CGP 2019

ECOLOGY AND ECOSYSTEM

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Man is an important part of the biotic component of the environment. Ecological approach to the study of **man-environment relationships** is based on the **basic principle of ecology** which is the study of **mutual interactions between organisms and physical environment** on the one hand and **interactions among the organism** on the other hand in a given ecosystem.

Ecological school considers man to be most skilled and intelligent, as the leader of all biota and steward of the earth. Therefore, the relationship of man with the natural environment should be **symbiotic and not exploitative or suppressive.** Ecological approach lays emphasis on **wise and restrained use** of natural resources, application of appropriate environmental management programmes, policies and strategies.

The ecological approach lays emphasis on **rational exploitation of resources and optimum utilization through recycling of resources.** Therefore, humans as sentient species have the obligation to ensure **sustainable development** where all the organisms are treated equally and live in harmony.

1. ECOLOGY

1.1 Meaning of Ecology

Ecology, in a very simple term, is a **science** that studies the **interdependent, mutually reactive and interconnected relationships** between the organisms and their physical environment on the one hand and maong the organisms on the other hand. The term **'ecology'** was first coined and used by the German biologist **Ernst Haeckel**.

Darwin's concept of the 'evolution of species' through natural selection involving interactions between biological species and habitat was the **key stone of the formulation of the idea of ecology.** The definition of ecology led to the development of **two approaches** to the study of ecology and its division into two branches:

1. **Autecology**: Ecological relations of individual species in a given ecosystem are studied.
2. **Synecology:** Study of plant communities in relation to their habitats of a given ecosystem.

1.2 Sub-division of Ecology

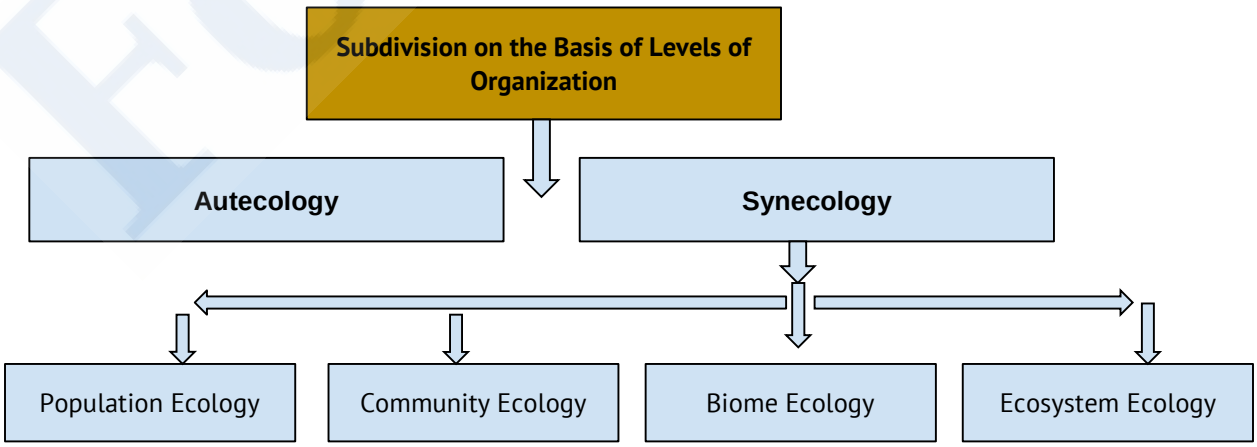
Sub-division based on taxonomic affinities:

- Plant Ecology
- Animal Ecology

Sub-division based on Habitat:

- Forest Ecology
- Grassland Ecology
- Freshwater Ecology
- Estuarine Ecology,
- Marine Ecology, etc.

Sub-division based on Basis of Levels of organization:



1.3 Ecological Concepts and Principles

There are certain basic principles that governs the various aspects of functioning of organisms.

- **Ecosystem is the basic fundamental unit** of ecological study because it comprises both biotic and abiotic components.
- At the largest scale, the whole biosphere becomes an ecosystem.
- Natural hazards adversely affects the biological communities.
- All living organisms and physical environment are mutually reactive.
- 'Nothing actually disappears when we throw it away' because all the materials are rearranged and cycled and recycled through a series of cyclic paths in the natural environment.
- Ecosystem functions through the input of energy mainly solar radiation. **R.L. Lindeman** has formulated principles about the relationship between trophic levels within a natural ecosystem.
    - **Principle 1:** As the distance between the organisms of a given trophic level and the initial source of energy (trophic level one) increases, the probability of the organisms to depend exclusively on the preceding trophic level for energy decreases.
    - **Principle 2:** The relative loss of energy due to respiration is progressively greater to higher trophic levels because the species at higher trophic levels are relatively larger in size and have to move and work for getting food and therefore more energy is lost due to respiration.
    - **Principle 3:** Species at progressively higher trophic levels appear to be progressively more efficient in using their available food supply.
    - **Principle 4:** Organisms at higher trophic levels are 'generalists' in their feeding habit and they are most efficient in using their available food supply.
    - **Principle 5:** Food chains tend to be reasonably short. Because loss of energy is progressively higher for higher trophic levels and species at higher levels tends to be less discrete.
- The chemical (inorganic) and organic substances are circulated among the various components of the biosphere through a series of closed system of cycles collectively known as 'biogeochemical cycles'.
- The ecosystem productivity (referred to as the rate of growth of organic matter per unit time by autotrophs at trophic level one) depends on two factors:
    - The availability of the amount of solar radiation to the primary producers at trophic level one.
    - The efficiency of plants to convert solar energy into chemical energy.
- The 'normal' or 'uneventful' ecosystem attains its stability through 'homeostatic mechanisms' There is inbuilt self-regulating mechanism in a natural ecosystem through which any change caused by external factors in the ecosystem is counterbalanced by the responses of the ecosystem to the change in such a way that ultimately ecosystem or ecological stability is achieved. The ecological concept of diversity/stability has been illustrated in the following manner:
    - Increase in the diversity of food webs promote ecosystem stability because the increased food web diversity increases the resilience of the system to outside invasions of exotic organisms and reduced the fluctuations in the population within a given ecosystem. (C.S. Elton)
    - The ecosystem stability increases with increase of number of links in the food web because a large number of interacting feeding links provides alternative channels of energy flow and thus is generates a wide variety of adjustment of the population to environmental changes and stresses within the ecosystem. (P.H. MacArthur)
    - High species diversity of a mature ecosystem representing a 'climax community' is related to more stability of natural ecosystem because as the community succession operates, 'homeostasis' increases due to more protection available to the member of the community against external environmental change. (E.P. Odum)
- Evolution of species epitomises the inherently dynamic nature of ecosystem.
- The concept and principle of succession are very important in ecology as there is successional development of species mainly vegetation communities.
- Man, being an active agent of environmental change, modifies the ecosystem through the exploitation of natural resources.
- The ultimate goal of ecological study is to preserve ecological resources by maintaining the ecological diversity and ecosystem stability.

1.4 Ecological Succession

F.E. Clement postulated the concept of Vegetation/Ecological succession which is the process of change in the species structure of an ecological community over time. The time scale can be decades (after a wildfire), or even millions of years after a mass

extinction (Permian, Triassic, cretaceous). The development of vegetation community in any ecosystem or habitat is affected and controlled by:

1. Climate
2. Edaphic factors
3. Biotic factors
4. Physiographic factors
5. Fire factors

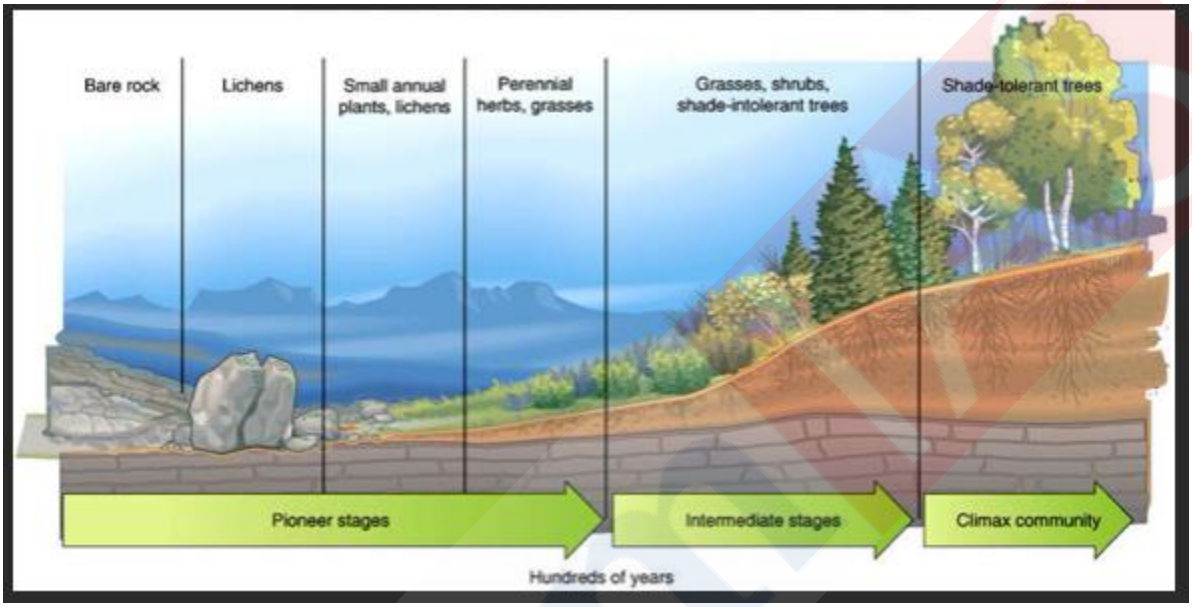


Figure: Stages in Ecological Succession

Characteristics of Ecological Succession

1. It results from modification of the physical environment of the community. Ex. Development of pioneer species like algae and lichens on bare surface like Krakatoa Island, etc.
2. It is an orderly process of community development.
3. The time required for development of climax vegetation in secondary succession is much less than primary succession.
4. Nutrient variation determines the settlement of new community.
5. Deflected climax due to arresting factors like jhuming cultivation results in plagioclimax.
6. Ecological succession is disrupted in communities like Savanna, Chaparral, etc. by fire.
7. At climax vegetation:
    - Ecosystem is stable and self-perpetuating
    - Biomass increases to maximum
    - Net community production decreases
    - Food chain becomes highly complex changing to food web.

Types of Ecological Succession

Clements has divided succession in two types:

1. **Primary Succession:** Primary succession refers to developmental sequence of vegetation in those bare areas where there were no vegetation and animals earlier. Ex. Newly emerged sea floor, island of Krakatoa, etc.
2. **Secondary Succession:** Secondary succession refers to the developmental sequences of vegetation in those areas which had vegetation earlier but now have been rendered nude due to destruction by:
    - Natural processes: Lava flow, forest fires, catastrophic floods, etc.
    - Anthropogenic processes: Jhuming cultivation, overgrazing, etc.

Phases of biotic succession:

1. **Phase of Nudation:** creation of bare area devoid of vegetation. Ex. Newly emerged volcanic island

2. **Phase of Migration**: Arrival of seeds in to the new bare area
3. **Phase of Ecesis:** Seeds are germinated
4. **Phase of Reaction**: Competition between plants and physical environment
5. **Phase of Stabilization**: Equilibrium condition of populations of plant species

Climax Vegetation

The vegetation community developed at the last stage of biotic succession is called climax vegetation which is indicative of a mature ecosystem wherein the dominant vegetation is in equilibrium with the environment. At climax:

- Ecosystem is stable and self-perpetuating
- Biomass increases to maximum
- Net community production decreases
- Food chain becomes highly complex changing to food web.

Plagioclimax Vegetation

A Plagioclimax community is an area or habitat in which the influences of the humans have prevented the ecosystem from developing further. The ecosystem may have been stopped from reaching its full climatic climax or deflected towards a different climax by activities (arresting factors) such as: jhuming cultivation, large scale afforestation, overgrazing, etc. In each case, human activity has led to a community which is not the climax community expected in such an area. It is of two types:

1. **Arrested succession:** The natural succession would continue, if the arresting factors are removed. Ex. If cultivation is stopped in Gangetic plains and Great Plains of USA, normal sere of vegetation succession will start.
2. **Deflected succession:** Even if the interferences are removed, succession to the original climax community is no longer possible. Ex. Shola forest (Nilgiris), Sahara Desert, Thar Desert, etc.

Fire climax community

Some landscape never reach a stable climax in the traditional sense because they are characterized by and adapted to periodic fire disruption. Ex. Savanna, chaparral of California, etc.

Characteristics of the plants:

1. They reseed quickly after fires.
2. In fact, many plants require fire to eliminate competition
3. To prepare seed-beds for germination or to open cones or thick seed coats.

Climax Theories:

Two school of thoughts developed:

One who believed climax

1. **Monoclimax theory:** Clement stated that regional climate is the dominant control factor of climax vegetation.
2. **Polyclimax theory:** Tansley believed in mosaic of climaxes due to fire, topography, climate, drainage, etc. According to this theory, plant community is not always in equilibrium with the climate of that habitat.

One who does not believed climax:

1. Whittaker argued that communities are constantly adjusting in response to the physical environment and therefore no absolute climax.
2. Gleason saw community history to be very unpredictable. He argued that species are individualistic and each getting established according to its ability to colonize and reproduce in an area.

It is perhaps more accurate to say that the rate of succession is so slow in a climax community that, from the perspective of a single human life time, it appears to be unchanging.

1.5 Ecological Niche

- The term ecological niche was developed by Charles Elton.
- Ecological niche may be defined as 'the functional role and position (micro-habitat) of species in its ecosystem, including what resources it uses, how and when it uses the resources, and how it interacts with other species.
- The ecosystem stability depends upon the diversity of niche. The greater the niche diversity, the more is ecosystem stability because of larger number of pathways for the flow of energy and less fluctuation of species population.
- Sometimes it becomes difficult for two species to inhabit the same niche. In such cases the 'Law of Competitive Exclusion' works, which states that no two species will occupy the same niche and compete for exactly the same resources in the same habitat for very long.

- In such difficult situations, one species may adopt a few alternative paths i.e.
    - Either one species may migrate to new niche
    - May become extinct
    - May change physiological behaviour for the competition of same resources.
- The process of minimization of competition for resources is called 'Resource Partition' which can allow several species to utilize different parts of the same resource and coexist within a single habitat.
- Dominant species occupy extensive and broader ecological niche in comparison to less dominant species.

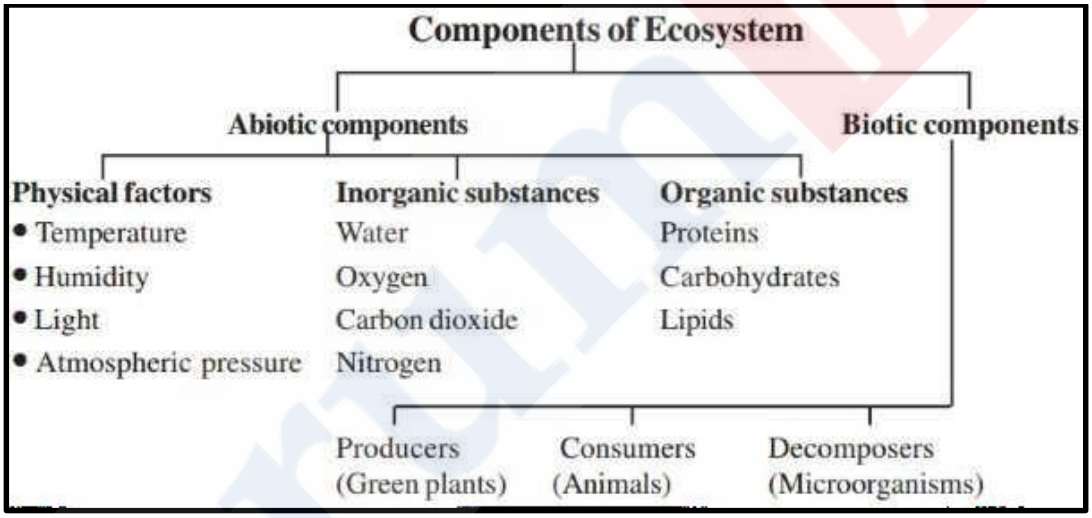
2. ECOSYSTEM

An ecosystem is **a community of living organisms in conjunction with the nonliving components** of their environment, **interacting as a system**. Its components are linked together through nutrient cycles and energy flows.

2.1 Components of an Ecosystem

There are three major components of ecosystems:

1. Energy component
2. Abiotic or physical component
3. Biotic component



Biotic Components

Producers:

- Plants are the 'producers' in the ecosystem as they manufacture their food by using energy from the sun.
- In the forest these form communities of plant life.
- In the sea these include tiny algal forms to large seaweed.

Consumers:

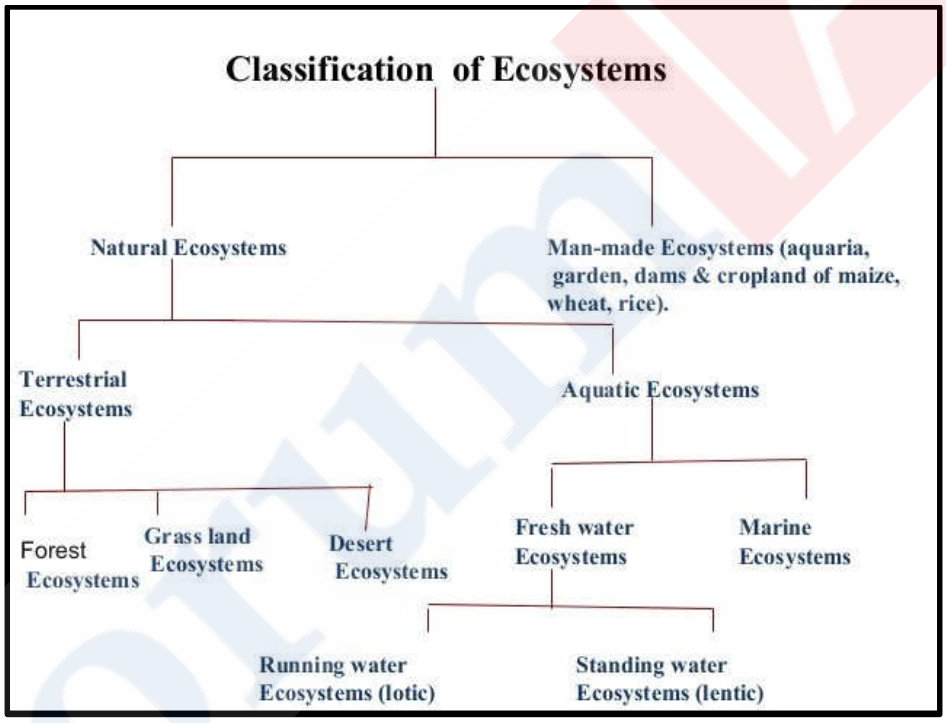
- The herbivorous animals are **primary consumers** as they live on the producers.
    - In a forest, these are the insects, amphibia, reptiles, birds and mammals.
    - In the semiarid areas, there are species such as the chinkara or Indian gazelle.
    - In the sea, there are small fish that live on algae and other plants.
- At a higher trophic level, there are carnivorous animals, or **secondary consumers**, which live on herbivorous animals.
    - In our forests, the carnivorous animals are tigers, leopards, jackals, foxes and small wild cats.
    - In the sea, carnivorous fish live on other fish and marine animals.

Decomposers:

- Decomposers or detritivores are a group of organisms consisting of small animals like worms, insects, bacteria and fungi, which break down dead organic material into smaller particles and finally into simpler substances that are used by plants as nutrition.
- Decomposition thus is a vital function in nature, as without this, all the nutrients would be tied up in dead matter and no new life could be produced.

2.2 Classification of Ecosystems

- Ecosystems are divided into terrestrial or land based ecosystems, and aquatic ecosystems in water.
- At a sub-global level, this is divided into biogeographical realms.
- Example: Eurasia called the Palaearctic realm; South and South-East Asia (of which India forms a major part) is the Oriental realm; North America is the Nearctic realm; South America forms the Neotropical realm; Africa the Ethiopian realm; and Australia the Australian realm.
- Natural ecosystems include the forests, grasslands, deserts, and aquatic ecosystems such as ponds, rivers, lakes, and the sea.
- Man modified ecosystems include agricultural land and urban or industrial land use patterns.



2.3 Functioning of Ecosystems

- The functioning of an ecosystem depends upon the the pattern of energy flow as the living components of an ecosystem depend on energy flow which also helps in the distribution and circulation of organic and inorganic matter within the ecosystem.
- While the energy flow follows unidirectional path the circulation of matter follows cyclic paths.
- The energy pattern and flow are governed by first and second law of thermodynamics.
    - **Law 1:** In any system of constant mass, energy is neither created nor destroyed but it can be transformed from one type to another type.
    - **Law 2:** When work is done, energy is dissipated and the work is done when one form of energy is transformed into another form.

