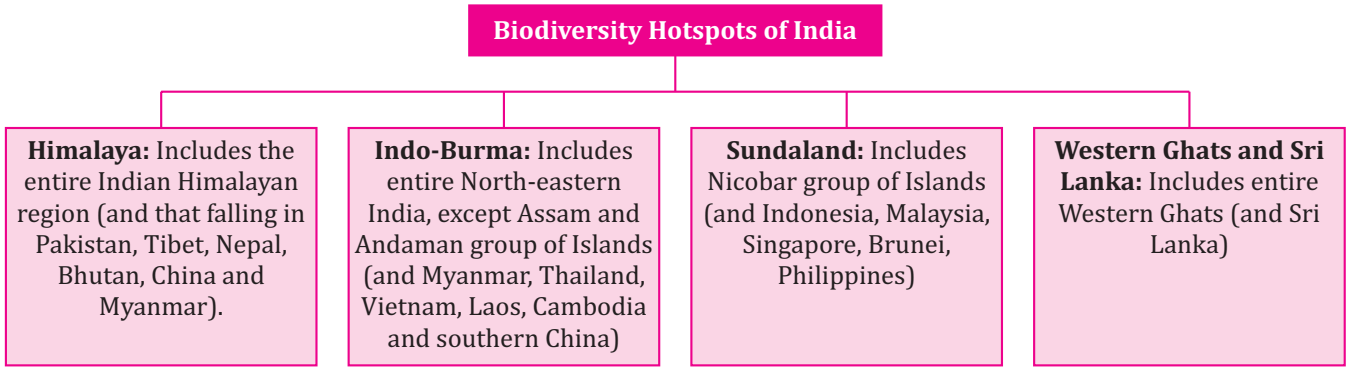


Fig. 5.5

5.3.1 Key Biodiversity Areas

- Key Biodiversity Areas (KBAs) is an **umbrella term commonly used to include areas that contribute to the global persistence of biodiversity,** including vital habitat for threatened plant and animal species in terrestrial, freshwater and marine ecosystems.
- **Globally KBAs are designated based on criteria defined under five broad categories**: Threatened biodiversity, geographically restricted biodiversity, Ecological integrity, Biological processes, Irreplaceability.

- The criteria for designating a site as KBA have been **described by IUCN.** IUCN identifies 531 KBA sites in India but these have **no legal basis.**

Important Bird Areas

Bird Life International

Bird Life International is a global partnership of conservation organisations that strives to conserve birds, their habitats, and global biodiversity, working with people towards sustainability in the use of natural resources.

It is the **world's largest partnership of conservation organisations**, with over 120 partner organisations.

Bird Life International is the **official Red List authority for birds** for the IUCN.

It identifies the sites known/referred to as **Important Bird and Biodiversity Areas**.

- The IBA **programme of Birdlife International** aims to identify, monitor and protect a global network of IBAs for conservation of the world's birds and associated biodiversity.
- According to Birdlife International, designation of IBAs is based on standardised criteria, namely:
- Hold significant numbers of one or more globally threatened bird species,
- Be one of a set of sites that together hold a suite of restricted-range species or biome restricted species
- Have exceptionally large numbers of migratory or congregatory birds.
- **Bombay Natural History Society** (BNHS) and **Birdlife International** have identified **467 IBAs** in India.
  - BNHS, founded in **1883**, is **one of the largest NGO in India engaged in conservation and biodiversity research**.

5.4 WORLD HERITAGE SITES

- A World Heritage Site is a landmark or area with legal protection by an international convention administered by the **UNESCO**.
- World Heritage Sites are designated by UNESCO for having cultural, historical, scientific or other forms of significance.
- To be included on the World Heritage List, sites must be of outstanding universal value and meet at least one out of ten selection criteria.
- World Heritage Sites are the places on Earth that are of outstanding universal value to humanity.

7 Natural World Heritage Sites

Kaziranga National Park
Keoladeo National Park
Manas Wildlife Sanctuary
Sunderbans National Park
Nanda Devi and Valley of Flowers National Park
Western Ghats
Great Himalayan National Park

- The **Convention on the Protection of the World Cultural and Natural Heritage, adopted by UNESCO in 1972**, provides a framework for protection of Cultural and Natural Heritages across the world.
- **Under Biological Diversity Act,** 2002 (BDA) the State Government in consultation with local bodies may notify areas of biodiversity importance as Biodiversity Heritage Sites.
- There are total **40 World Heritage Sites** in India:
  - 32 Cultural Sites
  - 7 Natural Sites
  - 1 Mixed Site (Khangchendzonga National Park)
- **19** of the **36 States and UTs** are home to the World Heritage Sites, with **Maharashtra** having the highest number of sites i.e., **5**.

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6 Conservation Projects and Programmes

6.1 PROJECT TIGER

- **Tiger Reserve** are areas that are notified for the protection of the tiger and its prey and are governed by Project Tiger which was launched in the country in 1973 from **Jim Corbett** National Park of Uttarakhand as a Centrally Sponsored Scheme.

Tiger Task Force

Based on the recommendations of the **National Board for Wildlife**, a task force was set up to look into the **problems of tiger conservation** in the country.

The recommendations of the Task Force include **strengthening Project Tiger** by giving it statutory and administrative powers.

- **Its objective** was to protect **'Endangered' Tiger population** from extinction by ensuring a viable population in their natural habitats.
- Tiger is an **Umbrella species.** Protection of these species indirectly protects the many other species that make up the ecological community of its habitat.
- **Tiger is Schedule 1 animal** under Wildlife Protection Act, 1972 and in no case, the **tiger can be declared vermin**.
- Tiger can be killed under two conditions of **being diseased or disabled beyond recovery and being a threat to human life.**
- The scientific name for the tiger is **Panthera Tigris** which is found in **eight subspecies.**
  - While 5 subspecies, named after the region, they belong to, i.e., Bengal, South China, Indochinese, Sumatran, and Siberian are present in the wild.
  - The **Caspian, Bali, and Javan are extinct**.

Buffer Zone

Peripheral area to critical tiger habitat or core area, where a lesser degree of habitat protection is required to ensure the integrity of the critical tiger habitat with adequate dispersal for tiger species.

Aims at promoting co-existence between wildlife and human activity with due recognition of the livelihood, developmental, social and cultural rights of the local people.

The limits of such areas are determined on the basis of **scientific and objective criteria** in consultation with the concerned **Gram Sabha** and an **Expert Committee**.

No alteration in the boundaries of a tiger reserve shall be made **except on a recommendation of the NTCA and the approval of the National Board for Wild Life.**

Core Zone

Critical tiger habitat areas established, on the basis of scientific and objective criteria.

These areas are required to be kept as inviolate for the purposes of tiger conservation, without affecting the rights of the Scheduled Tribes or such other forest dwellers.

These areas are notified by the State Government in consultation with an Expert Committee (constituted for that purpose).

Critical Wildlife Habitats (CWHs) have been envisaged in **Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006.**

Fig. 6.1

- There are **53 tiger reserves in India** (Oct 2021) that are governed by Project Tiger, administrated by the NTCA.
  - **Rajasthan has become the first state to launch project Leopard** to conserve it by improving their prey base, mitigating man and leopard conflict and controlling poaching.
- In October 2021, NTCA designated the combined areas of the **Guru Ghasidas National Park** (last known habitat of the Asiatic cheetah) and **Tamor Pingla Wildlife Sanctuary in Chhattisgarh** as the 53rd Tiger Reserve of the country.
- **Largest Tiger Reserve in India**: **Nagarjunsagar-Srisailam Tiger Reserve** (Andhra Pradesh, Telangana).
- **Smallest Tiger Reserve in India**: **Bor Tiger Reserve** (Maharashtra).
- A tiger reserve is demarcated based on **core-buffer strategy.**

6.1.1 Tiger Census 2018

- Every 4 years, NTCA conducts a tiger census across India. First was conducted in 2006, followed by 2010, 2014 and in 2018.

Global Tiger Initiative (2008)

An initiative of the **World Bank** to bring global partners together to strengthen Tiger conservation.

- Tiger census uses **Pugmark technique, Camera trapping**, **M-STrIPES** (Monitoring System for Tigers-Intensive Protection & Ecological Status) etc.
- India is home to **80 percent** of tigers in the world. In **2006**, there were **1,411 tigers** which increased to **1,706** in **2010**, **2,226** in **2014** and **2967** in **2018**.
- The Census found Madhya Pradesh (526), Karnataka (524) and Uttarakhand (442) to be **top 3 States** in terms of Tiger population.

Global Tiger Forum (GTF)

- GTF is an **inter-governmental international body** established in 1993; at **New Delhi** with the objective to protect the Tigers in their habitats.
- It is the **only Inter-Governmental body to save the tiger worldwide**.
- Tiger range countries are its members.

- Census did not record any Tigers in **Buxa** (West-Bengal), **Palamau** (Jharkhand) and **Dampa** (Mizoram) **Tiger Reserves**.

Asian Elephants

There are **three subspecies of Asian elephant** which are the **Indian, Sumatran and Sri Lankan**.The Indian subspecies has the widest range and accounts for the majority of the remaining elephants on the continent.**Global Population is e**stimated between 20,000 to 40,000. **IUCN Red List** have them as **Endangered,** Wildlife (Protection) Act, 1972 under **Schedule I** and CITES **in Appendix I.**

African Elephants

There are two subspecies of African elephants, the Savanna (or bush) elephant and the Forest elephant.**Global Population is estimated a**round 4,00,000. **IUCN Red List Status** have African Savanna as **Endangered and** African Forest Elephant as **Critically Endangered**. **CITES** puts them in **Appendix II.**

Fig. 6.2

6.1.2 Petersburg Tiger Summit 2010 (TX2)

- **Leaders of 13 tiger range countries** resolved to double Tiger numbers in the wild, with a popular slogan **'Tx2'**. **The base year is 2006.**
- Goal has been set by the **World Wildlife Fund** (WWF) through the **Global Tiger Initiative, Global Tiger Forum,** and other critical platforms.
- **India achieved** its **St. Petersburg Declaration** target by doubling Tiger population (in 2019) ahead of the 2022 target.
- All **13 Tiger Range Countries** are in **Asia**, namely, India, Bangladesh, Bhutan, Cambodia, China, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Russia, Thailand and Vietnam.

6.1.3 Conservation Assured (CA) | Tiger Standards (TS) Asia

- CA|TS is a **conservation tool** that sets best **practices and standards** to manage Tigers and it has been implemented by the World **Wildlife Fund since 2003**.
- At present, only 2 sites are CA|TS compliant:
  - Chitwan National Park in Nepal &
  - Sikhote - Alin Nature Reserve in Russia.
- India became the **1st** among the **13 tiger range countries** to nationally adopt **CA|TS**.

6.2 PROJECT ELEPHANT

- It was launched in **1992** as a Centrally Sponsored Scheme for Asian elephant (**Endangered)** & African elephant (**Vulnerable)** for protecting these elephants, their habitat & corridors, preventing man-animal conflict and welfare of captive elephants.
- Project Elephant is being implemented in 16 states namely, Karnataka, Meghalaya, Tamil Nadu, Uttar Pradesh, Jharkhand, Maharashtra, Orissa, Uttarakhand, Chhattisgarh, Kerala Nagaland Tripura West Bengal, Andhra Pradesh, Arunachal Pradesh, Assam.
- MoEF&CC **provides financial & technical support** to wildlife management efforts by states.
- **GoI in the year 2010 declared Elephant as the National Heritage Animal** of the country on the recommendations of the standing committee of the National Board for Wildlife.
- As notified by the government, there are **around 32 elephant Reserves in India**. The very first elephant reserve or elephant sanctuary was the **Singhbhum Elephant Reserve of Jharkhand**.
- Indian elephant (**Elephas maximus)** is found in the central and southern Western Ghats, North-east India, eastern Indian and northern India and in some parts of southern peninsular India.
- Elephants have a **gestation period of 22 months, the longest for any mammal**. Females give birth every four to five years.
- Elephants are described as **Ecological Engineers** because they **create** and **maintain ecosystems** by physically changing habitats. Elephant society is **matriarchal**.

Gaj Yatra

- Aims at **securing 100 elephant corridors** across India.
- It is an initiative of **MoEF&CC** and the **Wildlife Trust of India** (WTI).

6.2.1 Elephant Census

- Elephant census is conducted **once in 5 years** under the aegis of **Project elephant**.
- In 2017 a population of **27312** elephants was estimated from 23 states in India.
- **Karnataka** has the **highest number of elephants** (6,049), followed by **Assam** (5,719) and **Kerala** (5706) - as per Census of 2017.

6.2.2 Elephant Corridors

- Narrow strips of land that allow elephants to move from one habitat to another.
- **Meghalaya** has maximum Intra-state elephant corridors.
- Jharkhand and Odisha share maximum inter-state corridors.
- Maximum International corridors India shares with **Bangladesh**.
- **Out of the total of 88 corridors**, 20 are in south India.

6.2.3 Other Attempts at Protection of Elephants

Monitoring of Illegal Killing of Elephants (MIKE)	• Started in **2003** by **CITES**. • **Objective**: to measure levels and trends in the illegal hunting of elephants. • **India has 10 MIKE sites** Chirang-Ripu, Dihing Patkai, Eastern Dooars, Deomali, Garo Hills, Mayurbhanj, Shivalik, Mysore, Nilgiri, Wayanad Elephant Reserve.
Haathi Mere Saathi' Campaign	• **The "Haathi Mere Saathi" Campaign** was launched by the **MoEF&CC** and the **Wildlife Trust of India** (WTI) at the **Elephant-8 Ministerial meeting Delhi**, in **2011**. • **E-8 countries** are India, Botswana, Congo, Indonesia, Kenya, Sri Lanka, Tanzania and Thailand

Project REHAB	• A pilot project **REHAB** (Reducing Elephant-Human Attacks using Bees) has been launched in **Karnataka** which entails installing bee boxes along the periphery of the forest and the villages to mitigate **human-elephant conflict**. • **Implementing Agency: Initiative of Khadi and Village Industries Commission** (KVIC).
Elephant Task Force	• The **Union government** constituted an **Elephant Task Force** (ETF) in **2010** under the leadership of **historian Mahesh Rangarajan** to review the existing policy of **elephant conservation in India and formulate future interventions.** • The task force came out with a **comprehensive report** in August that year**, called Gajah**: **Securing the Future for Elephants in India**.

6.3 VULTURE CONSERVATION

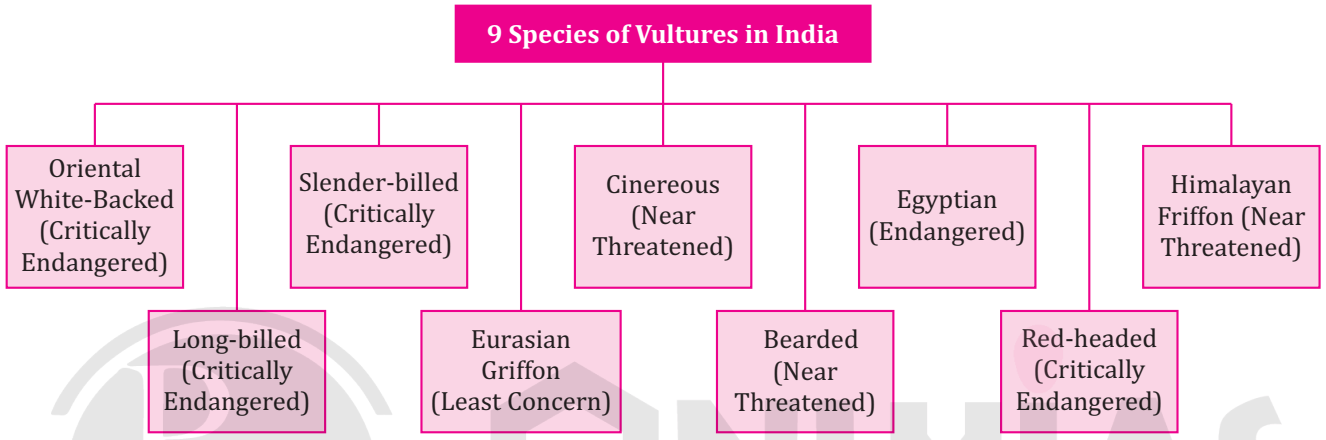


Fig. 6.3

- A vulture is a bird of prey that **scavenges** on carrion, and lives predominantly in the **tropics** and **subtropics**. Vultures are also known as **nature's clean-up crew**.
- Bearded, Long-billed, Slender-billed, Oriental white-backed are protected in the **Schedule-1 of the WPA 1972**. Others are protected under **Schedule IV**.
- In South Asia, mainly in **India** and Nepal, vultures have **declined dramatically** since the early 1990s.
- Use of **diclofenac**, a veterinary nonsteroidal anti-inflammatory drug (NSAID) in 2004, which is used to treat pain and inflammatory diseases such as gout in carcasses that vultures would feed off.
  - Drug **Diclofenac is** implicated as the main cause of vulture decline. It is banned and replaced by **Meloxicam.**
  - Vultures die of **kidney** (Renal) **failure** caused by Diclofenac poisoning.

6.3.1 Action Plan for Vulture Conservation (2020-2025)

- Plan was approved by the National Board for Wildlife (NBWL) for setting up Vulture Conservation & Breeding Centers (**VCBC**) **at Uttar Pradesh, Tripura, Maharashtra, Karnataka & Tamil Nadu**.
  - VCBC is a joint project of the Haryana Forest Department & the Bombay Natural History Society (BNHS).
  - VCBC aims to save **the three species of vultures from extinction, namely,** the White-backed vulture, Long-billed vulture and Slender-billed vulture.
- Establishment of at least one Vulture Safe Zone in each state and four rescue centres, in **Pinjore** (Haryana), **Bhopal** (Madhya Pradesh), **Guwahati** (Assam) and **Hyderabad** (Telangana).
- **Vulture Care Centre (VCC)** was set up at Pinjore, Haryana in 2001 to study the cause of deaths of vultures in India.
- **Jatayu Conservation Breeding Centre in Pinjore is the world's largest facility** within the state's Bir Shikargah Wildlife Sanctuary for the breeding and conservation of Indian vulture species.
- To save three critically important species **(Oriental White-backed, Long-billed and Slender-billed vulture)** from extinction through a single programme **Saving Asia's Vultures from Extinction** (SAVE) was initiated.

6.4 INDIAN (ONE HORN) RHINO VISION (IRV) 2020

- IRV was launched in **2005**, with support from WWF India and the **International Rhino Foundation** (IRF).
- It is implemented by **Assam State Government with the Bodo Autonomous Council** as an active partner for attaining a wild population of **at least 3,000** one-horned rhinos spread over seven protected areas in state of **Assam** by 2020.

Seven Protected Areas

- Kaziranga National Park
- Orang National Park
- Laokhowa Wildlife Sanctuary
- Manas National Park
- Bura Chapori Wildlife Sanctuary
- Pobitora Wildlife Reserve
- Dibru Saikhowa Wildlife Sanctuary

Vulture Safety Zones

Aim of developing **VSZs** is to establish **targeted awareness activities surrounding 150 km radius of vultures' colonies** so that no diclofenac or the veterinary toxic drugs are found in cattle carcasses, the main food of vultures (to provide safe food).

The VSZ is **spread around in several hundred kilometers covering the Jim Corbett in Uttarakhand, Dudhwa** and **Kartarniaghat forest reserves in UP** which is adjoining the Indo-Nepal border. **Nepal has already set up VSZ** on the Indian borders.

VSZ provides **safe source of food that is free of contamination from veterinary drugs, poisons and other agricultural chemicals.**

- Only the Great One-Horned Rhino is found in India. Also known as **Indian rhino, it is the largest of the rhino species**.
- **In India, rhinos are mainly found in** Assam, West Bengal and Uttar Pradesh.
- Assam has an estimated **2,640 rhinos in four protected areas**, i.e. **Pobitora Wildlife Reserve**, Rajiv Gandhi Orang National Park, Kaziranga National Park, and **Manas National Park.**
- **IUCN Red List** marks them as **Vulnerable**, **CITES** puts in **Appendix I** (Threatened with Extinction) and **Wildlife Protection Act, 1972** lists under **Schedule I.**

6.4.1 New Delhi Declaration on Asian Rhinos 2019

- The **five rhino range nations** (India, Bhutan, Nepal, Indonesia and Malaysia) have signed a declaration for the **conservation, review** and **protection** of the population of the Greater one horned, Javan and Sumatran rhinos every 4 years to reassess the need for joint actions to secure their future.
- **The National Rhino Conservation Strategy** was launched in 2019 to conserve the greater one-horned rhinoceros.

6.5 PROJECT SNOW LEOPARD

- It was launched in **2009,** to promote an inclusive and participatory approach to conserve snow leopards and their habitat and to safeguard & conserve India's unique natural heritage of high-altitude wildlife populations.
- As per the **IUCN Red List** they are Vulnerable, **CITES** puts them in **Appendix I** and **WPA (1972)** has listed them in **Schedule I.** They are also listed in the **Convention on Migratory Species** (CMS).
- Most of the Snow leopards are found in **China** followed by Mongolia and India.
- Snow leopards **act as an indicator of the health of the mountain ecosystem** in which they live, due to their position as the top predator in the food web.
- **Geographical range encompasses:**
  - Mountainous regions of **Central and Southern Asia.**
  - **Western Himalayas** i.e., Jammu and Kashmir, Himachal Pradesh.
  - **Eastern Himalayas** i.e., Uttarakhand and Sikkim and Arunachal Pradesh.
- Hemis National Park, Ladakh is the **biggest national park in India** and is regarded as **Snow**
- **Himal Sanrakshak** is a community volunteer programme, to protect snow leopards, launched in 2020.
- **The SECURE Himalaya** project was funded by **Global Environment Facility (GEF)- UNDP** for conservation of high-altitude biodiversity and reducing the dependency of local communities on the natural ecosystem.
- **Global Snow Leopard and Ecosystem Protection (GSLEP) Programme** is a high-level **intergovernmental** alliance of all the 12 snow leopard range countries. The snow leopard countries

are, India, Nepal, Bhutan, China, Mongolia, Russia, Pakistan, Afghanistan, Kyrgyzstan, Kazakhstan, Tajikistan, and Uzbekistan.

- Snow Leopard is **on the list of 21 critically endangered species for the recovery programme** of the MoEF&CC.
- Snow Leopard **Conservation Breeding Programme** is undertaken at **Padmaja Naidu Himalayan Zoological Park, Darjeeling, West Bengal.**
  - Species such as Snow Leopard, Asiatic Ibex, Tibetan Argali, Ladakh Urial, Chiru, Takin, Serow and Musk Deer will particularly benefit from this project.

6. 5.1 Project Secure Himalaya

- Launched in 2017 by Govt. of India in association with UNDP, the GEF -Global Environment Facility for securing livelihoods, conserve, restore & sustainably use Himalayan ecosystems.

Project Implemented in Specific Landscapes

1. **Changthang**: Jammu and Kashmir
2. **Lahaul**: Pangi and Kinnaur (Himachal Pradesh)
3. **Gangotri**: Govind & Darma Byans Valley (Uttarakhand)
4. **Kanchenjunga**: Upper Teesta Valley (Sikkim).

- It covers the high **Himalayan Ecosystem** spread over: Uttarakhand, Sikkim, Jammu & Kashmir and Himachal Pradesh.
- Also, **focused on** the protection of **snow leopard** & **other endangered species** and their habitats in Himalayas.
- Government also launched the India **Wildlife mobile App** and released the **National Wildlife Action Plan** for the period **2017-2031**.

6.6 PROJECT SEA TURTLE

- This project was **launched** in **2005** by MoEF&CC in association with UNDP and **implemented by Wildlife Institute of India, Dehradun.**

Olive Ridley Turtles

- **Status in IUCN Red List** is Vulnerable
- Largest Mass Nesting Site of Olive Ridley Turtles **is Odisha Coast.**
- **Habitat**: Warm Waters of Pacific Ocean, Atlantic Ocean and the Indian Ocean

- **Sea turtles** are protected under the WPA of 1972, under **Schedule I Part II.**
- Leatherback tortoise, Haskabile tortoise, Loggerhead tortoise, Green turtle, Olive Ridley tortoise are the turtles found in India.
- **Operation Kachhapa** was launched in 1998 by The Wildlife Protection Society of India to reduce turtle mortality and try to safeguard the future of Olive Ridley Sea Turtle.
- **Operation Save Kurma** was conducted to combat the proliferating illegal trade of live turtles and its parts from the country to destinations abroad.
- **Arribada** is the unique mass nesting of Olive Ridley Turtles (female turtles assemble on the same beach to lay eggs).
- Leatherback sea turtles can travel more than **10,000 miles** every year. Female turtles lay their eggs at the same beach on which they were born. Green turtles can hold their breath for up to **5 hours**.

6.7 PROJECT CROCODILE

- **The project was launched** in 1975 by **GoI** in association with **UNDP**, **FAO** with following objectives:
  - Protecting the remaining population of crocodilians.
  - Enhancing their population through 'rear & release' technique.
  - promoting captive breeding.
- Central Crocodile Breeding & Management Training Institute is located at Hyderabad, Telangana.
- There are **three crocodilians** species found in **India**.

Mugger Marsh or Crocodile

The **mugger** is an egg-laying and hole-nesting species. mugger is also known to be dangerous. It is already **extinct in Bhutan and Myanmar.**

Habitat: It is mainly restricted to the Indian subcontinent where it may be found in a number of freshwater habitat types including rivers, lakes and marshes.

IUCN status for Crocodile is **Vulnerable,** CITES put it in **Appendix I and** Wildlife Protection Act, 1972 has under **Schedule I.**

Estuarine or Saltwater Crocodile

It is considered as the Earth's largest living crocodile species. The **estuarine crocodile** is infamous globally as a known **man-eater**.

Habitat: It is found in Odisha's **Bhitarkanika National Park**, the **Sundarbans** in West Bengal and the Andamans and Nicobar Islands. It is also found across Southeast Asia and northern Australia.

IUCN considers it **Least Concern, CITES** notes it under **Appendix I** (except the populations of Australia, Indonesia and Papua New Guinea, which are included in Appendix II) and **Wildlife Protection Act, 1972 lists it in Schedule I.**

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Fig. 6.4

6.8 PROJECT HANGUL (KASHMIR STAG)

- It was launched in the 1970s by Govt. of Jammu and Kashmir, IUCN and WWF. Hangul is a **state animal of Jammu and Kashmir.**
- **Kashmir Stag** has **Critically Endangered** IUCN status and is listed under **Schedule I of the Wildlife (Protection) Act, 1972**.

Wildlife Conservation Fund

- Founded in **2010** to save the wildlife and Wilderness in **Jammu and Kashmir**. **Hangul Conservation Project** was launched by the Wildlife **Conservation Fund**.
- **WCF** aims at resolving issues related to various species of **Hangul** in **Kashmir**, particularly in the **Dachigam National Park**.

- Its habitat is dense riverine forests in the high valleys & mountains of the Kashmir and northern Chamba district in Himachal Pradesh.
- In Kashmir, it's found in the Dachigam National Park, Rajparian Wildlife Sanctuary, Overa Aru, Sind Valley, Kishtwar & Bhaderwah.
- Hangul is the **only surviving species of the Asiatic member of the red deer family**. Hangul society is matriarchal & only male members have antlers.

6.9 DOLPHIN CONSERVATION

- **Conservation Breeding Programmes** were launched for **captive propagation of endangered species** for maintaining genetic diversity, produce viable individuals to mitigate species' extinction.

The Other Three Freshwater Dolphins

1. **Bhulan (Indus River Dolphin)** is **National Mammal** of **Pakistan** and State aquatic animal of **Punjab**, India.
2. **Baiji:** now functionally **extinct** from the **Yangtze River** in China
3. **Boto:** Amazon River in Latin America.

- **Ganges River Dolphins can only live in freshwater**, are **blind** and catch their prey using **ultrasonic sound** waves. It makes a sound **while breathing** called the **Su-Su**.
- It is a reliable **indicator of the health of the entire river ecosystem**.

- It was recognised as the **National Aquatic Animal in 2009**, by the Government of India.
- They are found mainly in the Indian subcontinent, particularly in **Ganga-Brahmaputra-Meghna and Karnaphuli-Sangu River** systems of **Nepal, India, and Bangladesh**. It is also found in the Ganga's tributaries.
- In India they are distributed across 7 states, namely, **Assam, Uttar Pradesh, Madhya Pradesh, Rajasthan, Bihar, Jharkhand and West Bengal.**
- **Vikramshila Ganges Dolphin Sanctuary** was established in Bihar under WPA, 1972.

6.10 SOUTH ASIA WILDLIFE ENFORCEMENT NETWORK (SAWEN)

- SAWEN was set up in **2011** in Paro Bhutan **with a secretariat** at **Kathmandu, Nepal.**
- It is an inter-government wildlife law enforcement support body of South Asian countries for promoting & co-ordinating regional cooperation for **curbing illegal wildlife trade** in wild flora and fauna of South Asia.
- **Wildlife Crime Control Bureau** is the nodal point for SAWEN in India.

Name of the Species	Name of the Zoo
Red Panda & Snow Leopard	Padmaja Naidu Himalayan Zoological Park, Darjeeling
Hoolock Gibbon	Biological Park, Itanagar
Clouded Leopard	Sepahijala Zoological Park, Agartala
Indian Pangolin	Nandankanan Biological Park, Bhubaneswa
Lion-tailed Macaque	Ariganr Anna Zoological Park, Chennai
Grey Jungle Fow	Sri Venkateswara Zoological Park, Tirupati
Dolphin	Vikramshila Gangetic Dolphin Sanctuary, Bhagalpur.
Crocodile	Madras Crocodile Bank, Chennai

- **Member countries** are Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka.

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7 Environmental Pollution and Degradation

7.1 INTRODUCTION

- **Environmental Pollution** is deterioration of the environment due to the addition of harmful materials (pollutants) to it.
- **Environmental Degradation** is the process through which the environment becomes unfit or less suitable for the survival of different life forms thereby causing immense ecological damage.
- Uncontrolled human population, Rapid industrialization, Urbanization, Exploitation of nature, Forest fires, Radioactivity, Volcanic eruptions, Strong winds etc., all contribute to environmental pollution.

Classification of Pollution	
On the basis of the form in which they persist	• **Primary pollutants**: Persist in the form in which they are added to the environment e.g. DDT, plastic. • **Secondary Pollutants**: Formed by interaction among the primary pollutants e.g. peroxyacetyl nitrate (PAN)- interaction of nitrogen oxides and hydrocarbons.
On the basis of existence in nature	• **Quantitative Pollutants**: Occur in nature and become pollutant when concentration reaches beyond a threshold level. E.g. carbon dioxide, nitrogen oxide. • **Qualitative Pollutants**: These are man-made and do not occur in nature. E.g. fungicides, herbicides, DDT etc.
On the Basis of Disposal	• **Biodegradable Pollutants**: Waste products or the pollutants which are decomposed/ degraded by natural processes microbial action. E.g. sewage. • **Non Biodegradable Pollutants**: The pollutants which don't decompose naturally or decompose slowly e.g. DDT, Aluminium cans.
On the basis of Origin	• **Natural**: These pollutants are released during volcanic eruptions, forest fires, grass fires, etc. • **Anthropogenic**: CO_2 emission from the burning of fossil fuels.

7.2 AIR POLLUTION

- It is defined as degradation of air quality due to the contamination of pollutants.
- It was the **4th leading risk factor** for early death worldwide in 2019 (**State of Global Air Report** 2020).
- **Industries (51%), Vehicles (27%), and Crop burning (17%)** are the largest contributors to Air pollution.
- **Indoor air pollution (IAP) amounts to t**he poor air quality within and around buildings. It is caused by burning of **solid fuel such as firewood, dung for cooking.**
- **Outdoor (ambient) air pollution** originates from natural and anthropogenic sources. For example **bushfires, volcanoes, Automobile emission,** etc.

7.2.1 Effects on Vegetation

Types of Air Pollutants

Primary pollutants enter the atmosphere directly from their source like **Co_2.**

Secondary pollutants are result of a chemical reaction of primary pollutants for example Ozone (O_3), Acid rain.

- Retard photosynthesis, Sulphur dioxide causes chlorosis, plasmolysis, membrane damage and metabolic inhibition.
- Hydrocarbons such as ethylene cause premature leaf fall, fruit drop, shedding of floral buds, curling of petals and discoloration of sepals.
- **Ozone damages chlorenchyma** and thus destroys the foliage in a large number of plants.