Energy Flow

- Solar energy is the basic input of energy entering the ecosystem.
- Only a small proportion of radiant energy is used by plants to make food through the process of photosynthesis. The green plants convert solar energy into food/chemical energy.

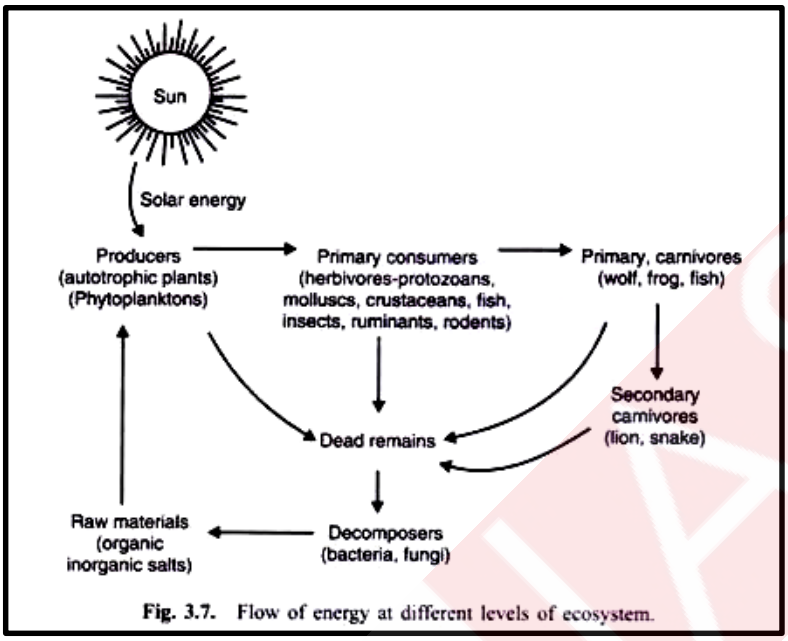


Fig. 3.7. Flow of energy at different levels of ecosystem.

- The chemical energy stored at trophic level one becomes the source of energy to the herbivorous animals at trophic level two of the food chain.
- Some portion of energy is lost from trophic level one through respiration and some portion is transferred to plant eating animals at trophic level two.
- A substantial portion of chemical energy is released by carnivores at trophic level three through respiration because more energy is required for the work to be done by carnivores at trophic level three.
- Some portion of potential chemical energy is transferred from trophic level three to trophic level four or top trophic level represented by omnivores. Some energy is released by omnivores through respiration.
- The remaining energy in the plants and animals is transferred to decomposers when they become dead.

Matter Flow

- The circulation of elements or matter nutrients (organic and inorganic both) is made possible through energy flow.
- The organic and inorganic substances are moved reversibly in the biosphere, atmosphere, hydrosphere and lithosphere through various closed system of cycles in such a way that the total mass of these substances almost remains the same.
- The materials or nutrients involved within the circulation within an ecosystem are grouped into three categories:
    - **Micro-elements:** oxygen, carbon and hydrogen.
    - **Minor elements:** Nitrogen, phosphorous, potassium, calcium, magnesium and sulphur.
    - **Trace elements:** Iron, zinc, manganese and cobalt.
- Nutrients driven by energy flow pass into various components of biotic communities through the process known as 'biogeochemical cycles'.

2.4 Ecosystem Productivity

The productivity of ecosystem refers to the rate of growth of energy or organic matter per unit time by autotrophs at trophic level one through the process of photosynthesis with the help of solar energy. Ecosystem Productivity depends upon:

- The availability of the amount of solar radiation to the primary producers at trophic level one.
- The efficiency of plants to convert solar energy into chemical energy.

Primary Production

- The production of organic matter or energy by autotrophs.
- Primary production is measured in two ways:
- Net Primary Production: It excludes the amount of energy which is lost through respiration by the autographs.It represents the usable amount of energy at trophic level one, which is available to higher trophic levels.
- The ecosystem productivity whether gross or net is measured in gram/m2day or year

Secondary Production

- Secondary production is the rate of generation of heterotrophic biomass, driven by the transfer of organic matter between trophic levels.

Biomass

- It refers to the quantity or weight of living materials per unit area and is represented in terms of dry weight.

2.5 Difference between Ecology, Environment and Ecosystem

- **Ecology** = the study of the ecosystems and the environment.
- **Environment** = a group of ecosystems.
- **Ecosystem** = a functional unit of environment (mostly biosphere).
- **Habitat** = Area where an organism lives.
- **Biosphere** = The region on earth that supports life.

3. FOOD CHAIN, FOOD WEB AND ECOLOGICAL PYRAMIDS

3.1 Food Chain

- The **transfer of energy from the source in plants through a series of organisms by eating and being eaten** constitutes **food chains**.
- At each transfer, **a large proportion of energy is lost in the form of heat**.
- At each linkage in the chain, a major part of the energy from the food is lost for daily activities.
- Each chain usually has **only four to five such links**. However, **a single species may be linked to a large number of species**.
- **Why food chain**: The most obvious aspect of nature is that **energy must pass from one living organism to another**.
    - When herbivorous animals feed on plants, energy is transferred from plants to animals.
- **Detritus' food chain:** In an ecosystem, some of the animals feed on other living organisms, while some **feed on dead organic matter**. The latter form the **'detritus' food chain**.

3.2 Food Web

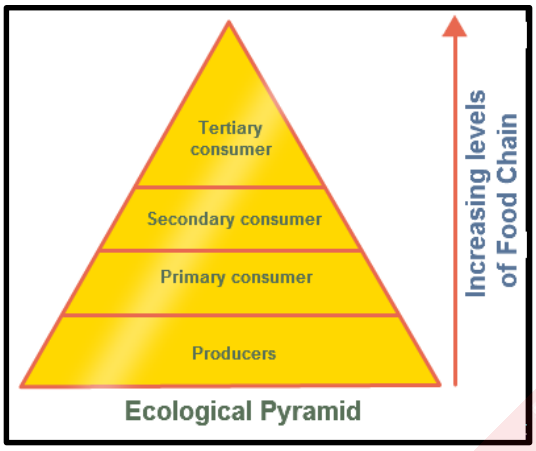
- These food chains are not isolated sequences, but are interconnected with each other. This interlocking pattern is known as the food web.
- Impact of human interference: If the linkages in the chains that make up the web of life are disrupted due to human activities that lead to the loss or extinction of species, the web breaks down.

3.3 Ecological Pyramids

- It is **a graphic representation of the relationship between organisms at various trophic levels** in a food chain.
- depicts the **number of organisms, biomass and productivity** at each trophic level.
- Basis of an ecological pyramid is = biomass, energy, and number.
- Concept of ecological pyramids = first introduced by Charles Elton, the pioneer British Ecologist.

Features:

- The **bottom of an ecological pyramid is the broadest** and is **occupied by the Producers**, which form the **first trophic level**.
- In a food chain, the producers are consumed by the primary consumers. In an ecological pyramid, the **next level is occupied by the primary consumers**.
- The next level of the pyramid is occupied by the **secondary consumers** and the last, by the **tertiary consumers**.



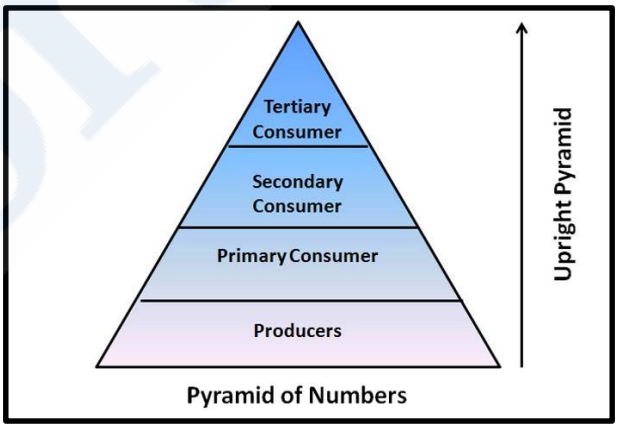
Types of Ecological Pyramids

There are 3 types of ecological pyramids:

1. Pyramid of energy
2. Pyramid of numbers
3. Pyramid of biomass

3.3.1 Pyramid of Number

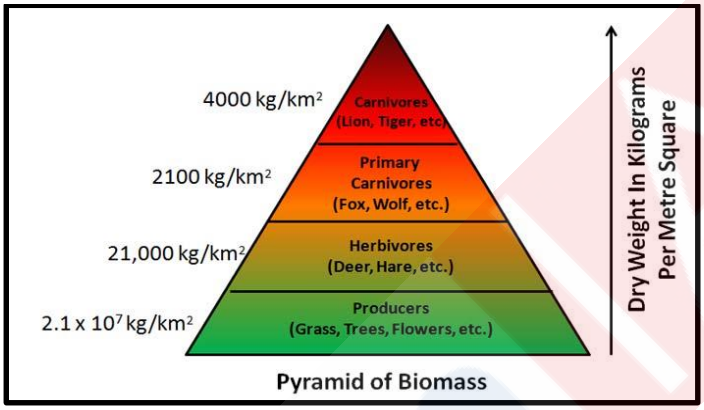
- It graphically **represents the population (total number of individuals) present at each trophic level**.
- This type of pyramid **can have two different forms** depending on the number of organisms: **upright and inverted.**
    - In an **upright pyramid of number**, the number of organisms generally decreases from the bottom to top. This generally occurs in grassland and pond ecosystems where the **plants** (usually the grasses) occupy the base of the pyramid. The succeeding levels of the pyramid include the consumers.
    - An **inverted pyramid of number** is just the opposite of the former. It is usually observed in tree ecosystems with the trees as the producers and the insects as consumers.
- Issues: Among the three types of ecological pyramids, the **pyramid of number is the least accurate** because **it does not take account the exact number of population** and therefore **cannot completely define the trophic structure in that ecosystem**.



3.3.2 Pyramid of Biomass

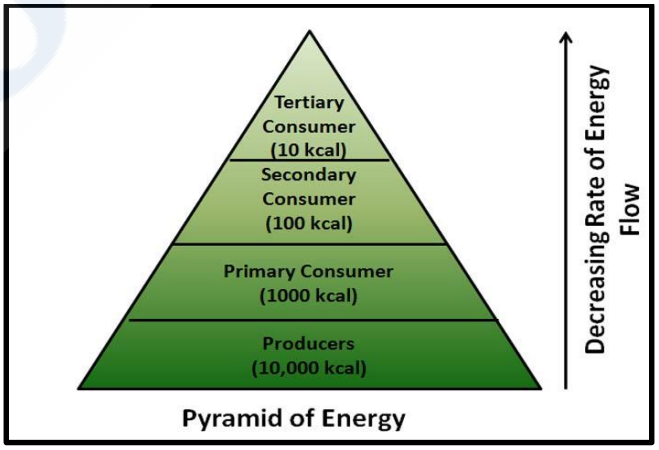
- **Biomass** = it refers to the food available for the succeeding trophic level
    - the amount of biomass per unit area product of the living material present in an organism and the total number of organisms present) in a specific trophic level.

- A pyramid of biomass is **a depiction of the amount of food available and how much energy is being passed on at each trophic level**.
- Like the pyramid of numbers, the **pyramid of biomass can either have two forms: upright and inverted**.
- Examples:
    - terrestrial ecosystems = characterized by an upright pyramid of biomass having a larger base (primary producers) with the smaller trophic levels (consumers) located at the top.
    - Aquatic ecosystems = inverted structure of the pyramid; because the phytoplankton producers (with generally smaller biomass) are located at the base while the consumers having larger biomass are located at the top of the pyramid.



3.3.3. Pyramid of Energy (PoE)

- It shows the **overall energy in the ecosystem** and **how much energy is required by organisms as it flows up the higher trophic levels**.
- The pattern of the energy flow in PoE is **based on the principles of thermodynamics** (energy is neither be created nor destroyed; only transformed into another form.)
- PoE shows that **energy is transferred from lower trophic levels with more amount of energy (producers) to higher ones (consumers) and converted in the biomass**.
    - Therefore, it can be concluded that **organisms found at the highest trophic levels of shorter food chains bear a greater amount of energy than the ones found in longer ones.**
- Unlike the first two ecological pyramids, the pyramid of energy is **always illustrated in an upright position**, with the **largest energy carriers at the base**.
- **Significance of PoE:** The idea of PoE is very crucial in the idea of **biological magnification** (tendency of toxic substances to increase in amount as we go up the trophic levels)



3.3.4 Limitations of Ecological Pyramids

- These types of pyramids **only are applicable in simple food chains (and not food webs)**, which do not necessarily occur naturally.
- They also **do not consider the possible presence of the same species at different trophic** levels.
- None of the three ecological pyramids provide any idea related to variations in seasons and climates.
- **Other organisms like microorganisms and fungi are not given specific role in the pyramids despite their vital roles in ecosystems**.

4. BIOGEOCHEMICAL CYCLES

- **There is circulation of chemical nutrients like oxygen, carbon, nitrogen, phosphorus, calcium and water, etc. through the physical and biological world**; between atmosphere, hydrosphere, lithosphere and biosphere. These cycles are known as **biogeochemical cycles**.
- These cycles are **natural pathways of circulation of essential elements of life**.
- For the survival of the major ecosystem, it is essential that **all chemical elements make up the living cells must be recycled**.
- As effect of these elements being recycled, in some cycles the elements get accumulated for a long period of time and form reservoirs like ocean or lake.
- Biogeochemical cycles are classed as **in which the reservoirs are** the air or the oceans via evaporation.

Important biogeochemical cycles includes:

- The Carbon cycle,
- The Nitrogen cycle,
- The Oxygen cycle,
- The Phosphorus cycle,
- The Sulfur cycle,
- The Water cycle,
- The Nutrient cycle and
- The Rock cycle.

Gaseous Cycle

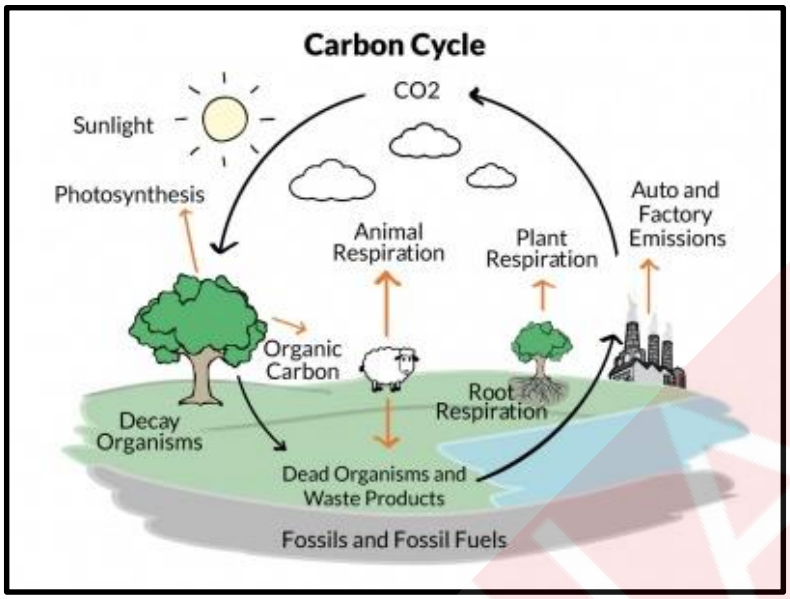
- It includes that of nitrogen, oxygen, carbon and water.
- They move rapidly and adjust more readily to the changes in the biosphere because of the large atmospheric reservoir.
- For example, accumulations of CO_2 are scattered by winds or are absorbed by plants.

Sedimentary Cycle

- Sedimentary cycle **varies from one another**, **varies from one element to the other**, **each cycle consists of a solution and a rock or sediment phase**.
- Weathering of rocks releases minerals in the form of salts which dissolve in water and can pass through a series of organisms and can reach deep sea where they settle out of circulation indefinitely.
- Other salts settle as deposit as sediment and rock in shallow seas.

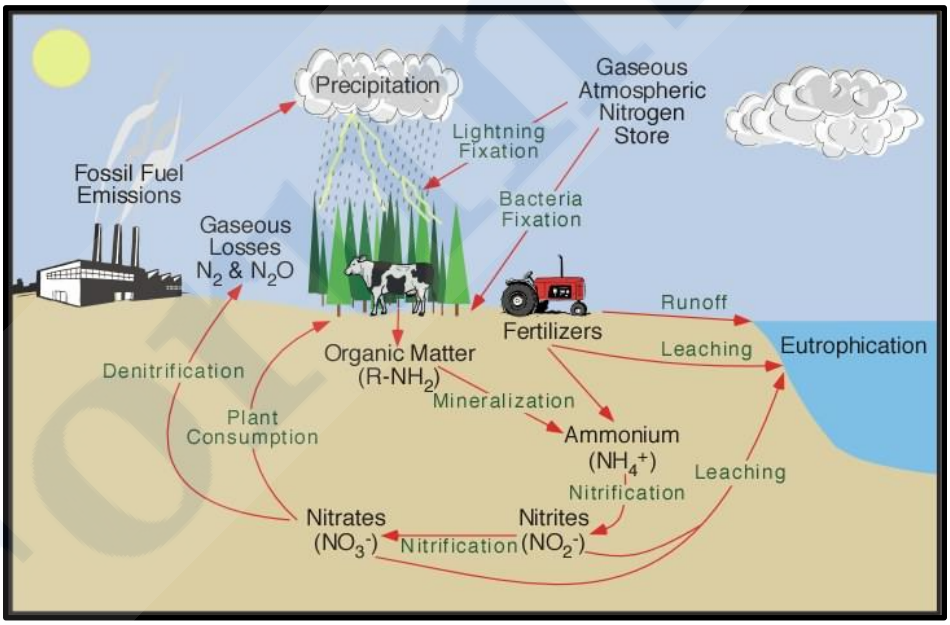
Carbon Cycle

- It is a cycle where there is **exchange of carbon among all the spheres of the ecosystem**.
- It is the **balance of exchange of carbon between carbon reservoirs or between specific spheres**; **carbon is exchanged among the biosphere, hydrosphere, atmosphere, pedosphere and geosphere** as a result of physical, biological, chemical, and geological processes.



Nitrogen Cycle

- It is the **transformation between its various chemical forms in both biological and physical processes**.
- Important processes of this cycle is **nitrogen fixation, ammonification, nitrification and denitrification**.
- Atmospheric nitrogen being the largest reservoir of nitrogen is available in limited amounts for biological use.



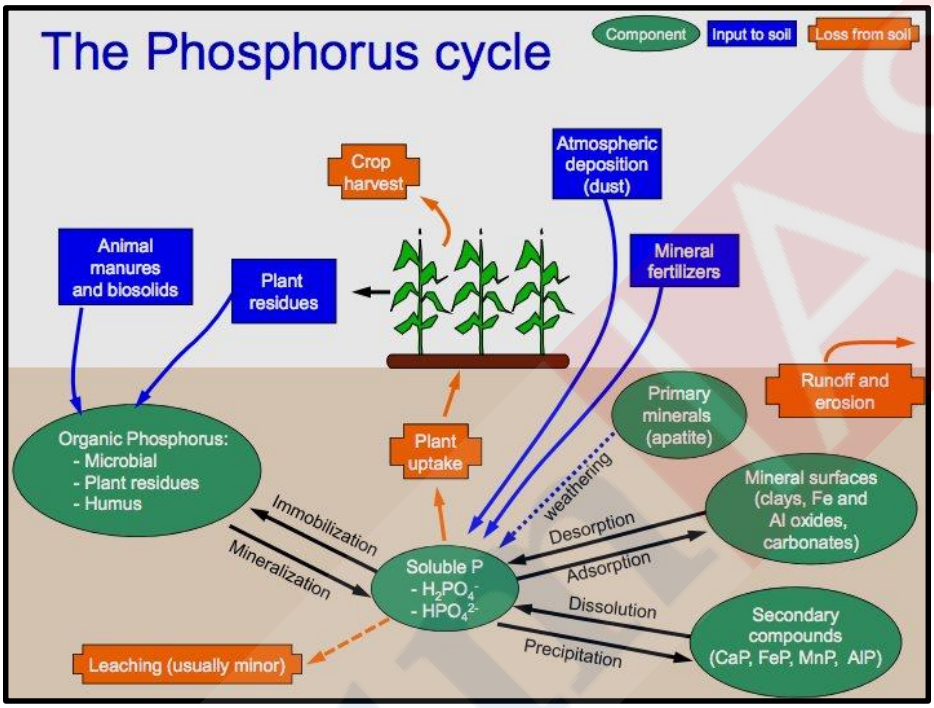
Oxygen Cycle

- It describes the **movement of oxygen within the atmosphere, biosphere and the lithosphere**.
- Failures of occurence of oxygen cycle in the hydrosphere => Creation of hypoxic zones.
- Photosynthesis = main factor for the oxygen cycle

Phosphorus Cycle

- It is the **movement of phosphorus through the lithosphere, hydrosphere and biosphere**.

- In this cycle, the atmosphere does not play a significant role as **phosphorus and phosphorus based compounds are usually solids at the typical range of temperatures of Earth**.
- Phosphorus has gradually become less available to plants as it is slowly lost in runoff.
- Phosphorus is essential for plant growth and microbial biomass.
- Microorganisms of the soil act as sink and source of phosphorus available in the biogeochemical cycle.

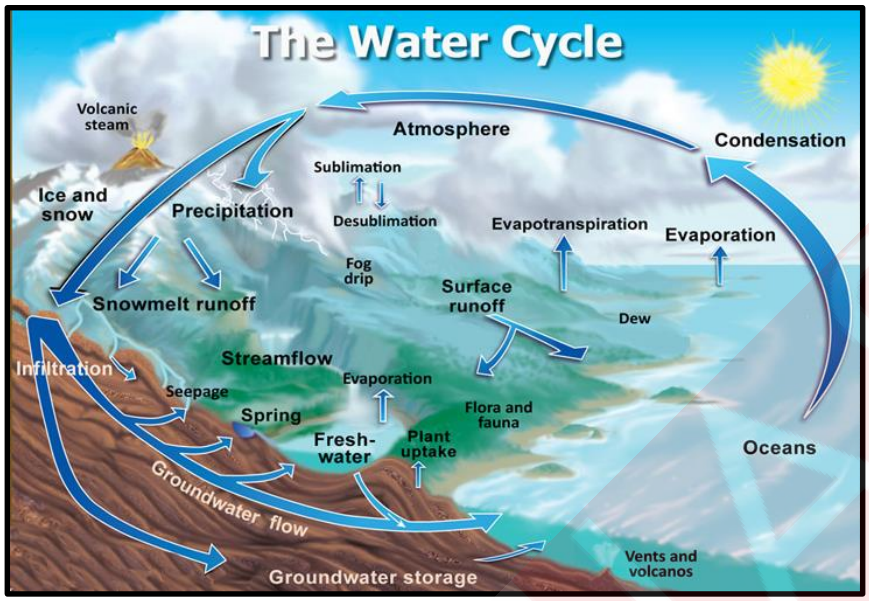


Sulphur Cycle

- It is the group of processes through which **sulphur moves to and from the mineral, waterways and the living systems**.
- sulphur is constituent of many proteins and cofactors.

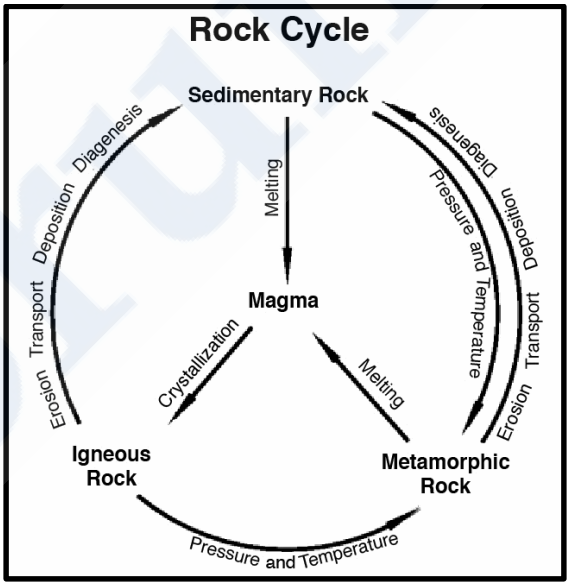
Water Cycle

- It **describes the continuous movement of water on, above, and below the surface of the Earth**.
- Water moves from one reservoir to another by physical processes of **evaporation, condensation, precipitation, infiltration, runoff and substrate flow**.
- Through these processes water undergoes **different phases like liquid, solid and gas**.



Rock Cycle

- It **describes the dynamic transitions through geologic time among three main rock types sedimentary, metamorphic and igneous**.
- In this cycle, **<u>each type of rocks is altered or destroyed when it is forced out of equilibrium conditions</u>**.
- Due to the forces of the rock cycle, tectonic plates, and water cycle; the rocks do not remain in equilibrium and are forced to change in their new environments.

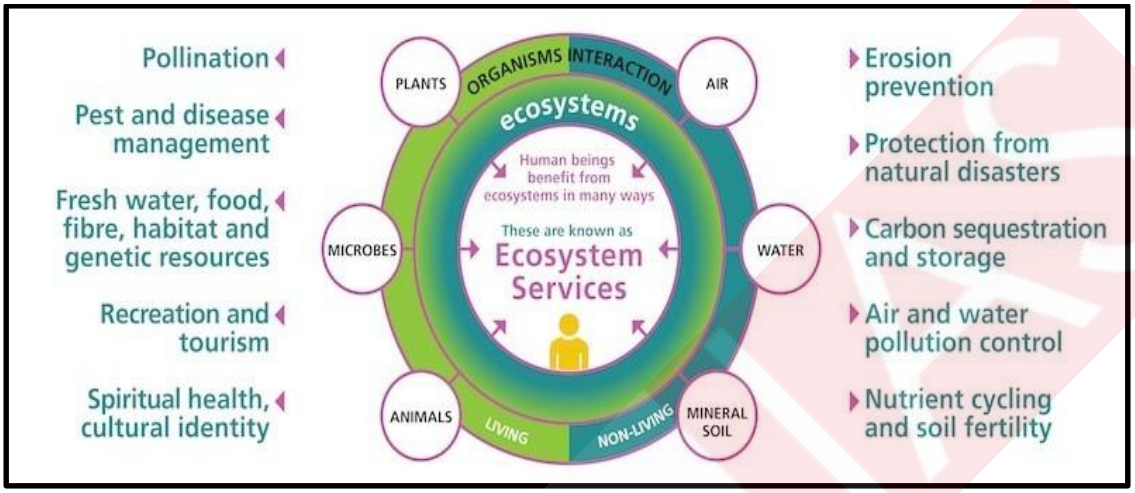


Nutrient Cycle

- The nutrient cycle is the movement and exchange of organic and inorganic matter back into the production of living matter.
- This process is regulated by food web pathways and decomposes matter into mineral nutrients.

5. ECOSYSTEM SERVICES

Economic services are the many benefits which society derives from **nature.** They include fresh water; fertile soil; wild plant resources such as foods, fibres, medicinal plants and the wild relatives of crops; wild pollinators and the natural enemies of crop pests; carbon sequestration from the atmosphere; and the important spiritual, aesthetic and recreational values of nature.



5.1 Ecosystem goods and services

- **Direct Values:** These are resources that people depend upon directly and are easy to quantify in economic terms.
    - Consumptive Use Value - Non-market value of fruit, fodder, firewood, etc. that are used by people who collect them from their surrounds.]
    - Productive Use Value - Commercial value of timber, fish, medicinal plants, etc. that people collect for sale.
- **Indirect Values:** These are uses that do not have easy ways to quantify them in terms of a clearly definable price.
    - Non-consumptive use value - scientific research, bird-watching, ecotourism, etc.
    - Option value - maintaining options for the future, so that by preserving them one could reap economic benefits in the future.
    - Existence value - ethical and emotional aspects of the existence of wildlife and nature.

5.2 Case Study: Decline in Pollinators:

Context: Across India's agrarian plains, plantations and orchards, millions of birds, bats and insects toil to pollinate crops. However, many of these thousands of species may be in dangerous decline.

Pollination

- It is the vital process in **flowering plant reproduction**
- It involve the **transfer of pollen grains from the anther (or male part) to the *stigma* (or female part) of the same, or another plant of the same species**.
- The **fertilised egg cells grow into seeds** which are then spread in the many fruits and vegetables that are eaten.
- This **transfer of pollen can be done by the wind, birds, bats, mammals and insects.** Most important of them are the honey bees that pollinate on a huge commercial scale.

Significance of Pollination:

- Pollination is important for the food crops i.e. food security.
- It's also vital for the foraging crops, such as field beans and clover, used to feed the livestock.
- It **maintains the genetic diversity** of the flowering plants.

Significance of Pollinators for India:

In 2015, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) found that **pollinators lead to huge agricultural economic gains**.

- The report estimated pollinator contribution in India to be **$0.831-1.5 billion** annually for just six vegetable crops.
- This is an underestimation considering that nearly 70% of tropical crop species are dependent on pollinators for optimal yields.
- The **wild pollinators now are declining**, and their loss will imperil human food supply. Most of our staple food crops (wheat, rice, sorghum, barley and maize etc) do not require animals for their pollination. However, **wild pollinators play a very important role in the production of crops such as some pulses, sunflower seeds, cardamom, coffee, cashew nuts, oranges, mangoes and apples**.
- In the Himalayas, **apple yields in recent years have decreased**. The decreases have been attributed to reduction in the number of bees, but the exact causes of low yields are not known.
- In North India, **lowering yields of mustard cultivation** may be caused by disappearing pollinators.

Reason behind decline of Pollinators:

Anthropogenic Activities: The decline of moths, bees, butterflies, hoverflies and other pollinators is undeniably linked to **human activity**:

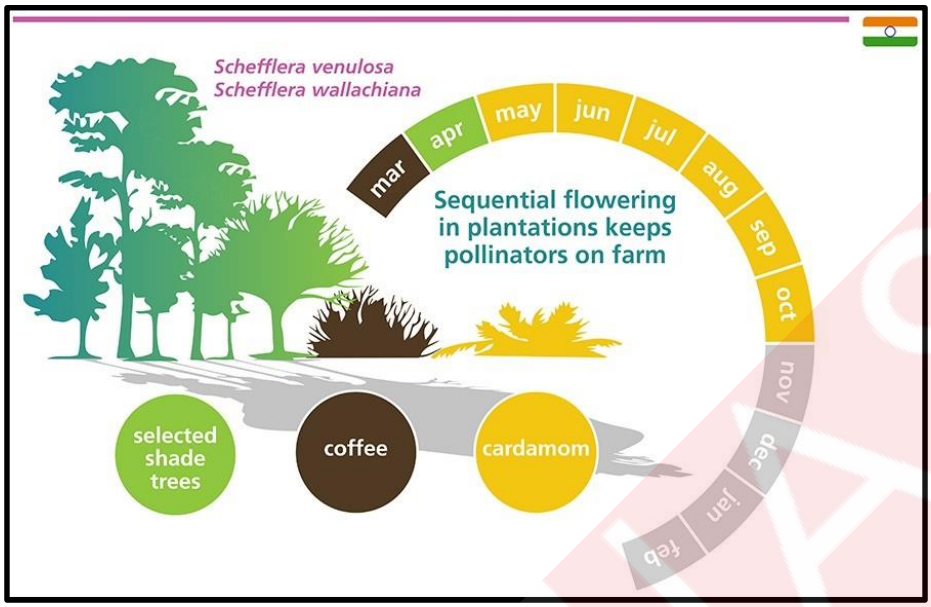
- **Large tracts of natural habitats have been cleared for monoculture cultivation**
- The **use of pesticides and fertilisers** is pushing out nature's little helpers.
    - Native Indian bees, when exposed to multiple pesticides, suffer from memory and olfactory impairment, lower response rates, and oxidative stress which damages cells.
    - Case studies:
        - Between 1964 and 2008, there was a 40-60% growth in relative yields of pollinator-dependent crops, while pollinator-independent crops such as cereals and potatoes saw a corresponding 140% rise in yields.
        - In Kashmir, researchers have pinned lowering yields of apple trees on the declining frequency of bee visits. In north India, lowering yields of mustard cultivation may be caused by disappearing pollinators.
- Researchers at the University of Virginia have discovered that **air pollution from automobiles and power plants has been inhibiting the ability of pollinators such as bees and butterflies to find the fragrances of flowers**.

Natural causes:

- Rapid transfer of parasites and diseases of pollinator species around the world
- Changes in seasonal behaviour due to global warming: In 2014, the Intergovernmental Panel on Climate Change reported that **bees, butterflies, and other pollinators faced increased risk of extinction because of global warming due to alterations in the seasonal behaviour of species.** Climate change was causing bees to emerge at different times in the year when flowering plants were not available.

Initiatives taken in India to control decline on Pollinators

- In India, **selected shade trees were planted on coffee and cardamom farms**. The temperature control that these trees provide in April help to keep pollinators on-farm between flowering of coffee in March and the flowering of cardamom, which starts in May.



- The Ministry of Environment, Forests and Climate Change has recently **launched a programme to establish a network of Indian Long Term Ecological Observatories (I-LTEO) to monitor the country's ecosystems**. The I-LTEO network **offers tremendous opportunities to monitor wild pollinators**.

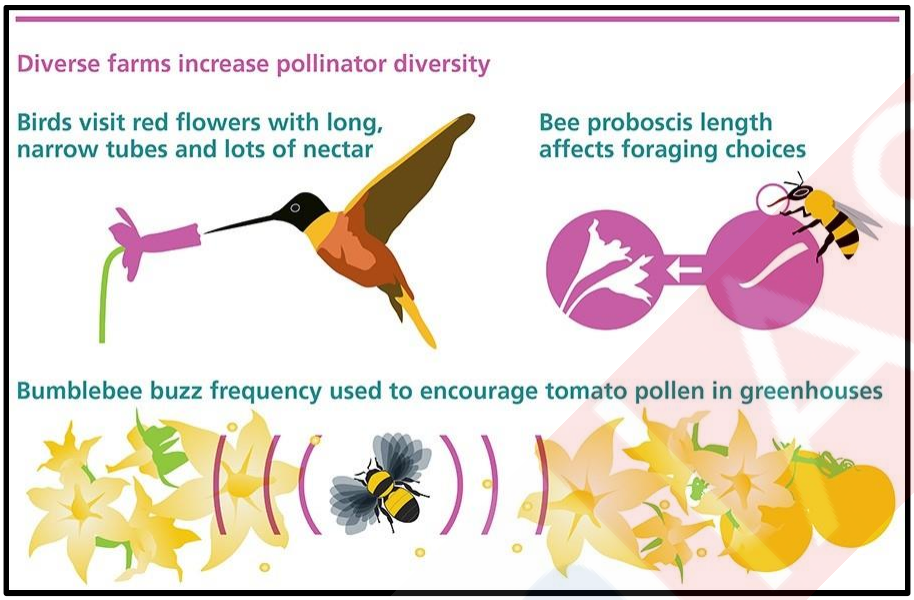
International Initiatives to control decline on Pollinators

- The U.S. has established a **Pollinator Health Task Force** and a national strategy that **focuses on increasing the monarch butterfly population and planting native species and flowers** in more than 28,000 sq. km to attract pollinators.
- The U.K. developed 23 key policy actions under its **National Pollinator Strategy.**
- After the IPBES report, almost 20 countries have joined the **Coalition of the Willing on Pollinators**.
- The **EU** has formed **Pollinators' Initiative.** This can provide pointers to India, particularly as a **policy of direct payment support to farmers** to provide buffer strips for pollinators for nectar- and pollen-rich plants.

What needs to be done:

- The IPBES report makes a number of recommendations to restore the integrity of pollinators:
  - improvements in the science of pollination,
  - strong regulations underlying pesticide use, and
  - restoration and protection of habitats for wild pollinators.
- Promote organic farming
- Landscape management
  - Adoption of The EU Pollinators' Initiative: a policy of **direct payment support to farmers to provide buffer strips for pollinators for nectar- and pollen-rich plants**.
  - India has millions of hectares of reserve forests, some of which have been converted to pulpwood plantations.
- There is an urgent need for **monitoring wild pollinators**, and for **strengthening the governance of natural assets**.
- **Pollinators in urban areas can service and enhance food production in peri-urban areas. Wild biodiversity, including pollinators, must become a significant component of future 'smart cities'**.
- The IPBES assessment serves notice to government agencies that they must **rethink conventional sectoral approaches and narrow disciplinary perspectives**.
- Pollinators have different tastes, physiologies, and are active at different times of the year. Birds typically visit red flowers with long, narrow tubes and lots of nectar, while bee proboscis length affects the type of foraging they can do.

Accounting for these differences by **diversifying crops** not only lead to increased agricultural yields: birds can act as natural pest control; bees produce honey; and the buzz frequency of bumblebees actually encourages tomato pollination.



- In general, for the country as a whole, **we have a very poor knowledge of the pollination systems of our animal pollinated crops, and how best we can manage the pollinators for optimal yields.** How are our wild and managed pollinators responding to ongoing loss and fragmentation of natural habitats? What are the effects of widespread pesticide use? Is climate change implicated in the spread of new diseases among honeybee colonies? We need ample research on these.

6. FOREST ECOSYSTEM

Forests are **formed by a community of plants** which is predominantly structurally defined by its trees, shrubs, climbers and ground cover. The forest ecosystem has two parts:

- The **non-living or abiotic aspects of the forest**: The type of forest depends upon the abiotic conditions at the site. Forests on mountains and hills differ from those along river valleys. Vegetation is specific to the amount of rainfall, the local temperature which varies according to latitude and altitude and the type of soil.
- The **living or the biotic aspects of the forest**: The plants and animals form communities that are specific to each forest type. The biotic component includes both the large (macrophytes) and the microscopic plants and animals.
    1. Plants include the trees, shrubs, climbers, grasses, and herbs in the forest. These include species that flower (angiosperms), and non-flowering species (gymnosperms) such as ferns, bryophytes, fungi and algae.
    2. The animals include species of mammals, birds, reptiles, amphibians, fish, insects and other invertebrates and a variety of microscopic animals.

6.1 Forest types in India:

- Forests in India can be broadly divided into **Coniferous forests** and **Broadleaved forests**.
- They can also be classified according to the nature of their tree species – **evergreen, deciduous, xerophytic or thorn trees, mangroves**, etc.
- They can also be classified according to the most abundant species of trees such as **Sal or Teak forests**.

Coniferous forests grow in the Himalayan mountain region, where the temperatures are low.

These forests have tall stately trees with **needle like leaves** and **downward sloping branches** so that the snow can slip off the branches. They have **cones instead of seeds** and are called **gymnosperms**.
Broadleaved forests have several types, such as evergreen forests, deciduous forests, thorn forests, and mangrove forests. Broadleaved forests have **large leaves of various shapes**.

Forest communities:

Forest type	Plants Examples	Common Animal Examples	Rare Animal Examples
Himalayan Coniferous	Pine, deodar	Wild goats and sheep, Himalayan black bear.	Snow leopard, Hangul, Himalayan brown bear, Musk deer, Himalayan Wolf.
Himalayan Broadleaved	Maple, oak		
Evergreen North-east, Western Ghats, Andaman & Nicobar	Jamun, Ficus, Dipterocarpus	Tiger, Leopard, Sambar, Malabar whistling thrush, Malabar Pied hornbill, tree frogs.	Pigmy Hog, Rhino, Liontailed macaque
Deciduous – Dry	Teak, Ain, Terminalia	Tiger, Chital, Barking deer, Babblers, Flycatchers, Hornbills.	
Moist	Sal		
Thorn and scrub, Semiarid forests	Babul, Ber, Neem	Blackbuck, Chinkara, Fourhorned antelope, Partridge, Monitor lizard.	Wolf, Bustard, Florican, Bustards,
Mangrove Delta Forests	Avicenia	Crocodile, shorebirds – sandpipers, plovers, fish, crustacea.	Water monitor lizard.

6.2 What more need to be done for Conservation of forest ecosystems:

- **Controlled Deforestation:** While deforestation cannot be avoided completely, we must look to control it.
  - Young and immature trees should not be felled as far as possible.
  - avoid large-scale commercial deforestation
  - Adapting practices such as **clear-cutting or selective cutting**
- **Protect against Forest Fires:** Precautions must be taken.
  - Some of the fire suppression techniques are to **develop three-metre-wide five lanes around the periphery of the fire**, back fires, **arrangement of water spray**, **fire retardant chemicals** should be sprayed from back tank and if possible by helicopters.
  - **clearing out dry leaves and trees**
  - There must be a trained staff of firefighters to control the fire.
- **Reforestation and Afforestation:** any forested land which has been destroyed by fire or mining activities should be reforested. In rugged terrain **aerial seeding** is the method of choice.
  - Besides all this, fresh afforestation programmes should be started. **New plantations will not only increase the forest cover but also help in making up the eco-balance**.
  - For afforestation, **selection of trees should be done according to local geographical conditions**
- **Better Farming Practices:** Control Slash and burn farming, overgrazing by cattle, shifting agriculture
- The natural forests with all their diverse species must be protected as National Parks and Wildlife Sanctuaries where all the plants and animals can be preserved.

- **Check over Forest Clearance for Agricultural and Flabitation Purposes:**
    - Most of the present-day agricultural land was once forested and then cleared for the use of agriculture. But now it has reached the stage where further clearance will be dangerous for the entire ecosystem.
    - For the conservation of forest, this should be checked and an **alternative system should be suggeste**d to them.
    - Similarly, for the development of villages, towns and cities, forest lands have been cleared and this process continues to this day causing loss of forest cover. This also should be checked and **green belts around cities should be developed**.
- **Protect from forest disease:** There are several forest diseases resulting from parasitic fungi, rusts, mistletoes, viruses and nematodes which cause the destruction of trees. The forests should be protected either by use of chemical spray, antibiotics or by development of disease resistant strains of trees.