7.2.2 Major Air Pollutants and Their Sources

Gas	Properties	Sources	Impact
Carbon Monoxide (CO)	Colourless, odourless, tasteless and highly toxic gas, slightly less dense than air. Short-lived (stay only a few months) in the atmosphere.	**Anthropogenic:** Incomplete combustion of fuels such as propane, natural gas, gasoline, oil, coal, or wood. **Natural**: volcanic eruptions, forest fires, tropospheric photo-chemical reactions etc. Also, from the combustion of natural and synthetic products such as cigarettes.	**Environmental:** • It is a weak greenhouse gas • Helps formation of ground- level ozone and can elevate concentrations of methane (a strong greenhouse gas) **Health:** • More easily combined with haemoglobin than oxygen, hence, lowers the amount of oxygen that enters our blood. • It can slow our reflexes and make us confused and sleepy.
Carbon Dioxide (CO_2)	Colourless, odourless greenhouse gas, heavier than air.	**Natural**: volcanoes, hot springs and geysers. **Anthropogenic**: burning coal, oil, and natural gases. As it is **soluble in water**, it occurs naturally in groundwater, rivers and lakes, in ice caps and glaciers and also in seawater.	**Environmental:** It is a quantitative pollutant and Principle Greenhouse gas. Since the industrial revolution it has led to global warming. **Health**: CO_2 is an asphyxiant gas. Concentrations of CO_2 may cause suffocation, dizziness, headache, and unconsciousness, etc.
Chloro-Fluoro Carbons (CFC)	Organic chemicals contain carbon, (sometimes hydrogen,) chlorine, and fluorine.	Released mainly from air-conditioning systems and refrigeration.	**Environmental**: It rises to the stratosphere, comes in contact with few other gases, which lead to depletion of the ozone layer that protects the earth from the harmful ultraviolet rays of the sun. **Montreal Protocol**: an international treaty to protect the ozone layer by phasing out the production of numerous substances including CFCs which are responsible for ozone depletion.
Ozone (O_3)	It is a gas that occurs **both in the Earth's upper atmosphere and at ground level.** Ozone can be **good** or **bad** for our health and the environment, depending on its location in the atmosphere.	Major source at ground level: Vehicles and industries. Carbon monoxide, Nitrogen dioxide play a major role in converting O_2 to O_3.	**Environmental**:Occurs Naturally in the upper layers of the atmosphere, shielding earth atmosphere from harmful UV rays of the sun. At the ground level, it is a pollutant with highly toxic effects. **Health**: Makes our eyes itch, burn, and water, also lowers our resistance to cold and pneumonia.
Nitrogen Oxide (NOx)	Generic term for the various nitrogen oxides produced during combustion.	**Natural**: Lightening Agricultural fertilisation and the use of nitrogen-fixing plants contribute to atmospheric NOx. **Anthropogenic:**Produce from burning fuels including petrol, diesel, and coal.	**Environmental:** NOx gases react to form smog and acid rain. Photochemical Smog produced by the reaction of NOx and volatile organic compounds (VOCs) in the presence of sunlight. **Health**: Irritation and inflammation of lungs, breathlessness, causes bronchitis and asthma.

Gas	Properties	Sources	Impact
Sulphur Dioxide (SO_2)	It is a toxic gas with a pungent, irritating smell.	**Natural**: volcanic activity **Anthropogenic**: Produced from burning coal, mainly in thermal power plants. Industrial processes like production of paper and smelting of metals, produce sulphur dioxide.	**Environmental**: Major contributor to smog and acid rain. **Health**: increased respiratory symptoms and premature death.
Volatile Organic Compounds (VOCs)	Large group of carbon-based chemicals that easily evaporate at room temperature	Main indoor sources: perfumes, hair sprays, furniture polish, glues, air fresheners, repellents wood preservatives, and other products.	**Health**: Irritation of the eye, nose and throat, headaches, nausea and loss of coordination.

7.2.3 Particulate Pollutants

7.2.3.1 Particulate Matter (PM)

- PM is a **mixture of solid particles & liquid droplets** found in the air. They originate from vehicles, power plants, construction activities, oil refinery, railway yard, industries, etc.
- **PM10** are inhalable particles sized 10 micrometres or less in diameter.
- **PM2.5** fine inhalable particles, sized 2.5 micrometres or less in diameter. These are more harmful to health as they move freely with air current & block the tiny pores in our lungs.

Aerosols

Aerosols are **suspension of fine solid particles or liquid droplets in air**. Some of them, like black and brown carbon, warm the Earth's atmosphere, while others, like sulphate droplets, cool it.

Aerosols **cause scattering and absorbing of the solar and infrared radiation,** and they **change the microphysical and chemical properties of clouds** and possibly their lifetime and extent.

Aerosols can be transported thousands of kilometres from the sources of origin by winds and upper-level circulation in the atmosphere.

Human activity has increased the amount of aerosols in the atmosphere in several ways like, burning of fossil fuels, using of ammonia as fertilizers, industrial processes too releases a wide variety of aerosols, etc.

The amount of very fine material generally referred to as **PM 2.5** particulate matter less than **2.5 microns** across has increased by **60 percent** since before the **Industrial Revolution**.

7.2.3.2 Fly Ash

- Fly ash is ejected mostly by **thermal power plants** as by-products of coal burning operations.
- It pollutes air and water and may cause **heavy metal pollution in water bodies and also affects crops and vegetation** as a result of its direct deposition on leaf surfaces.

7.2.3.3 Lead

- Lead is present in petrol, diesel, lead batteries, paints, hair dye products, etc.
- **Tetraethyl lead** (TEL) is used as an anti-knock agent in petrol for a smooth and easy running of vehicles. The lead particles coming out from the exhaust pipes of vehicles are mixed with air.
- Lead mixed with water and food can create cumulative poisoning and **can also cause nervous system damage and digestive problems, cancer, etc**. It has long term effects on children as it **lowers intelligence**.

7.2.3.4 Metallic Oxides

- **Oxides of iron, aluminium, manganese, magnesium, zinc** and other metals have an adverse effect due to deposition of dust on plants during mining operations and metallurgical processes.
- These oxides create **physiological, biochemical and developmental disorders in plants** and may result into **reproductive failure in plants**.

7.2.3.5 Nanoparticles (NPs)

- Nanoparticles are particles with dimensions comparable to 1/109 of a metre.
- **Natural NPs** are sourced from forest fires, volcanic eruptions, weathering, dust storms etc.
- **Anthropogenic NPs** are unknowingly or purposely released in the environment during various industrial and mechanical processes.

- **Heterogeneous in size**, **NPs** can be transported over thousands of kilometres and remain suspended in the air for several days thus influencing **dust cloud formation, environmental hydroxyl radical concentration, ozone depletion, or stratospheric temperature change**.

7.2.3.6 Soot and Dust

- **Soot or black carbon** is the minute particles of **impure carbon** resulting from **incomplete combustion** of hydrocarbons. Mixed with atmospheric dust they can directly enter the blood streams of living organisms.
- These aerosols lead to formation of Asian brown clouds over east and south Asia. Asian brown clouds carry large amounts of soot and black carbon (NPs) and deposit them on the Himalayan glaciers.

7.2.3.7 Fog

- Fog is a cloud of smoke particles, water droplets, or mixtures of these components suspended in the air.
- Fog usually appears over a region of high pressure where humidity is greater than **75%**. It reduces visibility & causes accidents.

7.2.3.8 Smog

- Smoke mixed with Fog yields **Smog** (a type of intense air pollution). Smog is a harmful mixture of fog, dust & air pollutants such as nitrogen oxides, VOCs, etc.
- **Smog** causes itchy and burning eyes, damage in lung tissues, cardiac and respiratory disorders, it can kill plants etc. Sulphurous smog & Photochemical smog are two of its types.

7.2.3.8.1 Sulphurous Smog (London Smog)

- Mixtures of Smoke, Fog & Sulphur Dioxide in a cool humid climate produce this Smog.
- Chemically, it is a reducing mixture and so it is also called reducing smog.
- London smog is also called **winter smog or classic smog**.

7.2.3.8.2 Photochemical Smog

- Produced when **sunlight reacts with Nitrogen Oxides & volatile organic compounds** in the atmosphere which results in the formation of **Bad ozone.**
- It is visible as a brown haze. Contains more oxidising agents.
- Often referred to as **summer smog** or **Los Angeles smog,** it occurs most prominently in urban areas.

Black and Brown Carbon

Black Carbon	Black Carbon
Black Carbon is a component of fine particulate matter formed through the incomplete combustion of fossil fuels, biofuel, and biomass. It is a short-lived pollutant with a lifetime of only days to weeks.	Brown carbon is a ubiquitous and unidentified component of organic aerosol. Biomass burning (possibly domestic wood burning) is shown to be a major source of brown carbon.
It is found in soot which leads to higher absorption of the sun's heat (reduced albedo) and potentially contributing to the increased melting of glaciers.	Brown carbon is generally referred for greenhouse gases and black carbon for particles resulting from impure combustion, such as soot and dust.

Fig. 7.1

7.3 ACID RAIN

- Normal rain has a **pH of about 5.6** when pH falls below this; it is called **Acid rain** (pH 4.2 to 4.4).
- Acid rain results when Sulphur Dioxide (SO_2) & Nitrogen Oxides (NOX) react with water, oxygen & other chemicals to form Sulfuric & Nitric acids.
- Harms microorganisms in the soil, inhibit the activity of nitrogen fixation bacteria, soil acidification, ocean acidification, affects the growth of plants, effects on food chain, kill aquatic animals, corrosion of metals & weathering of stone buildings & statues.

Acid Rain (HNO_3 + H_2SO_4) = NOx + SO_2 + Moisture + other chemicals.

7.4 FLY ASH

- Fly ash is a fine powder that is a **by-product of burning pulverised coal** in electric power generating plants.
- Indian coal is of low grade with more ash content (30-45%) compared to imported coal.
- Silicon dioxide (SiO_2), Aluminium oxide (Al_2O_3) & Calcium oxide (CaO) are its **main components**.
- Arsenic, Beryllium, Boron, Cadmium, Chromium, Hexavalent Chromium, Cobalt, Lead, Manganese, Mercury, Molybdenum, Selenium, Strontium, Thallium, Vanadium, & Un-burnt Carbon are **also found in it**.
- **Fly Ash** contains acidic, toxic & radioactive matter, **carcinogenic** & **damages nervous system, causing cognitive defects, developmental delays**, and other **respiratory diseases**.
- GoI has made it mandatory for use of fly ash bricks in construction activities happening 300 kms around thermal power plants.
- As **soil conditioner** for acidic soils. Also, it improves the porosity & water holding capacity of the soil. Fly Ash is used **as a replacement** for some of the **Portland cement** contents.
- **Maharashtra** is the first state in India to adopt the Fly Ash Utilisation Policy.
- The Government has launched the **ASHTRACK** mobile app for fly ash utilisation.

7.5 OTHER IMPORTANT POLLUTANTS

Benzene	Ethylene	Asbestos
• It is one of the elementary petrochemicals and a **natural constituent of crude oil**. • Benzene has a high-octane number. (a measure of the performance of Petrol. The higher the octane number of fuels, the more compression it can withstand before exploding).	• Widely used in the chemical industry. • Much of this goes toward polyethylene, a widely used plastic containing polymer chains of ethylene units. • Important natural plant hormone, used in agriculture to force the ripening of fruits.	• A set of six naturally occurring silicate fibrous minerals: chrysotile, crocidolite, amosite, anthophyllite, tremolite, and actinolite.
• Increases the risk of cancer and other illnesses. Also, it is a notorious cause of bone marrow failure.	• Leads to headache, drowsiness, dizziness and unconsciousness. Ethyleenoxide (not ethylene) is a carcinogen.	• Prolonged inhalation can cause lung cancer, mesothelioma, and asbestosis (a type of pneumoconiosis).
Radon is emitted naturally by the soil and due to modern houses having poor ventilation, it is confined inside the house and causes lung cancers.		

7.6 OCCUPATIONAL HEALTH HAZARDS

7.6.1 Black Lung Disease

- It is the common name for pneumoconiosis (CWP) or Anthracosis, a lung disease of older workers in the coal industry, caused by inhalation over many years, of small amounts of coal dust.
- In coal mining areas coal dust is the main air pollutant. The particles of fine coal dust accumulate in the lungs.
- The deposits of coal dust make miners' lungs look black instead of a healthy pink and hence the name black lung disease.

7.6.2 Silicosis

- It is a **progressive lung disease caused by inhalation of silica** over a long period of time.
- Silicosis is characterised by shortness of breath, cough, fever and bluish skin.
- Silicosis is an incurable condition with its potential to cause permanent physical disability.
- Silicosis occurs most commonly in people working in the quarrying, manufacturing, and building construction industries.
- In 2019 **Saharia tribe** miners in Madhya Pradesh have appealed to the government to treat them for silicosis rather than Tuberculosis.

7.6.3 Pneumoconiosis

- It is the general term for a class of **interstitial lung diseases** (the tissue and space around the alveoli) where inhalation of dust has caused interstitial fibrosis.

- It is an occupational **health disease** and mostly affects workers who work and inhale toxic dust in the mining and construction sectors, esp. in mica and textile industry.

7.6.4 Byssinosis

- It is an occupational lung disease caused by **exposure to cotton dust** in inadequately ventilated working environments.
- Commonly occurs in workers who are employed in yarn and fabric manufacture industries.

7.6.5 Asbestosis

- It is a **chronic, inflammatory lung disease caused due to prolonged exposure** to asbestos.
- Commonly occurs in **workers associated with the asbestos industry.** Asbestos also causes malignant diseases such as lung cancer, pleural mesothelioma and peritoneal mesothelioma.

Bharat Stage Norms

These are emission standards **set by CPCB** under the MoEF&CC to reduce vehicular pollution.

India **introduced emission norms in 1991 & BS-1 in 2000 based on European standards.**

India **skipped BS-V** & moved to **BS-VI** norms directly in 2020.

BS-VI fuel is estimated to bring **around 80% reductions in Sulphur content.**

BS-VI will cut down the harmful NOx (Nitrogen Oxides) from diesel cars by nearly 70% and 25% in the petrol cars.

BS-VI will **bring down the cancer-causing PM** in diesel cars by a phenomenal 80%.

7.7 AIR POLLUTION IN INDIA

- Of the world's top 20 polluted cities, 13 are in India. Air pollution **slashes life expectancy by 3.2 years for the 660 million** Indians who live in cities.
- Ranging from agriculture waste burning, power utilities, industry, dust, transport and waste (accounts for nearly 95% of the sources of air pollution) all constitute **sources of pollutants**.

7.7.1 The Air (Prevention & Control of Pollution) Act 1981

- This Act was enacted to prevent, control & abate air pollution. It expanded the authority of the Central Pollution Control Board (CPCB) to include Air Pollution under it.
- Under this Act, all industries operating within designated air pollution control areas must obtain a **permit from the State Boards**. The states are required to prescribe emission standards for industry & automobiles.
- The **1987 amendment** introduced a citizen's suit provision into the Air Act & extended the Act to include **Noise Pollution**.

Nitrogen Pollution

Nitrogen **becomes a pollutant when it escapes into the environment & reacts with other organic compounds.**

Agriculture, fossil fuel burning sewage etc., are main sources.

Global warming, acid rain and eutrophication etc., are results of Nitrogen Pollution.

UNEP's Colombo Declaration aims to halve Nitrogen waste by 2030.

7.7.2 National Air Quality Index (NAQI) and National Ambient Air Quality Standards (NAAQS)

- CPCB **launched AQI in 2014 under the Swachh Bharat Abhiyan** to disseminate information on air quality in an easily understandable form for the general public.
- AQI has **six categories** of air quality and it transforms complex air quality data of 8 pollutants into contains a single number, nomenclature, colour.
  - The 8 pollutants are Particulate Matter (PM10), Particulate Matter (PM2.5), Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2), Carbon Monoxide (CO), Ozone (O_3), Ammonia (NH_3) and Lead (Pb)
- **NAAQS** was issued **by CPCB** under powers given to it by the Air Act, 1981 in **2009.**
- For air pollution monitoring and its health impact implications **NAAQS** covers **12 pollutants**, namely, Sulphur Dioxide, Nitrogen Dioxide, PM10, PM2.5, Ozone, Lead, Carbon Monoxide, Ammonia, Benzene, Benzo Pyrene, Arsenic, Nickel.

7.7.3 Air Quality Early Warning System (AQEWS) and Graded Response Action Plan (GRAP)

- AQEWS is an initiative of the **Ministry of Earth Sciences and Environment (MoES)** which aims to predict extreme air pollution events over the Delhi region & give alerts to take necessary steps as per the **Graded Response Action Plan (GRAP).**
- Developed by the **Indian Institute of Tropical Meteorology (IITM), Pune,** AQEWS uses data of stubble burning incidents from the past 15 years to predict and help authorities to act in advance.

- **GRAP is a set of stratified actions** to enforce in the NCR for control air pollution if the pollution level reaches a certain specified limit i.e., **from 'Poor' to 'Very Poor' on AQI**.
- It was **formulated by the Environment Pollution (Prevention & Control) Authority (EPCA)** on the advice of the Supreme Court in 2016.

System of Air Quality and Weather Forecasting and Research (SAFAR)

SAFAR was **indigenously developed by Indian Institute of Tropical Meteorology, Pune and is run by India Meteorological Department (IMD)** for providing real-time air quality index on 24×7 basis with colour coding along with 72-hour advance weather forecast.

Another goal is to issue health advisory to prepare citizens well in advance.

- GRAP works **only as an emergency measure, not throughout the year.**
- These measures were **earlier implemented in Delhi** only but now GRAP has been **extended to the NCR towns also.**

7.7.4 Continuous Ambient Air Quality Monitoring System (CAAQMS)

- It will **monitor air pollution** of the city **on a real-time basis** and its readings will be considered a benchmark of quality
- It includes measuring pollutants like SO_2, NO, NO_2, NH_3, CO, O_3, VOC, and particulate matters (PM 10 and PM 2.5).
- It will also display relative humidity, ambient temperature, solar radiation, wind speed and direction, barometric pressure and rain gauge.
- The data so collected can be remotely monitored on the internet and can also be published in various desired formats for public awareness.

Central Pollution Control Board (CPCB) of India

- The CPCB is a **statutory organisation** established **under** the **Water** (Prevention and Control of Pollution) **Act, 1974**.
- It is also **entrusted with the powers & functions under** the **Air** (prevention and control of pollution) **Act,** 1981.
- It works under the Ministry of Environment, Forest & Climate Change (**MoEF&CC**).
- **Functions include:**
  - To prevent, control & abate water & air pollution in the country
  - To provide technical services to the MoEF&CC under the provisions of the Environment (Protection) Act, 1986
  - Collect, compile & publish technical and statistical data relating to water and air pollution.

Environment Pollution (Prevention and Control) Authority

EPCA is a **Supreme Court mandated statutory body**, notified by MoEF&CC in 1998 **under Environment Protection Act, 1986.**

The objective of EPCA is to protect and improve the environmental quality & pollution control in the NCR-National Capital Region (Delhi).

It enforces Graded Response Action Plan (GRAP) in NCR as per the pollution levels and EPCA has the power to take Suo-moto action.

7.7.5 Low-Emission (Green) Crackers

- Developed by **CSIR-NEERI,** these crackers are produced **using less harmful raw materials** & have additives which reduce emissions by suppressing dust.
- They come with names like **"Safe Water Releaser (SWAS)", "Safe Minimal Aluminium (SAFAL)" & "Safe Thermite Cracker (STAR)".**
- Firecrackers are regulated by **PESO(Petroleum & Explosives Safety Organisation)** which is an office under the Department for Promotion of Industry & Internal Trade, Ministry of Commerce and Industries.

7.8 AIR POLLUTION IN DELHI

7.8.1 Causes of Air Pollution

- Seasonal change in wind direction during winter (north-westerly), dip in wind speed, & dust storms (from the Gulf) make the landlocked Delhi region more prone to pollution.

- Vehicular Pollution and firecrackers, emissions from nearby industries & thermal power plants and stubble burning in surrounding states are other contributing factors.

7.8.2 Measures taken to Tackle

- Implementation of the GRAP and introduction of **BS-VI vehicles**, push for electric vehicles (EVs), Odd-Even scheme to reduce vehicular pollution.
  - **Delhi** is the **1st city in India** running with **BS-VI fuels** & scheduled to use **Hydrogen-CNG.**
- Subsidy to farmers for buying **Turbo Happy Seeder** to reduce stubble burning. **Happy Seeder** is a tractor-mounted machine that cuts & lifts rice straw, sows wheat into the bare soil, and deposits the straw over the sown area as mulch.
- Development of the National AQI for public information and the initiative of **The Great Green Wall of Aravalli** green ecological corridor along with **Aravalli range** from **Gujarat to Delhi**.

Torrefaction is a thermal process to convert biomass into a coal-like material, which has better fuel **characteristics** than the original biomass. Torrefied biomass is more brittle, making grinding easier & less energy-intensive.

7.8.3 National Clean Air Programme (NCAP)

- NCAP was launched **by the MoEF&CC in 2019** as the **first-ever effort** by India **to frame** a **national framework** for air quality management with a **time-bound reduction** target.
- Its objective is to reduce particulate matter (PM) pollution by 20-30% in at least 102 **non-attainment cities** by 2024 with 2017 as the base year.
  - **Non-attainment cities** are those that have fallen short of the NAAQS for over five years.

Other Important Suggestions

Hydrogen-enriched Compressed Natural Gas (HCNG)	The Great Green Wall of Aravalli
• HCNG is cleaner, safer & more economical than CNG and it reduces the engine's unburned hydrocarbon emissions and speeds up the process of combustion. • HCNG ensures 70% more Carbon Monoxide reductions compared to CNG. • Limitation is that it requires new infrastructure to prepare HCNG and is costlier than CNG. • Also, there is difficulty in determining the most optimised H_2/ NG ratio.	• It will be a 1,400km long & 5km wide **green belt from Gujarat to the Delhi-Haryana border**. • The **'Green wall'** idea was mooted in the COP14 of **UNCCD**, India in 2019. • It intends **to restrict** land degradation & the eastward march of the **Thar Desert**. • Also, it will **act as a barrier for dust** coming from the deserts in western India and Pakistan.

India's UNFCCC Commitments
(Intended Nationally Determined Contributions)

- Improve the emissions intensity of its GDP by 33 to 35 per cent by 2030 below 2005 levels.
- Increase the share of non-fossil fuels-based electricity to 40 per cent by 2030.
- Enhance forest cover which will absorb 2.5 to 3 billion tonnes of carbon dioxide by 2030.

7.9 OZONE POLLUTION

- Ozone is a **secondary** pollutant, it can be **good or bad, depending on where it is found**.
- Stratospheric ozone is good ozone that protects the earth from UV radiation.
- Ground-level ozone, which is bad ozone, is a colourless & highly irritating gas that forms just above the earth's surface (lower troposphere).
- Health problems like **chest pain, coughing, throat irritation, reduced lung function, can worsen bronchitis, emphysema, & asthma** are associated with Ozone Pollution.
- It **inhibits photosynthesis** thus, slows down plant growth & reduces CO_2 absorbing ability.

7.9.1 Ozone Depletion

Ozone Depletion Is Strongest Over the Poles and in the Winters

During winters, polar vortices are strengthened, especially in the southern hemisphere. This leads to formation of polar stratospheric clouds which contain water, nitric acid, sulfuric acid etc. Such clouds accelerate the process of ozone depletion.

- The gradual decline in the concentration of ozone in the stratosphere, especially over the polar areas, is known as ozone depletion or ozone hole.
- **Depletion of ozone is due to increase in halo-carbons (**chloro-carbons, bromo-carbons etc.)
- Ozone depleting substances are dissociated under sunlight to form free radicals like chlorine atoms that destroy the ozone molecule.
- Halocarbon refrigerants, solvents, propellants, and foam-blowing agents (Chlorofluorocarbons (CFC), Hydrochlorofluorocarbons (HCFC), Hydrobromofluorocarbons (HBFC), Halons (used in fire extinguishers), Methyl Bromide, Carbon Tetrachloride, Methyl Chloroform etc., are called **Ozone depleting substances.**

7.9.2 International Efforts to Mitigate Ozone Depletion

7.9.2.1 Vienna Convention for the Protection of The Ozone Layer and Montreal Protocol

- The Convention for the Protection of the Ozone Layer (Vienna Convention) was agreed upon in 1985. It established global monitoring and reporting on ozone depletion.
- It **does not include legally binding reduction goals** for the use of CFCs, the main chemical agents causing ozone depletion.
- It also created a framework for the development of protocols for taking more binding action.
- **Montreal Protocol under the Vienna Convention (the protocol)** was agreed in 1987.
- It facilitates global cooperation in reversing the rapid decline in atmospheric concentrations of ozone.
- Under the protocol **countries agreed to phase out the production and consumption of certain chemicals that deplete ozone.**
- Phasing out of these substances is required by **specific deadlines.**
- Vienna Convention and its Montreal Protocol are the **first and only global environmental treaties to achieve universal ratification, with 197 parties.**
- As a result of the international agreement, the **ozone hole in Antarctica is slowly recovering.**
- Climate projections indicate that the ozone layer will return to 1980 levels between 2050 and 2070.

7.9.2.2 Kigali Amendment to Montreal Protocol 2016

- In the 28th meeting of the Parties (2016) to the Montreal Protocol, negotiators from 197 nations have **signed an agreement to amend the Montreal Protocol in Kigali**.
- The parties are expected **to reduce the manufacture and use of Hydrofluorocarbons** (HFCs) by **roughly 80-85% from their respective baselines, till 2045**.

7.9.2.3 Gothenburg Protocol, 1999

- It aims **to Abate Acidification, Eutrophication & Ground-level Ozone and it is** also **known as the multi-effect protocol**.
- It was adopted by the countries of **UNECE (United Nations Economic Commission for Europe)**.
- The protocol sets national emission ceilings for 2010 up to 2020 for four pollutants: **Sulphur dioxide, Nitrogen Oxides (NOx), volatile organic compounds (VOCs) & Ammonia (NH_3)**.
- Protocol also is a **part of the convention on Long Range Transboundary Air Pollution**.

Ozone Depleting Substances (Regulation and Control) Rules

- The ODS (Regulation and Control) Rules, 2000 were issued **under the Environment (Protection) Act**, in July 2000.
- These Rules **set the deadlines for phasing out of various ODSs, besides regulating production, trade impaort and** export of ODSs and the product containing ODS.
- Ozone Depleting Substances (Regulation and Control) Rule, 2000 was **amended in 2001, 2003, 2004, 2005 and 2019** to facilitate implementation of ODS phase-out at enterprises in various sectors.
- These Rules **prohibit the use of CFCs in manufacturing various products beyond 1st January 2003,** except in metered dose inhaler and for other medical purposes.
- Further, the **use of methyl bromide has been allowed upto 1st January 2015**. Since HCFCs are used as interim substitutes to replace CFC, these are **allowed upto 1st January 2040.**
- MoEFCC issued a **notification to prohibit the issuance of import licence for HCFC-141b from January 1, 2020**, under ODS (Regulation and Control) Amendment Rules, 2019 issued under the Environment (Protection) Act, 1986.

7.10 WATER POLLUTION

- Water pollution is the **contamination of water bodies**, usually as a result of human activities.
- **Point pollution sources**, where the source is a well-defined location.
- **Non-point pollution sources**, which are spread over larger areas.
- Agricultural sources, Sewage water, Industrial effluents, Thermal Pollution, Oil-spills, ships & other economic activities are main causes of water pollution.
- Water pollution results in decline of dissolved oxygen (DO), increase in BOD, death of Aquatic species and eutrophication etc.

7.10.1 Comparing Dissolved Oxygen, BOD and COD

Dissolved Oxygen (DO)	Biological Oxygen Demand (BOD)	Chemical Oxygen Demand (COD)
• The amount of oxygen that is present in water. • Oxygen is poorly soluble in water. Its solubility is related to Pressure & Temperature. • The higher the temperature, the lower the DO levels in the water. • During summer due to increased biological oxidation, the DO level reduces.	• The amount of oxygen required by microorganisms for the aerobic decomposition of organic matter in the water body. • It is a measure of the amount of oxygen required to remove waste organic matter from water. • It is used as an indicator of the degree of pollution. • The greater BOD indicates the lower amount of DO available in the water.	• Measures the amount of oxygen in ppm required to oxidise organic and oxidizable inorganic compounds in the water sample. • Breakdown of organic matter is done by chemical reagents. • CoD is a slightly better mode used to measure pollution load in the water than BoD.

7.10.2 Major Industries/Sectors and Water Pollutants

Industry	Water Pollutants
Mining	• Chlorides, various metals, ferrous sulphate, sulphuric acid, hydrogen sulphide, ferric hydroxide, surface wash offs, suspended solids, chlorides and heavy metals
Iron and Steel	• Suspended solids, iron cyanide, thiocyanate, sulphides, oxides of copper, chromium, cadmium, and mercury
Pharma	• Organic solvent, intermediate products, drugs and antibiotics
Paper and Pulp	• Sulphides, bleaching liquors, organic acids.
Chemical Industries	• Various acids and alkalis, chlorides, sulphates, nitrates of metals, phosphorus, fluorine, silica and suspended particles, aromatic compounds solvents
Agricultural Runoff	• It contains dissolved salts such as nitrates, phosphates, ammonia and other nutrients from fertilisers and chemical toxins (such as pesticides, insecticides like DDT, Endosulfan etc.) which ultimately flow into the surface water bodies and also leach into the groundwater.
Thermal Pollution	• Nuclear and thermal power plants, chemical and other industries use a lot of water for cooling purposes, and the used hot water is discharged into rivers, streams or oceans, which may increase the temperature of the water and lead to decrease of dissolved oxygen in the water. • Aquatic organisms are more sensitive to temperature changes, thus a sudden rise in temperature is very harmful to marine flora and fauna.
Groundwater Pollution	• In India at many places, the groundwater is threatened with contamination due to seepage from industrial and municipal wastes and effluents, sewage channels and agricultural runoff.

7.10.3 Marine Pollution

- Oceans are the ultimate sink of all natural and manmade pollutants from dumping of sewerage and garbage to navigational discharge of oil, grease, detergents, oil spills, etc.
- Oil being lighter than water covers the water surface as a thin film cutting off oxygen to floating plants and other producers.
- Plastics and microplastics are a major pollutant in the marine waters as they are not decomposed naturally. Microplastics can enter the marine food chain and cause bioaccumulation and biomagnification.

International Conventions to Mitigate Marine Pollution

- Convention on Dumping Wastes at Sea or London Convention (1972).
- 1996 Protocol to the Convention on the Prevention of Marine Pollution and 2006 amendments to the protocol.
- United Nations Convention on Law of the Sea.

7.10.4 Effects of Water Pollution

7.10.4.1 On Aquatic Ecosystem

- Polluted water reduces Dissolved Oxygen (DO) content, thus eliminates sensitive organisms like plankton, molluscs and fish etc.
- Biocides, polychlorinated biphenyls (PCBs) and heavy metals directly eliminate sensitive aquatic organisms.
- Hot waters discharged from industries, when added to water bodies, lowers its Dissolved Oxygen (DO)

7.10.4.2 On Human Health

Bio-magnification

It is the process where toxic substances move up the food chain and become more concentrated at each consecutive level. E.g., DDT.

It adversely affects human and marine life. It can also destroy Coral Reefs. It can disrupt the food chain.

Tubifex Worms or Sludge Worm poses a significant risk for trophic transfer & bio- magnification of micro-plastics up the aquatic food chain. They can survive in heavily polluted areas where almost no other species can endure. It is an indicator species for polluted water.

- Polluted water usually **contains pathogens** like virus, bacteria, parasitic protozoa and worms, a source of water borne diseases like jaundice, cholera, typhoid, amoebiasis etc.
- **Mercury compounds** in wastewater are converted to toxic methylmercury, causing numbness of limbs, lips and tongue, deafness, blurring of vision and mental derangement.
- Water contaminated with cadmium can **cause itai-itai disease also called ouch-ouch disease.**
- **Compounds of lead cause** anaemia, headache, loss of muscle power and bluish line around the gum.
- Presence of **excess nitrate in drinking water** is dangerous for human health and may be fatal for infants (blue baby syndrome).
- **Excess fluoride in drinking water causes:** neuro-muscular disorders, gastro-intestinal problems, teeth deformity, hardening of bones and stiff and painful joints.
- **Over exploitation of ground water** may lead to leaching of arsenic from soil and rock sources and contaminate groundwater. Chronic exposure to arsenic causes **black foot disease**.