7. GRASSLAND ECOSYSTEM

- Grasslands are highly dynamic ecosystems that include **vegetation that is mainly dominated by grass or grass-like plants**.
- These can be **in the form of natural and semi-natural pastures, woodlands, scrub and steppe formations** (Intermediate areas between forests and deserts made up of small grasses).
- The UNESCO defines grassland as “land covered with herbaceous plants with less than 10 percent tree and shrub cover” and "wooded grassland as 10-40 percent tree and shrub cover".

7.1 Formation of Grasslands

- Grasslands cover areas **where rainfall is usually low** and/or the **soil depth and quality is poor**.
- The **low rainfall prevents the growth of a large number of trees and shrubs**, but is **sufficient to support the growth of grass cover during the monsoon**.
- Low rainfall can also trigger droughts and fires that prevent the development of dense forests but grasses can survive fires and heat and their stems can grow again from where they have been burnt off.

Seasonal events in Grassland Ecosystem:

- Many of the grasses and other small herbs become dry and the part above the ground dies during the summer months.
- In the next monsoon the grass cover grows back from the rootstock and the seeds of the previous year. This change gives grasslands a highly seasonal appearance with periods of increased growth followed by a dormant phase.

Evolution in Grassland Ecosystem:

- A variety of grasses, herbs, and several species of insects, birds and mammals have evolved so that they are adapted to these wide-open grass covered areas.
- These animals are **able to live in conditions where food is plentiful after the rains**, so that they can **store this as fat that they use during the dry period** when there is very little to eat.
- Man began to use these grasslands as pastures to feed his livestock when he began to domesticate animals and became a pastoralist in ancient times.

The grasses are successful invaders and are capable of colonization in various habitats due to their following adaptabilities:

1. They can grow in both hydrophytic and xerophytic habitats
2. Many of the grasses show xeromorphic adaptations
3. Their life span is from annual to perennial
4. Habit varies from trailing to erect
5. Size varies from small to dendroid
6. Meristematic activity both apical and intercalary.
7. Superficial rooting habit
8. High reproductive capacity and capability for both sexual and vegetative reproduction
9. They produce light seeds which are easily and quickly dispersed by wind and animals
10. Grasses can withstand trampling. Grazing and fire
11. Grasses have wide ecological amplitudes
12. Grasses tolerate poor growth conditions

13. They can act as pioneer colonizer in Primary and Secondary successions

7.2 Grasslands of the World

- Grasslands **cover about 2/3rd of the landmass of the world** and m**akeup about one-fourth of the earth's surface**. Grasslands contain diverse types of grasses numbering to over 10,000 and about 12,000 species of legumes that often grow with grasses.
- Grasslands are usually divided into two categories—
    1. **Tropical** (grasslands located near the equator such as those in Africa, southern Asia, Australia and northern South America) and
    2. **Temperate** (grasslands located between the equator and the poles including those in North America, Europe, southern South America, Africa and Australia).
- Some of the typical grasslands found in the world include prairies, savannas, veldts, steppes, llanos, campos, downs, meadows, moors, pamir, pampas, pantanals, patanas, punas, pusztas, and sahel.

7.3 Grassland Types in India

- Grasslands **occupy nearly 24 percent of the geographical area in India**.
- According to Rawat and Adhikari (2015), the **major types of grasslands in India are**
    - **the alpine moist meadows of the Greater Himalayas**;
    - alpine arid pastures or steppe formations of the trans Himalayas;
    - hillside grasslands in the mid-elevation ranges of the Himalayas;
    - 'Chaurs' of the Himalayan foothills; 'Terai' grasslands on the Gangetic and the Brahmaputra floodplains;
    - 'Phumdis' or floating grasslands of Manipur;
    - 'Banni' and 'Vidis' of Gujarat; savannas of western and peninsular India;
    - plateau and valley grasslands in the Satpuras and Maikal hills;
    - dry grasslands of the Andhra Pradesh and Tamil Nadu plains and
    - 'Shola' grasslands of the Western Ghats.

7.4 Location of Grasslands in India:

- Grasslands in India are **located in different climatic conditions** ranging from near desert conditions, to patches of shola grasslands that occur on hillslopes alongside the extremely moist evergreen forests in South India.

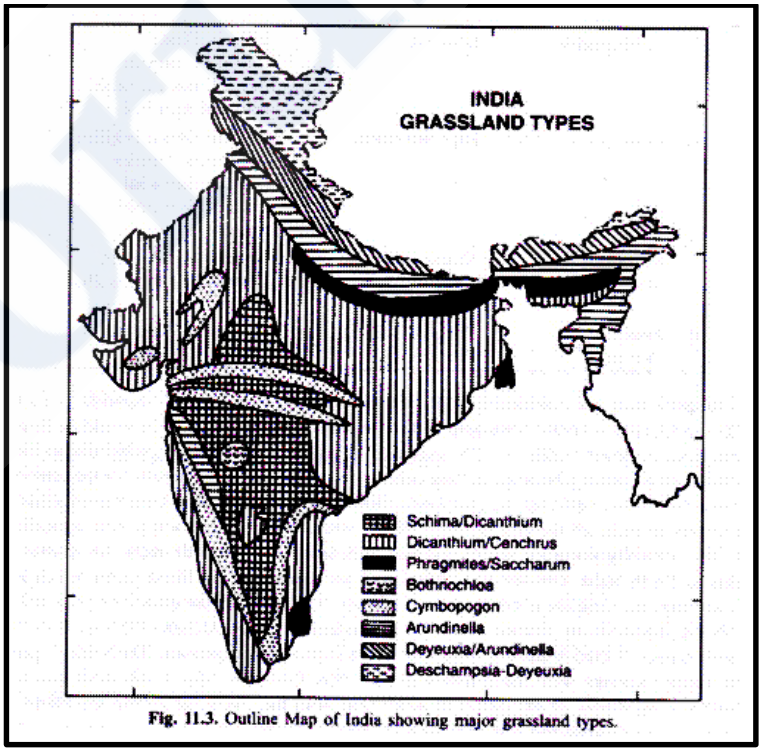


Fig. 11.3. Outline Map of India showing major grassland types.

7.5 Significance of Grasslands:

- Grasslands provide vital ecosystem services such as **water and climate regulation that support agriculture, biogeochemical cycling, carbon storage, cultural and recreational services**.
- Grasslands are **important reservoirs of the crop gene pool** and **many of the crops like wheat, corn, rice and millets that support human survival have originated from grasslands**.
- Grasslands also **serve as a critical habitat for a range of plants and animals**.
- **Significance for the rural economy?**
    - In India grazing-based livestock husbandry plays an important role in the rural economy.
    - Pasturelands over an area of 12 Mha constitute the main grazing resources that are available.
    - Nearly 30 pastoral communities in hilly or arid/semi-arid regions in the northern and western parts of India, as well as 20 in temperate/hilly regions, depend on grazing-based livestock production.

7.6 Threats faced by Grasslands in India

Grassland ecosystems continue to be **one of the most neglected ecosystems in the country** and are **increasingly under threat of being exploited and destroyed for economic gains** or being treated as wastelands.

Anthropogenic causes:

- Many natural grasslands like wet grasslands of Terai and Shola grasslands of the Western Ghats, dry grasslands of Deccan are **being converted to plantations even in Protected Areas (PAs)**.
- Anthropogenic pressures, **land-filling, overgrazing**, **habitat destruction or fragmentation**, **uncontrolled growth of invasive species** and **climate change** are further increasing the threat to grasslands.
- **Overutilization** and **changes in land use of the 'common grazing lands' of rural communities** has lead to their degradation.
- **conversion of grasslands into irrigated farmlands**.
    - **Case study:** In the Deccan, grasslands have been altered to irrigated farms and are now mainly used to grow sugarcane. After continuous irrigation such land becomes saline and useless in a few years. More recently many of these residual grassland tracts have been converted into industrial areas. This provides short-term economic gains but result in long-term economic and ecological losses.
- Grasslands have a limited ability to support domestic animals and wildlife. Increasing this pressure by **increasing the number of domestic animals reduces the 'naturalness' of the grassland ecosystem leading to its degradation**.

Natural causes:

- **Forest Fires:** When fires are lit in the grasslands in summer, the burnt grass gets a fresh flush of small green shoots which the domestic animals graze on. If this is done too frequently the grasslands begin to deteriorate. Finally, grasslands become bare, the soil is solidly compacted by trampling, or is washed away during the monsoon by rain and whipped into dust storms during the hot dry summer. The land is degraded, as there is no grass to hold the soil in place. It becomes a wasteland.

7.7 Government Initiatives for Regulation and protection of grasslands

- Although grasslands have an important role to play in the rural economy and biodiversity conservation, it is shocking to know that there is **still no policy in place to protect grasslands**.
- The **Task Force Report on Grasslands and Deserts** in 2006 submitted to the Planning Commission of India aptly describes the precarious situation the grasslands are in. It states, "**Grasslands are not managed by the forest department whose interest lies mainly in trees**; **not by the agriculture department who are interested in agriculture crops**; **nor the veterinary department who are concerned with livestock but not the grass on which the livestock is dependent**. The grasslands are the 'common' lands of the community and are the **responsibility of none**. They are the most productive ecosystems in the subcontinent but they belong to all, are controlled by none, and they have no godfathers."

7.8 What needs to be done to protect Grassland Ecosystem?

- Grassland as critical habitats was first recognised by the **National Forest Commission** in 2003 and **recommended protection of grasslands to protect wildlife and livestock by developing a centrally coordinated and funded scheme**.
- The need for a policy on grasslands was identified in the **Report of the Task Force on Grasslands and Deserts** submitted in 2006 to the Planning Commission of India. The report had suggested special schemes for the conservation of grasslands and made the following recommendations:

    - Formulate a **National Grazing Policy** to ensure the sustainable use of grasslands and biodiversity conservation.
    - **Modifications in the Environment Impact Assessment (EIA) guidelines** to include grasslands and deserts into ecologically-fragile and environmentally-sensitive areas.
    - Start **Integrated Research and Development Programmes** in the grasslands to understand the impact of climate change and land use practices on grasslands.
    - Include grasslands and desert ecosystems in Protected Area system.
    - Start a separate division or section to look after grasslands issues.
- Experts feel that a good start would be to update this report and work on its recommendations on an urgent basis.
- Grasslands **should not be overgrazed** and areas of the grasslands should be closed for grazing.
    - It is **better to collect grass for stall feeding cattle**.
    - **A part of the grassland in an area must be closed every year so that a rotational grazing pattern is established**.
- **Fires must be prevented and rapidly controlled**. In hilly areas soil and water management in each micro-catchment helps grasslands to return to a natural highly productive ecosystem.
- To protect the most natural undisturbed grassland ecosystems, **Sanctuaries and National Parks must be created**.
    - Their management should focus on preserving all their unique species of plants and animals.
    - Thus they should not be converted into plantations of trees.
    - The open grassland is the habitat of its specialised fauna. Planting trees in these areas reduces the natural features of this ecosystem resulting in the destruction of this unique habitat for wildlife.
- We need to **create an awareness** among people that grasslands are of great value. If we are all concerned about our disappearing grasslands and their wonderful wildlife, the Government will be motivated to protect them.

8. WETLAND ECOSYSTEM

- A wetland is a place **where the land is covered by water, either salt, fresh or somewhere in between**.
- Wetlands = land area where **soil is saturated with moisture either permanently or seasonally**
- Examples of wetlands: **all lakes and rivers, underground aquifers**, swamps and marshes, wet grasslands, peatland, oases, estuaries, delta at the mouth of a river and tidal flats, **mangroves** and other coastal areas, **coral reefs**, and all **human-made sites such as fish ponds, rice paddies, reservoirs and salt pans**.
- Wetlands are **transition zones between terrestrial and aquatic ecosystems**. Eg.
    - Mangroves,
    - Lake littorals (marginal areas between highest and lowest water level of the lakes)
    - Floodplains (areas lying adjacent to river channels beyond the natural levees and periodically flooded during high discharge in the river) etc.

8.1 Significance/Functions of Wetlands:

- Mitigation effect : they **acts as carbon sinks.**
- **Water Filtration:** Wetlands aid in water filtration by removing excess nutrients, slowing the water allowing particulates to settle out of the water which can then be absorbed into plant roots.
    - Studies have shown that **up to 92% of phosphorus and 95% of nitrogen can be removed from passing water through a wetland**.
    - Wetlands also **let pollutants settle and stick to soil particles**, up to 70% of sediments in runoff.
    - **Some wetland plants have even been found with accumulations of heavy metals** more than 100,000 times that of the surrounding waters' concentration.
    - Wetlands can even **filter out and absorb harmful bacteria from the water**. **Their complex food chain hosts various microbes and bacteria, which invertebrates feed on**. **These invertebrates can filter up to 90% of bacteria out of the water this way**.
- **Water Storage:** Wetlands **can store approximately 1-1.5 million gallons of floodwater per acre**.
    - By storing and slowing water, wetlands **allow groundwater to be recharged**.
    - And combining the ability of wetlands to **store and slow down water with their ability to filter out sediments**, wetlands **serve as strong erosion buffers**.

- **Biological Productivity**
  - Through wetlands ability to absorb nutrients, they are able to be **highly biologically productive (able to produce biomass quickly)**.
  - Freshwater wetlands are even comparable to tropical rainforests in plant productivity. Their ability to efficiently create biomass may become important to the **development of alternative energy sources**.
- **Wetland as habitat**
  - Wetlands **support a vast and intricate food web** The wetlands are important wildlife habitats. Many species are dependent upon wetlands.
  - They often **support high concentrations of animals**—including mammals, birds, fish and invertebrates—and **serve as nurseries for many of these species**.

Significance for Human:

- Without wetlands, cities have to spend more money to treat water for their citizens, floods are more devastating to nearby communities, storm surges from hurricanes can penetrate farther inland, animals are displaced or die out, and food supplies are disrupted, along with livelihoods.

8.2 Functions, Related Effects of Functions, Corresponding Societal Values, and Relevant Indicators of Functions for Wetlands

Hydrologic Function	Effects	Societal Value	Indicator
Short-term surface water storage	Reduced downstream flood peaks	Reduced damage from floodwaters	Presence of floodplain along river corridor
Long-term surface water storage	Maintenance of base flows, seasonal flow distribution	Maintenance of fish habitat during dry periods	Topographic relief on floodplain
Maintenance of high water table	Maintenance of hydrophytic community	Maintenance of biodiversity	Presence of hydrophytes

Biogeochemical Function	Effects	Societal Value	Indicator
Transformation, cycling of elements	Maintenance of nutrient stocks within wetland	Wood production	Tree growth
Retention, removal of dissolved substances	Reduced transport of nutrients downstream	Maintenance of water quality	Nutrient outflow lower than inflow
Accumulation of peat	Retention of nutrients, metals, other substances	Maintenance of water quality	Increase in depth of peat

Accumulation of inorganic sediments	Retention of sediments, some nutrients	Maintenance of water quality	Increase in depth of sediment

Habitat and Food Web Support Function	Effects	Societal Value	Indicator
Maintenance of characteristic plant communities	Food, nesting, cover for animals	Support for furbearers, waterfowl	Mature wetland vegetation
Maintenance of characteristic energy flow	Support for populations of vertebrates	Maintenance of biodiversity	High diversity of vertebrates

8.3 Threats faced by Wetlands

Anthropogenic Activities:

- **Excessive pollutants (Industrial effluents, domestic waste, agricultural runoff etc) are dumped into wetlands** beyond the recycling capacity.
- Dams: Dams **alter the natural flow of water** and impact on existing ecosystems.
- **Habitat destruction and deforestation** = creates ecological imbalance by altering the population of wetland species.
- **Conversion of wetlands for agriculture**
- **Encroachment** by public and mafia.
- **Overfishing and fish farming** (Aqua culture).
- **Overgrazing in marshy soils**.
- Removal of sand from beds near seas makes the wetland vulnerable to wave action and tidal bore.

Natural factors:

- **Climate change** : Increases in temperature are causing polar ice to melt and sea levels to rise. This in turn is leading to **shallow wetlands being swamped** and some species of mangrove trees being submerged and drowned.
- Estuarine wetlands typically protect the coastline from erosion and flooding, but if sea level increases and development prevents inland migration of wetlands, more wetlands will be converted to open water.
- Drought: wetlands - estuaries, floodplains, and marshes - are being destroyed through drought.
- erosion and inundation from sea level rise and storms

8.4 Government Initiatives to Protect Wetlands:

National Wetland Conservation Programme (NWCP)

- Under the programme 115 wetlands have been identified till now by the Ministry which requires urgent conservation and management initiatives.
- **Aim of the Scheme:** Conservation and wise use of wetlands in the country so as to prevent their further degradation.
- **Objectives of the Scheme**
    - to lay down policy guidelines for conservation and management of wetlands in the country;
    - to undertake intensive conservation measures in priority wetlands;
    - to monitor implementation of the programme; and
    - to prepare an inventory of Indian wetlands.
- **Conservation and management of wetlands is primarily vested with the State/UTs**, who are in physical possession of the area.
- After **identification of wetlands under the Scheme**, the **State/UTs are to submit long-term comprehensive Management Action Plans (MAPs) for a period of 3-5 years**, preferably 5 years, coinciding with the Plan period.

- The State Governments are advised to **define objectives taking into consideration factors responsible for degradation of the wetland**.
- The MAP should also have short-term objectives to cater to immediate problems confronting wetlands and to go in for immediate rectification measures.
- Under the Scheme, Ministry also **sponsor multidisciplinary research projects by academic/ managerial/ research institutions** on various aspects of wetland conservation to supplement execution of MAP in more realistic manner.

Ramsar Convention on Wetland

- The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is **an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources**.
- There are presently 158 Contracting Parties to the Convention, with 1758 wetland sites, totaling 161 million hectares, designated for inclusion in the Ramsar List of Wetlands of International Importance.
- Ramsar Convention is **the only global environment treaty dealing with a particular ecosystem**.
- In addition, **many wetlands are international systems lying across the boundaries of two or more countries**, or are part of river basins that include more than one country.
- Major obligations of countries which are party to the Convention are:
    - Designate wetlands for inclusion in the **List of Wetlands of International Importance**.
    - Promote, as far as possible, **the wise use of wetlands in their territory**.
    - Promote **international cooperation** especially with regard to transboundary wetlands, shared water systems, and shared species.
    - Create **wetland reserves**.

Montreux Record

- Montreux Record under the Convention is **a register of wetland sites on the List of Wetlands of International Importance where changes in ecological character have occurred, are occurring, or are likely to occur as a result of technological developments, pollution or other human interference**.
- It is **maintained as part of the Ramsar List**.
- The Montreux Record is **employed to identify priority sites for positive national and international conservation attention**.
- **Sites may be added to and removed** from the Record **only with the approval of the Contracting Parties in which they lie**.

Wetlands (Conservation and Management) Rules, 2017

Notified by Ministry of Environment, Forests and Climate Change

Salient Features:

- Scope: The rules apply to:
    - wetlands categorised as "wetlands of international importance" under the Ramsar Convention.
    - wetlands as notified by the central and state governments and UT administration.
- Fact: There are at least 115 wetlands that are officially identified by the central government and of those 26 are identified as wetlands of international importance under Ramsar Convention which is an international intergovernmental treaty for conservation of wetlands.
- **Definition of wetland** : Wetlands are defined as an area of marsh, fen, peatland or water.
    - It could be natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt.
    - It includes areas of marine water the depth of which at low tide does not exceed six metres.
- **State Wetlands Authority (SWA):** The new rules stipulate **setting up of a State Wetlands Authority in each State and union territories** that will be **headed by the State's environment minister** and **include a range of government officials**.
    - They will also include one expert each in the fields of wetland ecology, hydrology, fisheries, landscape planning and socioeconomics to be nominated by the state government.
    - These authorities will need to

    - **develop a comprehensive list of activities to be regulated and permitted within the notified wetlands and their zone of influence**, **recommend additional prohibited activities for specific wetlands**,
    - define strategies for conservation and wise use of wetlands, and
    - undertake measures for enhancing awareness within stakeholders and local communities on values and functions of wetlands.
    - Wise use is defined as the principle of sustainable uses that is compatible with conservation.
- It is up to the states to decide which wetlands are to be notified.
- Under the new rules, the **powers have been given to the State governments so that protection and conservation work can be done at the local level**. Central government has mainly retained powers regarding monitoring
- **National Wetlands Committee (NWC):**
    - The rules stipulates for setting up of NWC, headed by MoEFCC Secretary, **to monitor implementation of these rules and oversee work carried out by States**.
    - NCW will also advise Central Government on appropriate policies and action programmes for conservation and wise use of wetlands, recommend designation of wetlands of international importance under Ramsar Convention, advise on collaboration with international agencies on issues related to wetlands etc.
- **Digital inventory of all wetlands:** It is mandatory for **state authorities to prepare list of all wetlands and list of wetlands** to be notified within six months.
    - Based on it, a comprehensive digital inventory of all wetlands will be created and will be updated every ten years.
- **Restrictions:**
    - The rules **prohibit activities like conversion of wetland for non-wetland uses** including **encroachment of any kind**, **setting up of any industry and expansion of existing industries**, **manufacture or handling or storage or disposal of hazardous substances** and **construction and demolition waste**, solid waste dumping, discharge of untreated wastes and effluents from industries, cities, towns, villages and other human settlements.