Ocean Acidification

- Ocean acidification is the **reduction in the pH** of seawater due to excessive absorption of CO_2 by the oceans.
- It results into loss of Coral reefs, marine biodiversity, disruption in food chain etc.

Diseases Associated with Water Pollution

Disease	Potential sources / cause & their effects
Minamata	Neurological disease caused by severe mercury poisoning.
Blue Baby Syndrome	It is a bluish discoloration of infants' skin because of poorly oxygenated blood due to Nitrate contamination in water.
Itai-Itai	Cadmium pollution causes lung and liver cancer.
Skeletal Fluorosis	Fluoride contamination causes teeth deformity, hardening of bones and joint pains.
Trachoma	An infectious eye disease caused by unclean water.

Combating Water Pollution	
Restricting Pollutant Inflow into Water Bodies	• Minimising the toxins and pollutants in the effluents going into water bodies through sewage treatment plants and effluent treatment in industries. • This approach is suitable for point sources of pollution.
Reducing Pollution Levels in Water Bodies	• Can be done through processes like bioremediation, phytoremediation etc. • This approach is most suitable for reducing pollution from diffuse sources of water pollution.
Bioremediation	• It is the use of microorganisms (bacteria and fungi) to degrade the environmental contaminants into less toxic forms. • Microorganisms can be specifically designed for bioremediation using genetic engineering techniques. • **In-situ bioremediation techniques:** **Bioventing**: supply of air and nutrients through wells to contaminated soil to stimulate the growth of indigenous bacteria. **Biosparging**: Injection of air under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of contaminants by naturally occurring bacteria. **Bioaugmentation**: Microorganisms are imported to a contaminated site to enhance the degradation process. • **Ex situ bioremediation techniques:** **Land-farming**: turning contaminated soil for aeration & sifting to remove contaminants, or deliberately depleting soil of nitrogen to remove nitrogen-based organisms. **Bioreactor**: the use of specially designed containers to hold the waste while bioremediation occurs **Windrows**: rely on the periodic turning of piled polluted soil to enhance bioremediation by increasing degradation activities of indigenous and/or transient hydrocarbon clastic bacteria present in polluted soil.
	• **Biopiling:** It is a hybrid of composting & land farming. **Advantages:** Useful for destruction of a wide variety of contaminants; Can be carried out on-site, without disturbing normal activities; Less expensive & effective treatment. **Disadvantages:** Limited to only biodegradable compounds; Biological processes are often highly specific; Takes a longer time & consumes more area as well as water. • **Note:** Using bioremediation techniques, TERI has developed a mixture of bacteria called 'Oilzapper and Oilivorous-S' which degrades the pollutants of oil contaminated sites, leaving behind no harmful residues.
Coagulation or Flocculation	• A coagulant like Aluminium Sulphate (alum), Ferric Sulphate etc. are added to the polluted water, this causes the tiny particles of dirt in the water to stick together or coagulate. • These coagulations can then be easily removed.
Phytore-mediation	• Phytoremediation is the use of plants to remove contaminants from soil and water. • Natural phytoremediation is carried out by mangroves, estuarine vegetation and other wetland vegetation
Disinfection	• Water can be disinfected to kill any pathogen and parasites in it. • Common disinfectants that are used include chorine and ozone gases.
Ph Correction	• Lime is added to the filtered water to adjust the pH and stabilise the naturally soft water in order to minimise corrosion in the distribution system and within customers' plumbing.
Other Measures	• Treatment of sewage water and the industrial effluents, Sustainable Agriculture, Conservation of wetlands, etc.

7.10.4.3 Governmental Efforts for addressing Pollution

- **Water** (Prevention and Control of Pollution) **Act, 1974:** The Act was made to provide for the prevention and control of water pollution, and for the maintaining or restoring of wholesomeness of water in the country.
- **Ganga Action Plan:** An ambitious plan launched in 1985 to save the river Ganga.
- **Central Pollution Control Board (CPCB):** an apex body in oxygen, BOD, total coliform, free ammonia, electrical conductivity etc.

7.11 SOIL POLLUTION

- Soil pollution is the deterioration in quality & fertility of soil due to the presence of toxic pollutants.

7.11.1 Important Sources of Soil Pollution

Causes	Effects
Poor Agricultural & Livestock practices. Improper solid waste management Unsafe storage of hazardous chemicals & nuclear waste Urban and transport infrastructure Natural calamities	Naturally contributes to air pollution may alter plant metabolism & reduce crop yields Bio-magnification leads to soil erosion & eutrophication Reduced nitrogen fixation & loss of soil nutrients Carcinogenic

7.11.2 Soil Contaminants and their Effects on Health & Environment

Substance	Potential Sources & Their Effects
Lead (Pb)	Lead paint, mining, foundry activities, vehicle exhaust, construction-activities, agriculture activities, and batteries etc., May leads to Learning difficulties, abdominal cramps & vomiting, Fatigue, Neurological problems, Headache, Growth reduction etc.
Mercury (Hg)	From mining, incineration of coal, alkali and metal processing, medical waste, volcanoes & geologic deposits. A tingling sensation in one's limbs, Speech impairment, Loss of balance & coordination, Tremors, Depression, mood changes, Severe neurological damage, Itching, burning, pain, Damage to brain, kidneys, and lungs, Pink disease (acrodynia) – a skin discoloration, High BP & Hyper-salivation
Arsenic (As)	From mining, coal-fired power plants, lumber facilities, electronics industry, foundry activities, agriculture, natural accumulation. Leads to Neurotoxicity, abdominal pain, muscle cramps, blood in urine, pregnancy complications, infant mortality, cognitive problems in infants, bladder or lung cancer
Herbicides/ Insecticide	From agricultural activities, gardening etc. Birth defects, Endocrine disruption, Reproductive problems, Leukaemia and other cancers.
Nickel	Mining; foundry activities; construction activities Lung cancer, Neurological problems, Childhood developmental issues, Kidney and liver failure, Cardiovascular disease.
Effects of Soil Pollution	
Reduced soil fertility, Reduced nitrogen fixation, Increased erosion, Runoff due to deforestation cause loss of soil and nutrients, Deposition of silt in tanks and reservoirs due to soil erosion.	

7.12 NOISE POLLUTION

- It is an **unwanted** or **excessive sound** that **can have adverse effects** on human health, wildlife, and the environment.

7.12.1 Effects of Noise Pollution

- Noise pollution affects both the health & behaviour of people and wildlife.
- Cardiovascular disorders, hypertension, high-stress levels, tinnitus, hearing loss, sleep disturbance, Cognitive issues and Behavioural Change.

7.12.2 Control Measures

- Control at receiver's end, Suppression of Noise at Source, Acoustic Zoning, Sound Insulation at Construction Stages, Planting trees, Strict legislative measures.

7.13 RADIOACTIVE POLLUTION

- **Radioactive pollution** is the result of the release of radioactive substances into the environment.
- **Radioactive substances** are those which can emit high energy particles like **alpha, beta & gamma rays**.
- These substances are **highly unstable** & are continuously emitting these particles **to gain some stability**.
- It is **not a constant or regular phenomenon** & hence the **duration and frequency** of pollution **vary** with time & conditions.
- **Accidental leakage is one of the biggest threats of radiation** and Three Mile Island, Chernobyl and Fukushima incidents were caused by this.
- **Safe disposal of radioactive wastes** is of utmost importance.

Types of Radiation	Effects on the Human Body
Alpha particles	Generally, they cannot penetrate the skin. But if their source is inside the body, they can cause damage to bones or lungs.
Beta particles	Can penetrate the skin but cannot damage the tissues. They can damage the skin and eyes(cataract).
Gamma particles	Can easily penetrate the body and pass through it. They cause damage to the cell structure.
X-rays	Can travel very far and pass through the body tissues except bones. They can cause damage to the cells.

7.13.1 Causes/Sources of Radioactive Pollution

- Uranium mining & processing (thorium (monazite is the ore of thorium).
- Radiation therapy (X-Rays, Chemotherapy, etc.).
- Nuclear power reactors, & use of radionuclides in industries.
- Nuclear tests carried out by the defence personnel, wars (strontium-90, caesium-137, iodine-131, etc.).
- Disposal of nuclear waste.
- Natural sources like; radiation from space & earth crust (radium-224, uranium-238, thorium-232, potassium-40, carbon-14).

7.13.2 Effects of Radioactive Pollution

- Genetic Mutations causes **cancer, leukaemia, anaemia, haemorrhage, premature ageing** etc.,
- Radioactive material can enter the food chain, remains in the environment for hundreds of years causing somatic damage i.e., damage to organs of the body.
- Exposure to radiation may result in **soil infertility.**

7.14 LIGHT POLLUTION

- Light pollution is excessive, misdirected, or obtrusive artificial (usually outdoor) light.
- It washes out starlight in the night sky, interferes with astronomical research, disrupts ecosystems, has adverse health effects and wastes energy.

7.15 SOLID WASTE MANAGEMENT

- Solid waste consists of Municipal Solid Waste (MSW), e-waste & Biomedical wastes.
- Solid Waste Management involves a collective activity involving segregation, collection, transportation, re-processing, recycling & disposal of various types of wastes.

7.15.1 Waste Minimization Circles (WMC)

- WMC helps Small and Medium Industrial Clusters in waste minimisation in their industrial plants. It is assisted by the World Bank with the Ministry of Environment and Forests acting as the nodal ministry.
- Implementation is done with the assistance of the **National Productivity Council (NPC**), New Delhi.
- **WMC aims** to realise the objectives of the **Policy Statement for Abatement of Pollution (1992),** which states that the government should educate citizens about environmental risks, the economic and health dangers of resource degradation and the real economic cost of natural resources.

Methods of Solid Waste Disposal	
Open Dumps	• It refers to uncovered areas that are used to dump solid waste of all kinds. It is a breeding ground for flies, rats and other insects that spread diseases
Landfills	• Pits that are dug on the ground and are generally located in urban areas. The garbage is dumped, and the pit is covered with soil everyday thus preventing the breeding of rats and flies
Sanitary Landfills	• More hygienic and built in a methodological manner to solve the problem of leaching. These are lined with materials that are impermeable soil.
Incineration Plants	• Process of burning waste in a large furnace. In these plants, the recyclable material is segregated, and the rest of the material is burnt, and ash is produced.
Pyrolysis	• Process of combustion of material in absence of oxygen. It is an alternative to incineration. The gas and liquid thus obtained can be used as fuels.
Composting	• Biological process in which microorganisms mainly fungi and bacteria decompose degradable organic waste into humus like substances in the presence of oxygen.
Vermiculture	• Earthworms are added to the compost. These worms break the waste, and the added excreta of the worms makes the compost very rich in nutrients

7.16 E-WASTE

- E-waste is any electrical or electronic equipment that's been discarded. **India's first e-waste clinic** is established in **Bhopal**.

E-waste Sources	Constituents	Health effects
PCBs, glass panels, and Computer monitors	**Lead**	Damage nervous systems, & kidney, Impair child's brain development
Resistors and Semiconductors	**Cadmium**	Accumulates in kidney & liver, Causes neural damage
Relays and switches, & PCBs	**Mercury**	Damages brain, Respiratory & skin disorders
Galvanised steel plates & decorator or hardener	**Chromium**	Causes Bronchitis
Cabling, Computer & housing	**Plastics & PVC**	Burning produces Dioxin that causes reproductive & developmental problems
Electronic equipment & circuit boards	**Brominated flame-retardants**	Disrupt endocrine systems
Front panels of CRTs	**Barium, Phosphorus & Heavy metals**	Muscle weakness & damages heart, liver
Copper wires, PCB tracks	**Copper**	Stomach cramps, nausea, liver damage
Nickel Cadmium batteries	**Nickel**	Skin Allergy, asthma
Lithium-ion battery	**Lithium**	Li can pass into breast milk & may harm a nursing baby may cause lung edema
Motherboards	**Beryllium**	Carcinogenic Beryllium

7.16.1 E-Waste (Management) Rules, 2016

- Notified by the **Ministry of Environment, Forest & Climate Change.**
- The new e-waste rules **included CFL & other Mercury-containing lamps**, as well as other such equipment.
- Rules have brought the producers under **Extended Producer Responsibility** (EPR), along with targets.
- Producers can have a **separate Producer Responsibility Organisation (PRO)** & ensure the collection & disposal of E-waste in an environmentally sound manner.
- **Deposit Refund Scheme** has been introduced, wherein the producer charges an additional amount as a deposit at the time of sale and returns it to the consumer along with interest when equipment is returned.
- The **role of State Governments** has also been **introduced to ensure the safety and health & skill development** of the workers involved in dismantling & recycling operations.
- **Bulk consumers must file annual returns. It prescribes** a waste collection target of 30% waste generated for the first 2 years and progressively going up to 70% in the 7th year from rule notified.
- There is provision of **penalty for violation of rules.**
- **Urban Local Bodies has been assigned the duty to collect & channelize the orphan products** to authorised dismantlers or recyclers.

7.17 INTERNATIONAL CONVENTIONS REGARDING WASTE DISPOSAL

7.17.1 Stockholm Convention on Persistent Organic Pollutants

- International environmental treaty which aims to eliminate or restrict the production and use of persistent organic pollutants (POPs).
- POPs: chemical substances that persist in the environment, bioaccumulate through the food web, and pose a risk of causing adverse effects to human health and the environment

7.17.2 Basel Convention

- **Basel Convention on control of transboundary movements of hazardous wastes and their disposal** is an international treaty that was designed to reduce the movements of hazardous waste between nations.
- Its objective is to prevent the **transfer of hazardous waste from developed to less developed countries (LDCs).** It does not address the movement of radioactive waste.

7.17.3 Rotterdam Convention

- Rotterdam Convention **on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade.**
- It is a **multilateral treaty** to promote shared responsibilities in relation to the importation of hazardous chemicals.
- Promotes an open exchange of information and calls on exporters of hazardous chemicals to use proper labelling, safe handling, and inform purchasers of any known restrictions or bans.
- Signatory nations can decide whether to **allow or ban the importation of chemicals listed in the treaty**.

7.18 PLASTICS POLLUTION

- It is the harmful accumulation of synthetic plastic products in the environment.
- India aims to **eliminate single-use plastic by 2022**.
- UNEP's 2018-World Environment Day's theme: 'Beat Plastic Pollution'.
- **Causes/Sources of Plastic Pollution**: Households, Industrial use, Bio-medical wastes, Agriculture, Fishing and marine economic activities.

7.18.1 Effects of Plastic Waste

- The land gets littered by plastic bag garbage and becomes ugly and unhygienic.
- Upset food chain
- Conventional plastics have been associated with reproductive problems in both humans and wildlife.
- **Dioxin** (highly carcinogenic and toxic) by-product of the manufacturing process is one of the chemicals believed to be passed on through breast milk to the nursing infant.

Dioxins
• Environmental pollutants that belong to the so-called "dirty dozen" i.e., a group of dangerous chemicals known as persistent organic pollutants (POPs).
Plastic Waste in Road Construction
• Polyblend is a fine powder of recycled and modified plastic waste. • This mixture is mixed with the bitumen that is used to lay roads. • Blends of Polyblend and bitumen, when used to lay roads, enhanced the bitumen's water repellent properties, and helped to increase road life by a factor of three.
Micro-Plastics
• Microplastics are any type of plastic fragment that is **less than 5 mm in length**. E.g., Microbeads, microfibers. • They enter natural ecosystems from a variety of sources, including cosmetics, clothing, & industrial processes. These toxins **can block the gastrointestinal tracts** of organisms.

- Burning of plastics, especially PVC releases dioxin and also furan into the atmosphere.

7.18.2 The Global Tourism Plastics Initiative

- The **Initiative is led by UNEP & the World Tourism Organization**, in collaboration with the Ellen MacArthur Foundation.
- Aims to **address the root causes of plastic pollution.**
- Developed within the **framework of the 'One Planet Sustainable Tourism Programme'.**
- It enables businesses, governments, & other tourism stakeholders to make a set of concrete & actionable commitments by 2025.

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8 Laws and Policies on Environment

8.1 CONSTITUTIONAL PROVISIONS

- **Fundamental right under article 21** reads, "no person shall be deprived of his life or personal liberty except according to procedures established by law". This is complemented by various **Supreme Court judgements** giving this fundamental right as broad an **interpretation** as the time requires.
- **In Maneka Gandhi vs. Union of India,** the Supreme Court interpreted the right to life and personal liberty to include the right to a clean environment.
- Also, in the Directive Principles of State Policy **(DPSP)** under **article 48A,** the is directed to endeavour for protecting and improving the environment and to safeguard the forests and wildlife of the country.
- As per the **fundamental duty under article 51A(g)** it is the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and have compassion for living creatures.

8.2 THE WATER (PREVENTION AND CONTROL OF POLLUTION) ACT (1974)

- This Act was brought with objectives of **prevention and control of water pollution** and maintaining or restoring of wholesomeness and purity of water (in the streams or wells or on land).
- The Act **vests regulatory authority in State Pollution Control Boards (SPCB). SPCBs** control sewage and industrial effluent discharges by approving, rejecting, or imposing conditions while granting consent to discharge.
- **Central Pollution Control Board (CPCB)** performs the same functions for Union Territories and formulates policies and coordinates activities of different State Boards.
- The Act grants power to SPCB and CPCB to **test equipment and to take the sample for analysis.**
- **The 1988 Amendment to the Water Act** empowered SPCB and CPCB to close a defaulting industrial plant.

8.2.1 The Water (Prevention and Control of Pollution) Cess Act (1977)

- **Under this Act,** a tax is levied on water consumed by persons operating and carrying on certain types of industrial activities and it is called **Water Cess**.
- **Local government authority** entrusted with the duty of supplying the water is also liable to pay the cess.
- This cess creates economic incentives for pollution control and requires local authorities and certain designated industries to pay a **cess (tax) for water effluent discharge**.
- To encourage capital investment in pollution control, the **Act gives a polluter a 70% rebate of the applicable cess upon installing effluent treatment equipment.**

8.3 THE AIR (PREVENTION AND CONTROL OF POLLUTION) ACT (1981)

- To implement the decisions taken at the **United Nations Conference on the Human Environment held at Stockholm** in June 1972, Parliament enacted the **Air Act**.
- **Objective:** to improve the quality of air and to prevent, control, and abate air pollution in the country.
- The framework of this Act is **similar to that of the Water Act of 1974** which expanded the authority for the central and state boards established under the Water Act, **to include air pollution control**.
- States not having water pollution boards were required to set up **Air Pollution Boards**.
- As per the Act, all industries operating within designated air pollution control areas **must obtain "consent" (permit) from the State Boards.**
- The states are required to **prescribe emission standards for industry and automobiles** after consulting the central board and noting its ambient air quality standards.
- The Act granted power to SPCB for **testing any equipment and taking the sample for analysis** from any chimney, fly ash or dust or any other.

- **The 1988 Amendment Act** empowered SPCB and CPCB to close a defaulting industrial plant and introduced a citizen's suit provision into the Air Act and extended the Act to **include noise pollution**.

8.4 THE WILDLIFE PROTECTION ACT (1972)

- The WPA 1972 was enacted with the objective to protect wild animals, birds, plants & matters connected with them.
- The Act provided for **appointments of** Wildlife Advisory Board, Wildlife Warden, Central Zoo Authority and National Board for Wildlife and **establishment of** National Parks, Wildlife Sanctuaries, Conservation reserve, Community reserves & Tiger reserves.
  - In-situ & ex-situ conservation of wildlife and regulations for hunting wild animals & birds.
- The Act provided for **licence for trade & commerce in some wildlife species** and **ban on trade or commerce in scheduled animals.**
- There are **6 Schedules** which give **varying degrees of protection to listed animals and plants.**
- The **2006 Amendment to the WPA** created the National Tiger Conservation Authority & Wildlife Crime Control Bureau (WCCB).

Schedules I & II	Provide absolute protection with highest penalties for violation.
Schedules III & IV	Species in this Schedule too are protected, but the penalties are lower.
Schedule V	This Schedule includes Vermin animals, which can be hunted.
Schedule VI	This includes endemic plants that are prohibited from cultivation & planting

Fig. 8.1

8.5 THE FOREST (CONSERVATION) ACT (1980)

- To protect the forest and control its deterioration, the Forest Act was passed.
- Central Government's prior approval for diversion of forest land for non-forestry purposes was made mandatory.
- The Act stops deforestation & encourages afforestation.

8.5.1 National Forest Policy, 1988

- The Forest Policy was prepared to ensure environmental stability & ecological balance with following objectives:
  - Conservation of existing Natural Heritage and **generation of work opportunities and involvement of women.**
  - Checking **soil erosion and denudation in catchment areas**, dunes in desert areas of Rajasthan and along coastal tracts.
  - Substantially increasing **Forest or Tree Cover** through Afforestation & **Social Forestry**.
  - Encourage efficient utilisation of **forest produce & optimum use of wood (timber**) while increasing productivity of forests.
- **Forest Policy, 1952 recommended 33% forest cover** (60% in mountainous region & 25% in plain area) of the total area.

8.5.2 New Draft National Forest Policy (2018)

- With focus on the international challenge of climate change, the Policy was brought to bring a minimum of one-third of India's total geographical area under forest cover through scientific interventions and enforcing strict rules to protect the dense cover.
- The draft has introduced some new concepts like **evaluation of ecosystem services, forest certification** and **NFEMIS** i.e., National Forest Ecosystem Management Information System.
- The 1988 forest policy had a local community- and ecology-centric approach but in this draft, the importance offered to the rights of local, forest-dependent communities are being diluted. The draft also stresses the need to stimulate growth in the forest-based industry sector.
- **The current draft mentions about the livelihoods of local communities**
  - As passive recipients of benefits accruing from wildlife tourism
  - As labour for forest-based industries
  - In relation to **Non-Timber Forest Produce** (NTFP)
- The draft proposes a **public-private partnership model** for afforestation and reforestation activities.
- The policy **proposes to restrict schemes and projects which interfere with forests** that cover steep slopes.

- The Draft suggested setting up of two national-level bodies for better management of the country's forests.
- Efforts are to be taken up to ensure synergy between Gram Sabha & JFMC (Joint Forest Management Committee) **for better community participation.**
- The compensatory afforestation fund which is being transferred to the states will finance the management of forests.
- Mapping the vulnerable areas, developing and strengthening early warning systems, using remote sensing technology and improved community participation are to be employed as **measures to safeguard ecosystem from forest-fires.**
- **Climate change:** Forests are natural carbon sinks, assisting in climate change mitigation.
- Quick response, dedicated teams of well-equipped and trained personnel would be developed to address **human-wildlife conflict**.

8.6 THE ENVIRONMENT (PROTECTION) ACT, 1986

- In the **aftermath of Bhopal Gas Tragedy** (1984), the Act was enacted with the objective **to protect and improve the environment & reduce pollution** from all sources.
- The Act provides procedures for setting standards of emission or discharge of environmental pollutants.

8.7 INDIAN FOREST ACT, 1927

- The Act aimed at regulating the **movement of forest produce** and duty leviable forest produce.
- It categorised forests into **Reserve Forest, Protected Forest & Village Forest.**
- The Act **defines forest offences**, Specifies the acts prohibited inside a Reserved Forest, and penalties for the violation.

8.8 THE SCHEDULED TRIBES AND OTHER FOREST DWELLERS (RECOGNITION OF FOREST RIGHTS) ACT (2006)

- The Act is **aimed at restoring** the forest rights of the **Scheduled Tribes** & other traditional **forest dwellers** across India. It grants **legal recognition to the rights** of traditional forest-dwellers.
- **National Parks,** Sanctuaries, Reserve Forest & Protected Forests are included for the recognition of such Rights.
- The Act defines **Critical wildlife habitats** as areas of national parks & wildlife sanctuaries that are kept aloof for wildlife conservation.
- **Recognized Rights**
  - **Title Rights** to legally hold forest lands (up to 4 acres). Applies for land that is being cultivated by the concerned family, no new lands are granted.
  - **Usage Rights** for Forest produce including non-timber forest produce of plants by the community.
  - **Community Forest Resource Rights** for protecting, regenerating, conserving or managing forest resources for sustainable use, providing for community governance of forests.
- **Process Followed**
  - **Gram Sabha** passes a resolution recommending whose rights to which resources should be recognized.
  - This resolution is then screened & approved at the level of the sub-division (or taluka) and the district level by a **screening committee**; these committees also hear appeals.
  - The Committee consists of **three government officials** (from Forest, Revenue & Tribal Welfare Departments) and **three elected members** of the local body at that level.

8.9 THE BIOLOGICAL DIVERSITY ACT, 2002

Eligibility Criteria

Must be a Scheduled Tribe in the area where the right is claimed.

Primarily resided in forest or forests land for three generations (25X3 = 75 years) **before Dec 13 2005**.

Depend on the forest or forest land for livelihood needs.

- The Act was enacted to meet the obligations under the **Convention on Biological Diversity** (CBD) with objectives of conserving and promoting sustainable use of biological diversity and ensuring fair & equitable sharing of its benefits.
- **Prior permission is mandatory to claim IPR** over Biodiversity & its derivatives. The Act prohibits the transfer of Indian genetic material outside the country, without specific approval.
- It also has provisions for regulation of the use of **GM organisms** and establishment of National, State, & Local Biodiversity Funds.
- Set up **Biodiversity Management Committees** at the local village level, **State Biodiversity Boards** at the state level, & **National Biodiversity Authority** at the national level.

8.10 THE NATIONAL GREEN TRIBUNAL ACT 2010

NGT deals with Water Act, 1974; Water Cess Act, 1977; Forest (Conservation) Act, 1980; Air Act, 1981; EPA, 1986; Public Liability Insurance Act, 1991; Biological Diversity Act, 2002.

It does not deal with Wildlife (Protection) Act (1972); Indian Forest Act (1927); Forest Rights Act (2006).

- Its objective is **effective & expeditious disposal** (within 6 months of appeal) of the environmental cases and to help reduce the burden of litigation in the higher courts.
- The Act establishes NGT which has jurisdiction **over all civil cases** involving substantial questions relating to the environment. **NGT Act**, draws inspiration from constitutional provision under article **48A (DPSP).**
- The Act **provides for Enforcement** of legal environmental rights, **relief** & **compensation** for damages caused.
- Tribunal is guided by **principles of natural justice & its order** is **executable** as a **decree of a civil court**.
- NGT **orders** are **binding but can be challenged in the SC within 90 days.**
- NGT's **principal bench is at New Delhi** & **4 regional benches** in Pune, Bhopal, Chennai & Kolkata. There is also a mechanism for circuit benches.
- The **chairperson** of the **NGT** is a **retired judge** of the **Supreme Court**.
- Each bench of the NGT comprises at **least one judicial member and one expert member**.

8.11 THE OZONE DEPLETING SUBSTANCES (ODS) RULES (2000)

- Rules were made to regulate production, consumption & phasing out the ODSs following the Montreal Protocol.
- **Rules notified under EPA, 1986**
  - Prohibit the use of CFCs except for medical purposes.
  - Since HCFCs are used as interim substitutes to replace CFCs, these are allowed up to 1st January 2040.
  - **Registration** of ODS producers, sellers, importers, and stockists was made **mandatory**.
- **ODS-Amendment Rules, 2019**
  - India achieved the **complete phase-out of HCFC** (Hydrochlorofluorocarbon)-**141b**. The issuance of an **import licence for HCFC-141b is prohibited** under this amendment.

8.12 THE PROTECTION OF PLANT AND FARMERS RIGHTS ACT (2001)

Researcher's Rights

Researcher **can use any of the registered variety** under the Act for conducting experiments or research.

Investment in R&D for the development of new plant varieties.

Facilitate the **growth of the seed industry**, ensure the availability of high-quality seeds & planting material.A

- The Act was passed to protect plant varieties, the rights of farmers and plant breeders and to encourage the development of new varieties of plants; Recognizes rights of Farmers, Breeders & researchers.
- Farmers **to get recognition and rewards** for the conservation of Plant Genetic Resources. A farmer who has developed a new variety is entitled to **registration and protection**.
- **Compensation** to the farmers for non-performance of variety.
- Farmers are not liable to pay any fee in any proceeding before the Authority/Registrar/Tribunal/ High Court under the Act.
- **Breeders will have exclusive rights** to produce, sell, market, distribute, import, or export the protected variety.

8.13 COMPENSATORY AFFORESTATION FUND (CAMPA) ACT (2016)

- For providing an appropriate institutional mechanism to utilise afforestation funds, Compensatory Afforestation Fund Management & Planning Authority (**CAMPA**) was set up at central & state level.
- **Established a National Compensatory Afforestation Fund under** the Public Account of India, & a State Compensatory Afforestation Fund under the Public Account of each state.
- **The National Fund** receives **10% & State Fund gets 90% of funds** collected. Funds are utilised for afforestation, regeneration of forest ecosystem, wildlife protection & infrastructure development.
- The Forest Conservation Act of 1980 provides that non-forest land, equal to the size of the forest, is the same.

8.14 THE COASTAL REGULATION ZONE RULES (2019)

- These rules were brought to promote sustainable development and conserve coastal environments.

They govern human and industrial activity close to the coastline.

- The Rules, mandated under **Environment Protection Act, 1986,** were first framed in 1991.
- **The Shailesh Nayak Committee** was set up on CRZ.
- For CRZ-III (Rural) areas, two separate categories are CRZ-III(A) and CRZ-III(B)
  - **CRZ-III(A)** with a population density of more than 2161, the **No Development Zone** (NDZ) **is reduced to 50 metres** from 200 metres from the High Tide Line (HTL).
  - **CRZ-III(B)** with a population less than 2161 the **NDZ is 200 metres from the High Tide Line** (HTL).
- A NDZ of 20 metres is specified for all Islands. **Temporary tourism facilities are permitted** in Beaches in the NDZ of the CRZ-III areas.
- **Involvement of coastal communities** for management of Critically Vulnerable Coastal Areas (CVCA) identified under the EPA, 1986.
- The treatment facilities are permitted in the CRZ-I B area to address pollution.

8.14.1 Andaman and Nicobar Island Protection Zone (IPZ) Rules (2019)

- The Rules allow **eco-tourism projects** 20 metres from the high tide line (HTL) in smaller islands like Baratang, Havelock and Car Nicobar, and at 50 metres in larger ones.
- **Eco-tourism activities** like mangrove walks, tree huts, and nature trails in island coastal regulation zone IA (classified as the most eco-sensitive region of the islands which includes turtle nesting grounds, marshes, coral reefs, etc) are also allowed.
- **Construction of roads**, on stilts by reclaiming land in exceptional cases for defence installations, public utilities, or strategic purposes in eco-sensitive zones. In case of mangroves, a minimum three times the mangrove area destroyed during the construction process shall be taken up for compensatory plantation of mangroves elsewhere.
- **Many new activities** in the intertidal zone between the low tide line and HTL.

8.15 THE WETLAND CONSERVATION RULES, 2010

- The **Ministry of Environment and Forests** has notified the **Wetlands** (Conservation and Management) **Rules, 2010**.
- Despite their immense importance, wetlands are one of the most degraded ecosystems globally. These Rules ensure better conservation and management and prevent degradation of existing wetlands in India.
- Research suggests that over-exploitation of **fish resources**, **discharge of industrial effluents**, **fertilisers** and **pesticides** and uncontrolled siltation and weed infestation, among other reasons, have severely damaged over **1/3rd of India's wetlands**.
- Wetland conservation has been accorded a high priority in India. Since **1987**, the National Wetlands Conservation Programme of India has been financially supporting wetland conservation activities all over India.
- This is the first time that **legally enforceable Rules** are being notified for such eco sensitive areas in our country. Under the Rules, wetlands have been classified for better management and easier identification.
- **The Central Wetland Regulatory Authority** has been set up to ensure proper implementation of the Rules and perform all functions for management of wetlands in India.
- Apart from necessary government representatives, the Authority shall have a few expert members to ensure that wetland conservation is carried out in the best possible manner.

8.15.1 The Wetland Conservation and Management Rules (2017)

- **The Rules Apply to** wetlands categorised as **wetlands of international importance** under the Ramsar Convention.
- Wetlands are to be notified by the central and state governments and UT administration.
- The new Rules farm out wetland **management to states and union territories**.
- The new rules have done away with the earlier **Central Wetlands Regulatory Authority (CWRA)** entirely. As per the new rules, encroachments on wetlands have been banned.

8.16 SOLID WASTE MANAGEMENT RULES (2016)

- **It replaces the Municipal Solid Wastes (Management and Handling) Rules, 2000**, are now applicable beyond municipal areas and have included urban agglomerations, census towns, notified industrial townships etc.
- **Focus on segregation of waste at source**, responsibility on the manufacturer to dispose of sanitary and packaging wastes, user fees for collection, disposal and processing from the bulk generator.
- It has also been advised that the **biodegradable waste** should be **processed**, **treated** and **disposed** of through composting or bio-methanation within the premises as far as possible and the residual waste shall be given to the **waste collectors** or agency as directed by the local authority.

- The **rules promote the use of compost**, conversion of waste into energy, revision of parameters for landfills location and capacity.
- **The Rules for the Safe Treatment of Legacy Waste** prescribe bioremediation and bio-mining in all open dumpsites and existing operational dumpsites in India.

8.17 BIO-MEDICAL WASTE RULES (2016)

- Objective is to **manage bio-medical waste** (2016 rules are an improvement over BMW-1998 rules).
- The **ambit of the rules has been expanded** to include vaccination camps, blood donation camps, surgical camps, or any other healthcare activity.
- The **use of chlorinated plastic bags, gloves & blood bags** to be phased out within two years.
- **Pre-treatment** of the laboratory waste, microbiological waste, blood samples & blood bags through disinfection on-site in the manner prescribed by the WHO or by the NACO.
- Regular training & immunisation for all health care workers.
- A **Bar-Code System for bags or containers** containing bio- medical waste for disposal.
- **Categorization of waste into** 4 categories instead of the earlier 10 to improve the segregation of waste at source.
- **The State Government has to provide the land** for common bio- medical waste treatment and disposal facilities.
- These rules shall not apply to **radioactive wastes, Wastes covered under the MSW Rules** (2000), **E-waste, Hazardous microorganisms.**

8.18 THE E-WASTE MANAGEMENT RULES (2016)

- These are notified under EPA, 1986 and include **CFL & other Mercury containing lamps** as e- waste. Producers are now under **Extended Producer Responsibility (EPR),** along with targets.
- **State Governments** have **to ensure safety, health** & **skill development** of the workers involved in dismantling & recycling operations.
- There is a penalty for violation of rules. **Urban Local Bodies** have the right to charge user fees and levy spot fines for littering and non-segregation.
- Focus is on **channelizing the E-waste generated in the country towards authorised dismantlers** & **recyclers** to formalise the e-waste recycling sector.
- E-waste collection targets under EPR have been revised i.e.,10% (for 2017-18) of the quantity of waste generated with a 10% increase every year until 2023. (Target set at 70% after 2023 onwards).
- There is provision of **separate E-waste collection targets** for **new producers**.

8.19 HAZARDOUS AND OTHER WASTES (MANAGEMENT AND TRANS-BOUNDARY MOVEMENT) AMENDMENT RULES, 2019

- These Rules aim at strengthening the implementation of environmentally sound management of hazardous waste, **prohibition** on the import of solid plastic waste **even in SEZ & EOU** (Export Oriented Units). Silk waste exports are exempted.
- Electrical & electronic assemblies and components manufactured in & exported from India if found defective can be imported back into the country, within a year of export, without obtaining permission.
- **Industries that do not require consent under Water Act 1974 & Air Act 1981, are exempted** under the 'Hazardous & Other Wastes Rules, 2016', if wastes generated by such industries are handed over to the authorised actual users, waste collectors, or disposal facilities.
- The manufacture, import, stocking, distribution, sale and use of the identified **single-use plastic will be prohibited with effect from the 1st of July, 2022.**
- The ban will **not apply to commodities made of compostable plastic.**
- For banning other plastic commodities in the future, other than those that have been listed in this notification, the **government has given industry ten years** from the date of notification for compliance.
- The permitted thickness of the plastic bags, **currently 50 microns, will be increased to 75 microns** from 30th September, 2021, and **to 120 microns from the 31st Dec 2022**.
- The Central Pollution Control Board, along with state pollution bodies, **will monitor** the **ban, identify violations, and impose penalties** already prescribed under the **Environmental Protection Act, 1986**.
- The plastic packaging waste, which is not covered under the phase out of identified single use plastic items, shall be collected and managed in an environmentally sustainable way through the **Extended Producer Responsibility (EPR)** of the Producer, Importer and Brand owner (PIBO), as per Plastic Waste Management Rules, 2016.

8.20 GENETIC ENGINEERING APPRAISAL COMMITTEE (GEAC)

Functions of GEAC

(as prescribed in the Rules 1989)

To appraise activities involving large scale use of hazardous **microorganisms** and recombinants in research and industrial production from the environmental angle.

To appraise proposals relating to release of genetically engineered organisms and products into the environment including experimental field trials.

The committee or any person authorized by it has **powers to take punitive action under the Environment Protection Act**.

- The Committee functions under the **Ministry of Environment, Forest and Climate Change** (MoEFCC).
- The GEAC is the **Apex Biotech Regulatory Body** in India. It is a **Statutory Body** under the **Environment Protection Act 1986**.
- As per Rules, 1989, it is responsible for appraisal of activities involving large scale use of hazardous microorganisms and recombinants in research and industrial production from the environmental angle.
- The committee is also responsible for appraisal of proposals relating to release of **genetically engineered** (GE) organisms and products into the environment including experimental field trials.

8.21 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Environmental Impact Assessment (EIA)	
Meaning	• It is a process of evaluating the likely environmental impacts of a proposed project or development, considering inter-related socio-economic, cultural and human-health impacts, both beneficial and adverse. • **As per UNEP**, EIA is a tool used to identify the environmental, social and economic impacts of a project prior to decision-making.
Aim	• To predict environmental impacts at an early stage in project **planning and design**, find ways and means to reduce adverse impacts, **shape projects** to suit the local environment and present the predictions and options to decision-makers.
EIA in India	• **Need first arose in 1976-77** when the Planning Commission asked the **Department of Science and Technology** to examine the river-valley projects from an environmental angle. • The **first EIA notification was promulgated in 1994 by the then Ministry of Environment and Forests** (now MoEF&CC). • **EIA in India is backed by the Environment Protection Act, 1986** which contains various provisions on EIA methodology and process.
2006 Amendment to the EIA Notification	• The Amendment classified the developmental projects in two categories: • **Category A (national level appraisal)** projects are appraised by **Impact Assessment Agency (IAA)** and the **Expert Appraisal Committee (EAC)** • **Category B (state level appraisal)** are appraised by **State Level Environment Impact Assessment Authority (SEIAA)** and **State Level Expert Appraisal Committee (SEAC)** for clearance to the Category B projects. • The Amendment introduced **four stages into EIA Cycle; Screening, Scoping, Public hearing and Appraisal.** • **Category A projects require mandatory environmental clearance** and thus they do not have to undergo the screening process. • Category B projects undergo a screening process and are further classified into B1 (Mandatorily requiring EIA) and B2 (Not requiring EIA). • Projects such as mining, thermal power plants, river valley, infrastructure (road, highway, ports, harbours and airports) and industries including very small electroplating or foundry units are mandated to get environment clearance.

8.21.1 Draft EIA Notification, 2020

- One of the major steps of the EIA Mechanism is public **participation**. The 2020 draft proposes to **reduce the notice period for public hearings from 30 days to 20 days**.
- Furthermore, by classifying several projects into A, B1 and B2, **a host of projects are exempted from public scrutiny.**
- It implies that even after a project gets approved by the concerned authority, **the proponent projects are required to adhere to certain rules** laid down in the EIA report to ensure that no further environmental damages take place.
- The new draft EIA proposes the **submission of compliance reports annually** whereas as per the 2006 notification, the compliance report was to be submitted every six months.
- **The EIA Notification 2020 excludes reporting of violations** and non-compliance by the public. Instead, the **government will take cognisance of reports only from** the violator-promoter, government authority, Appraisal Committee or Regulatory Authority.
- Another major proposal in the draft 2020 is granting **'post- facto clearance'** where a project that has been operating without environmental clearance, can be regularised or allowed to apply for clearance.
- **Firms found violating the terms of their establishment,** if they have to get the clearance, however, **will have to pay a penalty**.

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9 Environmental Organisations in India

9.1 CENTRAL WATER COMMISSION

- It is an **apex technical organisation of India in the field of Water Resources**. Functions as an attached office of the **Ministry of Jal Shakti**.
- It is charged with the general responsibilities of initiating and coordinating **schemes of control, utilisation and conservation of water resources** throughout the country.
  - These schemes are generally aimed at flood control, irrigation, Navigation, Drinking Water Supply and Water Power Development.
- The Commission also **undertakes the investigations, construction and execution** of any such schemes as required.
- **The work of the Commission is divided among 3 wings namely,**
  - River Management Wing (RM),
  - Designs and Research Wing (D&R)
  - Water Planning and Projects Wing (WP&P).
- CWC provides a classification of the tolerance limits for inland surface waters for the various classes of water use:
  - **Class A:** Drinking water source without conventional treatment but after disinfection
  - **Class B:** Outdoor bathing
  - **Class C:** Drinking water source with conventional treatment followed by disinfection.
  - **Class D:** Fish culture and wildlife propagation
  - **Class E:** Irrigation, industrial cooling or controlled waste disposal.

9.2 ANIMAL WELFARE BOARD OF INDIA (AWBI)

- AWBI was established in 1962 under the **Section 4 of the Prevention of Cruelty to Animals Acts 1960**, its headquarter is in **Ballabgarh** in **Haryana** (earlier based at **Chennai**).
- AWBI is a **statutory advisory body** under the Ministry of Fisheries, Animal Husbandry and Dairying.
- **Functions of AWBI**
  - Board is highly concerned about **abuse of animals in research** and cruelty involved when animals were used in entertainment.
  - It **advises governments** on the matters related to Animal welfare and the Board **oversees Animal Welfare Organizations** (AWOs) by granting recognition to them if they meet its guidelines and **provides financial assistance** to recognized ones.
  - The Board **suggests changes to laws and rules** about animal welfare and **issues publications to raise awareness** of various animal welfare issues.

9.3 CENTRAL ZOO AUTHORITY (CZA)

- CZA was e**stablished** in 1992 with HQ in New Delhi under MoEF&CC as a **statutory body** under 1991 Amendment to **Wildlife (Protection) Act 1972**.
- It has the Minister of Environment as **Chairman** and 10 members and a member Secretary.
- Objective is to oversee the functioning and development of zoos in the country.
- Its powers include recognition of Zoos; permission for acquisition of wild/captive animals; cognizance of offences; grant of licences, certificate of ownership, recognition; etc.
- Its **functions** are under:
  - Specify the **minimum standards for housing, upkeep and veterinary care** of animals kept in a Zoos.
  - **Identify endangered species of wild animals** for purposes of captive breeding
  - Co-ordinate the **acquisition, exchange and loaning of animals** for breeding purposes
  - Ensure **maintenance of studbooks of endangered species** of wild animals bred in captivity
  - **Coordinate research in captive breeding** and educational programs for the purposes of Zoos.

9.4 ZOOLOGICAL SURVEY OF INDIA (ZSI)

- For promoting faunistic survey and exploration of the resources leading to the advancement of knowledge on the exceptionally rich faunal diversity of the country, ZSI was established in **1916**. Its roots go back to **Asiatic Society of Bengal founded by Sir William Jones in 1784.**
- **Headquartered at Kolkata,** it has 16 regional stations located in different geographic locations of the country.
- ZSI is a subordinate organisation of the Ministry of Environment and Forests and Climate Change (MoEF&CC).
- It works for training, capacity building and Human Resource Development of the people involved and also for the development of **Environmental Information System** (ENVIS) and **Convention on International Trade in Endangered Species of Wild Fauna And Flora** (CITES) Centers.
- Red Data Book on Indian Animals Fauna of India, Fauna of States and Fauna of Conservation Areas zre its **Publications.**

9.5 FOREST SURVEY OF INDIA (FSI)

- Forest Survey of India was established in **1981** in **Dehradun, Uttarakhand** under Ministry of Environment and Forests and Climate Change (MoEF&CC)
- It started as **'Pre-Investment Survey of Forest Resources (PISFR)'** in 1965 before re-organized as FSI in 1981.
- To **prepare State of Forest Report biennially**, providing assessment of latest forest cover
- To conduct **inventory in forest and non-forest areas and develop databases** on forest tree resources.
- To prepare **thematic maps on 1:50,000 scale**, using aerial photographs.
- To **function as a nodal agency for collection, compilation, storage and dissemination of spatial databases** on forest resources.
- To **support State/UT Forest Departments (SFD)** in forest resources survey, mapping and inventory.
- **Forest Survey Report**: Released by FSI since 1987, biennially (once in two years).

9.5.1 India State of Forest Report (2021)

About	• It is an **assessment of India's forest and tree cover**, **published every two years** by the Forest Survey of India. • The **first survey was published in 1987**, and ISFR 2021 is the **17th.** • India is one of the few countries in the world that brings out such a survey every two years, and this is widely considered comprehensive and robust.
Used in	• Planning and formulation of policies in forest management as well as forestry and agroforestry sectors.
Categories	• Very dense forests (canopy density over 70%) • Moderately dense forests (40-70%) • Open forests (10-40%). • **Note**: Scrubs (canopy density less than 10%) are also surveyed but not categorised as forests.
Definition of Forest Cover	• **Forest cover** as all lands of a hectare or more with tree patches with canopy density of **more than 10 %.** • This **covers all lands**, irrespective of legal ownership and land use. • **Recorded forest area** includes only those areas recorded as forests in government records and includes pristine forests.
New Features	• **First time assessed forest cover in tiger reserves, tiger corridors and the Gir forest** which houses the Asiatic lion. • Forest cover in tiger corridors has increased by 37.15 square km (0.32%) between 2011-2021, but decreased by 22.6 square km (0.04%) in tiger reserves. • Forest cover has increased in 20 tiger reserves in these 10 years and decreased in 32. • **Increase in forest cover**: Buxa (West Bengal), Anamalai (Tamil Nadu) and Indravati reserves (Chhattisgarh). • **Highest losses**: Kawal (Telangana), Bhadra (Karnataka) and the Sundarbans reserves (West Bengal).

Findings	• **Increase of 2,261 sq km in the total forest and tree cover** of the country in last two years. • **Area-wise Madhya Pradesh has the largest forest** cover in the country. • **Percentage-wise Mizoram (84.53%)** has the largest forest cover in the country. • States in North East India have the highest percentage of forest cover. • Maximum increase in forest cover was witnessed in **Andhra Pradesh (647 square km)** followed by Telangana (632 square km) and Odisha (537 square km). • **17 states/UT's have above 33 percent** of the geographical area under forest cover. • Total carbon stock in country's forest is estimated to be 7,204 million tonnes, an increase of 79.4 million • Total mangrove cover in the country is 4,992 square km, an **increase of 17 square Km observed.**
Forests in India's Mountainous states	• Increase in forest loss in India's mountainous states along its Himalayan frontier, which are already in the throes of climate change • Jammu & Kashmir has lost very dense forests but gained open forests. The increase in open forests is led by commercial plantations. • The report has attributed the loss of forest cover in the Himalayas and North East to an increase in developmental activities as well as agriculture.
Forest cover at Lion Conservation Area (LCA) at Gir in Gujarat	• The LCA has seen a **decrease** of 33.43 square km in its forest cover during the last decade • It attributed the decrease to 'habitat improvement measures' taken in the last decade. • This includes the removal of Prosopis juliflora, an invasive species from grassland areas and canopy manipulation for creating openings in the Very Dense Forest and Moderately Dense Forest areas. • **Wetlands**: Gir National Park and Wildlife Sanctuary have 31 wetlands.

9.6 BOTANICAL SURVEY OF INDIA (BSI)

- BSI is the **apex taxonomic research organisation** of the country with mandate of biosystematics research, floristic studies, documentation of flora, digitization of herbarium specimens and advisory services etc.
- BSI publishes **'Red Data Book of Indian Plants'**.
- Its functions include:
  - Exploration, inventorying and documentation of Phyto-diversity in general and protected areas, hotspots and **fragile ecosystems in particular**.
  - Publishing of National, State and District Floras and developing the National database of Indian plants.
  - Identification of threatened and red list species and species rich areas needing conservation.
  - Ex-situ conservation of critically threatened species in botanical gardens.

9.7 WILDLIFE CRIME CONTROL BUREAU (WCCB)

- **WCCB** was established in **2006** under the Ministry of Environment and Forests and Climate Change (MoEF&CC) in New Delhi. It has regional offices **Kolkata, Mumbai, Chennai & Jabalpur**.
- It is a **statutory body** constituted under the **Wildlife (Protection) Act 1972 (WPA 2006, Amendment)** for combating organised wildlife crime.
- WCCB is the nodal point for **SAWEN** (South Asia Wildlife Enforcement Network) in India.
- WCCB has conducted Operation Save Kurma, ThunderBird, Wild-Net, Lesknow, Birbil, Clean Art etc.
- UNEP has awarded WCCB with '**Asia Environment Enforcement Awards**' in 2018.
- WCCB's functions are as under:
  - **Collect intelligence** related to organised wildlife crime activities.
  - Establish a **centralised wildlife crime data bank**.
  - **Coordinates with foreign authorities** and international organisation
  - Build capacity of the wildlife crime enforcement agencies for scientific and professional investigation
  - Assist State Governments to ensure success in prosecutions related to wildlife crimes.
  - **Advise the Govt** on issues relating to wildlife crimes having national and international ramifications.
  - It also **assists & advises** the **Customs authorities** in inspection of the consignments of **flora & fauna** as per the provisions of WPA, CITES & EXIM Policy.

9.8 NATIONAL BIODIVERSITY AUTHORITY (NBA)

- NBA was established in **2003,** in Chennai under the Ministry of Environment and Forests and Climate Change (MoEF&CC). NBA is a **statutory body under Biological Diversity Act, 2002**.
- The act was **enacted to give effect-to the Convention on Biological Diversity (CBD)** (India signed it in 1992)
- Its mandate is **to perform regulatory & advisory functions for the GoI** on issues of conservation, sustainable use of biological resources.
- NBA supports **creation of State Biodiversity Boards (SBBs).**
- **Biodiversity Heritage Sites** are notified by State Governments in consultation with local bodies.
- Its functions include:
  - Advising the Central and State Government on matters relating to the conservation of biodiversity.
  - Taking any measures necessary to **oppose the grant of Intellectual Property Rights** in any country outside India on transfer of biological resources or knowledge from India.

9.9 NATIONAL GANGA RIVER BASIN AUTHORITY

National Plan for Conservation of Aquatic Ecosystem

NPCA was launched in **2013** by merging **National Lake Conservation Plan** (NLCP) and **National Wetlands Conservation Programme** (NWCP) for Holistic conservation & restoration of lakes, wetlands to enhance water quality besides improving biodiversity and the ecosystem.

NPCA is presently operational on cost sharing between Central and respective state governments.

- NGRBA was established in **2009** under the Ministry of Jal Shakti at New Delhi with a mandate of abatement of pollution and conservation of the river Ganga.
- The NGRBA is **chaired by the Prime Minister** and other members include Union Ministers concerned, the Chief Ministers of the States through which Ganga flows.
- The Authority has both regulatory and developmental functions and takes measures for effective abatement of pollution and conservation of the river Ganga in keeping with sustainable development needs.
- Functions include:
  - Development of river basin management plan and regulation of activities
  - Maintenance of minimum ecological flows in the river Ganga
  - Collection, analysis and dissemination of information
  - Promotion of water conservation practices including recycling and reuse, rainwater harvesting, and decentralised sewage treatment systems
  - Issuance of directions under **Environment (Protection) Act 1986** for the purpose of exercising and performing all or any of the above functions and to take such other measures as the Authority deems necessary or expedient for achievement of its objectives.

9.10 NATIONAL BOARD FOR WILDLIFE (NBWL)

- NBWL replaced the **'Indian Board for Wildlife'** (which was formed in 1952 as an advisory board) established in **2003**, New Delhi. **The Prime Minister** is the **Chairperson.**
- NBWL is a **statutory body constituted under the WPA, 1972** under Ministry of Environment and Forests and Climate Change (MoEF&CC)
- **Objective**: To promote the conservation and development of wildlife and forests.
- **Power**: to review all wildlife-related matters and approve projects in and around national parks and sanctuaries.
- **No alteration of boundaries** in National Parks and Wildlife Sanctuaries can be done without approval of the NBWL.

9.11 NATIONAL TIGER CONSERVATION AUTHORITY (NTCA)

- Wildlife (Protection) Amendment Act, 2006 provides for creation of National Tiger Conservation Authority and Tiger and Other Endangered Species Crime Control Bureau (Wildlife Crime Control Bureau).
- NTCA, a statutory body, operates from New Delhi under the chairmanship of Minister of Environment and Forests and Climate Change.
- **State level Steering Committees** are set up in the Tiger States under the Chairmanship of respective **Chief Ministers.**
- NTCA addresses the livelihood interests of local people in areas surrounding Tiger Reserves.

9.12 BOMBAY NATURAL HISTORY SOCIETY

Internet of Birds

IT consultancy firm Accenture and the **BNHS** have developed the Internet of Birds platform that identifies bird species found in India using **Artificial Intelligence**, including machine learning and computer vision, from digital photos that are uploaded by the public.

- **Founded in 1883,** is one of the **largest NGO in India** engaged in conservation and biodiversity research. BNHS is the partner of **Bird Life International in India**
- The BNHS logo is the **Great Hornbill.**
- It supports many research efforts through **grants** and **publishes the Journal** of the BNHS.
- The Department of Science and Technology has designated it as a '**Scientific and Industrial Research Organisation'**. It also organises and conducts nature trails and camps for the public.
- Many prominent naturalists, including the ornithologists **Salim Ali** and **S. Dillon Ripley**, have been associated with it.

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10 Important Plans, Missions and Institutions

Plans/Funds/Missions/ Organisations	Establishment	Noteworthy Points
National Wildlife Action Plan	• Set up by the Ministry **of Environment, Forest and Climate Change** (MoEF&CC) for preservation of genetic diversity & sustainable development. • **Plan periods,** 1983 to 2001 1st Plan, 2002 to 2016 2nd Plan and 2017 to 2031 3rd Plan. Third Wildlife Action Plan was drafted by the **JC Kala committee.**	• This plan **recognized the impact of climate change** on wildlife for the 1st time. • It integrated climate change mitigation actions into the wildlife management with special focus on habitat conservation in coastal, marine, & inland aquatic ecosystems and also the **recovery** of threatened species.
National Afforestation and Eco-development Board (NAEB)	• NAEB was set up in **1992** under the **MoEF&CC** for promoting afforestation, ecological restoration and eco-development activities in the country.	• Special attention was given to the degraded forest areas and lands adjoining the protected areas as well as the ecologically fragile areas like the Western Himalayas, Aravallis, Western Ghats, etc.
Joint Forest Management (JFM)	• **JFM recognizes the importance of the local community** in managing forest resources. • It draws its powers from **National Forest Policy (1988)** & the **Joint Forest Management Guidelines** (1990).	• Under JFM, village communities are entrusted with the protection and management of nearby forests. • Joint conservation effort with the nomadic tribe of Maldharis, (vicinity of Gir National Park, Gujrat) has contributed to the improvement of Lion population.
National Bamboo Mission (NBM)	• NBM was **launched** in 2006-07 under the Mission for Integrated Development of Horticulture (MIDH), **Ministry of Agriculture**. It is a Centrally Sponsored scheme. • Bamboo is often termed as **green gold** as per the **green** and **yellow colour logo** of **NBM**.	• The Mission envisages promoting **holistic growth of the Bamboo sector** and **increasing the area under Bamboo plantation** in non-forest Government and private lands. • It aims to harness the potential of the **Bamboo** crop & livelihood development.

Plans/Funds/Missions/ Organisations	Establishment	Noteworthy Points
Eco Mark	• **It was launched** in 1991 by the MoEF&&CC as a **voluntary labelling scheme** for the identification of environment friendly products. • Purpose was to **create awareness among the consumers towards reducing environment impact.**	• Eco Mark is **administered by the Bureau of Indian Standards** (BIS). • It is one of **India's earliest efforts in environmental standards** (even before the 1992 Rio Summit).
Comprehensive Environmental Pollution Index (CEPI)	• Assisted by the **World Bank, it is implemented by** State governments. At national level the Conservation and Survey Division of MoEF&CC oversees the project.	• CEPI is a **rational number to characterise the environmental quality** at a given location. • Critically Polluted Areas have CEPI score of 70 & above and Severely Polluted Areas have CEPI score of above 60 & below 70.
Biodiversity Conservation and Rural Livelihood Improvement Project (BCRLIP)	• The **BCRLIP** is the first national level **attempt at linking conservation & local livelihoods** on a landscape scale. • **Developed by the CPCB** (Central Pollution Control Board) in collaboration with **IIT Delhi in 2009**	• Its objective is to conserve Biodiversity in selected landscapes (including wildlife protected areas) & **improve rural livelihood** through people participation.
Lighting A Billion Lives (LABL)	• LABL was launched in **2007 by TERI** - The Energy and Resources Institute for replacing kerosene-based lighting with cleaner, more efficient and reliable solar lighting devices in rural areas. • **LABL** works on the PPP model.	• It has 2 implementation approaches, one is **Fee-for-service model** wherein the poor users pay only nominal daily rent and other is **Loan finance model** which finances to create solar entrepreneurs. • Afghanistan, Kenya, Uganda, Ethiopia, Mozambique, Myanmar also adopted it.
National Clean Energy Fund	• It was created in 2010-11 using the **Carbon Tax/ Clean Energy Cess.** • It is a **Non lapsable fund** under Department of Expenditure, Ministry of Finance.	• Fund is used for research and innovative projects (both Public & private sector) in clean energy technologies.
Mangroves For the Future (MFF)	• MFF was established in 2006 as a collaborative project developed by **IUCN** & **UNDP.** • Aimed at **rebuilding the 2004 tsunami-hit areas, it** promoted investment in coastal ecosystem conservation for sustainable development.	• Bangladesh, Cambodia, India, Indonesia, Maldives, Myanmar, Pakistan, Seychelles, Sri Lanka, Thailand and Vietnam are members countries.

Plans/Funds/Missions/ Organisations	Establishment	Noteworthy Points
National Electric Mobility Mission Plan (NEMMP) (2020)	• NEMMP is the vision document / roadmap **for** the faster adoption of **Electric Vehicles (EV)** & **their manufacturing** in the country. • Government aims to **provide fiscal and monetary incentives** to kick start this nascent technology.	• As part of the NEMMP 2020, **the Ministry of Heavy Industries** formulated a Scheme viz. Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (**FAME India**) Scheme in the year 2015.
National Green Corps (NGC)	• National Green Corps (NGC) popularly known as a programme of **Eco-Clubs** is a nationwide initiative of the Ministry of Environment & Forests.	• NGC works with the motto of **"Where there is Green, there is Prosperity".** It was launched under the Environment Education Awareness and Training (EEAT).

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11 Climate Change

11.1 INTRODUCTION

- **Climate** is the average condition of temperature, humidity, pressure, wind, rainfall, and other meteorological elements on the Earth's surface for a long time.
- Climate change refers to the **alteration of climate due to direct or indirect anthropogenic activities** over comparable time periods. Climate change is usually measured in major shifts in temperature, rainfall, snow, and wind patterns lasting decades or more.

11.2 GLOBAL WARMING

Impacts of Global Warming

Rise in Sea level, Changes in rainfall patterns, Increased likelihood of extreme events such as heat wave, flooding, hurricanes etc., Melting of the ice caps and glaciers, Widespread vanishing of animal populations due to habitat loss, spread of disease (like malaria, etc), bleaching of Coral Reefs and Loss of Plankton due to warming of seas.

- Global warming is a gradual increase in the earth's temperature generally due to the greenhouse effect caused by increased levels of carbon dioxide, CFCs, and other pollutants.
- It is a **naturally occurring phenomenon** that blankets earth's lower atmosphere and warms it, maintaining temperature suitable for living things to survive (balance cooling and warming of the earth).
- Human-induced greenhouse gas emissions upset the natural balance & lead to increased warmth, otherwise called Global warming.
- In its absence, earth surface temperature **would be – 19 degrees Celsius instead of current 15 degrees Celsius**.
- Greenhouse gases released, Fossil fuels combustion, Deforestation, Agriculture and livestock are primary responsible factors.

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11.3 COMPARATIVE ACCOUNT OF CLIMATE CHANGE AND GLOBAL WARMING

Topic	Climate Change	Global Warming
Definition/ Meaning	• Climate changes are the changes occurring in the globe or a region over a long period of time.	• Global warming is the rising of the average temperature of the Earth over time.
Causes	• Both humans caused and naturally occurring.	• Mainly due to human activities.
Major Factors	• Volcanic eruptions, plate tectonics changes in ocean, pollution, deforestation and releasing of greenhouse gases, etc.	• Mainly due to the emission of greenhouse gases.
Major Impacts	• New weather patterns, rise in earth temperature. Changes in sea level, melting of ice, more frequent droughts.	• Rise of surface temperature of the Earth.

11.4 GREENHOUSE GASES (GHG)

- Natural as well as anthropogenic gaseous constituents of the atmosphere which **absorb and re-emit infrared radiations**.

Two important characteristics of GHGs are:

- How well the gas absorbs energy – Warming potential
- How long the gas stays in the atmosphere – Atmospheric Lifetime.

Carbon Budget

The carbon budget is an estimate of the maximum amount of greenhouse gases that can be released into the atmosphere over time and still keep warming limited to a specified level.

An Indian emitted only 1.97 tonnes of CO_2 (tCO_2) annually, while Americans and Canadians both emitted well over 16 tCO_2.

- **Global Warming Potential (GWP) is** the total energy that the gas absorbs for a certain period of time, mostly 100 years. GWP is always **compared to CO_2 as its GWP is '1' and is baseline.**
  - **CFCs, HFCs, HCFCs and SF6 are called high-GWP gases** because they trap more heat than CO_2.
- Atmospheric gases like Carbon Dioxide, Methane, Nitrous Oxide (N_2O), Water Vapour, and Chlorofluorocarbons **can trap the out-going infrared radiation** from the earth's surface thereby causing greenhouse effect.
- Oxides of Nitrogen with general formula NOx – NO, NO_2 – Nitrogen oxide, Nitrogen dioxide etc. are global cooling gases while Nitrous oxide (N_2O) is a greenhouse gas.

Gas	Natural Source	Human-Induced Source	Removal	Global Warming Potential	Atm. Lifetime (Years)
Water Vapour (Biggest contributor)	Evaporation from oceans etc. Amount of vapour in air related to amount of other greenhouse gases present	Humans not directly responsible CO_2 and other GHGs present increase water vapour in air	–	–	–
Carbon Dioxide (Co2) (Primary GHG)	Ocean exchange, Animal/human respiration, Soil respiration, Volcanic eruptions and Wildfires	Combustion of fossil fuels, Industrial emissions, Chemical & mineral reactions	Reduce fossil fuel usage Carbon sequestration	1	50 - 200
Methane (CH_4)	Wetlands, (largest) Oceans, Volcanic eruptions and Wildfires	Agriculture, Industries, Landfills, Wastewater	Reduce waste	21	10-15
Nitrous Oxide (N_2O)	Earth's nitrogen cycle Bacteria breaking it down in soils and oceans	Agriculture, Transportation, Fossil fuel, combustion During production of nitric acid	Absorbed by certain bacteria Destroyed by UV rays or chemical reactions	310 ns	120
Fluorinated Gases: **(1)** Hydrofluoro carbons-HFCs. **(2)** Perfluoro carbons-PFCs **(3)** Sulphur Hexafluoride - SF6	-	Aluminium & semi-conductor manufacturing Refrigerants, Aerosol, propellants, Fire retardants, Magnesium processing, Circuit breakers	Destroyed by sunlight in far upper atmosphere	HFC - 150 to 11,700 PFC- 6,500 to 9,200 SF6- 23,900	HFC - 1.5 to 209 PFC - 2,600 to 50,000 SF6 - 3,200

11.5 DETERIORATION OF CARBON SINKS

Cryosphere

The cryosphere is the frozen water part of the Earth water system. Polar regions, snow caps of high mountain ranges are all part of cryosphere.