Criticism of the Rules: Environmental experts pointed out that

- **Not comprehensive in the context of definitions:** The 2010 Rules included in the definition of wetlands, all inland waters such as lakes, reservoir, tanks, backwaters, lagoon, creeks, estuaries, etc. It also included man-made wetland and the zone of direct influence on wetlands.
    - However, the **2017 Rules are not as comprehensive** as the 2010 rules.
    - It **does not include**
        - **river channels, paddy fields, human-made water bodies/tanks specifically for drinking water purposes, aquaculture, salt production, recreation and irrigation purposes**.
        - wetlands under forest and coastal regulation zones.
- Provisions like "central government may consider proposals from the state government or union territory administration for **omitting any of the (prohibited) activities on the recommendation of the authority**" in the new rules can be misused.
- The **term 'wise use' is subjective and could dilute the earlier restrictions**.
- There is **no timeline specified for phasing out solid waste and untreated waste from being dumped into wetlands**.
- The restrictions on "any other activity likely to have an adverse impact on the ecosystem of the wetland" are not specified clearly in the Rules.
- As per the 2010 version of the rules, there was a Central Wetlands Regulatory Authority (CWRA) which will now be replaced by a national committee.
- Another major objection is about the **process of appeal against the decisions of wetland authorities**. According to the 2010 rules, anyone aggrieved with the CWRA's decisions could have filed an appeal with the National Green Tribunal, but the **new 2017 rules are silent on the appeal process**.
- At the outset, the **identification process by the State Wetland Authority does not distinguish between existing wetlands and especially those past wetlands which have been encroached and can be proved through legal documents**. It also **does not take into account the Jagpal Singh judgment of Justice Katju for restoration of encroached wetlands throughout the country.**

8.5 Wetland Ecosystem and India State of Forest Report (ISFR) 2017

- Forests play a vital role in water conservation and improve the water regime in the area.
- State Forest Departments besides plantation and protection also undertake steps to improve water conservation through different interventions such as building Check dams, vegetation barriers, percolation ponds, contour trenches etc. under various Central & State Government schemes
- As per the latest assessment, water bodies inside forest cover have increased by 2,647 sq kms during the last decade.
- Maharashtra (432 sq kms), Gujarat (428 sq kms), Madhya Pradesh (389 sq kms) are top three states showing increase in water bodies within forest areas. Overall, almost all the states have shown a positive change in water bodies.

8.6 Steps needed to conserve Wetlands:

- **Demarcation of wetlands** using latest technology
- **Eutrophication abatement** : Processing nutrient rich discharge into the water body.
- **Afforestation, weed control**
- **Preventing invasive species:** stop the introduction of exotic invasive species like water hyacinth
- Treatment of **industrial effluents** and **water from farm lands** before discharging into wetlands.
- Proper enforcement of laws and stringent punishments for violators.
- **Preventing unsustainable aquaculture** and cultivation of shellfish.
- Soil conservation measures + Preventing grazing in peripherals of wetlands.
- Involving local population in the conservation of wetlands.

9. MANGROVE ECOSYSTEM

- Mangroves = a characteristic **littoral (near the sea shore) forest ecosystem**.
- These are **mostly evergreen forests** that grow in sheltered low lying coasts, estuaries, mudflats, tidal creeks backwaters (coastal waters held back on land), marshes and lagoons of tropical and subtropical regions.
- Mangroves are located between the land and sea => they represent the best example of ecotone.

9.1 Features of Mangroves:

- Mangroves are shrubs or small salt tolerant trees(also called **halophytes**) capable of growing in marine intertidal environments; coastal saline or brackish water.
    - They **do not rely on salt water** but are **able to tolerate it**.
    - According to the IUCN, there are 70 species of mangroves, of which 11 are threatened with extinction
- They are adapted to the **low oxygen (anoxic)** conditions of waterlogged mud.
- They produces **pneumatophores (blind roots)** to overcome respiratory problem in the anaerobic soil conditions.
    - **Specialized roots enable mangroves to "breath" and anchor in soft sediments:** Mangrove habitats are **usually very low in oxygen beneath the surface**, especially in the sediments where microbes deplete available oxygen during metabolizing processes.
    - In order to deal with this non hostile environment, specialized forms of roots have emerged which enable the tree to breathe oxygen from the air, even when the roots are submerged in water.
- **Long- distance floating mangroves seeds that already grow on the trees:** All mangrove species **use the water to disperse their seeds** but **only some are *viviparous*** meaning **their seeds already grow to seedlings *on* the plant** before being released into the water.
    - Advantage: the fully grown seedling is ready to anchor itself wherever it gets washed up once it's fallen from its mother tree.
    - The already developed plant is capable of photosynthesising and growing straight away instead of being washed back and forth by the incoming tides.

9.2 Growing Areas:

- Mangroves **grow below the high water level of spring tides**.
- Mangroves occur worldwide in the tropics and subtropics, mainly between latitudes 25° N and 25° S.
    - Mangroves require high solar radiation to filter saline water through their roots.
- Best locations : **where abundant silt is brought down by rivers** or on the backshore of accreting sandy beaches.

9.3 Mangroves in India

- As per the ISFR 2017 report, the **total area of mangrove cover of India is 4921 km2**, (181 km2 positively changed with respect to 2015 mangrove cover assessment) which **contributes 3.3% to the global mangrove cover**.
- The deltas of the Ganges, Mahanadi, Krishna, Godavari, and Kaveri rivers contain mangrove forests.
- Backwaters in Kerala have high density of mangrove forest on the shores.
- Indian mangroves consist of 46 species (4 of which are natural hybrids) belonging to 22 genera and 14 families, representing about 57% of the world's mangrove species.
- **Mangroves of Sundarbans** : the largest single block of tidal halophytic mangroves of the world.
    - The major species of this dense mangrove forest include Heritiera fomes, Rhizophora spp., Bruguiera spp., Ceriops decandra, Sonneratia spp. and Avicennia spp..
    - Nypa fruticans are found along the creeks.
    - famous for the Royal Bengal Tiger and crocodiles.
    - Issue faced: Mangrove areas here are being cleared for agricultural use.
- **Bhitarkanika mangroves:** form India's second largest forest, located in the state of Odisha.
    - Bhitarkanika is created by the two river deltas of Brahmani and Baitarani river and one of the important Ramsar Wetland in India.
    - It is also the home of saltwater crocodiles and nesting olive ridley sea turtles.
- **Godavari-Krishna mangroves**: lie in the delta of the Godavari and Krishna rivers in the state of Andhra Pradesh. Mangroves ecoregion is under protection for Calimere Wildlife and Pulicat Lake Bird Sanctuary.
- **Pichavaram mangroves**: hosts the second largest mangrove forests in the world
- **Mumbai mangroves**: has mangroves on its coastline along the west coast of India.
    - These mangroves support a rich diversity of life forms, especially molluscs.
- **Baratang Island mangroves**: are located within the Andaman and Nicobar Islands.
    - The mangrove swamps of Baratang Island are situated between Middle and South Andaman Island.

9.4 Functions of Mangroves

- Mangroves **enhance and trigger the growth of phytoplankton** (due to the provided nutrients) which in turn supports adjacent fish populations.
- They not only **serve as a source for nutrients**, but also **act as a sink for excess nutrients** and thus play an extremely important ecological role in coastal areas.
    - An intact mangrove forest can substantially impact fishing yields and cleared areas are often followed by a collapse and/or sharp decline in catches
- Mangrove forests are also among the **most carbon-rich habitats on earth.**
    - They play a huge role in *carbon sequestration* (i.e. uptake of carbon from the atmosphere) and can **help counteracting climate change**.
    - **Huge amounts of carbon are stored in the sediments and within the roots and trunks systems of the mangrove trees**.
    - They are thus not only able to **absorb (sequester) CO2 from the atmosphere but also store it away forming a so-called carbon sink**.
- Mangroves provide food, fire wood, shelter and sustainable tourism opportunities to local people.
- As transition zones between land and sea **they clean land-driven wastewaters and sewage by filtering the water and burying many kind of toxic substances like heavy metals, dioxin-like compounds and other pollutants**.
- **Mangrove roots cause the water to slow down and enhance sedimentation**, which **traps colloidal particles in the fine sediments as well**.
- Generally, the water flow through mangroves forests disperses point sources of e.g. industrial waste water and sewage into vast areas and dampens the negative environmental effect.
- **Natural protection from tsunamis and hurricanes:** Mangrove forests **act as a natural protection in case of storms and decrease erosion on coastal areas**.
    - The huge amount of biomass dissipates the energy of incoming waves and may greatly decrease the impact of hurricanes and tsunamis in coastal areas.
- **Mangroves serve as kindergartens for many species:** The provided habitat enables many species to nurse in the shallow and usually clean waters of mangroves and a large amount of species stays here for a certain period of life to grow while being protected from bigger predators and benefiting from high prey availability.
    - A few examples are shrimps, sharks and reef fish as well as other pelagic predators.

9.5 Threats faced by mangrove forests and their habitats:

Anthropogenic Activities:

- **Clearing:** Mangrove forests have often been **cleared to make room for agricultural land, human settlements and infrastructure (such as harbours), and industrial areas**.
  - clearing for tourist developments, shrimp aquaculture, and salt farms
- **Overharvesting:** Mangrove trees are used for firewood, construction wood, wood chip and pulp production, charcoal production, and animal fodder. Harvesting in some parts of the world it is no longer sustainable, threatening the future of the forests.
- **River changes: Dams and irrigation reduce the amount of water reaching mangrove forests**, **changing the salinity level of water in the forest**.
  - If salinity becomes too high, the mangroves cannot survive.
  - Freshwater diversions can also lead to mangroves drying out.
  - In addition, increased erosion due to land deforestation can massively increase the amount of sediment in rivers. This can overcome the mangrove forest's filtering ability, leading to the forest being smothered.
- **Overfishing:** The ecological balance of food chains and mangrove fish communities can also be altered.
- **Pollution:** Fertilizers, pesticides, and other toxic man-made chemicals carried by river systems from sources upstream can kill animals living in mangrove forests, while oil pollution can smother mangrove roots and suffocate the trees.

Natural causes:

- **Destruction of coral reefs: Coral reefs provide the first barrier against currents and strong waves**.
  - When they are destroyed, the **stronger-than-normal waves and currents reaching the coast can undermine the fine sediment in which the mangroves grow**.
  - This can prevent seedlings from taking root and wash away nutrients essential for mangrove ecosystems.
- **Climate change**: Mangrove forests require stable sea levels for long-term survival. They are therefore extremely sensitive to current rising sea levels caused by global warming and climate change.

9.6 Government Initiatives to Conserve Mangroves:

- **Wetlands (Conservation and Management) Rules, 2017 (already covered under wetland ecosystems)**
- **National Wetland Conservation Programme (NWCP) (already covered under wetland ecosystems)**
- **Ramsar Convention on Wetland (already covered under wetland ecosystems)**
- **Montreux Record (already covered under wetland ecosystems)**
- **World Wetland Day (already covered under wetland ecosystems)**
- **Mangroves for the Future (MFF)**
  - is a unique multi- country, multi sectoral, partner- led initiative
  - have two objectives:
    - To strengthen the environmental sustainability of coastal development.
    - To promote the investment of funds and effort in coastal ecosystem management for sustainable development.
  - MFF is being coordinated by International Union for Conservation of Nature, IUCN covering, initially, six Tsunami affected countries namely India, Indonesia, Maldives, Seychelles, Sri Lanka and Thailand. India has agreed to participate in the IUCN- MFF Initiative.

9.7 Mangrove Ecosystem and India State of Forest Report (ISFR) 2017

- As per ISFR 2017, **mangrove forests have increased by 181 sq kms**.
- Maharashtra (82 sq kms), Andhra Pradesh (37 sq kms) and Gujarat (33 sq kms) are the top three gainers in terms of mangrove cover.
- 7 out of the 12 mangrove states have shown an increase in mangrove cover and none of them show any negative change.
- Mangrove ecosystems are rich in biodiversity and provide a number of ecological services. They also play a major role in protecting coastal areas from erosion, tidal storms and tsunamis.

CGP 2019

ENVIRONMENT AND ECOLOGY

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Environmental Impact Statement (EIA) is an integral part of Environmental Management. Environment conservation, protection and sustainable development have become the hallmarks for the unprecedented growth in the age of rapid industrialization and urbanization throughout the world.

1. Meaning of Environmental Impact Assessment (EIA)

EIA refers to the studies and statements which firstly attempt to produce estimates of future environmental changes attributable to a proposed action, and secondly attempt to suggest the likely impact of these changes (environmental changes to be brought in by human's actions).

Thus, environmental impact assessment is a method of evaluating environmental consequences i.e. environmental changes that are likely to be caused by the proposed human activities related to land use changes, construction of dams, reservoirs, roads, rails, bridges, etc. and the possible adverse effects of these environmental changes (environmental degradation and pollution resulting into ecological imbalance and ecosystem disequilibrium).

It is one of the tools available with the planners to achieve the goal of harmonizing development activities with the environmental concerns. It is one of the most successful interventions in environmental management.

2. Need for Environmental Impact Assessment

In present times anthropogenic activities have created immense pressure on the natural environment. Environmental degradation at this pace, if continues, will bring humanity on the brink of extinction. Therefore, to ensure that the economic development and environmental conservation goes hand in hand, appropriate methods and tools have to be formulated.

EIA as a tool aims to minimize the environmental impacts emanating out of any economic activity that have the potential to cause environmental degradation as shown below.

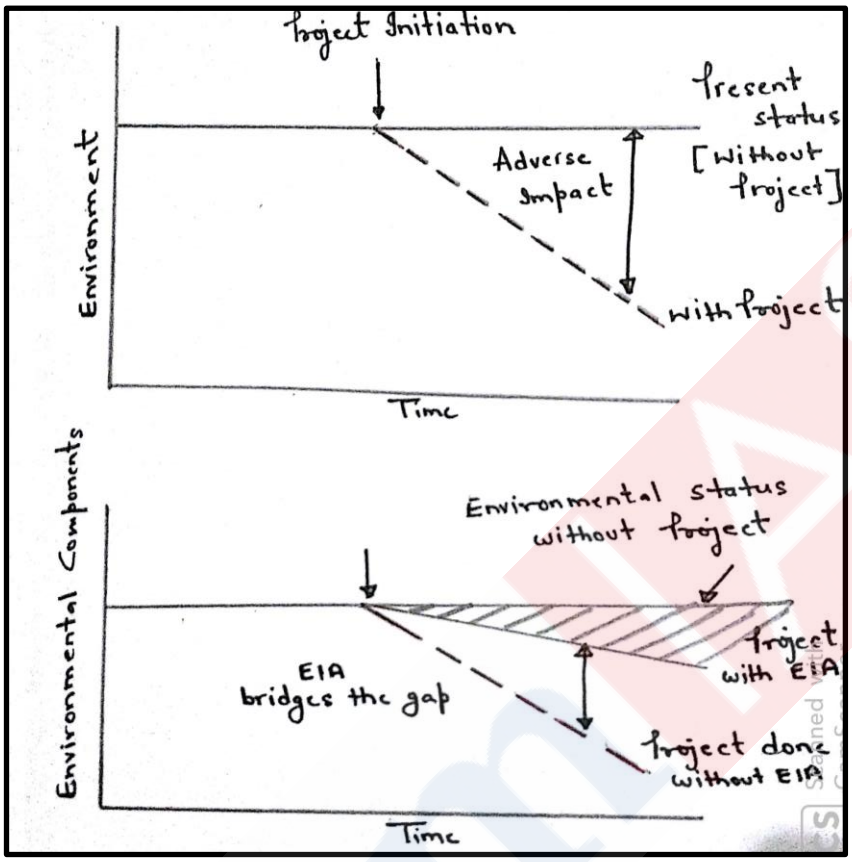


Figure: Environment impact rectification after EIA

3. Origin of EIA

The genesis of the concept and methods of environmental impact assessment has its root in the enactment of the National Environmental Policy Act (NEPA) in the year 1969 in the USA.

The Environmental Impact Statement (EIS) in India was started in 1976-77 when the Planning Commission asked the Department of Science and Technology to examine the river valley projects from environmental angle. EIA was made mandatory under the Environmental (Protection) Act, 1986.

4. Aims and Objectives of EIA

- To declare a national policy to encourage productive and enjoyable harmony between man and environment.
- To promote efforts to prevent or eliminate damage to the environment.
- To increase understanding of ecological system and natural resources important to the nation
- To establish a Council on Environmental Quality.

5. Environmental Impact Assessment and statements includes the following considerations:

- Presentation of the existing environmental conditions in terms of physical, biological, social and economic conditions of the site of the proposed project.
- Statements on the possible effects of proposed project, if implemented, on the proposed site.
- Statements about those unavoidable adverse effects which may come after the implementation.
- Presentation of viable alternative projects to the proposed projects.
- Evaluation of cost of the project and its probable benefits to the society.
- Statements on suitable remedial measures of adverse effects arising out of the project after its implementation.

6. Steps and Procedures of EIA process in India

Screening: It is done to see whether a project requires environmental clearances as per the statutory notifications. Screening criterias are based upon:

- Scales of investment
- Type of development
- Location of development

Scoping: It is a process of detailing the terms of reference of EIA. It has to be done by the consultant in consultation with the project proponent and guidance.
The Ministry of Environment and Forests has published sector wise guidelines which outline the significant issues which has to be addressed in the EIA studies. The areas of impacts that needs to be studied. Ex. Setting up of Hydro-electric project: impact on river, water, forests, impact on tribes, soil erosion, sediments deposition, seismicity, etc.

Baseline Data: It describes the existing environmental status of the identified study area. The site specific primary datas are monitored and supplemented with secondary datas.

Impact Prediction: Analyzing the possible effects on the physical, biological, social and economic conditions and suggesting alternatives. The predictions of impact can never be absolute and certain and thus there is a need to comprehensively consider all factors and take all possible precautions for reducing the degree of uncertainty.
Example: Impact on biological diversity in an area

- Impact on habitat due to deforestation and pollution
- Extent to which edge species are created
- Impact on endangered animals and migratory paths

- Impact on endemism
- Impact on breeding and nesting grounds

Assessment of alternatives, delineation of mitigation measures and Environmental Impact Assessment Report: For every project, possible alternatives should be identified and environmental attributes compared. Alternatives should then be ranked for selection of the best environmental option for optimum economic benefits to the community at large. Once alternatives have been reviewed, a mitigation plan is drawn up.
An EIA Report should provide clear information to the decision maker on the different environmental scenarios without the project, with the project and with project alternatives. Uncertainties should be clearly reflected in the EIA report.

Public Hearing: The public must be informed and consulted on a proposed development after the completion of EIA report. The Gram Sabhas must be consulted even before the projects initiates.

Environment Management Plan: Delineation of mitigation measures including prevention and control for each environmental component and rehabilitation and resettlement plan. It also includes delineation of financial plan.

Decision Making: It involves consultation between the project proponent and the impact assessment authority.