- High latitude forests store more carbon **than tropical rainforests. One third** of the world's soil-bound carbon is in taiga and tundra areas.
- When the **permafrost melts due to global warming, it releases carbon** in the form of carbon dioxide and methane.
- In the 1970s the tundra was a carbon sink, but today, it is a carbon source, all because of global warming. (Global warming leads to more global warming).

11.6 CLIMATE FORCING

- Climate forcing is the physical process of affecting the climate on the Earth through a number of forcing factors.
- Examples of positive forcing is **GHGs warming** the earth and that of negative forcing is Aerosols & volcanic eruptions **cooling** the earth.
- **Natural forcing** does not harm climate or cause drastic global temperature variations while GHGs, aerosols, etc., are results of **Human induced forcing**.

Radiative Forcing	• Change in earth's energy balance due to alterations in climate. ○ Positive forcing increases temperature. ○ Negative forcing reduces temperature.
Natural Forcing	• Changes in the amount of energy emitted by the sun. • Very slow variations in earth orbit. • Slight increase in solar energy since industrial revolution.
Human-Induced Forcing	• Due to greenhouse gases and aerosol emissions from fossil fuels. • Modification of land surface due to deforestation, agricultural use, etc.
Human-Generated Greenhouse Gases	• Have a warming effect, i.e., Positive climate forcing. • Largest climate forcing agent is Co_2 emitted from combustion of fossil fuels.
Human-Generated Aerosols	• Burning fossil fuels adds aerosols to the atmosphere. • Aerosols include water, ice, mineral dust, ash or acidic droplets • Aerosols have a cooling effect. • Aerosols deflect sun's energy & affect formation & life of clouds

11.7 RECEDING GLACIERS

- It is evident that the glaciers have been receding for decades now and melted ice is the result of the rising ocean levels.
- **Scientists predict** that by 2030, more glaciers will have melted resulting in potential threat to aquatic as well as terrestrial ecosystems.
- It will have a severe impact on agriculture and food security, health, pests and disease burden increase such as dengue, malaria, atmospheric circulation (cyclones in Arabian sea), monsoon patterns, changing ecosystems (forest fires etc), impact on oceans, economic losses etc.

11.8 SEA LEVEL CHANGE (SLR)

- Sea level change means the fluctuations in the mean sea level over a considerably long period of time.
- Changes in sea level occur over a broad range of temporal and spatial scales, with the many contributing factors making it an integral measure of climate change.
- As **Sea Level Rise** (SLR) is not uniform across the world, there is a need to differentiate regional SLR from the global rates.

11.8.1 Various Aspects Associated with Sea Level Change

Types of Change in Sea Level	• Eustatic changes: occur when the volume of sea water changes due to factors such as: Global warming and melting of ice sheets (rise in sea level) or ice ages (fall in sea level) Changes in the volume of mid-oceanic ridges. • Tectonic changes occur due to a change in the level of land
India's Status	• India's **7,516-kilometre-long coastline** includes 5,422 kilometres of coastline on the mainland and 2,094 kilometres on the islands belonging to **nine states and four UTs.** • The coastline accounts for 90% of the country's trade and it spans 3,331 coastal villages and 1,382 islands.
Factors Responsible for Sea-Level Rise	• **Anthropogenic activity** is at the root of this phenomenon. Specifically, since the industrial revolution, carbon dioxide and other greenhouse gas emissions have raised temperatures even higher in the poles. • **Burning of fossil fuels** has resulted in the build-up of greenhouse gases influencing the warming trend because they trap heat in the atmosphere. • **Oil and gas drilling** that emits methane which is the main constituent of natural gas is another contributor. • **Methane is more damaging to the environment than carbon dioxide**, locking in heat more efficiently and escalating global warming. • **Deforestation**, on the rise, across the globe, has a lot of negative effects like a rise in sea levels. • **In summer, Ice breaking ships** that head to the north in the Arctic Ocean leave trails of open waters, leaving the oceans with lesser ability to reflect back sun rays.
Impact of Sea Level Rise	• Coastal Flooding; Destruction of Coastal Biodiversity; Dangerous Storm Surges; Lateral and Inland Migration; Impact on Infrastructure; Threat to Inland Life; Tourism and Military Preparedness; Coastal hazards.
Measures to Address Sea Level Rise	• Relocation; Building Sea Wall; Building Enclosures; Architecture to Steer Flow of Water

11.8.2 Sinking Chain of Atolls

Carbon Footprint

Carbon footprint can be defined as the total amount of greenhouse gases produced to support human activities directly and indirectly, usually expressed in equivalent tons of carbon dioxide (CO_2). There are two types of carbon foot printing which are given below:

- **Organisational Emissions** are the emissions from all the activities across the organisation such as energy use, industrial processes and company vehicles.
- **Product Emissions** are the emissions over the whole life of a product or service, from the extraction of raw material and manufacturing rights through to its use and final reuse, recycling or disposal.
- **Carbon Watch** is a mobile application to assess the carbon footprint of an individual. **Chandigarh** became the first state or Union Territory in India to launch Carbon Watch. **India's 1st app to assess one's carbon footprint.**

- Due to constant rising sea level, many small atolls (circular coral colonies) of the Indian archipelago are sinking.
- Parali I Island of Lakshadweep has already sunk and Parali II has sunk almost 80% of its total area. Thinkara (14.38%) and Parali III (11.42%) are eroding at a fast pace.
- UNIPCC in its fifth report has stated that sea level in Lakshadweep has risen up **to 0.6 m in the last 20 years.**

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12 Strategies to Address Climate Change

12.1 CLEAN COAL USE

- Coal is a major fossil fuel used worldwide. CO (carbon monoxide) and CO2 are the major greenhouse gas which are released during burning of coal.
- Coal mined in India has **high ash content, high moisture and other impurities.** Along with the above gases, **nitrogen oxides** (destroys ozone) **and sulphur oxides** (acid rains) are also released.
- Various technologies like Coal preparation, coal washing are employed to remove unwanted minerals by mixing crushed coal with a liquid and allowing the impurities to separate and settle.
- Other systems control the coal burn to minimise emissions of sulphur dioxide, nitrogen oxides and particulates.
- **Gasification avoids burning** coal altogether. With gasification, steam and hot pressurised air or oxygen combine with coal to produce syngas.
- The **resulting syngas, a mixture of carbon monoxide and hydrogen, is then cleaned and burned in a gas turbine** to make electricity.
- **Wet scrubbers, or flue gas desulfurization systems**, remove sulphur dioxide, a major cause of acid rain, by spraying flue gas with **limestone and water.**
- India is building **supercritical and ultra-super-critical thermal power plants** (15-20% increase in efficiency) to burn Indian coal more efficiently.

12.2 CARBON SEQUESTRATION

- Carbon sequestration is a **process to capture and store CO_2 to curb global warming**. It is captured from the air, industries or power stations and stored permanently underground. This promotes:
- **Three main steps to Carbon Capture and Storage (CCS):**
  - Trapping & separating CO from other gases.
  - Transporting captured CO to storage location.
  - Storing CO far from the atmosphere, either in the deep ocean or underground.
- Long-term reserve of CO2 or forms of carbon to control temperatures.
- Lowering of the amount of GHGs present in air due to combustion of fossil fuels.

Types of Carbon Sequestration	
Ocean Sequestration	• Through direct injection or fertilisation
Geological sequestration	• Natural pore spaces in geological foundation • Has largest potential
Terrestrial sequestration	• Stored in soils and vegetation through decomposed matter & photosynthesis respectively.

Geological Sequestration Trapping Mechanism	
Hydrodynamic trapping	• Trapped as gas under low-permeability cap rock • Combines with solubility trapping
Solubility Trapping	• Dissolved in oil, water, etc. • Combines with hydrodynamic trapping
Mineral carbonation	• Forms stable compounds like iron, calcium by reacting with minerals/organic matter

12.3 CARBON SINKS

- Carbon sequestration is carried out by **pumping carbon** into **carbon sinks**. This is an **age-old process**. Only recently, these sinks are also being used for capturing carbon for environmental reasons.
- **Natural Sinks**: Oceans, forests, soil, mangroves etc.
- **Artificial Sinks**: Depleted oil reserves, unmineable mines etc.

12.4 THE BLUE CARBON INITIATIVE

- Conservation International (CI), International Union for Conservation of Nature (IUCN) and the Intergovernmental Oceanic Commission (IOC) of UNESCO has collaborated with governments and organisations across the world to develop mechanisms for ensuring coastal Blue Carbon ecosystems.

Blue Carbon

Removed by tidal marshes, mangroves, seagrass.

Stored in marine organisms, plants & sediments.

Coastal ecosystems accumulate large amounts of carbon, 5 times more than forests.

Found in all continents except Antarctica.

Green Carbon

Removed by photosynthesis

Stored in plants & soil.

Forests accumulate large amounts of carbon.

Afforestation and reforestation can enhance it.

Fig. 12.1

- It also comprises engagement of local, national and international organisations, comprehensive methods for carbon accounting and incentive mechanism.
- Scientific research for climate mitigation.

12.5 CARBON CREDIT

- A Carbon Credit is a **tradable permit that certifies the right to emit 1 ton of CO_2 or its equivalent.**
- As per gas emissions norms laid down by signatories of the Kyoto Protocol under UNFCCC, companies have two ways to reduce emissions:
- Reduce GHGs by adopting new technologies.
- Connect with developing countries to set up eco-friendly technology to earn credits. This credit becomes permit for companies to emit GHGs in its own country.
- **Status of developing nations –**
- India and China are the biggest sellers. Europe's biggest buyer.
- China is leading with 73% of market share, whereas India is second at 6 %.
- India's Multi Commodity Exchange (MCX) has become the 1st exchange in Asia to trade carbon credits.

Kyoto Protocol (COP 3; UNFCCC Summit 1997)

- Adopted in Kyoto, Japan, in 1997. **India ratified the Kyoto Protocol in 2002**.
- The Kyoto Protocol came into force in February 2005. There are **currently 192 Parties.**
- **The USA never ratified the Kyoto Protocol. Canada withdrew in 2012.**
- **Goal**: Fight global warming by reducing greenhouse gas concentrations in the atmosphere to a level that would prevent dangerous anthropogenic interference with the climate system.
- **Aimed**: to cut emissions of greenhouse gases across the developed world by about 5 per cent by 2012 compared with 1990 levels.
- The Protocol **is based on the principle of Common But Differentiated Responsibilities** (CBDR).
- The Kyoto Protocol is the **only global treaty with binding limits on GHG emissions.**

12.6 CARBON OFFSETTING

Credits for reductions in greenhouse gases made at another location.

- Sold in metric tonnes of carbon dioxide equivalent.
- Fastest way to achieve deepest reductions in business dealings.
- Provide employment opportunities, community development programmes, training, education.
- Must meet essential quality criteria.
- Cannot be double-counted.

Global Carbon Emissions in Various Sectors

Sector	Emissions %
Power	25
Agriculture & land use	24
Industry	21
Transport	14
Other	10
Buildings	6

12.7 GEO - ENGINEERING

- Geo-engineering is a technology that strives to modify, improve and cool the earth's environment. The concept is still in its nascent stage.

Ideas	Mechanism
Copy a Volcano	• By infusing atmosphere with Sulphur-dioxide gas through volcanic eruption, scientist believe it will block solar radiation and cool the planet. • Sulphur doesn't heat stratosphere and has cooling effect.
Shooting Mirrors into Space	• To deflect sunlight and bring earth's temperature back to pre-industrial levels. • Mirrors (size of Greenland) to be positioned between the planet and the sun.
Seeding the Sea with Iron	• Phytoplankton prefer iron. Iron pulls carbon out of atmosphere during photosynthesis • Scientists believe stimulating phytoplankton growth will reduce global warming potential.
Whiten Clouds with wind-powered Ships	• Cloud tops reflect solar radiation. • Spraying seawater into the sky through wind-powered ships will whiten clouds thus increasing reflection of solar radiation.
Build Fake Trees	• **Artificial tree** can capture 1 ton of carbon in atmosphere per day • Panels of absorbent resin on tree surface react with CO_2 to form a solid. • We can compare this to a furnace filter.

12.8 BIOFUELS

- Any hydrocarbon fuel that is produced from an **organic matter (living or once living material)** in a short period of time (days, weeks, or even months) is considered a biofuel.
- Biofuels are a type of carbon capture and utilisation where carbon is captured from the atmosphere, oceans and other sources to produce biofuels. Thus, the **net carbon emission is zero.**
- Biofuels may be **solid** (wood, animal & plant waste etc.), **liquid** (bioethanol, biodiesel etc.) or **gaseous** (biogas) in nature.

First Generation Biofuels

Made from food sources such as sugar, starch, vegetable oil, or animal fats using conventional technology.

E.g. Bio alcohols, Biodiesel, Vegetable oil, Bio ethers, Biogas etc.

Second Generation Biofuels

Produced from non-food crops or portions of food crops that are not edible and considered as wastes, e.g. stems, husks, wood chips, and fruit skins and peeling.

Thermochemical reactions or biochemical conversion process is used for producing such fuels.

E.g. cellulose ethanol, biodiesel.

Third Generation Biofuels

Produced from micro-organisms like algae.

Micro-organisms like algae can be grown using land and water unsuitable for food production, therefore reducing the strain on already depleted water sources.

E.g. Butanol

Fourth Generation Biofuels

Production of these fuels, crops that are genetically engineered to take in high amounts of carbon are grown and harvested as biomass

The crops are then converted into fuel using second generation techniques.

- Can be used to replace or in addition to diesel, petrol or other fossil fuels for transport, stationary, portable and other applications. Also, to generate heat and electricity.
- **Bioethanol, Biodiesel, Biogas, Biobutanol** etc., are major types of Biofuels.

12.9 BIOMASS

- Biomass is a renewable energy resource derived from the carbonaceous waste of various human and natural activities.
- It is derived from numerous sources, including the **by-products from the timber industry, agricultural crops, grassy and woody plants, residues from agriculture or forestry, oil-rich algae,** and the organic component of municipal and industrial wastes.
- Burning biomass releases about the same amount of carbon dioxide as burning fossil fuels. However, fossil fuels release carbon dioxide captured by photosynthesis during their formative years.
- **Biomass releases carbon dioxide that is largely balanced by the carbon dioxide captured in its own growth** (depending how much energy was used to grow, harvest, and process the fuel).
  - Hence, Biomass does not add carbon dioxide to the atmosphere as it absorbs the same amount of carbon in growing as it releases when consumed as a fuel.

12.10 IMPORTANT PROCESSES

Processes	Explanation
Anaerobic Digestion / Bio-methanation	Biomethanation, or methanogenesis, is a scientific process whereby anaerobic microorganisms in an anaerobic environment decompose biodegradable matter producing methane-rich biogas and effluent. The three functions that take place sequentially are hydrolysis, acidogenesis and methanogenesis.
Combustion/ Incineration	• In this process, waste is directly burned in the presence of excess air (oxygen) at high temperatures (about 800°C), liberating heat energy, inert gases and ash. • Combustion results in transfer of 65–80% of the heat content of the organic matter to hot air, steam and hot water. • The steam generated, in turn, can be used in steam turbines to generate power.
Pyrolysis/ Gasification	• Pyrolysis is a process of chemical decomposition of organic matter brought about by heat. • In this process, the organic material is heated in the absence of air until the molecules thermally break down to become a gas comprising smaller molecules (known collectively as syngas). • Gasification can also take place as a result of partial combustion of organic matter in the presence of a restricted quantity of oxygen or air. The gas produced is known as producer gas. • The gases produced by pyrolysis mainly comprise carbon monoxide (25%), hydrogen and hydrocarbons (15%), and carbon dioxide and nitrogen (60%).
Co-generation	• Co-generation is producing two forms of energy from one fuel. One of the forms of energy must always be heat and the other may be electricity or mechanical energy. • The potential for cogeneration thus lies in facilities with joint requirement of heat and electricity, primarily sugar and rice mills, distilleries, petrochemical sector and industries such as fertilisers, steel, chemical, cement, pulp and paper, and aluminium.
Conventional and Co-generation Power Plants	
• Fuel is burnt in a boiler to generate high-pressure steam. This steam is used to drive a turbine, which in turn drives an alternator through a steam turbine to produce electric power. • The low-pressure exhaust steam coming out of the turbine is not condensed, but used for heating purposes in factories or houses and thus very high efficiency levels, in the range of 75%–90%, can be reached.	

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13 Climate Change Organizations

13.1 GLOBAL ENVIRONMENT FACILITY (GEF)

- It is a unique partnership of multi agencies including UN agencies, multilateral development banks, national entities, and international NGOs.
- GEF Trust Fund (World Bank as Trustee) is available to developing countries and countries with economies in transition.
- It was established on the eve of Rio Earth Summit (1992) to tackle the planet's biggest environmental issues.
- Biological diversity, climate change, international waters, land degradation (primarily desertification and deforestation), ozone layer depletion; and persistent organic pollutants.
- GEF serves as financial mechanism for five major international environmental conventions –
  - Minamata Convention on Mercury
  - Stockholm Convention on Persistent Organic Pollutants
  - UN Framework Convention on Climate Change (UNFCCC)
  - UN Convention on Biological Diversity (UNCBD)
  - UN Convention to Combat Desertification (UNCCD)

13.2 REDD+

- Reducing Emissions from Deforestation and Forest Degradation (REDD+) is a mechanism developed by **Parties of the UNFCCC**.
- It creates financial value for the carbon stored in forests to offer incentives for the developing nations to reduce emissions from forested lands and invest in low-carbon paths.
- The developing nations will receive results-based payments for results-based actions.
- The REDD+ **goes beyond simply deforestation and forest degradation by including the role of conservation, sustainable management of forests and enhancement of forest carbon stocks.**
- This **improved North-South flow of funds** can ensure a significant reduction of carbon emissions and the promotion of inclusive development.
- It could also improve biodiversity conservation and secure vital ecosystem services.
- **Forests are a vital carbon sink and** thus, it is vital to increase its resilience to climate change.

13.3 INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

- IPCC was **established by the UNEP and WMO in 1988,** for assessing science related to climate change.
- For providing governments at all levels with scientific information that can be used to develop climate policies though it does not conduct any research, nor does it monitor climate related data.

Special Report	Global Warming of 1.5°C
Special Report	Climate Change and Land (SRCCL)
Special Report	The Ocean and Cryosphere in a Changing Climate (SROCC)
Meth-odology Report	2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

- **IPCC publishes an Assessment Report (AR)** about the state of scientific, technical, and socio-economic knowledge on climate change. Assessment report consists of:
  - Contributions from each working group.
  - Synthesis report.
  - Any Special reports prepared in that assessment year.
- IPCC has so far published 6 Assessment Reports.
  - The IPCC's 6th report highlights that climate changes will increase in all regions of the globe over the coming decades and that

- **even with 1.5°C of global warming, there will be increasing heat waves, longer warm seasons, and shorter cold seasons**. The same will become more intense at 2ºC of warming.

13.3.1 National Greenhouse Gas Inventories Programme (NGGIP)

- The **IPCC** established the National Greenhouse Gas Inventories Programme (NGGIP) to provide methods for estimating national **inventories of greenhouse gas emissions to, and removals from, the atmosphere.**
- **Guidance** of NGGIP is used by countries that are **Parties to the UN Framework Convention on Climate Change (UNFCCC)** to estimate the emissions and removals that they report to the UNFCCC.
- The NGGIP is **mandated** to carry out the work, as approved by the Panel, on inventory-related methodologies and practices.

13.4 GREEN ECONOMY

- Green Economy is defined as **low carbon, resource efficient and socially inclusive**. In a green economy, growth in employment and income are driven by public and private investment into such economic activities, infrastructure and assets that allow:
  - Reduced carbon emissions and pollution
  - Enhanced energy and resource efficiency
  - Prevention of the loss of biodiversity and ecosystem services.
- **Green Economy** focuses on **economy and investment, positive social and environmental outcomes, sustainable consumption and production and employment and skills and capital and infrastructure.**

13.5 THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY (TEEB)

- TEEB was launched by Germany and the European Commission in 2007 for highlighting the **growing cost of biodiversity loss and ecosystem degradation** and to draw together expertise from the fields of science, economics and policy to enable practical actions
- The study was led by Pavan Sukhdev.
- TEEB assesses, communicates and mainstreams the urgency of actions through its five deliverables:
  - Science and economic foundations, policy costs and costs of inaction,
  - Policy opportunities for national and international policy- makers,
  - Decision support for local administrators,
  - Business risks, opportunities, and metrics,
  - Citizen and consumer ownership.

13.6 GLOBAL CLIMATE FINANCE ARCHITECTURE

13.6.1 Special Climate Change Fund (SCCF)

- SCCF was established in response to guidance from the COP7 to finance projects relating to–
- Adaptation, Technology transfer and Capacity building
- Energy, transport, industry, agriculture, forestry, waste management and economic diversification.
- Operating entity: Global Environment Facility (GEF)
- It is open to all vulnerable developing countries.

13.6.2 Least Developed Countries Fund (LDCF)

Strategic Priority on Adaptation Program (SPA)

SPA sought to reduce vulnerability and increase resilience to the adverse effects of climate change by targeting each of the GEF focal areas.

Besides, it also encouraged cross-sectoral approaches like Biodiversity, Climate change, Ozone layer depletion, international waters, Land degradation.

- It was designed to address the special needs of **Least Developed Countries (LDCs)** under the UNFCCC.
- It helps LDCs in preparing and implementing the **National Adaptation Programme of Action (NAPAs).**
- NAPAs: They are country-driven strategies that identify the most immediate needs (such as water, agriculture, food security, health etc.) to adapt to climate change.
- Operating entity: GEF

13.6.3 Climate Investment Fund (World Bank as Trustee)

- It is implemented with the Multilateral Development Banks (MDBs) to bridge the financing and learning gap.
- It is additional to existing Official Development Assistance and aims to enable countries to meet their multilateral development goals.
- 2 types: Clean Technology Fund and Strategic Climate Fund

13.6.4 Green Climate Fund (GCF)

- It is a financial instrument under **UNFCCC**, discussed in **Cancun Summit 2010** and finally adopted in **Durban Summit 2011.**
- GCF's activities are aligned with the priorities of developing countries through the principle of country ownership.
- It aims to make an ambitious contribution to attaining the mitigation and adaptation goals of the international community.

13.6.5 Adaptation Fund (AF)

- It was established under the **Kyoto Protocol of UNFCCC** to finance concrete adaptation projects and programmes in developing countries that are vulnerable to adverse effects of climate change.
- AF-funded projects are implemented around the world through accredited implementing entities.

13.6.6 Biocarbon Fund

- The Biocarbon fund is administered by the World Bank for Adaptation, Mitigation – general and Mitigation-REDD.
- It supports developing countries' efforts to reduce emission through testing jurisdictional approaches that integrate reducing deforestation and degradation, sustainable forest management with the climate smart agricultural practices to green supply chains.

13.6.7 EU Initiatives

- **Global Climate Change Alliance (GCCA)** is for Adaptation, Mitigation - general, Mitigation- REDD
- Purpose is to build a new alliance on climate change between the European Union and the poor developing countries.
- Funded by **European Commission** and managed by **European Investment Bank , Global Energy Efficiency and Renewable Energy Fund,** is a Public-Private Partnership (PPP) designed to maximize the private finance leveraged through public funds.

13.6.8 Clean Technology Fund

- The Clean Technology Fund (CTF), one of two multi-donor Trust Funds within the **Climate Investment Funds (CIFs),** promotes scaled-up financing for demonstration, deployment and transfer of low-carbon technologies with significant potential for long-term greenhouse gas emissions savings.
- Funding is channelled through African Development Bank, Asian Development Bank, European Bank for Reconstruction and Development, Inter-American Development Bank, and World Bank Group. The CTF finances 12 country programmes and one regional programme.

13.7 WORLD METEOROLOGICAL ORGANIZATION (WMO)

- WMO was established by the ratification of the WMO Convention on 23rd March, 1950 as a **specialised agency of the UN for meteorology** (weather and climate), hydrology and related geophysical sciences.
- World Meteorological Congress (WMC) is its Supreme Body and it is headquartered at Geneva.
- **The State of Global Climate Report** is published by WMO.

13.8 UNITED NATIONS PROGRAMMES AND ASSEMBLIES

13.8.1 United Nations Development Programme (UNDP)

- UNDP (founded in1965) is UN's global development network which promotes technical and investment cooperation among nations to help people build a better life for themselves.
- United Nations Economic and Social Council is its parent organization, headquartered at New York.
- UNDP works for **development and poverty reduction** and its famous report is **Human Development Report.**

13.8.2 United Nations Environment Programme (UNEP)

United Nations Environment Assembly (UNEA)

UNEA is the governing body of UN Environment Program it was founded in June 2012, during the **United Nations Conference on Sustainable Development, also referred to as RIO+20.**

It is the world's highest-level decision-making body on the environment.

It addresses the critical environmental challenges facing the world today.

The **Environment Assembly meets biennially** to set priorities for global environmental policies and develop international environmental law.

- UNEP is the leading global environmental authority that sets the global environmental agenda, promotes the coherent implementation of the environmental dimension of sustainable development within the United Nations system.
- It was founded on 5th June 1972 (Environment Day) with headquarters at Nairobi, Kenya.
- UNEP's mission is to encourage, empower and engage with faith- based organisations as partners, at all levels, **toward achieving the Sustainable Development Goals and fulfilling the 2030 Agenda**.
- **Faith for Earth Initiative** is an UNEP programme, and its important reports are **Emission Gap Report, Global Environment Outlook.**

13.9 FOREST CARBON PARTNERSHIP FACILITY

- It is a **global partnership of governments, businesses, civil society, and Indigenous Peoples** focused on reducing emissions from deforestation and forest degradation, forest carbon stock conservation, the sustainable management of forests, and the enhancement of forest carbon stocks in developing countries (activities commonly referred to as REDD+).
- The **World Bank assumes the functions of trustee and secretariat**. The World Bank, the Inter-American Development Bank and UNDP are Delivery Partners under the Readiness Fund and responsible for providing REDD+ readiness support.
- Forest Carbon Partner Facility conducts its operation with following objectives:
  - **Assisting countries in their REDD+ efforts** by providing them with financial and technical assistance.
  - To pilot a performance-based payment system for REDD+ activities.
  - **Testing ways to sustain or enhance livelihoods of local communities** and to conserve biodiversity.
  - Disseminating broadly the **knowledge gained in Emission Reductions Programs (ERPs)**.

13.10 CLIMATE AND CLEAN AIR COALITION (CCAC)

- Few nations, along with the United Nations Environment Programme (UNEP), came together to form the Climate & Clean Air Coalition in 2012 as a partnership of governments, public and private sector, scientific institutions, civil society organisations, etc. **committed to protecting the climate through actions to reduce short-lived climate pollutants.**
- **Short-Lived Climate Pollutants (SLCPS)**
  - SLCPs have a relatively short lifetime in the atmosphere – a few days to a few decades. Though short-lived, their potential to warm the atmosphere can be many times greater than CO2.
  - SLCPs include black carbon, methane, tropospheric ozone, and hydrofluorocarbons and they are **responsible for up to 45% of current global warming, only next to CO2**.

13.11 ARCTIC COUNCIL

- The Arctic Council is **an intergovernmental forum** promoting cooperation, coordination and interaction among the Arctic states, Arctic Indigenous communities and other Arctic inhabitants on common Arctic issues, in particular on **issues of sustainable development and environmental protection in the Arctic**.

The Arctic Council consists of the eight Arctic States: **Canada, the Kingdom of Denmark (including Greenland and the Faroe Islands), Finland, Iceland, Norway, Russia, Sweden and the United States.**

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14 Climate Change and India

14.1 INTRODUCTION

- **India is the world's third largest emitter** of greenhouse gases (GHGs), after China and the US.
- **According to Emissions Gap Report 2020,** over the last decade, China, USA, EU27+UK and India combined, have contributed to 55% of the total GHG emissions.
- Carbon Neutrality Target: India has announced that it will reach carbon neutrality by 2070 as part of a five-point action plan that included reducing emissions to 50% by 2030.
- Major sources of emissions: Coal power plants, rice paddies, cattle.
- Displacement and extinction of animal populations due to habitat loss adds more species to 'threatened' and 'extinct' list.
- Spread of diseases like malaria, etc. puts stress on the health sector.
- Increase tree cover to create an additional cumulative carbon sink of 2,500-3,000 Mt CO2 by 2030.
- India also aims to install 5GW of offshore wind by 2022 and 30 GW by 2030. None has yet been installed.
- India has doubled the Clean Energy Cess on coal, which very few countries have, and the Clean Energy Fund already has over 3 billion US dollars to be used for promoting clean technologies
- India's National Solar Mission is being scaled up five-fold from 20,000 megawatts to 100,000 megawatts.
- The country could integrate 390GW of low-cost wind and solar generation into its grid by 2030, according to the Climate Policy Initiative (CPI).
- India's climate pledge notes that around 70% of its population depends on traditional biomass energy, which is inefficient and causes high levels of indoor air pollution.
- India is targeting **10GW** of such **bioenergy by 2022.**
- India has around **4.5GW of small hydro plants (below 25MW)**, against a **5GW target for 2022.**
- Action Plan for cleaning one of the longest rivers in the world, River Ganga will bring multiple benefits of pollution reduction and climate adaptation. We have also taken initiatives for protecting coastal, Himalayan, and forest areas.
- India has initiated preparations to develop a National Air Quality Index and have launched a National Air Quality Scheme.
- Setting-up of Ultra Mega Solar Projects in Tamil Nadu, Rajasthan, Gujarat, Andhra Pradesh and Ladakh to promote renewable energy.

14.1.1 Current Actions for Adaptation & Mitigation

- Adaptation includes actions taken to reduce negative consequences of climate changes. Switching to drought-resistant crops, creating coastal buffer zones, early warning systems, etc. are such examples.
- Mitigation includes actions taken to lower Greenhouse Gas (GHG) concentrations and eliminating emissions at source. Examples are Wind farms, afforestation, energy-efficient vehicles, sequestering GHGs etc.

14.2 NATIONAL ACTION PLAN FOR CLIMATE CHANGE (NAPCC)

- NAPCC was launched in 2008 which outlines existing and future policies and programs addressing climate change. Plan identifies 8 core national missions.

14.2.1 National Solar Mission

- To promote development & use of solar energy for power generation & other uses.
- Inaugurated in 2010 with a target of **20 GW by 2022,** later increased to **100 GW in 2015**.
- MNRE has proposed to achieve 60 GW from large and medium scale solar projects, and 40 GW through rooftop solar projects.
- Committed to **Nationally Determined Contributions (Paris Accord),** India made a pledge that by 2030, 40% of installed power generation capacity shall be based on clean sources.
- It was determined that 175 GW of renewable energy capacity will be installed by 2022 which includes 100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro power.
- India is at 5th global position for overall installed renewable energy capacity.

14.2.2 National Mission for Enhanced Energy Efficiency (NMEEE)

- NAPCC recognizes energy efficiency as an important lever to address the issue of climate change.
- Aimed to promote the market for energy efficiency by fostering innovative policies and effective market instruments.
- **The Energy Conservation Act** led to the creation of a statutory body, the **Bureau of Energy Efficiency (BEE)** with dedicated powers and responsibilities to promote energy efficiency and conservation in different sectors of the economy.
- The Ministry of Power, GoI through BEE, looks over the progress of the NMEEE mission.
- Mandating energy consumption decreases in large energy- consuming industries with trade of energy-saving certificates.
- Energy incentives, including taxes on energy efficient appliances.
- 4 initiatives under this are:

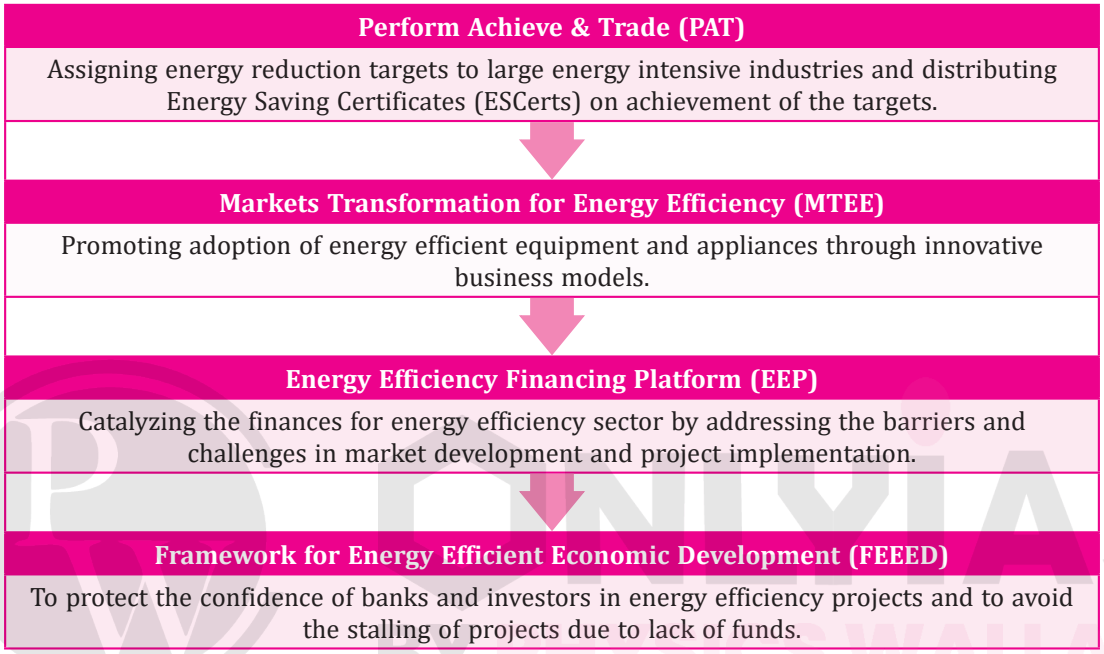


Fig. 14.1

14.2.3 National Mission on Sustainable Habitat

- To promote energy efficiency as a core component of urban planning. Extending existing Energy Conservation Building Code.
- Waste management, recycling, including power production from waste. Incentives to use public transport.
- Use of automotive fuel economy standards & pricing measures.

Mission is being implemented through the following programmes of Ministry of Urban Development:

- Atal Mission on Rejuvenation and Urban Transformation (AMRUT)
- Swachh Bharat Mission
- Smart Cities Mission
- Urban Transport Programme

14.2.4 National Water Mission

- To ensure integrated water resource management helping to conserve water, minimise wastage and ensure more equitable distribution both across and within states.
- Ensure that a considerable share of the water needs of urban areas are met through recycling.
- Ensure that the water requirements of coastal cities are met through modern desalination technologies.
- Increase storage both above and below ground, rainwater harvesting.

14.2.5 National Mission for Sustaining Himalayan Ecosystems

- To conserve biodiversity, forest cover & study traditional societies where global warming has resulted in receding of glaciers. Building human & institutional capacities.
- Network knowledge systems & develop coherent databases.

- Detecting & decouple natural & anthropogenic global environment changes.

14.2.6 National Mission for a Green India

- Aims at protecting; The mission has a cumulative target of increasing forest cover on 5 million hectares of land while improving the forest cover on additional 5 hectares.
- Fulfilling **India's Nationally Determined Contribution (NDC)** target of sequestering **2.5 Billion tonnes** of Carbon emissions by 2020-30, which it submitted to UNFCCC.
- Goals include afforestation of 10 million hectares of land, expanding forest cover from 23% to 33%.
- Increase forest-based livelihood income of about 3 million households.
- Enhanced annual CO2 sequestration by 50 to 60 million tons in the year 2020.
- Eco-restoration of shifting cultivation areas, cold deserts, mangroves, ravines and abandoned mining areas.
- Increase wage labour opportunities during the lean agriculture season, especially communities living in remote forest areas.
- A submission on **Cold Desert Ecosystem**s under this mission is National Sea buckthorn Initiative launched by MoEF&CC and DRDO to fix atmospheric nitrogen.

14.2.7 National Mission on Sustainable Agriculture

- Aim is to **develop climate-resilient crops**, expansion of weather insurance & agricultural practices especially in rain-fed areas.
- **60% of the country's net sown area is rainfed** and accounts for 40% of the total food production.
- Promote **'laboratory to land'** research through model village & farm units.
- Linking of panchayat-level Automatic Weather Station Networks to existing insurance mechanisms.

Key dimensions by NMSA

- Improved crop seeds
- livestock and fish cultures
- Water Use Efficiency
- Pest Management
- Improved Farm Practices
- Nutrient Management
- Agricultural insurance
- Credit support
- Access to Information
- Livelihood diversification
- Soil Health Card Scheme
- Soil Health Management

14.2.8 National Mission on Strategic Knowledge for Climate Change

- Formation of knowledge networks among the existing knowledge institutions engaged in research and development relating to climate science.
- Research networks in the areas of climate change impacts on important socio-economic sectors like agriculture, health, natural ecosystems, biodiversity, coastal zones, etc.
- Data sharing & exchange through policy framework & institutional support.
- Strengthen indigenous capacity build partnerships through global collaboration.

14.2.9 National Bioenergy Mission

- Mission is for pushing **sustainable development of the renewable energy sector**.
- Improving energy efficiency in traditional biomass consuming industries, seek to develop a bioenergy city project and provide logistics support to biomass processing units
- GIS-based National Biomass Resource Atlas to map potential biomass regions in the country is proposed.
- As per estimates, the biomass from agro and agro-industrial residue can potentially generate 25,000 MW of power in India.

Net Metering

- Net Metering is billing mechanism for grid connected Home Rooftop Solar Installation where
- The electricity generated by the solar panels is fed into the utility grid
- Household draws electricity from the utility grid
- The household pays only for the difference between the energy units it consumes from the grid and the energy units fed into the grid. This is measured by a bi-directional meter called Net Meter.

14.2.10 National Communication (NATCOM)

- In partnership with MoEFCC, funded by Global Environment Facility, the project aims to enable India undertake activities to prepare its Third National Communication to the UNFCCC according to the guidelines provided by the Conference of Parties (COP).
- **Indian Network on Climate Change Assessment** was launched by MoEFCC in an effort to promote domestic research on climate change.

- Reports prepared by the INCCA will form a part of India's National Communication (Nat Com) to the United Nations Framework Convention on Climate Change (UNFCCC).

14.2.11 National Action Programme to Combat Desertification

- India is a party to the **UN Convention to Combat Desertification (UNCCD)** and MoEF&CC is the National Coordinating Agency for the implementation of the UNCCD in the country.
- As an affected party, a 20 year comprehensive National Action Programme (NAP) to combat desertification in the country has been prepared with following objectives:
  - Community based approach to development,
  - Activities to improve the quality of life of the local communities
  - Drought management preparedness and mitigation,
  - R&D initiatives and interventions which are locally suited,
  - Strengthening self-governance leading to empowerment of local communities.
- It is proposed to initiate activities that include, among others, **assessment and mapping of land degradation, drought monitoring and early warning system groups,** drought preparedness contingency plans, and on-farm research activities for development of indigenous technology etc. will be taken up.

14.3 GREEN BUILDINGS

- A green building is **a building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environmen**t. Green buildings preserve precious natural resources and improve our quality of life.
- Practice of creating structures & using processes that are environmentally responsible & resource-efficient throughout a building's life-cycle from design to construction, operation, maintenance, renovation, deconstruction.
- These are designed to reduce the overall impact of the built environment on human & environmental health.

14.3.1 Net Zero Energy Buildings (NZEB)

- A net-zero energy building is **one that relies on renewable sources to produce as much energy as it uses**, usually as measured over the course of a year.
- The **Indian Green Building Council (IGBC)** has come out with a **Net Zero Energy Buildings** rating system in collaboration with the World Green Building Council and the United States Agency for International Development (USAID).
- Solar panels, heat recovery systems, geothermal heating and wind turbines are among the other technologies used to achieve net-zero status.
- **Indira Paryavaran Bhavan in New Delhi is India's first net zero energy building** that has been constructed with the adoption of solar passive design and energy-efficient building.

Bureau of Energy Efficiency (BEE)

BEE is a statutory agency under the Ministry of Power.

It was created in March 2002 under the provisions of the nation's 2001 Energy Conservation Act.

BEE's function is to develop programs which will increase the conservation and efficient use of energy.

It mandatory for certain appliances in India to have BEE ratings.

14.4 STANDARD AND LABELLING PROGRAMME (BEE STAR LABEL)

- The scheme was launched in **2006 to provide the consumer an informed choice about energy saving**.
- Frost Free Refrigerators, Direct Cool Refrigerator, Variable Capacity Inverter Air conditioner, Tubular Fluorescent Lamp,LED Lamps, Distribution Transformer, Electric Geysers, Agricultural Pumpsets, Color TV, Room Air Conditioner (Cassettes, Floor Standing) are Mandatory Appliances under this.

14.5 ENERGY CONSERVATION BUILDING CODE (ECBC)

- The Energy Conservation Building Code (ECBC) was launched by **the Ministry of Power, Government of India in May 2007**, as a first step towards promoting energy efficiency in the building sector.
- It sets **minimum energy standards** for new commercial buildings having a connected load of 100kW (kilowatt) or contract demand of 120 KVA (kilovolt-ampere) and above.
- ECBC has following objectives :
  - Providing technical support to **BEE** to implement the ECBC in a rigorous manner.
  - Developing **reference material and documentation** to support the Code.
  - Develop ECBC Training material for workshops and training programs and a road map for **ECBC implementation**.

14.5.1 Eco Niwas Samhita 2021

- It is an **Energy Conservation Building Code for Residential Buildings (ECBC-R)** to give a further fillip to India's energy conservation efforts.
  - The building sector is the second largest consumer of electricity after industry but it is expected to become the largest energy consuming sector by 2030.
- It specifies code compliance approaches and minimum energy performance requirements for building services, and verification framework with **Eco Niwas Samhita 2021**.
- These initiatives will help enhance the energy-efficiency levels in residential buildings across the country, thereby leading to sustainable habitation.

14.5.2 Green Rating for Integrated Habitat Assessment (GRIHA)

- GRIHA was conceived by **TERI (The Energy & Resources Institute)** and developed by the **Ministry of New & Renewable Energy** for helping evaluation of 'greenness' of buildings against nationally acceptable benchmarks.
- Benefits of GRIHA buildings are listed here:
  - Reduced energy consumption without sacrificing the comfort levels;
  - Reduced destruction of natural areas, habitats, and biodiversity, and reduced soil loss from erosion etc.;
  - Reduced air and water pollution (with direct health benefits);
  - Reduced water consumption and pollution loads;
  - Limited waste generation due to recycling and reuse;;
  - Increased user productivity and **enhanced image and marketability.**

14.6 NATIONAL INITIATIVE ON CLIMATE RESILIENT AGRICULTURE (NICRA)

- NICRA was launched by **Indian Council of Agricultural Research (ICAR) in 2010-2011** primarily for enhancing resilience of crops, livestock & fisheries through development of production & risk management.
- NICRA facilitates strategic research on adaptation and mitigation and capacity building of different stakeholders.
- It also works for technology demonstration on farmers' fields to cope with current climate variability and sponsored and competitive research grants to fill critical research gaps.

14.7 BSE - GREENEX

- 25th dynamic index hosted on the Bombay Stock Exchange; it is India's first carbon-efficient live index developed by BSE in collaboration with IIM Ahmedabad in 2012.
- GREENEX is India's first objective green equity index to employ index constituent weight capping. **It is co-developed by g-Trade Carbon Ex Ratings Services Private Limited** with BSE.
- The index seeks to assess and quantify the energy efficiency of firms, based on energy and financial data.
- It **follows a sector-specific algorithm** whereby a firm's performance is measured in comparison to others in the same sector.
- 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

14.8 FAME - INDIA PROGRAMME

- **National Electric Mobility Mission Plan (NEMMP) 2020** is a National Mission document providing the **vision and the roadmap for the faster adoption of electric vehicle**s and their manufacturing.
- Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India), 2015 was launched by the **Department of Heavy Industry** to promote manufacturing of electric and hybrid vehicle technology under NEMMP 2020.
- **First Phase of FAME India Scheme (2015)** had four focus areas, namely, Demand Creation, Technology Platform, Pilot Project and Charging Infrastructure.
- **Second Phase of FAME India Scheme (2019-20) aims to generate demand** by way of supporting 7000 **e-Buses,** 5 lakh **e-3 Wheelers,** 55000 **e-4 Wheeler Passenger Cars** (including Strong Hybrid) and 10 lakh **e-2 Wheelers**.
- Applicable mainly to vehicles used for public transport or those registered for commercial purposes in e-3W, e-4W and e-bus segments. Privately owned registered e-2Ws also covered under the scheme.
- Construction of **electric charging stations** is also to be carried out.

14.9 LONG TERM ECOLOGICAL OBSERVATORIES (LTEO)

- Under the Climate **Change Action Programme a science plan** of LTEO was released during 21st COP to the UNFCCC at Paris in December 2015.

- **First phase** includes health assessment of Western Himalaya, Eastern Himalaya, North-Western Arid Zone, Central Indian Forests, Western Ghats, Andaman & Nicobar Islands, Jammu & Kashmir, Sundarbans.
- LTEO aims to **understand biophysical & anthropogenic** drivers in select biomes & effects on socio-ecological responses.
- Its activities include assessment of change of structure & function in natural ecosystems, monitoring population of species, animal movements, soil processes, biophysical variables, etc.

14.10 NATIONAL ADAPTATION FUND FOR CLIMATE CHANGE (NAFCC)

- NAFCC was introduced in 2015-16. Was to be revised in 2020.
- Fund meant to assist national & state level activities for areas vulnerable to climate change.
- Central Sector Scheme with NABARD as National Implementing Entity.
- Aim - Support adaptive activities which are not covered under ongoing government schemes.

6th Mass Extinction due to Climate Change

The Holocene extinction, otherwise referred to as the sixth mass extinction or Anthropocene extinction, is an ongoing extinction event of species during the present Holocene epoch.

Human beings are causing this irreversible event on the planet and the researchers have found that populations on the brink go extinct 94% of the time.

Increasing population and consumption rates, meat consumption, overhunting, overfishing, and ocean acidification and the decline in amphibian populations Breakage of food web/species links are major factors responsible for this mass extinction.

Population boom of urchins on kelp forests in the Bering sea, leading to the extinction of the kelp-eating steller's sea cows and massive volcanic eruptions, depletion of ocean oxygen or collision with an asteroid are other responsible factors.

Scientists, as an approach to avoid this mass extinction, propose classifying all species with less than 5000 individuals as critically endangered on the IUCN list implement a global comprehensive binding agreement requiring parties to address the extinction crisis, **tackling the illegal and legal wildlife trade** and **strictly preventing the land-grabbing and devastating deforestation.**

14.11 NATIONAL POLICY ON BIOFUELS, 2018

- Under the Policy biofuels are categorised as **Basic biofuels- First Generation (1G) (bioethanol and biodiesel) and Advanced Biofuels- Second Generation (2G)** (**ethanol, Municipal Solid Waste (MSW) to drop-in fuels, Third Generation (3G) biofuels, bio-CNG)** etc.
- It expands the scope of raw material for ethanol production by allowing use of Sugarcane Juice, Sugar containing materials like Sugar Beet, Sweet Sorghum, Starch containing materials like Corn, Cassava, Damaged food grains like wheat, broken rice, Rotten Potatoes, unfit for human consumption for ethanol production.
- It **allows use of surplus food grains for production of ethanol for blending with petrol** with the approval of **the National Biofuel Coordination Committee**.
- Under the policy, a **viability gap funding scheme for 2G ethanol Bio refineries of ₹5000 crore** in 6 years in addition to additional tax incentives, higher purchase price as compared to 1G biofuels will be provided..
- It encourages setting up of supply chain mechanisms for biodiesel production from non-edible oilseeds, Used Cooking Oil, short gestation crops.

Classification of Biofuels

- **First generation biofuel** refers to the **fuels that have been derived from sources like starch, sugar, animal fats and vegetable oil**.
- **Second generation biofuels** are produced from **non-food crops, such as cellulosic biofuels and waste biomass** (stalks of wheat and corn, and wood). Examples include advanced biofuels like biohydrogen, biomethanol.
- **Third generation biofuels** are produced from **specially engineered energy crops** such as **algae**.
- **Fourth generation biofuels** use **genetically modified (GM) algae** to enhance biofuel production.

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15 Indian Agriculture and Climate Change

15.1 INTRODUCTION

- Agriculture in India is primary activity and in the Constitution, it has been placed as **Entry 14** in the State List.
- Agriculture includes **raising crops, animal husbandry, agroforestry and pisciculture**.
- **India's Agriculture Export Policy** aims to increase the agriculture export to over **US$ 60 billion by 2022**.
- Third largest consumer of edible oil; Top States: Gujarat (Groundnut), UP (Mustard), MP (Soyabean). India is the **fourth largest oilseed-producing country** and **second largest fish producer** in the world.
- India is also the **first in milk production since 1998**; 20 % of world milk production comes from India and the largest bovine population in the world lives in India.

15.2 FEATURES OF INDIAN AGRICULTURE

- **Subsistence Agriculture:** The type of agriculture in India is mostly Subsistence agriculture. In Subsistence agriculture the agricultural produce is for self-consumption only, there is no surplus production to sell in the market.
- **Commercial Agriculture:** It is the agricultural practice where large agricultural produce is sold in the market by the firms for making profits. E.g. tea plantation in Assam, coffee in Karnataka, coconut in Kerala, etc.
- **Limited Land Resources:** Since the land resource in India is limited the pressure of increasing population on agriculture is increasing day by day.
- **Mechanisation:** After the Green Revolution, there has been an increasing trend in the use of machines in farm operations. This has led to the mechanisation of Indian agriculture. Punjab, Haryana, Western Uttar Pradesh, River valleys of Andhra, and Tamil Nadu are major agriculturally mechanised areas in India.
- **Monsoon Dependency:** Due to lack of irrigation facilities Two-third of Indian agriculture is dependent on monsoon rains.
- **Variety of Crops:** Due to the presence of different types of topography, diverse soil (like alluvial, red, black cotton soil, etc), and different types of climate, India is blessed with the production of different varieties of crops in different regions. For e.g., hilly areas are suitable for tea cultivation, plains for rice cultivation.
- **Predominance of Food Crops:** In order to feed a large population and predominance of subsistence agriculture, food crops are mainly grown in order to keep with the food security demands of the huge Indian population.

15.3 CROPPING SEASONS IN INDIA

Kharif	Rabi	Zaid
The kharif cropping season is from July to October during the South-West Monsoon. Crops are Rice, maize, sorghum, pearl millet/bajra, finger millet/ragi (cereals), arhar (pulses), soyabean, groundnut (oilseeds), cotton etc.	The rabi cropping season is from October to March during the North-East Monsoon. Crops include wheat, barley, oats (cereals), chickenpea/ gram (pulses), linseed, mustard (oilseeds) etc.	The crop season is from March to June. Crops include Seasonal fruits and vegetables.

Fig. 15.1

15.4 CROP CLASSIFICATIONS

Based on Life of Crops/ Duration of Crops	• **Seasonal crops:** A crop completes its life cycle in one season. E.g. rice, Jowar, wheat etc. • **Two seasonal crops:** crops complete their life cycle in two seasons. E.g. Cotton, turmeric, ginger. • **Annual crops:** Crops require one full year to complete its life cycle. E.g. sugarcane. • **Biennial crops:** Crops require two years to complete its life cycle E.g. Banana, Papaya. • **Perennial crops:** crops live for several years. E.g. Fruit crops, mango, guava etc.
Based on Cultural Method/Water	• **Rain fed:** Cultivation of crop mainly based on the availability of rain water. E.g. Jowar, Bajara, Mung etc. • **Irrigated crops:** Crops cultivated with the help of irrigation water. E.g. Chili, sugarcane, Banana, papaya etc.
Based on Root System	• **Tap Root:** The main root goes deep into the soil. E.g. Tur, Grape, Cotton etc. • **Fibre Rooted:** The crops whose roots are fibrous, shallow & spreading into the soil. E.g. Cereal crops, wheat, rice etc.
Based on Economic Importance	• **Cash crop:** Grown for earning money. E.g. Sugarcane, cotton. • **Food crops:** Grown for raising food grain for the population and & fodder for cattle. E.g. Jowar, wheat, rice etc.

Types of Agriculture	
Silviculture	The art of cultivating forest trees
Sericulture	The rearing of silkworms for the production of raw silk.
Apiculture	The maintenance of honey bee colonies, commonly in hives, by humans
Olericulture	The science of vegetable growing, dealing with the culture of non-woody (herbaceous) plants for food.
Viticulture	The science, production and study of grapes
Floriculture	It is a discipline of horticulture concerned with the cultivation of flowering and ornamental plants for gardens
Arboriculture	The cultivation, management, and study of individual trees, shrubs, vines, and other perennial woody plants
Pomology	It is a branch of horticulture which focuses on the cultivation, production, harvest, and storage of fruit, etc.
Aeroponics	It is the process of growing plants in an air or mist environment without the use of soil or an aggregate medium
Hydroponics	It is a method of growing plants using mineral nutrient solutions, in water, without soil.
Geoponic	Growing plants in normal soil
Aquaponics	Both fish and plants can grow in one integrated ecosystem. It is an ecologically sustainable model that combines Hydroponics with Aquaculture.

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15.5 CHALLENGES BEFORE INDIAN AGRICULTURE

- Fragmentation of land holding; Existence of small and marginal farmers; Regional variation; Dependence of seasonal rainfall; Low productivity of land; Increasing of disguised unemployment; Disorder in marketing of Agricultural products; Weak land reformation.
- It is the shifting of the land after the cultivation of a crop when the soil losses its fertility (generally in 2 to 3 years).

Region-wise Name in India
• **Jhum** in Assam, • **Poonam** in Kerala, • **Podu** in Andhra Pradesh And Odisha • **Bewar Masha Penda** and Bera in various parts of Madhya Pradesh.

15.6 SHIFTING CULTIVATION

- Forest land is cleared and cultivated. It is also called land rotation because the same crop (generally rice) is grown on a different piece of land.
- Due to the cultivation of the same crop on the same cleared forest land year after year, soil productivity is lost. After the land fertility is lost, the crop is shifted to other slashed and burnt land.
- Shifting cultivation leads to Soil Erosion.
- Shifting cultivation is practised in north-eastern states of India, Chotanagpur plateau of Jharkhand, M.P., and in Hilly areas of the Himalayas, the Western Ghats, and the Eastern Ghats.

15.6.1 Different Names of Shifting Cultivation

Names of Shifting Cultivation	
Names	**Country**
Ray	Vietnam
Tavi	Madagascar
Masole	Congo (Zaire river Valley)
Fang	Equatorial African Countries
Logan	Western Africa
Comile	Mexico
Milpa	Yucatan and Guatemala
Echalin	Guadeloupe
Milya	Mexico and Central America
Konuko	Venezuela
Roka	Brazil
Chetemini	Uganda, Zambia and Zimbabwe
Caingin	Philippines
Taungya	Myanmar
Chena	Sri Lanka
Ladang	Java and Indonesia
Tamari	Thailand
Humah	Java and Indonesia

15.7 FIRST GREEN REVOLUTION

First Green Revolution in India	
Introduction of High Yielding Varieties	• The HYVs of wheat and rice have been the key elements in the Indian green revolution. • HYVs usually require a lot of water and hence irrigational facilities were a prerequisite for the green revolution.
Use of Chemical Fertilisers and Pesticides	• **Nitrogen containing fertilisers** e.g. ammonium sulphate, ammonium nitrate and urea. • **Phosphate containing fertilisers** e.g. ammonium phosphate, calcium dihydrogen phosphate (superphosphate). • **Potassium contains fertilisers** e.g. potassium sulphate and potassium nitrate.
Mechanization of Agriculture	• Increase in productivity on large areas of land brought the idea of farm mechanisation. • The machines which perform various jobs at the farm are water pump, ploughs, combine harvesters, land levellers, cultivators, power operated tractor sprays, reapers, threshers, trolleys and mechanical pickers etc.

First Green Revolution in India	
Irrigation	• **Wells** are of two types i.e., **dug wells and tube wells**. Over exploitation of wells is well observed in Punjab-Haryana region. • **Canals**: An elaborate and extensive irrigation system. Canals receive water from one or more reservoirs or from rivers. Well suited for regions with clayey soil is clayey soil prevents water percolation. Mostly practised in south India and Ganga-Yamuna region. • **River Lift Systems:** In areas where canal flow is insufficient or irregular due to inadequate • reservoir release, the lift system is more rational. Water is directly drawn from the rivers for supplementing irrigation in areas close to rivers. Mostly in S. India • **Tanks**: These are small storage reservoirs, which intercept and store the run-off of smaller catchment areas.

15.8 SECOND GREEN REVOLUTION

- The second Green Revolution aims at creating sustainable agriculture by leveraging advancements in technology

15.8.1 Need of Second Green Revolution

- With the growing population and over-exploitation of land resources, the pressure on food security will continue and rise. Growth in the agricultural sector has been almost stagnant.
- 65% of the population is still living in the villages and over 70% of the rural people are dependent on agriculture for their livelihood.
- The Green Revolution has made us self-sufficient in food grains, but the environmental consequences and ecological costs are offsetting the progress made.
- The groundwater is depleted and polluted. The lakes and ponds are becoming life less due to eutrophication– a direct consequence of the Green Revolution.
- GM Crops are marred in various controversies related to intellectual property, ecological consequences, health consequences etc.
- Global warming is said to engulf productive coastal lands due to rise in sea levels. This creates an urgent need to raise agricultural productivity.
- It was necessary to develop a suitable strategy to improve agricultural development in India and the Green Revolution turned India from begging bowl to leading producer of food-grains.

15.8.2 Bringing Green Revolution to Eastern India (BGREI)

- BGREI is about bringing similar benefits to eastern India that largely remained untouched of the wonder that converted the north-west into a grain bowl.
- BGREI is flagship programme under Rashtriya Krishi Vikas Yojana (RKVY) intended to address the constraints limiting the productivity of rice based cropping systems in seven eastern states.
- Seven States are Assam, Bihar, Chhattisgarh, Jharkhand, Odisha, West Bengal and eastern Uttar Pradesh (Purvanchal).

15.8.3 Government Initiatives

- The ICAR has established **Indian Agricultural Research Institute (IARI)**, Hazaribagh in Jharkhand and **Indian Institute of Agricultural Biotechnology**, Ranchi.
- It has also established the **National Research Centre for Integrated Farming** at Motihari in Bihar to further strengthen the agricultural research for the eastern region.

15.8.4 Produce Based Revolutions in India

Green	Food grain Production
Golden	Fruit Production
Grey	Fertilizer Production
Blue	Fish Production
Pink	Prawn Production
Red	Meat/Tomato Production
Silver	Egg/Poultry Production
White	Milk Production
Yellow Oil	Seeds Production

TAKACHAR is the Harvesting Value from Agricultural Waste
• Takachar is a social enterprise founded by Vidyut Mohan in 2018. • It **enables farmers to prevent open burning of farm residues (waste) and earn extra income** by converting them into value-added chemicals. • It is a meaningful and immediate solution to the triple planetary crises of climate change, biodiversity loss and pollution. • **Takachar buys rice husks, straw and coconut shells from farmers** and turns them into charcoal, saving the debris from the fires, which are also a driver of climate change. • Open burning of agricultural residues is a big source of air pollution in many parts of the world. • This innovative technology can help farmers turn what is currently thought of as waste into a valuable resource while helping clean up our environment. • Enables rural farmers to earn 40% more by converting their crop residues into fuels, fertilisers and value-added chemicals like activated carbon (AC) on-site. • It is estimated that by 2030, Takachar will impact 300 million farmers affected by this problem, create USD 4 billion/year equivalent in additional rural income and jobs, and mitigate one gigaton/year of CO2 equivalent.

15.9 AGRICULTURE AND CLIMATE AFFECTING EACHOTHER

- **Greenhouse Gases:** Farming in particular releases significant amounts of methane (produced by livestock during digestion due to enteric fermentation) and nitrous oxide, two powerful greenhouse gases.
- **Excessive Fertiliser Use:** Fertilisers rich in nitrogen pollute water and threaten the aquatic ecosystem.
- **Monocultural Practices:** Monocultures along with pesticides and herbicides lead to the loss of biodiversity.
- **Primitive Agriculture Practice:** Clearing uncultivated land for farming can lead to the destruction of natural ecosystems, have a devastating effect on the local wildlife and biodiversity and the micro-climate.
- **Water Intensive:** Many agricultural sectors need large amounts of water, which may cause water scarcity and drought.

Effect of Climate on Agriculture
Extreme Heat
Crops need suitable soil, water, sunlight, and heat to grow. However, extreme heat events and reductions in precipitation and water availability have hampered the crop productivity.
Changing Rainfall Pattern
Rainfall patterns have already begun shifting across the country, and such changes are expected to intensify over the coming years.
Floods
Flooding in many agricultural regions of the country have been witnessed and these floods have devastated crops and livestock, accelerated soil erosion and have polluted water.

15.10 IMPACT ON INDIAN AGRICULTURE

- Depleting groundwater and water scarcity is contributing to food insecurity. Crops are impacted by rainfall variability and heat stress.Climate change has a direct impact on crop **evapotranspiration**.
- Milk yield in livestock is also impacted during heat waves.
- Changes in breeding season in marine fisheries with shift in seasonal catch.
- Significant negative impact on commercial poultry due to heat stress.
- High rainfall leads to greater loss of topsoil due to erosion.
- Rise in sea level may lead to loss of farmland by inundation and increasing salinity of groundwater in coastal areas.
- The major impacts of climate change will be on rain fed or un-irrigated crops, which are cultivated on nearly 60 percent of cropland.

- Increase in the mean seasonal temperature can reduce the duration of many crops and hence reduce final yield.
- The share of agriculture in total GHG emissions has gradually declined from 28% in 1994 to 14% in 2016.

15.10.1 Emission Classification

- Agricultural emissions in India are primarily from the livestock sector (54.6%) and the use of nitrogenous fertilisers (19%).
- Rice cultivation in anaerobic conditions accounts for a major portion of agricultural emissions (17.5%).
- Agricultural soils are the largest single source of nitrous oxide (N2O) emissions.
- **Air Pollution:** As per the World Air Quality Report, 2020 22 of the 30 most polluted cities in the world are in India and Delhi is the world's most polluted capital. Delhi suffers severely from air pollution during the winter months due to stubble burning in adjoining states.
- The Sixth Assessment Report by the IPCC has issued a code red to humanity declaring 1.5°C warming of the planet as inevitable.

15.10.2 International Maize and Wheat Improvement Centre (CIMMYT)

- A study by the CIMMYT pointed out that **India has the potential to cut 18% of its annual greenhouse gas** emissions from the agriculture and livestock sector. Study estimated that 50 percent of this reduction could be achieved by implementing these **three measures**
  - Efficient use of fertiliser
  - Adoption of zero-tillage
  - Management of water used to irrigate paddy.

15.11 SUSTAINABLE AGRICULTURE

Sustainable Agriculture	
Meaning	It is the production of food, fibre, plant or animal products using farming techniques that protect the environment, public health, human and animal welfare. E.g. Organic farming.
Principles	**Environmental sustainability** is to be achieved through **protecting, recycling, replacing and maintaining** the natural resources base such as land (soil), water and wildlife. **Economic sustainability** is to be achieved through e.g. improving soil management and crop rotation which raise yields. **Social sustainability** through upholding social justice and cultural cohesion
Benefits	Supports profitable production; Protects environmental quality; Uses natural resources efficiently; Provides consumers with affordable, high-quality products; Decreases dependency on non-renewable resources; Enhances the quality of life for farmers and rural communities; and· Will last for generations to come.
Methods of Sustainable Agriculture	Crop Rotation; Agroforestry; Biointensive Integrated Pest Management; Planting Cover Crops; Permaculture; Zero Budget Natural Farming; Organic Farming.

Important Terms	
Cropping Intensity	Number of crops cultivated in a piece of land per annum is the cropping intensity.
Cropping Pattern	Different crops grown in an area at a particular point of time are called cropping patterns. It depends on climate (temperature, rainfall, wind etc.), soil, support price, value, demand market, labour availability, historical setting, etc.
Multiple Cropping	Growing more than two crops in a piece of land in a year in orderly succession
Inter Cropping	Growing two or more crops simultaneously with distinct row arrangement on the same field at same time.