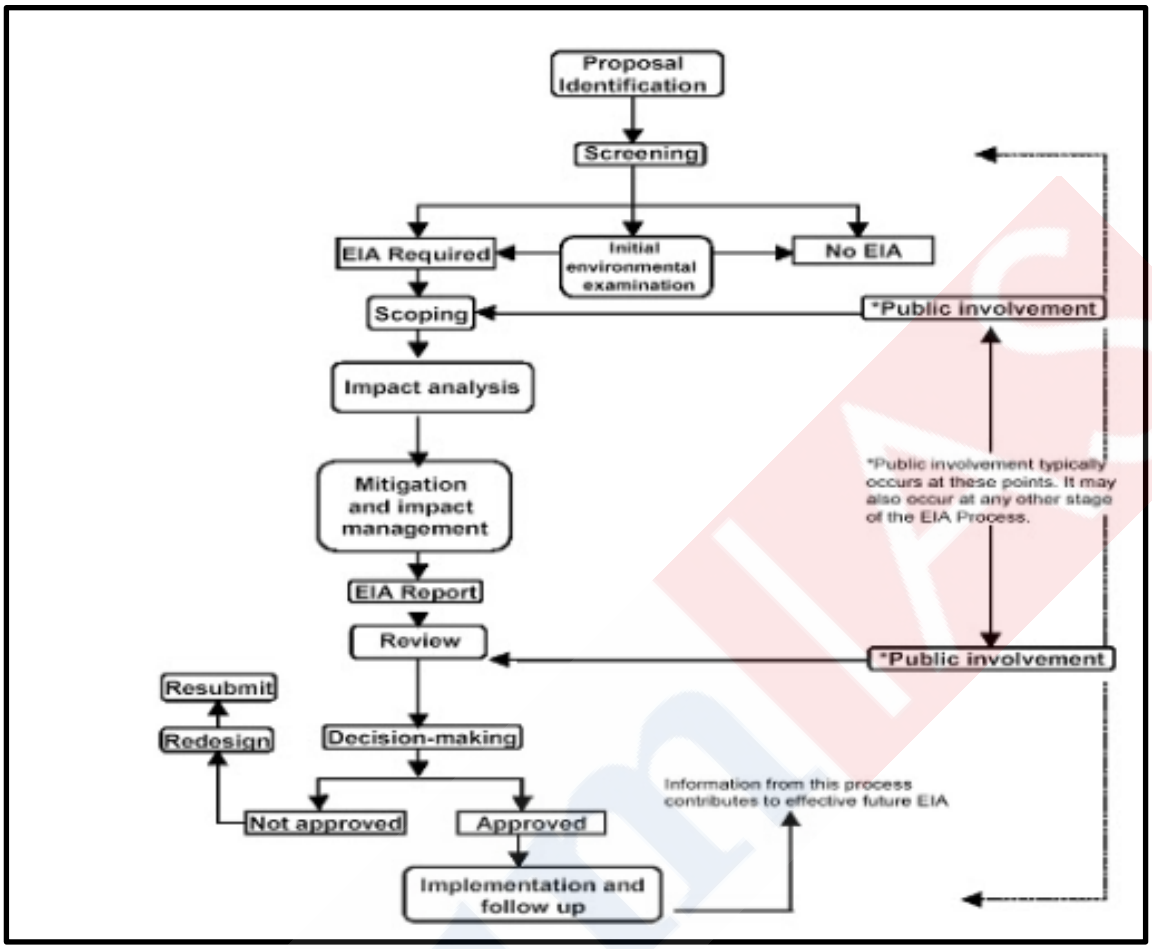
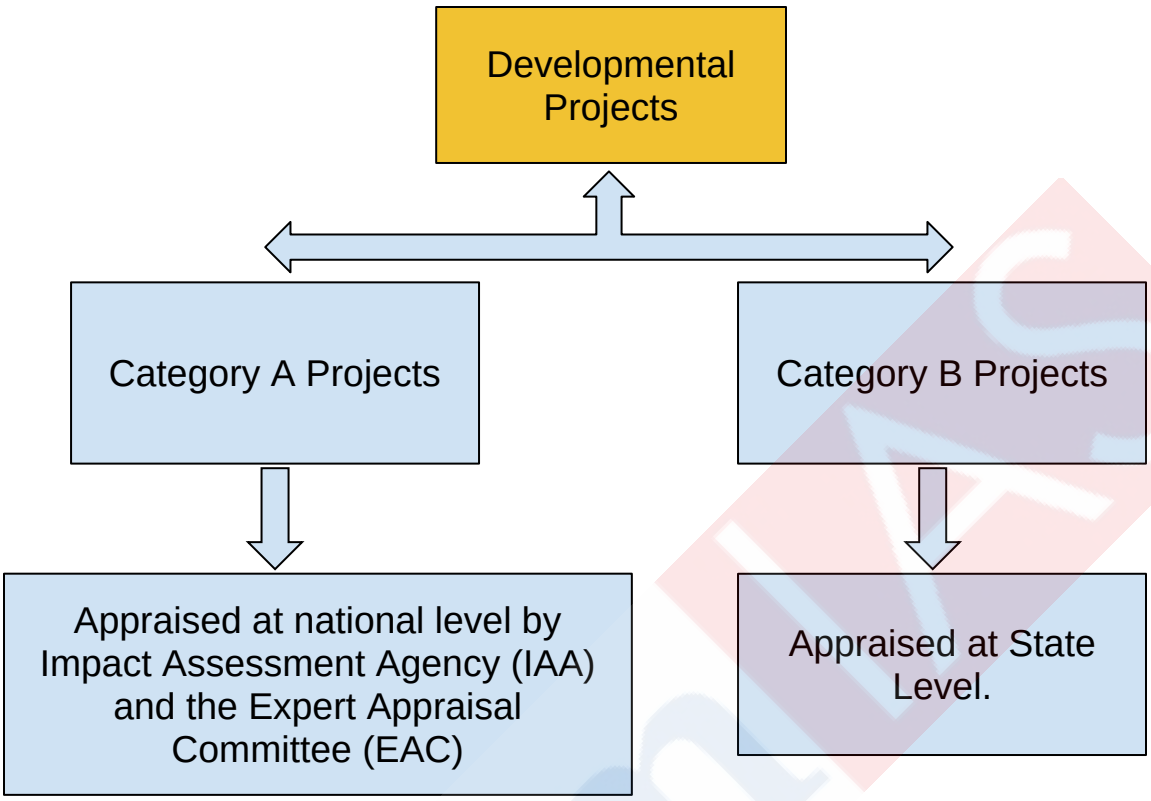


Figure: Areas of Decision Making in the complete EIA process.

Monitoring the clearance conditions: To monitor the compliance with the report throughout the project to ensure corrective actions, wherever the impacts exceed the predicted levels. Monitoring will enable the regulatory agency to review the validity of the predictions and the conditions of implementation of the environmental management plan.

7. Salient Features of 2006 Amendment

- Environmental Impact Assessment Notification 2006 has decentralised the environmental clearance projects by categorising the developmental projects in two categories i.e. Category A and Category B.



- State Level Environment Impact Assessment Authority (SEIAA) and State Level Expert Appraisal Committee (SEAC) are constituted to provide clearance to category B projects.
- After 2006 Amendment, EIA comprises of four cycles:
  - ❖ Screening
  - ❖ Scoping
  - ❖ Public Hearing
  - ❖ Appraisal
- Category A Projects requires mandatory environmental clearance and screening process is not required. Category B projects undergo screening process and they are classified in two types:
  1) Category B1 Projects: Mandatory requires EIA
  2) Category B2 Projects: Do not require EIA

  Thus category A projects and category B1 projects undergo the complete EIA process whereas Category B2 projects are excluded from complete EIA process.

8. Procedure for Public Hearing

1. **Process of public Hearing**

   The environmental clearance projects shall be submitted to the State Pollution COntrol Board.

2. **Notice of Public Hearing**

The State Pollution Control Board shall cause a notice for environmental public hearing which shall be published in at least two newspapers widely circulated in the region around the project. One of them must be in local vernacular language.

Suggestions, views, comments and objections of the public shall be invited within thirty days from the date of publication of the notification.

3. **Composition of public Hearing Panel**

The composition of the public hearing panel may consists of:

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

9. Difference between Rapid EIA and Comprehensive EIA

The difference is in the time scale of the data supplied. Rapid EIA is for speedier appraisal process. But both types require complete coverage of all EIA procedures.

Rapid EIA: Under Rapid EIA data supplied is of only one season (other than monsoon) to reduce the time required.

Comprehensive EIA: It collects data from all four seasons.

Rapid EIA is acceptable if it does not compromise upon the quality of decision making. The review of Rapid EIA submissions will show whether a comprehensive EIA is warranted or not. Therefore, submission of comprehensive EIA in the first stance would generally be more efficient approach.

10. Critical evaluation of EIA in India

1. **Applicability:** There are several projects with environmental impacts that are exempted from the notification. Ex. Low scale sand mining.

Case study: Neutrino Observatory, Bodhi Hills, Theni

The project has been approved under category B item 8(a) — building and construction projects — of the Schedule to the Environmental Impact Assessment (EIA) Notification, 2006. But it should have been treated as category A as the project lies just 4.9 km from the national park in Idukki district of Kerala.

For one, the EIA was done by the Salim Ali Centre for Ornithology and Natural History, which is an “unaccredited agency”.

And though a public consultation with local people who have a “plausible stake” in the project was conducted in July 2010, the details of the meeting were submitted only by the end of February 2018.

2. **Inadequate capacity of EIA approval authorities:** Lack of technical environmental, anthropologists and social scientists among the members and crony capitalism leads to faulty decision making.
3. **Deficiencies in screening, scoping and impact analysis:** There are no independent bodies and no standardized formats for project evaluation. Absence of standardized baseline data brings arbitrariness in impact prediction. It is done by those persons which are on payroll of company which creates conflict of interest. They intentionally exclude forests and impact on tribes during scoping process.
4. **Poor quality EIA reports:** EIA is used presently as a project justification tool rather than as a project planning tool to contribute to achieving sustainable development.

Case Study: World Trade Centre" in Nauroji Nagar in south Delhi.

The consultant for the Nauroji Nagar project has used material from copyrighted papers, webpages and other EIA reports.

It even mentions that the water quality study was undertaken in 2015, one year before the project was commissioned to NBCC.

It cites eight water quality monitoring locations for the study which are situated in Tamil Nadu. This content can be traced back to the EIA report of Tamil Nadu Minerals Ltd. which was prepared by the same consultant.

The EIA's 'Terms of Reference' (ToR) for Nauroji Nagar, which is essentially a commercial project, fail to mention the word "commercial". Instead, it states that the project is for the "modernization" of government residential colonies.

5. **Inadequate public participation:** In contrast to many countries like Nepal, Argentina and Australia, where public involvement is mandatory at various stages of the EIA process (i.e. screening, scoping, report preparation and decision making), in India consultation occurs only once, just before decision making, and the points raised by the public are rarely taken into account. Even the notifications issued for public hearing are not published in local vernacular languages.
6. **Weak monitoring:** Monitoring is not done through an independent agency. EMP of strategic industries like nuclear energy are not put into public domain.

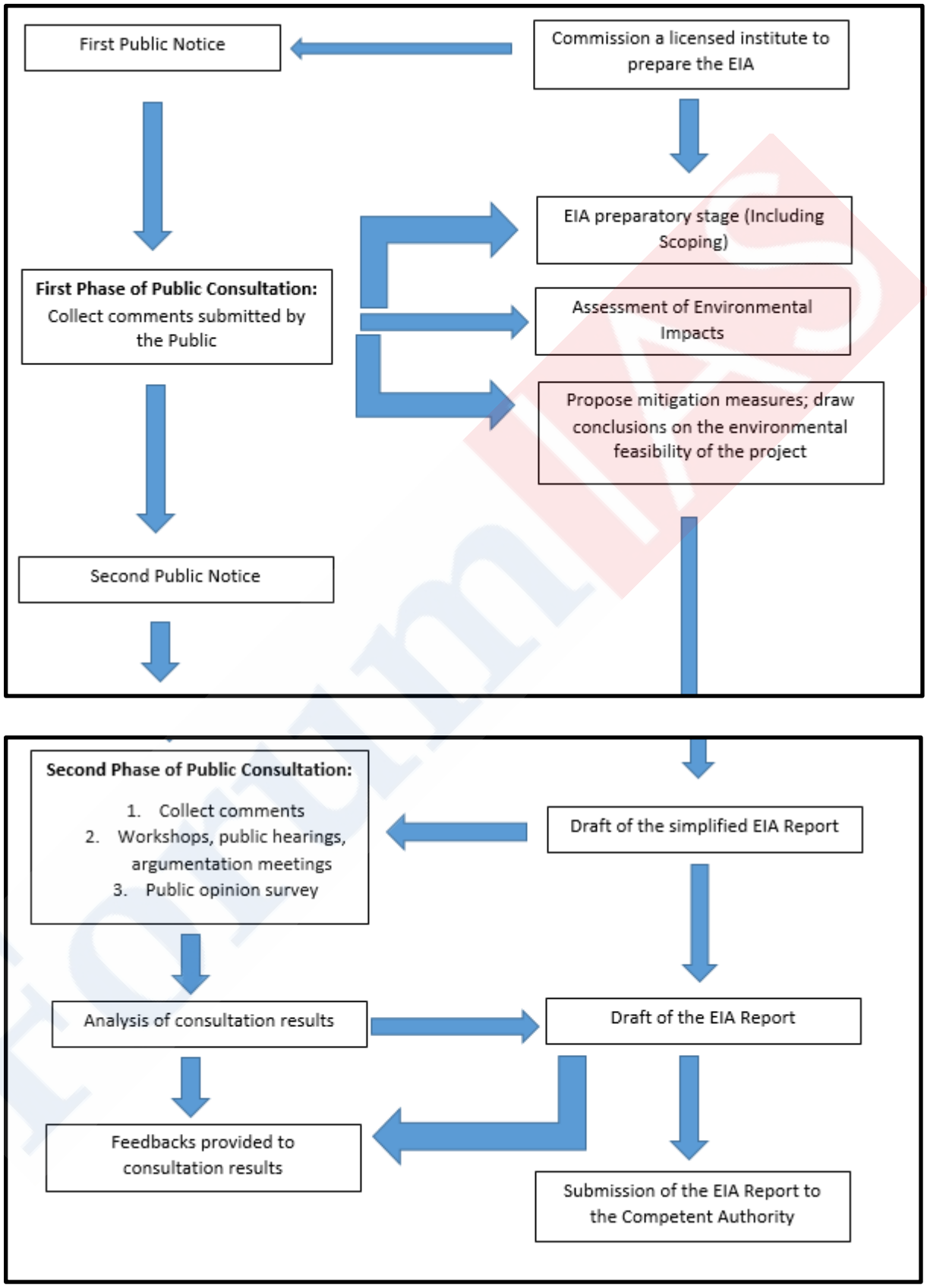
One of the main faults in India is that it is undertaken at a much later stage, especially after the project has been designed, approved and almost ready for construction. By the time EIA is mandated, huge costs are incurred and the project becomes too big to fall.

While shortcomings are challenging, Government of India is showing a high degree of commitment. The EIA system in the country is undergoing progressive refinements by steadily removing the constraints.

11. Ways for strengthening the EIA process

1. **Independent Agency:** The entire EIA process right from screening to monitoring should be done by independent agencies and establishing a National Accreditation Body for agencies carrying out EIA.
2. Creation of **centralized baseline data bank**.
3. **Applying Precautionary Principle:** The list of concerns raised by the public should be studied in detail to arrive at any conclusion. Ex. GM crops. Clearances given to project that is not aptly justified becomes questionable as happened in Sethusamudram Project.
4. **Strategic Environment Assessment**: It helps in choosing a project and not just evaluate it. It offers alternatives and guides project financing. The directives of SEA are reflected in the National Environment Policy 2006. Nepal also carries out SEA's.
5. **Robust and Inclusive public hearing:** A key role for local people through Panchayats and ULB's at every stage. Special focus on forests and tribals. The traditional knowledge of locals needs to be incorporated.

Case Study: EIA Public Participation process in China


First Public Notice
Commission a licensed institute to prepare the EIA
EIA preparatory stage (Including Scoping)
First Phase of Public Consultation: Collect comments submitted by the Public
Assessment of Environmental Impacts
Propose mitigation measures; draw conclusions on the environmental feasibility of the project
Second Public Notice
Second Phase of Public Consultation:
1. Collect comments
2. Workshops, public hearings, argumentation meetings
3. Public opinion survey
Draft of the simplified EIA Report
Analysis of consultation results
Draft of the EIA Report
Feedbacks provided to consultation results
Submission of the EIA Report to the Competent Authority

6. **Greater transparency** in the clearance process and dissemination of all documents for public scrutiny.
7. **Capacity Building:** NGO's, civil society groups and local communities need to build their capacities to use the EIA notification towards better decision making on projects that can impact their local environments and livelihoods. Capacities can be built to proactively and effectively use the notification rather than respond in a manner that is seen as negative or unproductive.

In a world that is challenged by environmental degradation and social conflicts, scholars have upheld public participation to be a "threshold condition" for development. EIA provides this necessary element in the economic development process. Therefore, EIA-based approvals for most projects should mandatorily and necessarily involve the process of conducting public hearings in order that the views and opinions of people who are likely to be affected can be taken on board before a decision to approve the project is made.

ForumIAS

ENVIRONMENTAL POLLUTION

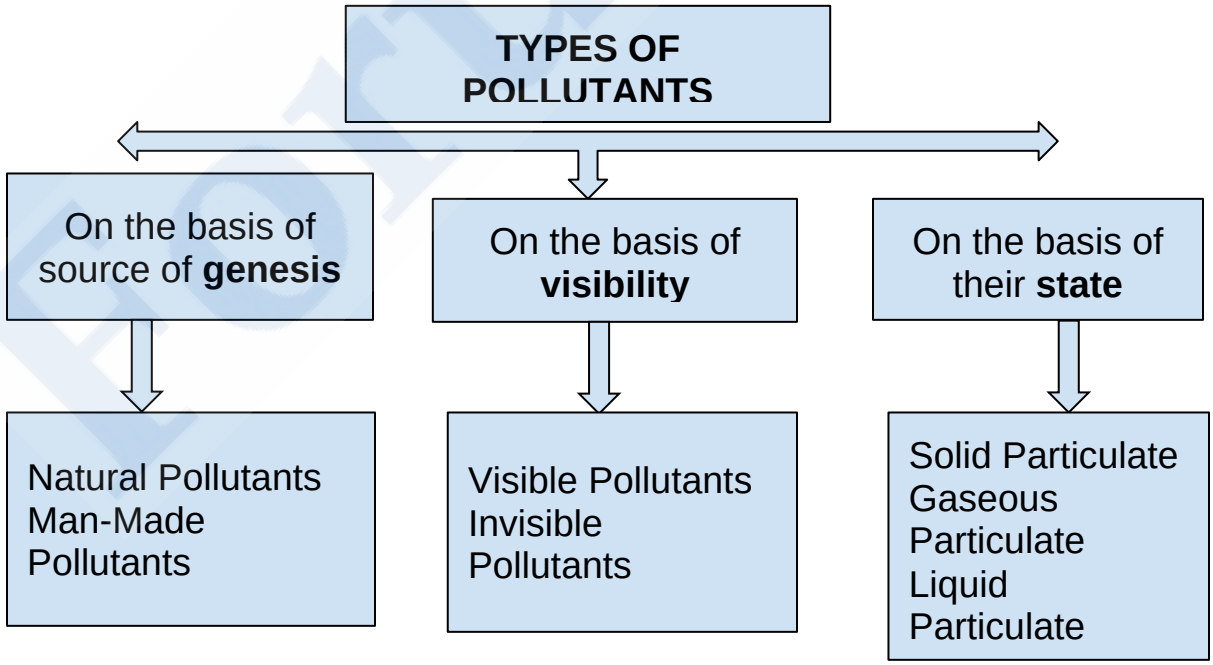
Environmental pollution means lowering of environmental quality at local scale caused exclusively by human activities whereas **environmental degradation** means lowering of environmental quality at local, regional and global scales by both natural processes and human activities.

SInce the realization of environmental pollution has now become of global concern and there is a growing realization that pollution also creates '**vicious cycle**' of poverty. Therefore, a **comprehensive study** of types of pollution, types of pollutants, sources of pollution, causes and processes of pollution, environmental and ecological effects of pollution, etc. has become necessary for planning strategies for future utilization and **comprehensive environmental management plans.**

It is commonly agreed that pollution is without doubt, the outcome of urban-industrial and technological revolution and rapacious and speedy exploitation of natural resources, increased rate of exchange of matter and energy and ever increasing industrial wastes, urban effluents and consumer goods.