Important Terms	
Mixed Cropping	Also known as polyculture, inter-cropping is a type of agriculture that involves planting two or more plants simultaneously in the same field, interdigitating the crops.
Strip Cropping	In this, crops are cultivated in alternate strips which are parallel to each other on the same piece of land. It is used when a slope is too steep or when there is no alternative method of preventing soil erosion.
Contour Bunding	It is the farming practice of ploughing/planting across a slope following its elevation contour lines, that create a water break which reduces the formation of rills and gullies during times of heavy water run-off; which is a major cause of soil erosion.
Crop rotation	Growing different crops on pieces of land in pre-planned succession in different seasons is known as crop rotation. Crop combination is done based on the duration of the crop. For example, Groundnut in Kharif + wheat in Rabi + Vegetation in Zaid

15.12 CLIMATE SMART AGRICULTURE

- Climate-smart agriculture (CSA) is an integrated approach to managing landscapes—cropland, livestock, forests and fisheries—that addresses the interlinked challenges of food security and accelerating climate change.
- **Objectives:**
  - Sustainably increasing productivity and incomes
  - Adapting to climate change
  - Reducing greenhouse gas emissions where possible
- **CSA aims to simultaneously achieve following three outcomes:**
  - **Increased productivity:** Produce more and better food to improve nutrition security and boost incomes, especially of 75 percent of the world's poor who live in rural areas and mainly rely on agriculture for their livelihoods.
  - **Enhanced resilience:** Reduce vulnerability to drought, pests, diseases and other climate-related risks and shocks; and improve capacity to adapt and grow in the face of longer-term stresses like shortened seasons and erratic weather patterns.
  - **Reduced emissions:** Pursue lower emissions for each calorie or kilo of food produced, avoid deforestation from agriculture and identify ways to absorb carbon out of the atmosphere.

Zero Tillage

Zero Tillage also called No-till Agriculture, is a cultivation technique in which the soil is disturbed only along the slit or in the hole into which the seeds are planted, the reserved detritus from previous crops covers and protects the seedbed.

15.13 ORGANIC FARMING

- India ranks 1st in number of organic farmers and 9th in terms of area under organic farming.
- Sikkim is the first State in the world to become fully organic in 2016.
- Major organic exports include flax seeds, sesame, soybean, tea, medicinal plants, rice and pulses.
- There was an increase of nearly 50% in organic exports in 2018-19.

15.13.1 Government Initiatives to Promote Organic Farming

Mission Organic Value Chain Development for North East Region (MOVCD)

- MOVCD is a **Central Sector Scheme**, a sub-mission under National Mission for Sustainable Agriculture (NMSA) which was launched by Ministry of Agriculture and Farmers' Welfare in 2015
- States like Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura were covered
- Aim is to develop certified organic production in a value chain mode to link growers with consumers and to support the development of the entire value chain.

Paramparagat Krishi Vikas Yojana (PKVY)
• PKVY was launched in 2015 as an elaborated component of Soil Health Management (SHM) of the major project National Mission of Sustainable Agriculture (NSA). • It promoted organic farming through adoption of organic villages by cluster approach and Participatory Guarantee System (PGS) certification.
National Program for Organic Production (NPOP)
• NPOP grants organic farming certification through a process of third-party certification for export purposes.
PM Formalization of Micro Food Processing Enterprises (PM-FME)
• The Ministry of Food Processing Industries (MoFPI) launched the PM FME scheme as a part of 'Atmanirbhar Bharat Abhiyan'. • Aims to bring in new technology, apart from affordable credit to help small entrepreneurs penetrate new markets.

15.13.2 Other Government Initiatives

- **Pradhan Mantri Krishi Sinchayee Yojana:** To ensure access to some means of protective irrigation to all agricultural farms in the country, to produce 'per drop more crop', thus bringing much desired rural prosperity.
- **Rashtriya Krishi Vikas Yojana:** It incentivises States to draw up plans for their agriculture sector more comprehensively taking agro-climatic conditions, natural resource issues and technology into account.
- **Pradhan Mantri Fasal Bima Yojana:** It is a comprehensive insurance scheme that covers the damage caused by natural calamities.
- **Dairy Processing and Infrastructure Development Fund:** To reduce the dependence of farmers on agriculture and provide other allied options.
- **Soil Health Card Scheme:** To issue soil health cards every 3 years, to all farmers of the country, so as to provide a basis to address nutrient deficiencies in fertilisation practices.

15.14 ZERO-BUDGET NATURAL FARMING (ZBNF)

- India is focusing on Zero-Budget Natural Farming (ZBNF). ZBNF was also highlighted in budget 2019 in the bid to double farmer's income by 2022.
- Zero Budget means without using any loan, and without spending any money on purchase of inputs (seeds, fertilisers).
- **Natural farming** is farming without chemicals, using biofertilizers, earthworms, cow dung etc.
- Originally promoted by **agriculturist Subhash Palekar**, who developed it in the mid-1990s as an alternative to the Green Revolution's methods that are driven by chemical fertilisers and pesticides and intensive irrigation.

Manure

Manure is comprised of a large quantity of organic matter that provides nutrients to the soil in small quantities.

Manure is prepared by the decomposition of animal and plant waste.

Using manure also helps to reduce organic waste and reduce the excessive use of fertilizer.

The following are three types of manure:

Compost: Organic waste decomposes in the pit is known as composting.

Vermicomposting: If the composition is done by using earthworms is called vermicomposting.

Green manure: Small Sunn hemp, guar like the tree are mulched by the plow and leave someday to decompose.

Four Components of ZBNF
Jeevamrutha
It is a mixture of fresh cow dung and aged cow urine (both from India's indigenous cow breed), jaggery, pulse flour, water and soil; to be applied on farmland.

Bijamrita
It is a concoction of neem leaves & pulp, tobacco and green chilies prepared for insect and pest management, that can be used to treat seeds.
Acchadana (Mulching)
It protects topsoil during cultivation and does not destroy it by tilling.
Whapasa
It is the condition where there are both air molecules and water molecules present in the soil. Thereby helping in reducing irrigation requirements.

Classification of Nutrients in Agriculture

Macronutrients	Micronutrients
Nitrogen	Iron
Phosphorous	Manganese
Potassium	Zink
Magnesium	Copper
Sulphur	Boron
Calcium	Molybdenum

15.15 PERMACULTURE

- Permaculture is an innovative framework for creating sustainable ways of agriculture. It is a practical method of developing ecologically harmonious, efficient and productive systems that can be used by anyone, anywhere.

Characteristics of Permaculture

- Reduced cost of agriculture as it would be using all the natural components of the ecosystem than conventional farming.
- Less waste as the waste products are recycled and manured back to the earth which are then used as natural fertilisers.
- Less soil pollution as it uses natural fertilisers this increases life of soil.
- Permaculture helps to produce a diverse variety of crops which results in self-sufficiency.
- Act as carbon sequestration thus helps to mitigate effects of Climate Change.
- Less labour is required as most varieties of plants grown are perennials.

15.16 NATIONAL INITIATIVE ON CLIMATE RESILIENT AGRICULTURE (NICRA)

- Launched by Indian Council of Agricultural Research (ICAR) in 2010-2011 to primarily enhance resilience of crops, livestock & fisheries through development of production & risk management.
- **Components of the Initiative:**
  - 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 stakeholders.

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16 Important Conventions on Environment

16.1 MAJOR INTERNATIONAL ENVIRONMENTAL CONVENTIONS

Nature Conservation
• United Nations Conference On Environment and Development (UNCED) • Convention on Biological Diversity (CBD) • Ramsar Convention on Wetlands • Convention on International Trade in Endangered Species of Fauna and Flora (CITES) • The Wildlife Trade Monitoring Network (TRAFFIC) • Convention on the Conservation of Migratory Species (CMS) • Coalition Against Wildlife Trafficking (CAWT) • International Tropical Timber Organization (ITTC) • United Nations Forum on Forests (UNFF) • International Union for Conservation of Nature and Natural Resources (IUCN) • Global Tiger Forum (GTF)
Hazardous Material
• Stockholm Convention • Basel Convention • Rotterdam Convention
Land
• United Nations Convention to Combat Desertification (UNCCD)
Marine Environment
• International Whaling Commission (IWC)
Atmosphere
• Vienna convention and Montreal Protocol • United Nations Framework Convention on Climate Change (UNFCCC) • Kyoto Protocol

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Conference

It is consulting together formally; a type of negotiations, there is only a broad theme.

In a conference the principle bodies are established for further deliberations if any is required on the broad theme for which the conference is called for.

Convention

It is a meeting or gathering to formulate or deliberate on a generally accepted principle, a framework in which the parties decide the basic guidelines.

Sometimes, the line between conference and a convention is very thin and sometimes they are interchangeably used because the outcome document of convention is arrived at the conference.

Protocol

A Protocol to the convention is an agreement that diplomatic negotiators formulate and sign as the basis for a final convention where the parties set specific aims or legal obligations.·

Usually, when a major provision is to be incorporated on regulations of the convention, a protocol is called among the countries, who are signatory of the original convention when it was signed and approved.

Fig. 16.1

16.2 UNITED NATIONS CONFERENCE ON THE HUMAN ENVIRONMENT (1972)

- United Nations Conference on the Human Environment (known as the **Stockholm Conference**) was an international conference convened under **United Nations** auspices held in Stockholm, Sweden (1972).
- It was the UN's first major conference on international environmental issues, and marked a turning point in the development of international environmental politics.

16.2.1 Stockholm Declaration

- It set out the principles for various international environmental issues, & the relationship between the environment and development.
- It is also known as 'The Declaration on the Human Environment'.

16.2.2 Stockholm+50

- It is a high-level meeting that the Government of **Sweden** planned to hold in conjunction with the **50th anniversary** of the **first UN conference** on the human environment – the **1972 Stockholm Conference**.
- Purpose is **to contribute to concrete action and leveraging sustainable consumption** and production patterns and nature-based solutions in order to achieve climate-neutral, resilient, circular and inclusive economies.

Brundtland Commission

- Formerly known as the **World Commission on Environment & Development** (WCED).
- Its mission is **to unite countries to pursue sustainable development together.**
- The Commission was **officially dissolved in December 1987 after releasing "Our Common Future",** also known as the **Brundtland Report**, in October 1987.
- The document popularised (and defined) the term **Sustainable Development**.

16.3 UNITED NATIONS CONFERENCE ON ENVIRONMENT AND DEVELOPMENT CLIMATE CHANGE (UNCED), 1992

- Also **known as the Rio Summit**, **Rio Conference, Earth Summit** held in Rio de Janeiro in June 1992.
- Earth Summit was held as a platform for Member States to collaborate in conservation efforts.
- **Systematic scrutiny of production of toxic components:** lead in gasoline, or poisonous waste including radioactive chemicals.
- **Alternative sources of energy** to replace the use of fossil fuels which are linked to global climate change
- **New reliance on public transportation systems** to reduce vehicle emissions, congestion in cities and the health problems caused by polluted air and smog.

- Following three Rio Conventions i.e., on Biodiversity, Climate Change and Desertification are derived directly from the 1992 Earth Summit:
  - United Nations Framework Convention on Climate Change (UNFCCC)
  - UN Convention on Biological Diversity (UNCBD)
  - UN Convention to Combat Desertification (UNCCD)
- The **Rio Declaration on Environment and Development** consisted of **27 principles** intended to guide countries in future sustainable development. It was signed by over **175 countries**.

16.3.1 Agenda 21

- It is a **non-binding action plan** sourced from Rio Earth Summit, 1992. The number "**21" refers to an agenda for the 21st century** which is to achieve Global sustainable development.
- Since 2015, Sustainable Development Goals have been included in the Agenda 2030.
- **Local Agenda 21 :** The implementation of Agenda 21 was intended to involve action at international, national, regional and local levels, often known as **'Local Agenda 21' or 'LA21'.**
- **Agenda 21 for culture:** Advocates establishing the groundwork of an undertaking by cities and local governments for cultural development.

- **RIO+5 (1997):** UN General Assembly held a special session to appraise the status of Agenda 21 (Rio +5).
- The Assembly recognized progress as 'uneven' and identified key trends such as increasing globalisation, widening inequalities in income and a continued deterioration of the global environment.

- **RIO+10 (2002): The Johannesburg Summit.**
- The Johannesburg Plan of implementation, agreed to at the World Summit on Sustainable Development (Earth Summit 2002).
- **UN commitment:** to full implementation of Agenda
- 21, alongside achievement of the MDGs and other international agreements.

- **RIO+20 (2012):** The attending members reaffirmed their commitment to Agenda 21 in their outcome document called **The Future We Want**. 180 nation leaders participated.
- Two main themes:
  - How to build a green economy to achieve sustainable development and lift people out of poverty; and
  - How to improve international coordination for sustainable development.

16.3.2 Forest Principles

- **Rio Forest Principles, 1992** is a **Non-legally binding document** on Conservation and Sustainable Development of all Types of Forest.

16.4 GLOBAL ENVIRONMENT FACILITIES (GEF)

- GEF was established on the eve of the **1992 Rio Earth Summit** to help tackle environmental issues.
- Located in **Washington D.C.**, United States + Parties: 184.
- The GEF is **jointly managed by UNDP, World Bank, & UNEP.**
- **As an independent financial organisation, GEF provides grants for projects related to**: Biodiversity, Climate change, International waters, Land degradation, Ozone layer, Persistent Organic Pollutants (POPs), Mercury, Sustainable Forest management, Food security, Sustainable cities.

Although **GEF is not linked formally to the Montreal Protocol** on Substances that Deplete the Ozone Layer, it supports implementation of the Protocol in countries with economies in transition.

GEF also serves as financial mechanism for six conventions

- Stockholm
- UN-FCC
- UN-CBD
- UN-CCD
- Montreal Protocol
- Minamata Convention

16.4.1 GEF's Small Grants Programme (SGP)

- It was launched in 1992 with 33 participating countries and provides financial & technical support to communities and Civil Society Organizations (CSOs)

- SGP is specifically designed to mobilise a community-led bottom-up approach for Sustainable Development.
- It is currently implemented by UNDP on behalf of GEF.

16.5 UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP) OR UN ENVIRONMENT

- UNEP is an **agency of the United Nation,** established on 5th June **1972 and headquartered at Nairobi, Kenya**. **UNEP's governing body** is called the United Nations Environment Assembly.
- UNEP coordinates the UN's environmental activities and is a leading **global environmental authority**.
- UNEP sets the global environmental agenda, promotes sustainable development within the United Nations system, and serves as an authoritative advocate for global environment protection.
- UNEP has been established by the **United Nations General Assembly (UNGA) in pursuance of the Stockholm Conference (1972).**

Major Campaigns
• Beat Pollution UN75
• World Environment Day • Wild for Life
Major Programmes of the UNEP
• Earth Hour • Clean up the World
• Billion Tree Campaign • Seal the Deal
• Pain for the Planet • TUNZA
Major Reports
• Emission Gap Report • Adaptation Gap Report • Global Environment Outlook • Frontiers • Invest into Healthy Planet

- **World Meteorological Organization and UN Environment** established the **Intergovernmental Panel on Climate Change (IPCC) in 1988.**
- It is also one of several Implementing Agencies for the **Global Environment Facility** (GEF) and the Multilateral Fund for the Implementation of the Montreal Protocol.
- **It has achieved several successes like the Montreal Protocol** (**1987**) and the **Minamata Convention** (**2012**).
- In 2019, **India joined the Climate & Clean Air Coalition (CCAC),** whose Secretariat is hosted by the UNEP.
- The **UNEP awarded PM Narendra Modi with the 'Champions of the Earth' award** along with French President Emmanuel Macron in the category 'policy leadership'.

United Nations Environment Assembly
• It is the governing body of the UN Environment Programme. • It is the world's highest-level decision-making body on the environment. • It meets biennially to set priorities for global environmental policies and develop international environmental law. • It was created in June 2012, during the United Nations Conference on Sustainable Development, also referred to as RIO+20. • Currently, it has 193 member states (all UN member countries).

16.6 INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

- It is the international body for **assessing the science related to climate change**.
- It was **set up in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP)** to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation.
- **The 2007 Nobel Peace Prize** was shared, in two equal parts, between the IPCC and an American Environmentalist.
- **IPCC** aims to assess scientific information relevant to: Human-induced climate change; Impacts of human-induced climate change; Options for adaptation and mitigation.
- IPCC assessments **provide a scientific basis for governments at all levels to develop climate related policies**, and they underlie negotiations at the UN Climate Conference – UNFCCC.

IPCC Assessment Reports (ARs)

- Every few years (about 7 years), the IPCC produces assessment reports that are the **most comprehensive scientific evaluations of the state of earth's climate.**
- **Assessment Reports - by three working groups of scientists:**
  - **Working Group-I** - Deals with the scientific basis for climate change.
  - **Working Group-II** - Looks at the likely impacts, vulnerabilities and adaptation issues.
  - **Working Group-III** - Deals with actions that can be taken to combat climate change.

16.6.1 Sixth Assessments Report (AR6)

- It is the **sixth in a series of reports** intended to assess scientific, technical, and socio-economic information concerning climate change.its theme was **"Climate Change 2021: The Physical Science"**.
- It noted that global net-zero by 2050 was the minimum required to keep the temperature rise to 1.5 degree Celsius.
- The report evaluates the physical science of climate change looking at the past, present, and future climate.
- It reveals how human-caused emissions are altering our planet and what that means for our collective future.
- Weather and climate events – such as extreme heat, heavy rainfall, fire conditions, and droughts – are becoming more severe and frequent because of climate change.
- The report finds **we are already edging closer to a 1.5 degrees Celsius warmer world**, and every day emissions rise the prospects for averting the worst impacts of climate change become dimmer.
- **Carbon dioxide has been and will continue to be the dominant cause of global warming** under all greenhouse gas emissions scenarios.
- Also, **the IPCC report vindicates India's position** that historical cumulative emissions are the source of the climate crisis that the World faces today.
- Major Concerns:
  - Arctic Sea ice is at its lowest level in more than **150 years**;
  - Sea levels are rising faster than at any time in at least the last **3,000 years**;
  - Glaciers are declining at a rate unprecedented in at least **2,000 years**.

16.7 UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)

- UNFCCC is the **primary multilateral treaty** governing actions to combat climate change through adaptation and mitigation efforts directed at control of emission of GHGs that cause global warming.
- **Negotiated & signed at the UN (CED)** - Conference on Environment & Development (Earth Summit), held in **Rio de Janeiro, June 1992.**
- UNFCCC is headquartered in Bonn**, Germany** and **came into force** on **21st March 1994.**
- Focus of UNFCCC is to stabilise Greenhouse Gas (GHG) concentrations in the atmosphere at a level that would stop dangerous anthropogenic interference with the climate system.
- It has been ratified by **197 countries** and is called to have a **near-universal membership**. The countries that have **ratified the convention** are called the **UNFCCC conference of parties (COP). India ratified** the UNFCCC in 1993.
- **COP is the supreme governing body** of the UNFCCC. The latest, **COP i.e. 26th , was held in Glasgow, Scotland in 2021.**
- **Nodal agency** for the UNFCCC in India is the Ministry of Environment, Forests and Climate Change (MoEFCC).
- Originally, it **set no binding limits on GHG emissions** for individual countries & contained no enforcement provisions.
- **The Kyoto Protocol (1997)** was negotiated under this framework.
- **Climate-Tech Centre Network** is the operational arm of UNFCCC. It promotes transfer of tech for low Carbon & Carbon resilient development.
- **UNFCCC along with** UN Convention on Biological Diversity and UN Convention to Combat Desertification **is combinedly called the Rio Convention.**

16.7.1 Kyoto Protocol

- Kyoto Protocol was an **international treaty which extended the 1992 UNFCCC** that commits state parties to reduce greenhouse gas emissions.
- **It was adopted in Kyoto**, Japan in **1997 at CoP3** of UNFCCC; Came into force by Feb-2005. **India ratified** the protocol in **2002**.
- 192 countries are **Parties to the Kyoto Protocol** (Andorra, Canada, South Sudan, & United States are not members).

- The Protocol aimed to cut emissions of GHGs across the developed world by about 5% by 2012 compared with 1990 levels, in the 1st commitment period, 2008 to 2012.
- It is based on the **Principle of Common But Differentiated Responsibilities**.
- **The Kyoto Protocol applies to the 6 GHG listed in Annex A**
- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur Hexafluoride (SF_6)
- There are two commitment periods under Kyoto Protocol i.e. **2008 to 2012 and 2013 – 2020 (Doha Amendment to the protocol, 2012).**

Annex–I Countries	• List of industrialized countries and economies in transition. • Compulsory binding targets to reduce GHG emissions.
Annex–II Countries	• A sub-group of Amex 1. • These countries are required to give financial assistance and technology to Non-annex countries.
Non-Annex–I Countries	• Developing countries like India, Brazil, China. • No binding targets to reduce GHG emissions
LDCs	• Least Developed Countries • No binding targets

Fig. 16.2

- The second commitment period is a **failure**, due to non- acceptance of the required (144) number of parties.
- The Kyoto Protocol is the only global treaty with binding limits on GHG emissions.
- **Apart from national measures, the agreement has three mechanisms that are means to achieve the Kyoto targets:**
  - International Emissions Trading
  - Clean Development Mechanism
  - Joint Implementation
- **India being a non-Annex I country** is exempt from the treaty's framework. The Indian government ratified the treaty in August 2002. Since the per capita emission rates are much smaller for developing countries compared to the developed countries, India takes the stand that the major responsibility of reducing emissions lies with the latter.
- **India is a non-Annex I country**. India is exempt from the treaty's framework. The Indian government ratified the treaty in August 2002. Since the per capita emission rates are much smaller for developing countries compared to the developed countries, India takes the stand that the major responsibility of reducing emissions lies with the latter.

Points to Ponder

A look at some of the observations and forecasts made by the panel on climate change

- Heatwaves and humid heat stress will become more intense and frequent over South-East Asia during the 21st century.
- Both annual and summer monsoon precipitation will increase, with enhanced interannual variability over Southeast Asia.
- Heat extremes have increased while cold extremes have decreased, and these trends will continue over the coming decades.
- Glacier run-off in the Asian high mountains will increase up to mid-21st century, and subsequently run-off may decrease due to the loss of glacier storage.
- Relative sea level around Asia increased faster than global average, with coastal area loss and shoreline retreat. Regional mean sea level will continue to rise.

16.7.2 Significan UNFCCC COPs Post Kyoto Protocol

Bali Summit COP13

- Introduction of **Nationally Appropriate Mitigation Actions (NAMA),** to engage developing countries in voluntary mitigation efforts.

Copenhagen Summit COP15

- This was the **first Climate Agreement which endorsed the 2°C warming limit as the benchmark** for global progress on climate change.
- Copenhagen Accord (2009) **abandoned the spirit of the Rio principles** & wanted voluntary GHG reduction targets.
- However, developing countries revolted & the Paris **Agreement was born out of Copenhagen and adopted in 2015.**

Cancun Summit COP16

- Cancun Agreement – all parties to the convention have agreed to report their voluntary mitigation goals for implementation.
- **Outcome of COP16:** Technology Mechanism, Green Climate Fund, Adaptation Fund.

Durban Summit COP17

- Second phase of Kyoto Protocol secured
- Launching the **Green Climate Fund (GCF)**
- Adaptation and Transparency mechanism
- Review of Adaptation Fund

Doha Summit COP18

- Amendment to the Kyoto Protocol to start second commitment period (2013-2020)

Warsaw Summit COP19

- Two important things emerged:
  - **INDC**: Intended Nationally determined Contribution
  - **REDD+**: Reduction in Emission from Deforestation and Forest Degradation

Lima Summit COP20

- Both developed and developing countries pledged for Green Climate Fund
- **NAPs**- National Adaptation Plans Global Network was launched. India communicated its INDC with UNFCCC.
- **Intended Nationally Determined Contributions (INDC) -** Intended reductions in greenhouse gas emissions under UNFCCC.
- All countries that signed the UNFCCC were asked to publish their INDCs at the 2013 United Nations Climate Change Conference held in **Warsaw**, **Poland**, in **November 2013**.
- The term was intended as a compromise between **Quantified Emissions Limitation and Reduction Objective** (QUELROs) and **Nationally Appropriate Mitigation Actions** (NAMAs) that the Kyoto Protocol used to describe the different legal obligations of developed and developing countries.
- Under the Paris Agreement, adopted in December 2015, the INDC will become the **first Nationally Determined Contribution** (NDC) when a country ratifies the agreement unless it decides to submit a new NDC at the same time.
- Once the Paris Agreement is ratified, the **NDC will become the first greenhouse gas targets under the UNFCCC** that applied equally to both developed and developing countries.

India's INDC

- Reduce intensity of GDP emission by **33-35%** by **2030** below **2005** level.
- Increase the share of non-fossil fuels-based electricity to **40 per cent** by **2030**.
- Total Renewable Energy of **175 GW** by **2022**.
- Increase additional carbon sink of **2.5 – 3 billion tonnes** by **2030**.

Paris Summit COP21

- It is a **legally binding** International Treaty on Climate Change.
- It was **adopted by 196 Parties at COP 21 in Paris, on 12 December 2015** & entered into force on 4 November **2016**.
- **Goal** is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels.
- It requires all parties to put forward their Nationally Determined Contributions (NDCs) which is voluntary in nature.
- **The agreement talks about 20/20/20 targets**
  - CO2 emissions reductions by 20%
  - To increase the Renewable energy market share by 20%
  - To increase energy efficiency by 20%
- **USA announced to withdraw** from the deal in 2017.
- Review is to be done every 5 years. First world review will be **done by 2023.**
- **Paris Ratchet Mechanism**: Also known as the **Paris Ambition Mechanism** that ensures that member nations reflect and progress their NDCs by raising ambitions to fight climate change over time.

Carbon Markets under the Paris Agreement

Market Mechanism 1

- It sets up a Carbon Market which allows countries to sell any extra emission reductions [called as **Internationally Transferred Mitigation Outcomes** (ITMO)] which they have achieved compared to their **Nationally Determined Contributions** (NDCs) target.
- This is a voluntary direct bilateral cooperation between countries aiming to promote sustainable development.

Market Mechanism 2

- The second mechanism will create a new international carbon market for the trading of emissions reduction created anywhere in the world by the public or the private sector.
- This new market is referred to as the **Sustainable Development Mechanism** (SDM) which seeks to replace the **Clean Development Mechanism** (CDM) of Kyoto Protocol.
- The delivery of **Overall Mitigation in Global Emissions** (OMGE) is a key requirement of **SDM**.

Marrakech Summit COP22

- Discussed on how to tackle Global Stock take.
- Parties conducted the first review of the Warsaw International Mechanism for Loss and Damage

Contentious issues

- Whether the Adaptation Fund would continue or not.
- **Orphan** issues on establishing common timeframe for NDCs

Bonn Summit COP23

- Talanoa dialogue to encourage the international community to take more action to close the global climate mitigation gap.
- Gender action plan to make women part of all climate change projects and decisions internationally and nationally.
- Clean Energy transitions programme to support clean energy transitions around the world.
- Global average temperature to keep the global average temperature rise below **2 celsius**.

Launch of Fiji clearing house for risk transfer

- A new online platform to help vulnerable countries find affordable insurance and solutions to avoid climate risk.
- By **2020**, long-term finance will deliver **$100 Billion** per year for countries to take climate action.

- Ocean pathway partnership to strengthen action and funding that link climate change action with healthy oceans.
- Insuresilience the climate risk insurance initiative **$125 million** insurance coverage from the government of Germany to protect **400 million** poor and vulnerable people from extreme weather events.
- By **2030 a new Small Island Developing State** (SIDS) health initiative will triple the levels of international financial support on climate and health for people living in SIDS.

Katowice Summit COP24

- UNFCCC's COP-24, **held in Katowice, Poland.**
- **Outcome**: **Katowice Rulebook** to implement Paris Agreement.
- Parties' commitment to NDCs was revised and enhanced.
- Guidelines for the **global stocktake** pledge-and-review cycle.
- Developed countries commitment of $100 billion annually from 2020 to fund climate action in developing countries
- **Katowice Rulebook includes:**
- The steps that each member nation is required to take to fight global climate change
- It operationalizes the provisions of the Paris Agreement.

- Extends support to developing nations to implement their NDCs.
- The **Global Stock Take** (GST) to assess the effectiveness of climate action in 2023.
- To assess progress on the development and transfer of technology
- **Significance**: ensure that each 'tonne of GHG emissions' is accounted for.
- **Issues**: Failure to agree common rules on carbon markets and emissions trading.
- **Non-agreement** on general commitment to limit global warming to below 1.5°C above pre-industrial levels.

COP25 Madrid

- It was **originally planned in Brazil but took place under the Presidency of Chile** & held with logistical support from Spain.
- Adopted the "**Chile Madrid Time for Action**" document.
- **"Santiago Network" was established**, as part of the Warsaw International Mechanism (WIM) [on loss & damage], to catalyse the technical assistance needed for most vulnerable countries.
- However, **no clear timeline** was set for nations to enhance their NDCs in 2020.
- Discussion and talks on various issues remain unresolved and have been pushed to COP26 (to be held in November 2021 at Glasgow).
- **Discussions were held on the following:**
  - UNEP Annual Report on Emission Gap
  - Global Carbon Project ReportIPCC special report on Lands, Oceans and the Cryosphere
  - Reiteration of Paris Ratchet Mechanism
  - Corporate Climate Movement
  - 39 countries committed to include oceans in their NDCs

Santiago Call for Action on Forests
• **Chile** as the President of **COP 25** of **UNFCCC** initiated the Santiago Call for Action on forests. • It states that forests & trees combined with improved land management could provide up to **30%** of GHG mitigation needed by **2030** to limit the global average temperature rise below **20C**.

COP26 Glasgow

- Four goals were outlined.
  - **Secure global net-zero by mid-century** and keep 1.5 degrees within reach.
  - **Adapt:** to protect communities and natural habitats.
  - **Mobilise finance**: To deliver on our first two goals, developed countries must make good on their promise to mobilise at least $100bn in climate finance per year by 2020.
  - **Finalise the Paris Rulebook**: Leaders will work together to frame a list of detailed rules that will help fulfil the Paris Agreement.

Glasgow Leaders' Declaration on Forests and Land Use
Conservation
Conserve forests and other terrestrial ecosystems and accelerate their restoration.
Sustainable Development
Facilitate trade and development policies, internationally and domestically, that promote sustainable development, and sustainable commodity production and consumption.
Building Resilience
Reduce vulnerability, build resilience and enhance rural livelihoods, including through empowering local communities.
Recognising Indigenous Rights
The development of profitable, sustainable agriculture, and recognition of the multiple values of forests, while recognising the rights of Indigenous.
Financial Commitments
Reaffirm international financial commitments and significantly increase finance and investment from a wide variety of public and private sources.

16.8 INDIA'S STAND ON THE DECLARATION

- India, Argentina, Mexico, Saudi Arabia and South Africa are the only G20 countries that did not sign the declaration.
- The declaration interlinks trade to climate change and forest issues.
- Trade falls under the World Trade Organization and should not be brought under climate change declarations.
- India and others had asked the word **trade** to be removed, but the demand was not accepted. Therefore, they didn't sign the declaration.

Indian PM Made Five Pledges

1. India will increase its non-fossil energy capacity to 50 GW by 2030.
2. India will meet 50% of its energy requirements from renewable energy by 2030.
3. India will reduce the total projected carbon emission by one billion tonnes from now to 2030.
4. By 2030, India will reduce the carbon intensity of its economy by 45% (from a previous target of 35%)
5. By 2070, India will achieve the target of net zero.

Net Zero

Net zero refers to a balance where emissions of greenhouse gases are offset by the absorption see net zero targets as a critical measure to successfully tackle climate change and its devastating consequences

Pledges by Top Three Emitters

China	Beijing announced no new pledges on Monday. It previously pledged net zero by 2060.
United States	The US touted domestic legislation to spend $555 bn to boost renewable power and electric vehicles. It has pledged net zero by 2050.
India	The country's economy will become carbon neutral by the year 2070

COP27 (Sharm El-Sheikh, Egypt)

- The final decision text, known as the Sharm el-Sheikh Implementation Plan was published on 20 November after negotiations overran the conference. The text reaffirms the commitment to limit global temperature rise to 1.5 degrees Celsius above pre-industrial levels.A key outcome was the launch of the Food and Agriculture for Sustainable Transformation initiative. The initiative aims to improve the quantity and quality of climate finance contributions to transform agriculture and food systems by 2030.