1. POLLUTANTS

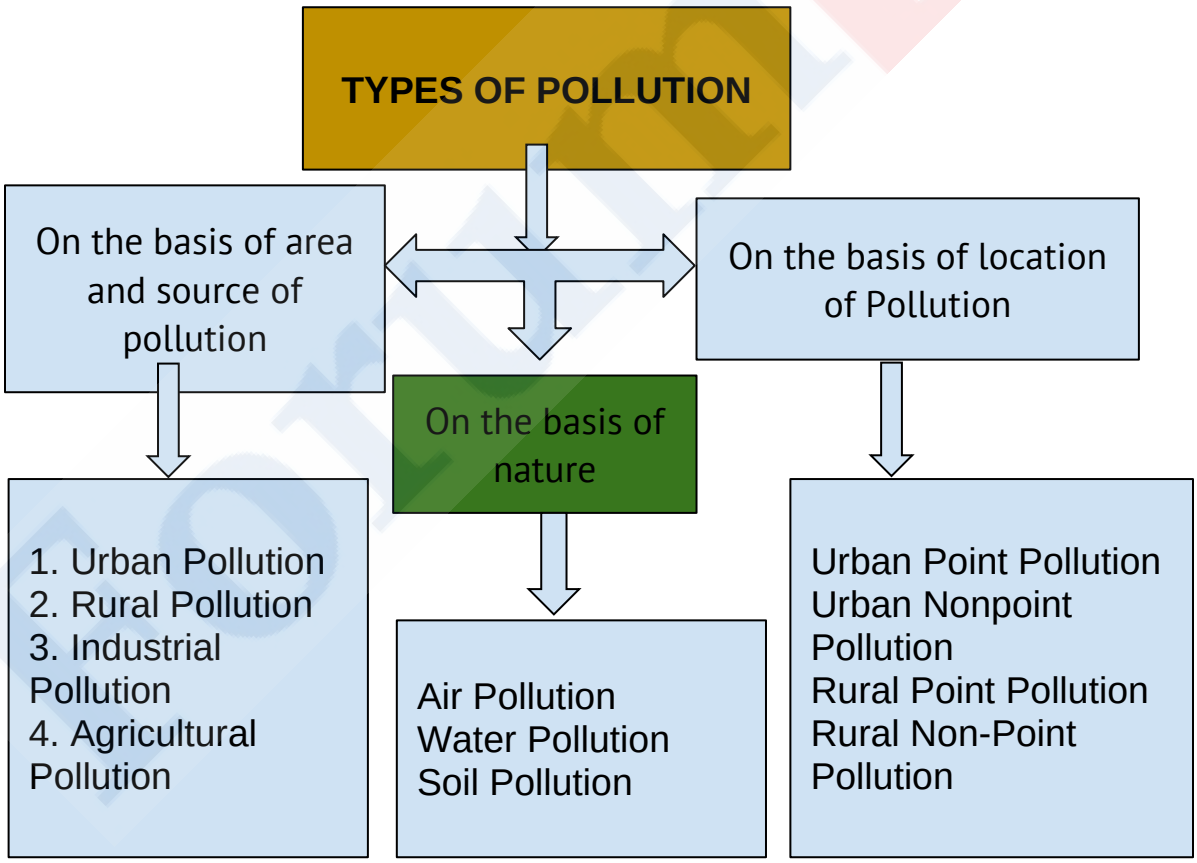
A pollutant is defined as any form of energy, or matter or action that causes disequilibrium state from equilibrium state in any existing natural ecosystem.



2. SOURCES OF POLLUTANTS

1. **Natural sources of pollution:** This includes volcanic ashes and dusts, undesirable substances brought to the surface due to seismic activities, flood water, etc.
2. **Anthropogenic sources of pollution:** This includes
    - **Industrial Source:** Industries adds gaseous pollutants like methane, carbon monoxide, sulphur, etc. solid pollutants, waste water, etc.
    - **Urban Source:** It includes sewage water, plastics, e-waste, solid wastes, etc.
    - **Agricultural Source:** This pollution is related to fertilizers, pesticides and insecticides.
    - **Population Source:** On an average increase in population of a nation has been positively correlated with pollution.

3. TYPES OF POLLUTION



Point Pollution: Point pollution is always visible and hence can be easily identified. Example: Discharge of effluents from a drain or pipe into river channel.

Nonpoint Pollution: Pollution of the area from unspecified location. It occurs mostly from agricultural practices. Nonpoint pollution is seldom visible. Example: Chemical fertilizers and pesticides and insecticides used in the agricultural fields.

5. AIR POLLUTION

According to **WHO**, air pollution is defined as limited to situation in which the outdoor ambient atmosphere contains materials in concentration, which are harmful to man and his/her surrounding environment.

The **nature, dimension and magnitude of air pollution** depends on a variety of factors such as residence time of pollutants in the atmosphere, sources of pollutants, nature of pollutants, amount of pollutants, etc. The **residence time of pollutants** in the atmosphere vary considerably depending upon the **nature of the pollutant**, on **meteorological factors** (amount of moisture, cloudiness, etc.) and on **sink mechanism** (vegetation, water bodies, etc.)

5.1 AIR POLLUTANTS

Air pollutant is a material in the air that can have adverse effects on humans and the ecosystem.

According to the form in which they persist after release into the environment, pollutants are classified as primary or secondary.

- **Primary pollutants:** These persist in the form in which they are added to the environment. Examples: ash from a volcanic eruption, carbon monoxide gas from motor vehicle exhausts, sulphur dioxide released from the factories.
- **Secondary pollutants:** These are formed by interaction and reaction among the primary pollutants. They are not emitted directly. Examples: peroxyacetyl nitrate (PAN) is formed by the interaction of nitrogen oxides and hydrocarbons; Ground level ozone, etc.

According to their existence in nature, pollutants are classified as:

- **Quantitative Pollutants:** These occur in nature and become pollutant when their concentration reaches beyond a threshold level. Example: Carbon dioxide, Nitrogen oxide.
- **Qualitative Pollutants:** These do not occur in nature and are man-made. Example: fungicides, herbicides, DDT etc.

5.2 MAJOR AIR POLLUTANTS AND THEIR SOURCES

Carbon Dioxide

- **Natural sources:**
    - Exhalation through organisms.
    - Forest fires and volcanoes, hot springs and geysers
    - It is freed from carbonate rocks by dissolution in water and acids.
    - Because carbon dioxide is soluble in water, it occurs naturally in groundwater, rivers and lakes, in ice caps and glaciers and also in seawater.

- **Anthropogenic sources:** burning of fossil fuels (coal, oil and natural gas) for industrial, domestic and transport purposes releases significant, though relatively smaller, amounts.
- **Effects on Health**
    - At normal environmental concentrations, carbon dioxide has no impacts on human health.
    - At extremely high (artificial) concentrations in an enclosed space the reduction in oxygen levels could lead to suffocation.
        - CO2 is an asphyxiant gas
        - Asphyxia = a condition arising when the body is deprived of oxygen, causing unconsciousness or death
- **Effects on Environment**
    - It is one of the main "greenhouse gases" contributing to global warming
    - it dissolves in water to form **carbonic acid => CO2 is** a major cause of **ocean acidification.**

Carbon Monoxide

- **Natural Sources:**
    - Worldwide, the largest source of carbon monoxide is natural in origin, due to **photochemical reactions in the troposphere**.
    - It is released into the atmosphere by volcanoes as they erupt, from the smoke of forest fires, from the natural gases in coal mines, and even from lightning!
    - Other natural sources of carbon monoxide are marsh gases, which are also called methane and produced by plants decomposing under water, marine algae, kelp and seed germination growth.
- **Health effects of CO**
    - Inhalation of carbon monoxide at high concentrations can be fatal, because **it prevents the transport of oxygen (in blood) around the body**.
        - It combines with hemoglobin to produce **carboxyhemoglobin**, which usurps the space in hemoglobin that normally carries oxygen.
    - Long-term exposure to lower concentrations (such as through smoking) could harm unborn babies or cause neurological damage.
- **Environmental Effects:** When carbon monoxide is emitted into the atmosphere it affects the amount of greenhouse gases, which are linked to climate change and global warming. => land and sea temperature increases changing to ecosystems, increasing storm activity and causing other extreme weather events.

Ozone

- **Sources:**
    - Vehicles and industries = major source of ground-level ozone emissions.
    - **Carbon monoxide, Nitrogen dioxide** play a major role in converting O_2 to O_3.

- Vegetation can also emit organic chemicals that help form ozone.

- **Impact of human health:**
  - Ozone can irritate the lining of the nose, airways and lungs.
  - Makes our eyes itchy, and watery.
  - It lowers our resistance to cold and pneumonia.
  - People with asthma might have more attacks and athletes might find it harder to perform as well as usual.

Sulphur Oxides (SO_x)

- **Sources:**
  - released naturally by volcanic activity + forest fires
  - from various industrial processes: production of paper and smelting of metals, oil refineries, roasting of sulfide ores such as pyrite, sphalerite, and cinnabar (mercury sulfide)
  - **burning coal in thermal power plants** and **diesel fuels**.
  - reactions involving Hydrogen Sulphide (H_2S) and oxygen.
- **Environmental Impacts:**
  - It contributes to **acid rain :** Oxidation of SO_2, usually in the presence of a catalyst such as NO_2, forms H_2SO_4, and thus acid rain
    - It can damage sensitive buildings or monuments
    - damages vegetation and wildlife and pollutes water bodies
  - Sulphur dioxide **can damage plants and reduce crop yields**.
  - Conversely, its antifungal properties can be beneficial for some plants.
- **Health impacts:**
  - Sulphur dioxide can irritate the eyes and respiratory system (air passages and lungs).
  - It also weakens the functioning of certain nerves.
  - Sulphur dioxide pollution **contributed to the "great London smog" in 1952** which is thought to have contributed to around four thousand premature deaths of people with lung disease or bronchitis.

Nitrogen Oxides (NO_x)

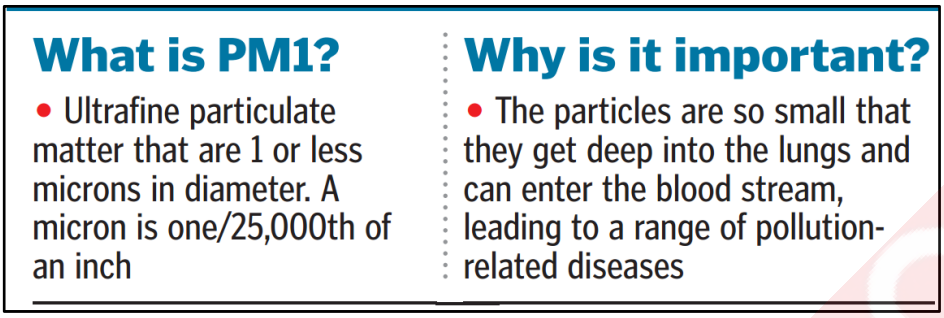
- **Natural Sources:**
  - **produced during thunderstorms by electric discharge**.
  - natural fires
  - from microbial processes in soils and water bodies.
- **Anthropogenic Sources:**
  - from the burning of fossil fuels (including vehicle emissions),
  - biomass burning (burning of forest and agricultural lands following harvest)
  - **Agricultural fertilization** and the **use of nitrogen fixing plants** also contribute to atmospheric NO_x, by promoting nitrogen fixation by microorganisms

- **Impact on Environment:**
    - High levels of nitrogen dioxide and nitrogen monoxide **damages plant life**.
    - Nitrogen dioxide **contributes to the formation of acid rain** which **damages vegetation, buildings and water bodies**.
    - Nitrogen dioxide is also **involved in the formation of ground level ozone** which **damages vegetation and other materials**.
    - When NO_x and volatile organic compounds (VOCs) react in the presence of sunlight, they form **photochemical smog**.
    - Nitrogen dioxide can **react with other air pollutants to form peroxyacetyl nitrates (PANs)** which then carry reactive and potentially damaging nitrogen-containing species for long distances.
    - NO_x emissions cause **global cooling** through the formation of -OH radicals that **destroy methane molecules**, countering the effect of greenhouse gases.
- **Impact on human health:**
    - Inhalation of higher than average environmental levels of nitrogen dioxide / nitrogen monoxide (found around congested urban roads for example) can **cause respiratory problems**, particularly in sensitive individuals such as asthmatics.
    - Nitrogen monoxide
        - is found naturally in the body
        - is involved in the cardiovascular (heart and blood circulation) and immune (disease protection) systems.
        - Aggravate **asthmatic conditions**

Volatile Organic Compounds (VOC)

- They are categorized as either methane (CH_4) or non-methane (NMVOCs).
- Other hydrocarbon VOCs = significant greenhouse gases because of their role in creating ozone and prolonging the life of methane in the atmosphere.
- The aromatic NMVOCs benzene, toluene and xylene = suspected carcinogens and may lead to leukemia with prolonged exposure.
- Main indoor sources: perfumes, hair sprays, furniture polish, glues, air fresheners, moth repellents, wood preservatives
- **Impact on human health:**
    - Irritation of the eye, nose and throat, headaches, nausea and loss of coordination.
    - Long term - suspected to damage the liver and other parts of the body.

Particulate Matters



- **Natural Sources:**
  - Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray.
- **Anthropogenic sources:**
  - Burning of fossil fuels in vehicles, power plants
  - Various industrial processes
- **Impact on Human health:**
  - Anthropogenic aerosols—those made by human activities—currently account for approximately 10% of our atmosphere.
  - Increased levels of fine particles in the air are linked to health hazards such as heart disease, altered lung function and lung cancer.
  - Particulates are related to respiratory infections and can be particularly harmful to those already suffering from conditions like asthma.
  - Persistent free radicals connected to airborne fine particles are linked to cardiopulmonary disease.

Chlorofluorocarbons (CFCs)

- **Sources:** They are released from air conditioners, refrigerators, aerosol sprays, etc.
- **Environmental & Health impact:** On release into the air, CFCs rise to the stratosphere. Here they come in contact with other gases and damage the ozone layer. This allows harmful ultraviolet rays to reach the earth's surface. This can lead to skin cancer, eye disease and can even cause damage to plants.

Secondary pollutants:

- **Smog** is a kind of air pollution.
  - **Classic smog** results from **large amounts of coal burning in an area caused by a mixture of smoke and sulphur dioxide**.
  - **Modern smog** does not usually come from coal but from vehicular and industrial emissions that are acted on in the atmosphere by ultraviolet light from the sun to form secondary pollutants that also combine with the primary emissions to **form photochemical smog**.
- **Ground level ozone (O_3)** formed from NO_x and VOCs.
- **Peroxyacetyl nitrate ($C_2H_3NO_5$)** – similarly formed from NO_x and VOCs.

Persistent organic pollutants (POPs)

- They are organic compounds that are **resistant to environmental degradation through chemical, biological, and photolytic processes**.
- Because of this, they have been observed
    - To persist in the environment,
    - To be capable of long-range transport, bioaccumulate in human and animal tissue, biomagnify in food chains, to have potentially significant impacts on human health and the environment.

5.3 INDOOR AIR POLLUTION

- **'Indoor Air Pollution'** if indoor air is contaminated by smoke, chemicals, smells or particles.
- Unlike outdoor air pollution, the effect of indoor air pollution is health related and less of an environmental issue.
- **Causes:**
    - In colder regions, building and heating methods make use of airtight spaces, less ventilation and energy efficient heating.
    - Sometimes synthetic building materials, smells from household care and furnishing chemicals can all be trapped indoors. As less fresh air gets indoors, the concentration of pollutants such as pollen, tobacco smoke, mold, pesticides, radon, asbestos and carbon monoxide trapped inside the building increases and people breathe that in.
- **Common indoor air pollutants:**
    - **Tobacco smoke:** smoke burning cigarettes or exhaled smoke by people smoking.
    - **Biological Pollutants**: These include allergens such as pollen from plants, hair from pets, fungi and some bacteria.
    - **Radon:** This is a gas that is naturally emitted from the ground. Radon can be trapped in basements of building and homes. The gas is known to cause cancer after exposure over a period.
    - **Carbon Monoxide:** This is a poisonous gas with no color or smell. Carbon monoxide is produced when fuels such as gas, oil, coal or wood do not burn fully.
    - **Formaldehyde** is a gas that comes mainly from carpets, particle boards, and insulation foam. It causes irritation to the eyes and nose and may cause allergies in some people.
    - **Asbestos** is mainly a concern because it is suspected to cause cancer.
- **Effects of Indoor Air Pollution on Health**
    - About 2 million premature deaths per year, wherein 44% are due to pneumonia, 54% from **chronic obstructive pulmonary disease (COPD)**, and 2% from lung cancer.
    - The most affected groups are women and younger children, as they spend maximum time at home.

- The morbidities associated with indoor air pollution are respiratory illnesses, viz., acute respiratory tract infection and COPD, poor perinatal outcomes like low birth weight and stillbirth, cancer of nasopharynx, larynx, lung, and leukemia.
- The harmful health effects of formaldehyde range from being an acute irritant, reducing vital capacity, causing bronchitis, to being a carcinogen causing leukemia and lung cancer.

5.4 ADVERSE EFFECTS OF AIR POLLUTION

Effects on Weather and Climate

- Air pollution changes our planet's climate
  - Some types cause global warming to speed up.
  - Others cause global warming to slow down by **creating a temporary cooling effect** for a few days or weeks.

Depletion of Ozone

- **Chlorofluorocarbons attacked and destroyed the ozone layer, producing holes that would allow dangerous ultraviolet light to stream through**.
- **In the 1980s, huge "ozone holes" started to appear over Antarctica** => prompting countries to unite and sign an international agreement called the **Montreal Protocol**, which rapidly phased out the use of CFCs. As a result, the ozone layer—though still damaged—is expected to recover by the end of the 21st century.

Greenhouse Gas Effect

- Air pollution includes greenhouse gases.
- Greenhouse gases **cause global warming by trapping heat from the Sun in the Earth's atmosphere**.
- **Some air pollutants slow down global warming**
  - Cars, trucks, and smokestacks also release tiny particles into the atmosphere = called aerosols.
  - They can be made of different things such as mineral dust, sulfates, sea salt, or carbon.
  - While different types of aerosols act differently in the atmosphere, **the overall effect of aerosols is cooling**.

Smog

- Smog is often categorized as being either summer smog or winter smog.
  - **Summer smog** is primarily associated with the photochemical formation of ozone.
- During the summer season when the temperatures are warmer and there is more sunlight present, photochemical smog is the dominant type of smog formation.
- During the winter months when the temperatures are colder, and atmospheric inversions are common, there is an increase in coal and other fossil fuel usage to heat homes and

buildings. These combustion emissions, together with the lack of pollutant dispersion under inversions, characterize winter smog formation.

- Smog formation in general relies on both primary and secondary pollutants.

Photochemical Smog

- It is a type of air pollution **derived from vehicular emission from internal combustion engines and industrial fumes**.
- These pollutants react in the atmosphere with sunlight to form secondary pollutants that also combine with the primary emissions to form photochemical smog.
- In certain other cities, such as Delhi, smog severity is often aggravated by stubble burning in neighboring agricultural areas.
- The atmospheric pollution levels of Los Angeles, Beijing, Delhi, Lahore, Mexico City, Tehran and other cities are often increased by an inversion that traps pollution close to the ground.

Acid Rain

- When rain falls through polluted air, it can pick up some of the pollution and turn more acidic—producing acid rain. = **Air pollution converts the rain into a weak acid**.
- Environmental Impact:
    - When acid rain accumulates in lakes or rivers, it gradually turns the entire water more acidic.
    - fish thrive only in water that is neutral or slightly acidic (typically with a pH of 6.5–7.0).
    - Once the acidity drops below about pH 6.0, fish soon start to die—and if the pH drops to about 4.0 or less, all the fish will be killed.
    - It also **causes the death of forests, reduces the fertility of soil, and damages buildings by eating away stonework**

Effect on Agriculture

- According to recent study by scientists from IIT Kanpur,
    - **erratic behaviour of monsoon rainfall, including phenomenon of concentrated heavy rainfall on small number of days in localized area can be attributed to the rising air pollution**, especially the increase in suspended particles in the atmosphere.
    - **An increase in the aerosol content in the atmosphere, a direct consequence of rising air pollution, is interfering with the stable cloud formation system and influencing rainfall patterns**
    - **these changes in cloud structure and cloud dynamics lead to sharp variability in rainfall**, the kind of which is being witnessed very often in India in the last few years.
    - The high pollution levels are not just changing cloud shape and size and depth, but also its microstructure.

Effect on Health

- The health effects caused by air pollution may include difficulty in breathing, wheezing, coughing, asthma and worsening of existing respiratory and cardiac conditions.
- **Mortality:** The World Health Organization estimated in 2014 that every year air pollution causes the premature death of some 7 million people worldwide.
- **Cardiovascular disease:** Air pollution is also emerging as a risk factor for stroke, particularly in developing countries where pollutant levels are highest.
- **High numbers of premature deaths:** Findings of **'Know what you breathe' report** researched by IIT-Delhi in collaboration with environmental NGO Centre for Environment and Energy Development (CEED)
    - Worsening air quality in the last two decades has emerged as one of the major reasons for high numbers of premature (earlier than the expected lifetime of the Indian population) deaths due to chronic exposure from pollution.
    - Annual mortality linked to **air pollution** to be in the range of 150-300 persons per 1 lakh population.
    - Premature mortality burden would reduce by 14%-28% annually with the achievement of Indian air quality standards.
- **Findings of World Health Organisation (WHO) report** titled "Inheriting a sustainable world: Atlas on children's health and the environment"
    - Polluted environment kills around 1.7 million children a year.
    - Every year, environmental risks such as outdoor and indoor air pollution, unsafe water, second-hand smoke, lack of sanitation and inadequate hygiene results in **quarter of all global deaths of children under five**.

5.5 TECHNOLOGIES AS CONTROL MEASURE

Dust collector

- A dust collector is a system used to enhance the quality of air released from industrial and commercial processes by collecting dust and other impurities from air or gas.
- Five main types of industrial dust collectors are: Inertial separators, Fabric filters, Wet scrubbers, Unit collectors, Electrostatic precipitators

Electrostatic precipitators (ESP)

- It is a filtration device that **removes fine particles, like dust and smoke,** from a flowing gas using the force of an induced electrostatic charge minimally impeding the flow of gases through the unit.
- In contrast to wet scrubbers which apply energy directly to the flowing fluid medium, an ESP **applies energy only to the particulate matter being collected** and therefore is **very efficient in its consumption of energy (in the form of electricity)**.