16.9 CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES OF WILD FAUNA AND FLORA (CITES)

- Came into force by July 1975, currently has 183 Parties.
- **1976**: India joined the CITES.
- CITES, **legally binding** but does not take the place of national laws.
- Amendments to the Convention must be supported by a two-thirds majority who are **present and voting**.

REDD

- UN REDD is a flagship partnership of the UN between FAO, UNEP and UNDP.
- To protect, manage and save their forest resources, delivering Paris Agreement and SDGs.
- It assists the countries to develop the capacities needed
- to develop commitments to meet UNFCCC-REDD+ commitments

REDD+

- REDD+ is a political framework under UNFCCC.
- Goes beyond deforestation and forest degradation. Includes Conservation, sustainable management of forests and enhancements of carbon stocks.
- It supports countries that reduce emissions and undertake sustainable management of forests by giving funds and resources as incentives.

- Also known as the **Washington Convention**–Located in Geneva.
- **Objective:** to ensure that international trade in specimens of wild animals & plants does not threaten their survival.
- Drafted in 1963, at IUCN members meet.

16.10 CONVENTION ON BIOLOGICAL DIVERSITY

- Legally binding treaty to conserve biodiversity has been in force since 1993.
- **Objectives:**
  - The conservation of biological diversity.
  - The sustainable use of the components of biological diversity.
  - The fair and equitable sharing of the benefits arising out of the utilization of genetic resources.
- **Ratification**: Nearly all countries have ratified it (notably, the US has signed but not ratified).
- **CBD Secretariat**: Montreal, Canada
- **Conference of Parties (COP):** The Parties (Countries) under Convention of Biodiversity (CBD), meet at regular intervals.
- **India and CBD**
  - India has ratified the CBD and also enacted the Biological Diversity Act in 2002 and notified the Rules in 2004 to give effect to the provisions of the CBD.

- India had the presidency of CBD for two years (2012- 14).

Cartagena Protocol

The Protocol seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology – protocol on Biosafety.

Nagoya Protocol

- On **Access to Genetic Resources** and the **Fair and Equitable Sharing of Benefits Arising** from their Utilisation (ABS)
- It not only applies to genetic resources that are covered by the CBD, and to the benefits arising from their utilisation but also covers traditional knowledge associated with genetic resources that are covered by the CBD and the benefits arising from its utilisation.

Aichi Targets

- Adopted by the Convention on Biological Diversity (CBD) at its **Nagoya conference**.
- It is a **short term plan that provides a set of 20 ambitious yet achievable targets**, collectively known as the Aichi Targets.

Classification of Targets

1. **Strategic Goal A:** Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society.
2. **Strategic Goal B:** Reduce the direct pressures on biodiversity and promote sustainable use.
3. **Strategic Goal C:** To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity.
4. **Strategic Goal D:** Enhance the benefits to all from biodiversity and ecosystem services.
5. **Strategic Goal E:** Enhance implementation through participatory planning, knowledge management and capacity building.

COP11 (Hyderabad)

- Total **170 countries** participated in the conference.
- The **last decade (2011-2020)** had been declared as the **United Nations Decade on Biodiversity** and **United Nations Decade for Deserts** and the Fight against Desertification.
- **COP 11-HYDERABAD** is the first conference during the above special 'decades'.
- Hyderabad also hosted the 6th meeting of parties to the **Cartagena Protocol on Biosafety** (under CBD). This is known as **COP-MOP-6.**

The Economics of Ecosystems and Biodiversity (TEEB)

- It is an international initiative to draw attention to the global economic benefits of biodiversity.
- In 2007, **environment ministers from G8+5 countries** meeting in Germany proposed TEEB to initiate the following processes
  - Analysing the global economic benefit of biological diversity,
  - The costs of the loss of biodiversity
  - The failure to take protective measures versus the costs of effective conservation.
- In response to TEED, a global study was initiated in 2017 and was **led by Pavan Sukhdev.**
- Pavan Sukhdev is an Indian environmental economist whose field of studies include green economy and international finance.

16.11 INTERNATIONAL CONVENTIONS TO REGULATE WASTE

Stockholm Convention

- International environmental treaty which aims to eliminate or restrict the production and use of Persistent Organic Pollutants (POPs).
- **POPs**: chemical substances that persist in the environment, bioaccumulate through the food web, and pose a risk of causing adverse effects to human health and the environment.

Basel Convention

- Basel Convention **on control of transboundary movements of hazardous wastes and their disposal** is an international treaty that was designed to reduce the movements of hazardous waste between nations.
- **Objective**: to prevent the transfer of hazardous waste from developed to less developed countries (LDCs).
- Does not address the movement of radioactive waste.

Rotterdam Convention

- Rotterdam Convention on the **Prior Informed Consent (PIC) Procedure** for Certain Hazardous Chemicals and Pesticides in International Trade.
- It is a multilateral treaty to promote shared responsibilities in relation to the importation of hazardous chemicals.
- Creates **legally binding obligations** for the implementation of the PIC procedure.
- **Promotes an open exchange of information** and calls on exporters of hazardous chemicals to use proper labelling, safe handling, and inform purchasers of any known restrictions or bans.

- **Signatory nations can decide whether to allow or ban the importation** of chemicals listed in the treaty.

16.12 RAMSAR CONVENTION ON WETLANDS

- It is an international treaty **for "the conservation and sustainable use of wetlands".**
- It is also known as the **Convention on Wetlands.** It is named **after the city of Ramsar in Iran.**
- The Convention was signed on **2nd of February 1971** (2nd Feb celebrated each year as World Wetlands Day).
- **Parties**: 171.
- It is the **only international treaty** that addresses a specific ecosystem (wetland.)
- The **Ramsar Convention** is **not a regulatory regime**.
- The convention works on three pillars that define the purpose of the Ramsar Convention:
- **Wise Use:** maintenance of ecological character within the context of sustainable development.
- **List of Wetlands of International Importance:** Designate suitable wetlands under the Ramsar List to effectively manage.
- **International Cooperation:** To bring cooperation internationally over the transboundary wetlands, shared wetland systems and shared species.
- **Examples of Wetlands:** Marine and coastal areas; Estuaries; Lakes and rivers; Marshes and peatlands; Groundwater and human-made wetlands such as rice paddies, shrimp ponds, and reservoirs.
- The convention comes with a **six-year strategic plan**. The **latest one is the 4th Ramsar Convention Strategic Plan 2016-2024 which was approved at COP12** of the convention.
- India regulated the Wetlands designated under the Ramsar List and those wetlands are notified under central, state, and UT rules.
- India does not regulate the River channels and Paddy fields under Wetlands Rules
- Human-made water bodies specifically constructed for drinking water purposes; aquaculture purposes; salt production purposes; recreation purposes; and for irrigation purposes
- Wetlands falling within areas covered under the Indian Forest Act, 1927; Forest (Conservation) Act, 1980; and State Forest Acts.
- Wetlands falling within areas covered under the Wildlife (Protection) Act, 1972.
- Wetlands falling within areas covered under the Coastal Regulation Zone Notification, 2011.

Ramsar Convention has Six international Organization Partners

- Birdlife International
- IUCN
- Wetlands International
- WWF
- International Water Management Institute
- Wildfowl and Wetlands Trust

16.12.1 Ramsar Site

- At the time of joining the Convention, **each Contracting Party undertakes to designate at least one wetland site for inclusion in the List of Wetlands** of International Importance.
- The inclusion of a "Ramsar Site" in the List embodies the government's commitment to take the steps necessary to ensure that its ecological character is maintained.
- There are over 2400+ Ramsar Sites on the territories of 171 Ramsar Contracting Parties across the world.
- The countries with the most Sites are the **United Kingdom with 175** and Mexico with 142.
- **Bolivia has the largest area** under Ramsar protection.

Montreux Record

- Montreux Record is a **register of wetland sites** on the List of Wetlands of International Importance **where changes in ecological character have occurred, are occurring, or are likely to occur** as a result of technological developments, pollution or other human interference.
- It is maintained as part of the Ramsar List.

- **2nd February, 2021** marked the **50th anniversary** of the Ramsar Convention.
- India on this occasion **established the Centre for Wetland Conservation & Management** which is the **first in the country**. It is set up under the MoEF&CC, at the National Centre for Sustainable Coastal Management (NCSCM) in **Chennai**.

16.13 UNITED NATIONS CONVENTION TO COMBAT DESERTIFICATION (UNCCD)

- Established in **1994**, it is the **sole legally binding international agreement** linking environment and development to sustainable land management.
- Its 197 Parties aim, through partnerships, **to implement the Convention and achieve the Sustainable Development Goals.** The end goal

is to protect land from overuse and drought, so it can continue to provide food, water and energy.It is the **only convention stemming from a direct recommendation** of the Rio Conference's Agenda 21.

It is called the Rio Convention along with its sister conventions:

- United Nations Framework Convention on Climate Change (UNFCCC)
- UN Convention to Combat Desertification.

- The **UNCCD is particularly committed to a bottom-up approach**, **encouraging the participation of local people** in combating desertification and land degradation.
- India is among the select few countries to have hosted the COP of all three Rio conventions on climate change (UNFCCC), biodiversity (UNCBD) and land (UNCCD).
- To help publicise the Convention, **2006** was declared.

16.13.1 International Year of Deserts and Desertification

- **Focus areas:** The Convention addresses specifically the arid, semi-arid and dry sub-humid areas, known as the drylands, where some of the most vulnerable ecosystems and peoples can be found.
- **Nodal Ministry:** The Ministry of Environment, Forest and Climate Change is the nodal Ministry for this Convention.
- Global Efforts To Check Land Degradation:
  - United Nations Convention to Combat Desertification (UNCCD)
  - Delhi Declaration of 2019, signed by 14th CoP of the UNCCD,

UNCCD COP 14 (2019)

Held in Greater Noida, this was the first time that India hosted an edition of the UNCCD COP.

- **Delhi Declaration**: Commitment for a range of issues, including gender and health, ecosystem restoration, taking action on climate change, private sector engagement, **Peace Forest Initiative** and recovery of five million hectares of degraded land in India.
- **Peace Forest Initiative:** It is an initiative of **South Korea** to use ecological restoration as a peace-building process. It aims at addressing the issue of land degradation in conflict-torn border areas.
- **Drought Toolbox:** launched as a one-stop-shop for all actions on drought. It is a sort of knowledge bank which contains tools that strengthen the ability of countries to anticipate and prepare for drought effectively and mitigate their impacts.
- **The Bonn Challenge:** To bring 150 million hectares of the world's deforested and degraded land into restoration by 2020, and 350 million hectares by 2030.
- **Great Green Wall:** Initiative by Global Environment Facility (GEF), where eleven countries in Sahel-Saharan Africa have focused efforts to fight against land degradation and revive native plant life to the landscape.

16.14 INTERNATIONAL WHALING COMMISSION (IWC)

- It is an **Inter-Governmental Organisation** set up by the terms of the International Convention for the Regulation of Whaling (ICRW) signed in **Washington, D.C in 1946.**
- **Aims**: to provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry.
- **Mandate:** 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.
- The body is the first piece of International Environmental Legislation established in 1946.
- **Commercial whaling was banned** by the IWC in 1986 after some species were almost driven to extinction.
- **89 countries have the membership** of IWC and all the member countries are signatories to this convention.
- **India** is a member state of the IWC.

16.15 GLOBAL TIGER FORUM

- In 1993, an International Symposium on Tiger Conservation in **New Delhi** recommended the formation of an **Inter-Governmental International Body** that would embark on a Global Campaign for the Protection of Tigers.
- Established in 1994, the **Global Tiger Forum** (GTF) has its headquarters in New Delhi.
- The General Assembly of GTF meets after every three years.
- It utilises cooperative policies, common approaches, technical expertise, scientific modules and other appropriate programmes.

16.16 THE WILDLIFE TRADE MONITORING NETWORK (TRAFFIC)

- TRAFFIC is a **NGO working globally on trade in wild animals & plants** in the context of both biodiversity conservation & sustainable development.

- Estb. in 1976, joint programme of **WWF & IUCN.**
- TRAFFIC is **complementary to CITES**.
- **Objective:** is to ensure that trade in wild plants & animals is not a threat to the conservation of nature.
- It investigates and analyses wildlife trade trends, patterns, impacts & drivers to provide the leading knowledge base on trade in wild animals & plants.
- Connectivity' to be integrated & prioritised in the new framework.
- COP 13, proposes to include ten new species for protection under CMS viz.
- **Three Indian Species**: Asian Elephant, Bengal Florican, Great Indian Bustard.

> - **Appendix-I includes the** threatened migratory species.
> - **Appendix-II i**ncludes the migratory species requiring international cooperation.

- **Parties**: As of 1st November 2019, there were 129 countries plus the European Union. Maldives is the latest country to join it (November 2019).
- **India has been a party** to the Convention since 1983.
- India has signed a **non-legally binding** MoU with CMS on conservation and management of Siberian Cranes (1998), Marine Turtles (2007), Dugongs (2008), and Raptors (2016).
- **India provides temporary shelter to**: Amur Falcons, Bar- headed Geese, Black-necked Cranes, Marine Turtles, Dugongs, Humpback Whales, etc.
- IUCN has observer & consultative status at the United Nations.

16.17 CMS: 13th COP FEB-2020

- Held in **Gandhinagar**, India. **India will host the presidency for the next 3 years**.
- **CoP-13 Theme**: Migratory species connect the planet & together we welcome them home.
- **Logo**: was inspired by the traditional **Kolam** from Southern India, which has a profound significance in the context of living in harmony with nature.
- **Mascot**: The GIBI - **Great Indian Bustard** (IUCN-Critically Endangered).
- 13th CoP has adopted the **Gandhinagar Declaration**, which calls for migratory species & the concept of 'Ecological
- The organisation was established under the **International Tropical Timber Agreement** (ITTA), which was sponsored by the United Nations Conference on Trade and Development and was ratified in 1985.
- Its mandate was renewed by the **International Tropical Timber Agreement, 1994** and again by the **International Tropical Timber Agreement, 2006**, which aims to promote sustainable management and legal harvesting of forests that produce tropical timber, and to promote expansion and diversification of international timber trade from these forests.

16.18 UNITED NATIONS FORUM ON FORESTS (UNFF)

- It is an **Intergovernmental** organisation, **established by the United Nations Economic & Social Council (ECOSOC)** in 2000. HQ: New York, USA.
- **Objective**: to strengthen political commitment to the management, conservation & sustainable development of all types of forests.
- UNFF is built on the **Forest Principles** together with the
- **Agenda-21** of **Rio Earth summit** (1992).

16.19 COALITION AGAINST WILDLIFE TRAFFICKING (CAWT)

- The Coalition Against Wildlife Trafficking (CAWT) was established by the **US Department of State** in **2005** as a **voluntary public-private** [international] coalition of like- minded governments and organisations that share the goal of eradicating the illegal trade in wildlife and wildlife products.

The CAWT's three objectives are:

- to lower consumer demand,
- to limit supply through increased enforcement
- to mobilise high-level political support.
- In 2008, the CAWT released its public awareness videos, which included Harrison Ford, an actor and wildlife conservationist.

16.20 VIENNA CONVENTION FOR PROTECTION OF OZONE

- It is one of the most successful treaties of all time, **ratified by 197 states**.
- It is a **multilateral environmental agreement** that was agreed upon by 1985 & entered into force in **1988**.
- **Not legally binding.**
- It acts as a framework for the international **efforts to protect the Ozone layer**.
- These are laid out in the **accompanying Montreal Protocol.**

16.20.1 Montreal Protocol

- It is a protocol to the Vienna Convention and it deals with the substances that deplete the Ozone Layer (ozone depleting substance-ODS).

- It was the **first treaty** to achieve universal ratification.
- The protocol recognizes that all nations should not be treated equally.

16.20.2 Kigali Agreement (2016)

- On 1st January 2019, the **Kigali Amendment to the Montreal Protocol** came into force.
- This amends 1987 Montreal Protocol to reduce the use of HFCs by more than 80% by late 2040s.
- It is a **legally binding** international agreement.
- India recently achieved complete phase out of ozone depleting Hydro-Chloro-Fluoro Carbons (HCFC-141b). Also, India proactively phased out production & consumption of CFCs in 2008 before the timeline.

> Though HFCs are not ODS they are included in Montreal Protocol through Kigali agreement due to their Global Warming potential.

16.21 MINAMATA CONVENTION ON MERCURY

- The Convention was **signed at Minamata, Japan in 2013** & entered into force in 2017.
- It is **an UNEP led international treaty** designed to protect Human health and the Environment from anthropogenic emissions & releases of Mercury and Mercury compounds.
- **India ratified** in 2018.
- Mercury is recognized as a substance producing significant adverse neurological & other health effects, with particular concerns expressed about its harmful effects on infants and unborn children.

16.22 GLOBALLY IMPORTANT AGRICULTURAL HERITAGE SYSTEM (GIAHS)

- **Purpose**: to create public awareness, safeguard world agricultural heritage sites.
- It was **started in 2002 by the UN-FAO** (Food & agricultural organisation).
- GIAHS are outstanding landscapes of aesthetic beauty that combine agricultural biodiversity, resilient ecosystems & a valuable cultural heritage.
- They sustainably provide multiple goods & services, food & livelihood security for millions of small-scale farmers.
- GIAHS constitute the foundation for contemporary and future agricultural innovations and technologies.
- Three regions of India which has been recognized as the GIAHS:
- Koraput Traditional Agriculture (Odisha)
- Saffron heritage of Kashmir Valley.
- Kuttanad.

Helsinki Protocol, 1985

Protocol to the 1979 Convention on Long-Range Trans-boundary Air Pollution on the Reduction of Sulphur Emissions.

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17 Important Reports and Indices

Environmental Performance Index	• Biennial index released by **Yale University and Columbia University** in collaboration with **World Economic Forum.**
Renewable Capacity Statistics	• It is released by the **International Renewable Energy Agency (IRENA).** • This publication presents renewable power generation capacity statistics for the past decade (2011- 2020). • China is the world's largest market for renewables and installed 136 GW of renewables last year, while the United States installed 29 GW. • India has achieved its target of achieving 40% of its installed electricity capacity from non-fossil energy sources by 2030 in November 2021.
India Energy Outlook Report	• Released by the **International Energy Agency (IEA)**, highlights the opportunities and challenges ahead for India as it seeks to ensure reliable, affordable and sustainable energy for a growing population. • India is the fourth-largest global energy consumer behind China, the United States and the European Union. • India will have the biggest share of energy demand growth at 25% over the next two decades, as it overtakes the European Union as the world's third-biggest energy consumer by 2030.
World Energy Outlook Report	• Released annually by the **International Energy Agency (IEA)**, it provides an indispensable guide to the opportunities, benefits and risks ahead at this vital moment for clean energy transitions. • It has **four scenarios** modelled, namely, **the Net Zero Emissions by 2050 Scenario (NZE), Announced Pledges Scenario (APS), Stated Policies Scenario (STEPS), and Sustainable Development Scenario (SDS)**.
World Energy Investment Report	• Released by the **International Energy Agency (IEA)**, the Report presents the latest data and analysis of how energy investment flows are recovering from the shock of the Covid-19 pandemic, including full-year estimates of the outlook for 2021.
Power Purchase Agreements Index	• Released in the 58th edition of the Renewable Energy Country Attractiveness Index by Ernst & Young. • Focuses on the attractiveness of renewable power procurement and ranks the growth potential of a nation's corporate PPA market. • India is ranked sixth among the top 30 PPA markets. • Released biannually by Ernst & Young since 2003. • India has retained the third position in the 58th Renewable Energy Country Attractiveness Index (RECAI), 2021- (3rd spot in 57th edition and 4th spot in 56th edition). • United States has been ranked first, China has been placed at second place. • Released by NITI Aayog in association with Ministry of JAL Shakti and Ministry of Rural Development.

	• Gujarat holds on to its rank one in the reference year (2017-18), followed by Andhra Pradesh, Madhya Pradesh, Goa, Karnataka and Tamil Nadu. • In North Eastern and Himalayan States, Himachal Pradesh has been adjudged number 1 in 2017-18 followed by Uttarakhand, Tripura and Assam.
Falkenmark Index	• For assessing the stress on water. It relates the total freshwater resources with the total population in a country and indicates the pressure that population puts on water resources, including the needs for natural ecosystems.
SDG India Index	• The third edition was released by the **NITI Aayog** in collaboration with the **United Nations in India.** • India's overall score across SDGs improved marginally by six points from 60 in 2019 to 66 in 2021. This rise in the score was due to the country-wide improvement across clean water and sanitation (Goal 6) and affordable and clean energy (Goal 7). • Kerala retained the top spot followed by Himachal Pradesh while Bihar featured at the bottom. • SDG index evaluates the progress of States/UTs on social, economic and environmental criteria and is released every year by the government.
SDG Urban Index	• Inaugural SDGs Urban Index and Dashboard 2021–22 was released by **NITI Aayog in collaboration with Indo-German Cooperation.** • It ranks 56 urban areas on 77 SDG indicators across 46 targets of the SDG framework. • Urban areas are ranked on a scale of 0-100, where 100 implies that the urban area has achieved the targets set for 203 and a score of 0 implies that it is the farthest from achieving the targets among the selected urban areas. • Top 5 Urban Areas: Shimla, Coimbatore, Chandigarh, Thiruvananthapuram, Kochi.
Sustainable Development Report 2021	• "Sustainable Development Report 2021: The Decade of Action for the Sustainable Development Goals." • The report was written by a group of authors led by Prof. Jeffrey Sachs, President of the Sustainable Development Solutions Network (SDSN), and tracks the progress on the Global Goals for 2030. • SDR-2021 presents data on countries' performance against the SDGs. It includes the sixth edition of the global SDG Index and Dashboards. • The SDG Index is an assessment of each country's overall performance on the 17 SDGs, giving equal weight to each Goal. The score signifies a country's position between the worst possible outcome (0) and the best, or target outcome (100). • **As per SDG Index 2021:** ❍ Finland's overall index was the highest with a score of 85.90 ❍ India ranked 120th with a score of 60.07
Comprehensive Environmental Pollution Index (CEPI)	• **The Central Pollution Control Board (CPCB)** has developed a Comprehensive Environmental Pollution Index (CEPI). • CEPI, which is a rational number to characterise the environmental quality at a given location following the algorithm of source, pathway and receptor, has been developed. • CPCB has done a nation-wide environmental assessment of Industrial Clusters based on CEPI and 43 such industrial clusters having CEPI greater than 70, on a scale of 0 to 100, have been identified as critically polluted. • Released by Germanwatch on the side-lines of the COP26. • The CCPI analyses and compares climate change mitigation efforts across 60 countries (plus EU as a whole) with the highest emissions. • India held its 10th spot from the 2020 index and retained its position as the top 10 best-performing countries with higher climate performance for the third year in a row.

	• Four main categories based on which the performance of the countries are evaluated - GreenHouse Gas Emissions, Renewable Energy, Energy Use, Climate Policy. • None of the countries managed to rank at the first three positions as per the report, Denmark occupied the top place with a fourth ranking as the highest-ranked country in CCPI 2022, followed by Sweden (5th), and Norway (6th), United Kingdom (7th), Morocco (8th) and Chile (9th).
Global Climate Risk Index 2021	• Released annually by the international environmental think tank Germanwatch. • Analyses the extent to which countries and regions have been affected by the impacts of weather-related loss events (storms, floods, heat waves etc.). • The 2021 Index does not include data from the United States of America. • India has improved its rankings from last year. It is ranked 7th in the 2021 Index as compared to 5th in 2020 Index. • The impact is calculated in terms of fatalities and economic losses.
State Energy Efficiency Index (2021)	• Developed by **Bureau of Energy Efficiency (BEE) and Alliance for an Energy Efficient Economy (AEEE).** • Index has 68 indicators covering all demand sectors – buildings, industry, municipalities, transport, agriculture – and DISCOMs. • Thirty-six states and union territories have been assessed in State EE Index 2020. Based on their efforts and achievements, states have been classified as 'Front runner', 'Achiever', 'Contender' and 'Aspirant'.
Confronting Carbon Inequality	• Released by **Oxfam International and the Stockholm Environmental Institute (SEI).** • It highlights that a rich person contributes more to the climate crisis than a poor person. • According to the report an Indian emitted only 1.97 tonnes of CO2 (tCO2) annually, while Americans and Canadians both emitted well over 16 tCO2. • About half of the richest 10% are associated with North America and the European Union.
Emissions Gap Report 2021	• Twelfth edition of the Emissions Gap Report is released by the **United Nations Environment Programme (UNEP).** • The report provides an update of global emissions pathways and progress towards achieving national mitigation pledges and the Paris Agreement goals as well as the resulting 'emissions gap'. • Highlights of the new national climate pledges combined with other mitigation measures put the world on track for a global temperature rise of 2.7°C by the end of the century.
Global Environment Outlook	• Series of reports on the environment issued periodically by th**e United Nations Environment Programme (UNEP).** • **The GEO project** was initiated in response to the environmental reporting requirements of UN Agenda 21 and to a UNEP Governing Council decision of May 1995 which requested the production of a new comprehensive global state of the environment report. • Sixth edition of the Global Environment Outlook (GEO-6) provides a clear assessment of the current state of the environment, the challenges that we face and how well we have dealt with them, with due consideration given to gender, indigenous knowledge and cultural dimensions. • Key groups include Youth, Cities and Local Governments, and Business.
World Risk Index	• Released annually by the **United Nations University Institute for Environment and Human Security (UNU-EHS), Bundnis Entwicklung Hilft and the University of Stuttgart in Germany**. • Oceania is at the highest risk among the continents, followed by Africa and the Americas. • As per the index India is 'poorly prepared' to deal with 'climate reality', due to which it is vulnerable to extreme natural disasters.

Food Waste Index (2021)	• The Food Waste Index Report aims at supporting the goals of SDG 12.3. • It does so by presenting the most comprehensive food waste data collection, analysis and modelling to date, generating a new estimate of global food waste; and publishing a methodology for countries to measure food waste, at household, food service and retail level, to track national progress towards 2030 and to report on SDG. • As per the report 50 kg of food is thrown away per person every year in Indian homes.
The Food Loss Index (FLI)	• Released by the **Food and Agriculture Organizations of the United Nations**. • Focuses on food losses that occur from production up to (and not including) the retail level. It measures the changes in percentage losses for a basket of 10 main commodities by country in comparison with a base period. • The FLI will contribute to measure progress towards SDG.
Global Hunger Index	• Jointly released annual report by Irish aid agency **Concern Worldwide and German Organization Welthungerhilfe.** • India's rank has dropped to the 101 st position among 116 countries in the Global Hunger Index (GHI) 2021 from the year 2020, where India was placed at 94 th spot, out of 107 countries. • Based on the values of the four indicators, the GHI determines hunger on a 100-point scale where 0 is the best possible score (no hunger) and 100 is the worst. • India is recorded at 27.5 out of 50, which comes under the serious category. Nepal (76), Bangladesh (76), Myanmar (71) and Pakistan (92). • 18 countries, including China, Brazil and Kuwait, shared the top rank with a GHI score of less than five. • Launched by NITI Aayog highlighting measures to ramp up urban planning capacity in India that includes ○ Programmatic Intervention for the Planning of Health, ○ Re-engineering of Urban Governance, ○ Revision of Town and ○ Country Planning Acts. • The report suggests that every city must aspire to become a 'Healthy City for All' by 2030 and has also recommended a Central Sector Scheme named '500 Healthy Cities Programme', for a period of 5 years. • Released by NITI Aayog and Ministry of Development of North Eastern Region with technical support from UNDP. • Index measures the performance of the districts of the eight states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura on the SDGs and ranks these districts on the basis of the same. • East Sikkim district of Sikkim has topped the North Eastern Region (NER) District SDG Index 2021-22 while the Kiphire district of Nagaland was ranked last amongst 103 districts in the ranking based on NITI Aayog's SDG India Index.
Global Forest Resources Assessment	• Released by the **United Nations Food and Agricultural Organization (FAO),** every five years from 2020. • Africa had the largest annual rate of net forest loss in 2010–2020, followed by South America. • Asia had the highest net gain of forest area in 2010–2020, followed by Oceania and Europe. • Largest proportion of the world's forests were tropical (45 per cent), followed by boreal, temperate and subtropical. • More than 54 per cent of the world's forests were in only five countries — the Russian Federation, Brazil, Canada, the United States of America and China. • The highest percent of plantation forests were in South America while the lowest were in Europe.

Living Planet Report 2020	• Released as a biennial report by the **World Wildlife Fund for Nature (WWF) in collaboration with the Zoological Society of London (ZSL).** • The report states that there has been a reduction of 68% in the global wildlife population between 1970 and 2016. • The UN Convention on Biological Diversity (CBD) has adopted LPI as the indicator of progress towards the convention's 2011-12 target to take actions to halt biodiversity loss.
Living Planet Index (LPI)	• Released by **Institute of Zoology (Zoological Society of London).** • The report was jointly produced annually by the UN FAO, IFAD, UNICEF, World Food Programme (WFP) and WHO. • The report states that between 720 and 811 million people in the world faced hunger in 2020, which is around 161 million more than in 2019. • As per the report Asia with 418 million (More than half of world hunger population) people faced hunger followed by Africa: 282 million (One-third), Latin America and the Caribbean: 60 million. • Published by the World Bank, it states that inclusive green growth is the pathway to sustainable development. • The report begins by stating that although economic growth has lifted more than 660 million people out of poverty over the past 20 years, it has often come at the expense of the environment.

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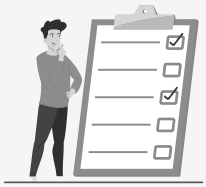


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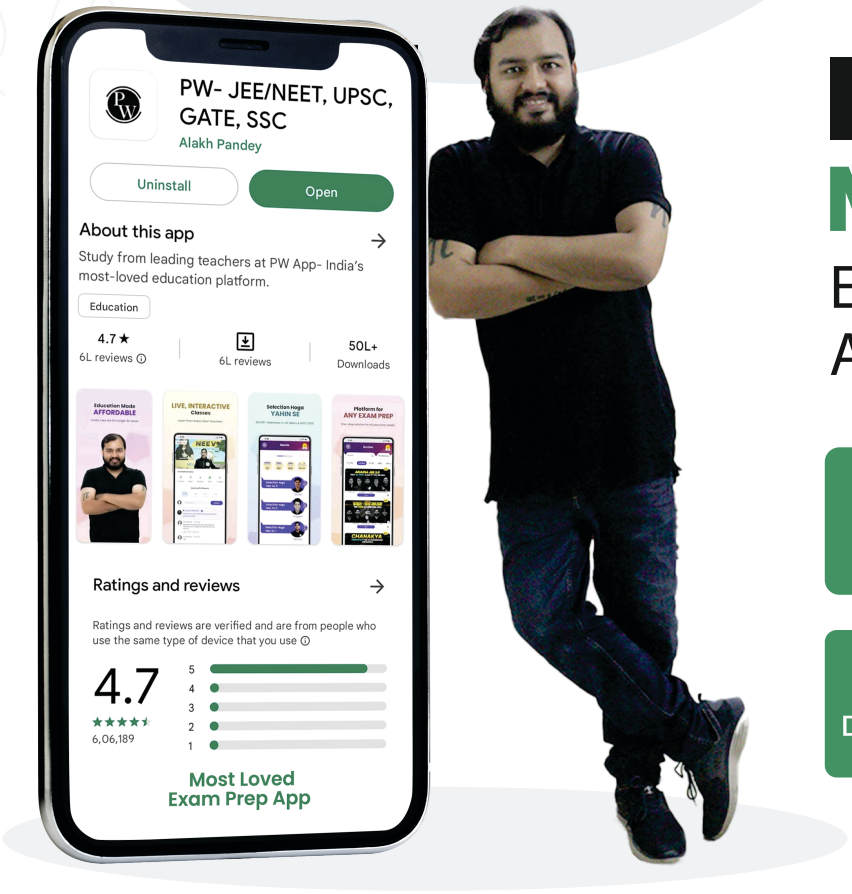
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