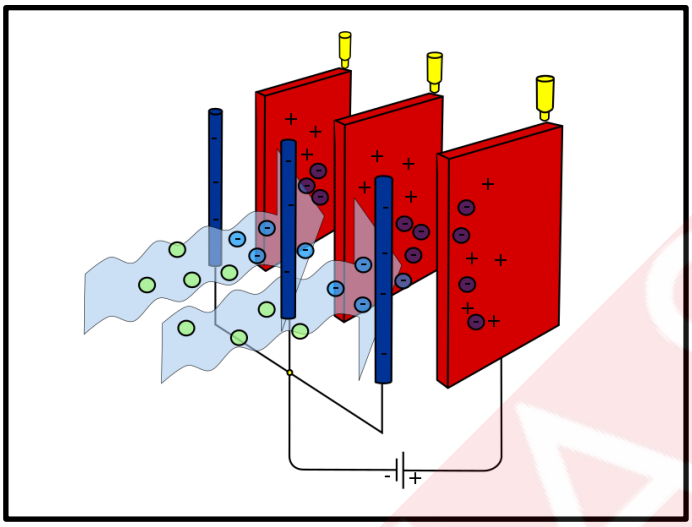


Fig: Conceptual diagram of an electrostatic precipitator

Catalytic converter

- **An exhaust emission control device**
- It converts **toxic gases and pollutants in exhaust gas from an internal combustion engine into less-toxic pollutants** by **catalyzing a redox reaction** (an oxidation and a reduction reaction).

Figure: Picture of catalytic converter

Biofiltration

- A pollution control technique using a bioreactor containing living material to capture and biologically degrade pollutants.
- Common uses include processing wastewater, capturing harmful chemicals or silt from surface runoff, and microbiotic oxidation of contaminants in air.

Scrubber systems

- Examples: chemical scrubbers, gas scrubbers
- These are a diverse group of air pollution control devices that can be used to remove some particulates and/or gases from industrial exhaust streams.

- Scrubbers are one of the primary devices that control gaseous emissions, especially acid gases.
- Scrubbers can also be used for heat recovery from hot gases by flue-gas condensation.

5.6 GOVERNMENT INITIATIVES

National Clean Air Programme(NCAP)

- The government has formulated NCAP as a medium term national level strategy to tackle the increasing air pollution problem across the country in a comprehensive manner.
- **Overall objective is :**
    - To augment and evolve effective ambient air quality monitoring network across the country
    - Ensuring comprehensive management plan for prevention, control and abatement of air pollution.

Technology Assessment Cell

- In order **to ensure use of new technologies** to combat the rising challenge of air pollution in India, a separate component on 'Technology Assessment Cell' has been envisaged under NCAP **to evaluate the technologies for prevention, control and abatement of air pollution**.

Harit Diwali-Swasth Diwali campaign

- Launched by Union Ministry of Environment, Forests and Climate Change (MoEFCC)
- aimed **to reduce adverse environmental conditions especially pollution in the country after post Diwali celebrations** due to excessive bursting of crackers which contributes significantly to air and noise pollution.

Graded Action Plan to reduce Urban Air Pollution

- The Government has notified a Graded Response Action Plan for Delhi and NCR
- It comprises **measures** such as
    - prohibition on entry of trucks into Delhi;
    - ban on construction activities,
    - introduction of odd and even scheme for private vehicles,
    - shutting of schools, closure of brick kilns, hot mix plants and stone crushers;
    - shutting down of Badarpur power plant,
    - ban on diesel generator sets, garbage burning in landfills and plying of visibly polluting vehicles etc.
- Besides, action related to stubble burning is to be implemented by Government of Punjab.

SAFAR (System of Air Quality and Weather Forecasting)

- It is **integral part of India's first Air Quality Early Warning System operational in Delhi**.
- It **will**
    - monitor all weather parameters like **temperature, rainfall, humidity, wind speed and wind direction**.
    - **measure sun's UV-Index (UVI), PM1, Mercury and Black carbon in real time**

- measure regular air quality and weather parameters like **PM2.5, PM10, Sulfur Dioxide, Ozone, Nitrogen Oxides, CO**.
- provide measurement of online automatic ultrafine particles PM1 and Mercury, both of which have direct relevance to human health.
- monitor existence harmful pollutants of **Benzene, Toluene and Xylene**.

National Air Quality Index: an initiative under Swachh Bharat Mission.

- It is '**One Number- One Colour-One Description**' for the common man to judge the air quality within his vicinity.
- It will put out real time data about level of pollutants in air.
- It takes multiple data on pollution already available with the country's **Central Pollution Control Board** and presents it as a color coded scale with six levels.
- Earlier measuring index was limited to 3 indicators, but NAQI has five additional (total 8) parameters.
- AQI will consider 8 pollutants (**PM10, PM2.5, NO2, SO2, CO, O3, NH3, and Pb**) for which short-term (up to 24-hourly averaging period) National Ambient Air Quality Standards are prescribed.

Major strategies/steps to tackle increasing air pollution in Indian cities and urban areas include

- Control and mitigation measures related to emissions from automobiles, industrial activities, notification of National Ambient Air Quality Standards;
- Formulation of environmental regulations / statutes;
- Setting up of monitoring network for assessment of ambient air quality;
- Introduction of cleaner / alternate fuels like gaseous fuel (CNG, LPG etc.), ethanol blending;
- Promotion of cleaner production processes;
- Universalization of BS-IV by 2017;
- Leapfrogging from BS-IV to BS-VI fuel standards by 1st April, 2020;
- Comprehensive amendments to various Waste Management Rules and notification of Construction and Demolition Waste Management Rules;
- Ban on burning of leaves, biomass, municipal solid waste;
- Promotion of public transport and network of metro, e-rickshaws, promotion of carpooling, Pollution Under Control Certificate, lane discipline, vehicle maintenance;
- Installation of on-line continuous (24x7) monitoring devices by major industries;
- Ban on bursting of sound emitting crackers between 10 PM to 6 AM etc;
- Issuance of directions under Section 18(1)(b) of Air (Prevention and Control of Pollution) Act, 1981 and under Section 5 of Environment (Protection) Act, 1986."

Environment Pollution (Prevention and Control) Authority (EPCA)

- Supreme Court mandated body **tasked with taking measures to tackle air pollution in the National Capital Region**.
- It was notified in 1998 by Environment Ministry **under Environment Protection Act, 1986**.
- Mandate:
  - to protect and improve quality of environment and prevent and control environmental pollution in National Capital Region.
  - to **enforce Graded Response Action Plan (GRAP) in NCR as per the pollution levels**.
- In November 2017, EPCA had enforced
  - ban on brick kilns,
  - closure of Badarpur thermal power plant, hot mix plants and stone crushers, and construction activities in NCR.

5.7 CASE STUDY: The Great Smog of Delhi, 2016

- The situation could very well have been like **London's Great Smog of 1952**, which had caused at least 4,000 deaths.
- Levels of **PM2.5 and PM10** particulate matter hit 999 micrograms per cubic meter, while the safe limits for those pollutants are 60 and 100 respectively.
- Although smog can happen in any busy city, it's a particular problem in places **where the local climate (influenced by the ocean and neighboring mountains) regularly causes a 'temperature inversion'**.
  - Normally, air gets colder the higher up you go but in a temperature inversion the opposite happens: a layer of warm air traps a layer of cold air nearer the ground.
  - This acts like a lid over a cloud of smog and stops it from rising and drifting away.
  - Largely because of their traffic levels, smog afflicts many of the world's busiest cities, including Athens, Beijing, Delhi, Madrid, Mexico City, Milan, Paris, and Tokyo.

6. WATER POLLUTION

Water Pollution refers to deterioration of **physical** (such as colour, odour, turbidity, taste, temperature), **chemical** (such as acidity, alkalinity, salinity, etc.) and **biological** (presence of bacteria, coliform MPN, algae, etc.) characteristics of water through **natural and anthropogenic processes** to such an extent that it becomes **harmful to human beings, plants and animal communities.**

6.1 SOURCES OF WATER POLLUTANTS

- **Natural Sources:** It includes soil erosion, eroded and weathered sediments, landslides, coastal and cliff erosion, volcanic eruptions and decay and decomposition of plants and animals.

- **Anthropogenic Sources:** It includes:
    - **Industrial Sources:** It includes industrial wastewater that contains chlorides, sulphates, nitrates, mercury, cadmium, arsenic, radioactive substances, etc.
    - **Agricultural Sources:** It includes chemical fertilizers, pesticides, insecticides and herbicides, etc.
    - **Urban Sources:** It includes sewage, municipal and domestic garbages, industrial effluents from the industrial units located in the urban centers, fall out of particulate matter of automobile exhausts, etc.

6.2 NATURE OF WATER POLLUTION

- The **nature and intensity of water pollution** is linked with many factors like wastewater disposal and treatment system, hydrological conditions and self-purification capacity of the streams, characteristics of effluents getting discharged and socio-economic conditions of the communities generating the waste.
- The water pollution is assessed on the basis of certain parameters: Physical, chemical and biological parameters.
- **Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and DIssolved Oxygen (DO) and pH** values are important indicators of water quality.

6.3 TYPES OF WATER POLLUTION AND ADVERSE EFFECTS

Surface (River) Water Pollution

Surface water includes river, lake and pond water but here only river water pollution is discussed as lake water pollution is discussed separately.

Major River Water Pollutants:

1. Sewage Wastes
2. Infectious agents includes germs and viruses which causes several types of diseases like typhoid, dysentery, cholera, etc.
3. Plants nutrients and dissolved substances e.g. chemical fertilizers, detergents, etc.
4. Particulate Matter e.g. soil and mineral particles
5. Radioactive Substances released from nuclear reactors
6. Mineral and Chemical Substances coming from industries and mining operations
7. Thermal e.g. hot water released by power plants, nuclear reactors, industries, etc.
8. Organic chemical exotics such as synthetic materials like pesticides, insecticides, etc.

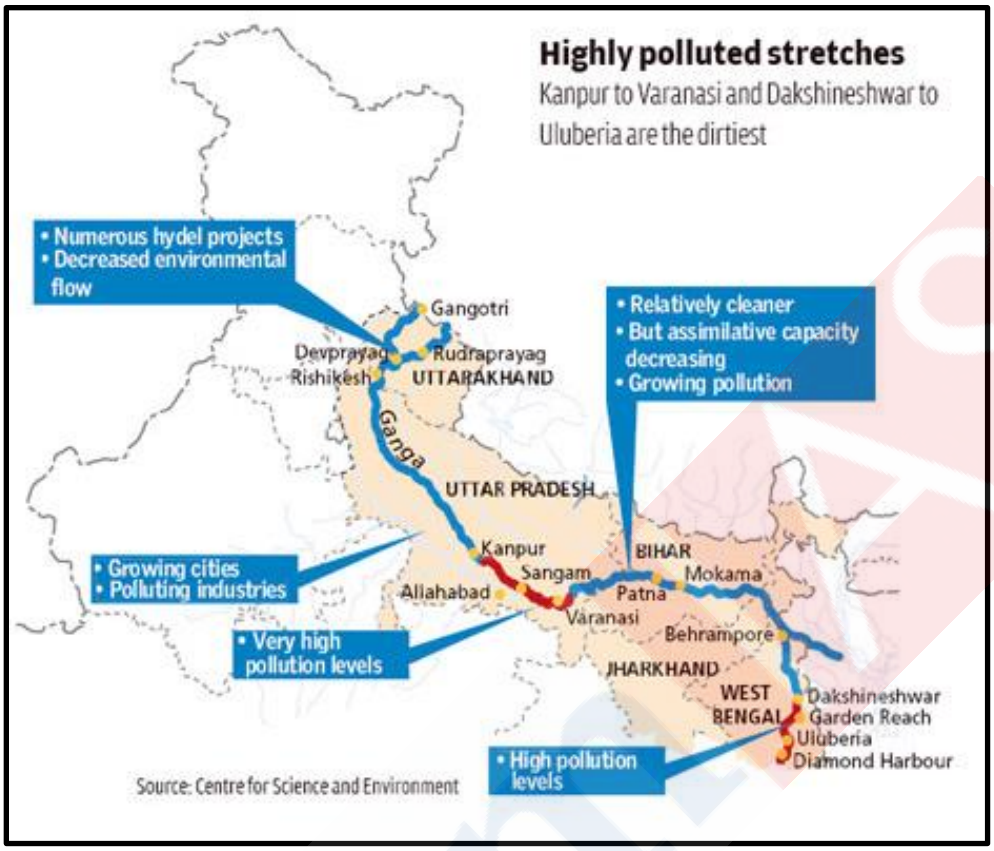
Sources of RIver Pollution

- **Point Pollution:** The main sources of point pollution of river waters are industrial and urban centers.
    - **Sewage Water**

        - Sewage water = discharges from houses, commercial and industrial establishments connected to public sewerage system.
        - The sewage contains human and animal excreta, food residues, cleaning agents, detergents and other wastes.
        - Domestic and hospital sewage contain many undesirable pathogenic microorganisms.
        - However, about 70% of the effluents are not treated and disposed off into the environmental media untreated.
    - **Industrial Wastes**
        - The industries discharge several inorganic and organic pollutants, which may prove highly toxic to the living beings.
        - Discharge of wastewater from industries like petroleum, paper manufacturing, metal extraction and processing, chemical manufacturing, etc., that often contain toxic substances, notably, heavy metals (defined as elements with density > 5 g/cm3 such as mercury, cadmium, copper, lead, arsenic) and a variety of organic compounds.
        - Geogenic contaminants : salinity, iron, fluoride, and arsenic
        - Plastic bags: not biodegradable, clog waterways, spoil the landscape; break down into ever smaller particles that continue to pollute the soil and water.
- **Non-Point Pollution:** discharge of pollutants from diffuse sources or from a larger area such as runoff from agricultural fields(agricultural runoff), grazing lands, construction sites, abandoned mines and pits, roads and streets.
    - Agricultural runoff contains dissolved salts such as **nitrates, phosphates, ammonia** and other nutrients, and toxic metal ions and organic compounds.
    - Excess fertilizers and pesticides may reach the ground water by leaching or may be mixed with surface water of rivers, lakes and ponds by runoff and drainage.
    - Animal excreta such as dung, wastes from poultry farms, piggeries and slaughter houses etc. = reach the water body though runoff and surface leaching during rainy season.
    - Huge amount of sediments caused by accelerated rate of soil erosion (such as deforestation) reaching the rivers is major cause of nonpoint pollution.

Examples of River Water Pollution in India

1. Pollution of Ganga



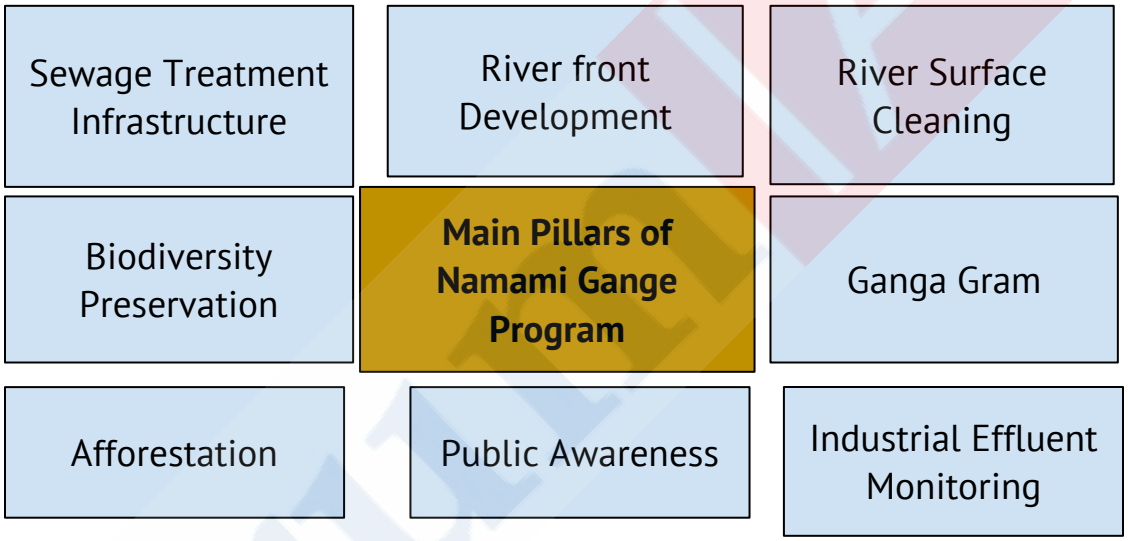
Causes

- **Human waste**
  - increase in the population density
  - various human activities such as bathing, washing clothes, the bathing of animals, and dumping of various harmful industrial waste into the rivers.
  - The river flows through 30 cities with populations over 100,000; 23 cities with populations between 50,000 and 100,000, and about 48 towns. A large proportion of the sewage water with higher organic load in the Ganga is from this population through domestic water usage.
- **Industrial waste:** Because of the establishment of a large number of industrial cities on the bank of the Ganga like Kanpur, Allahabad, Varanasi and Patna, countless tanneries, chemical plants, textile mills, distilleries, slaughterhouses, and hospitals prosper and grow along this and contribute to the pollution of the Ganga by dumping untreated waste into it.
  - Industrial effluents are about 12% of the total volume of effluent reaching the Ganga.
- **Religious traditions**
  - During festival seasons, over 70 million people bath in the Ganga
  - Some materials like food, waste or leaves are left in the Ganga which are responsible for its pollution.

- In Varanasi alone, an estimated forty thousand bodies are cremated every year, many of those are only half-burnt.

Clean up Efforts for Ganga

- **National River Ganga Basin Authority (NRGBA):** established by the Central Government of India, on 20 February 2009 under Section 3 of the Environment Protection Act, 1986.
- **Namami Gange Program:** It focus on pollution abatement interventions namely Interception, diversion and treatment of waste water flowing through the open drains through bio-remediation / appropriate in-situ treatment / use of innovative technologies / sewage treatment plants (STPs) / effluent treatment plant (ETPs); rehabilitation and augmentation of existing STPs and immediate short term measures for arresting pollution at exit points on river front to prevent inflow of sewage etc.



- **Clean Ganga Fund:** Aim of using the collection for various activities under the Namami Gange programme for cleaning the Ganga.
- **National Mission for clean Ganga:** It is the implementation wing of National Ganga Council which was set up in October 2016 under the River Ganga (Rejuvenation, Protection and Management) Authorities order 2016.

2. Pollution of Pamba River (Kerala)

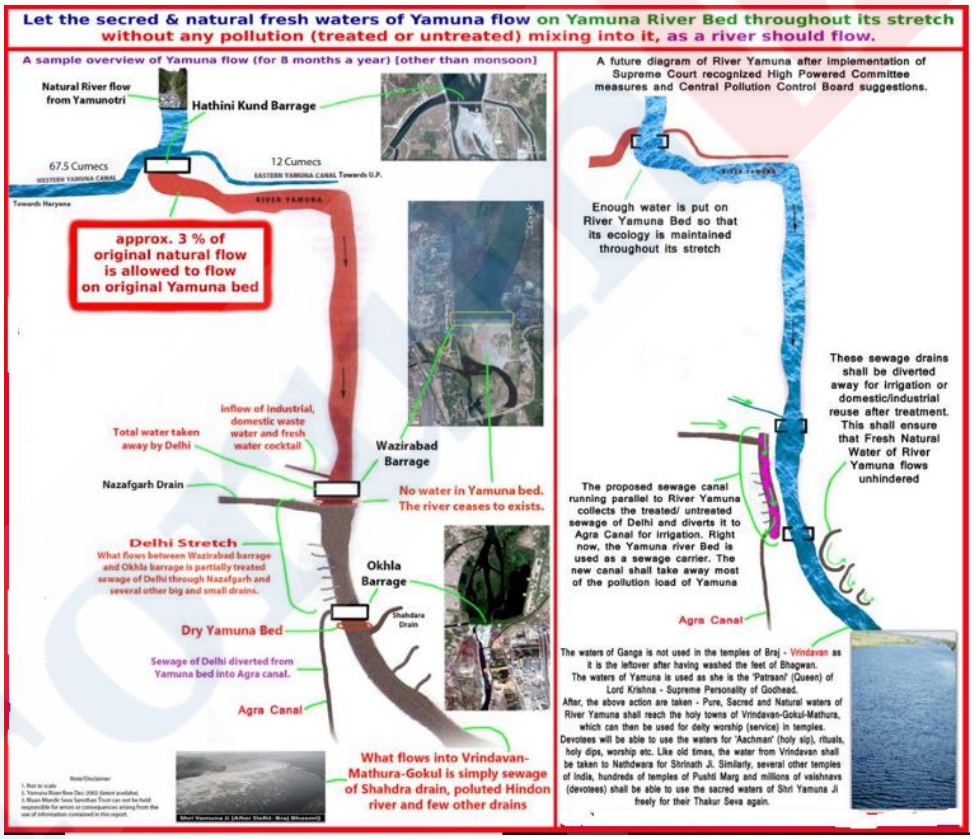
The water of the River, Pamba is influenced by:

- the wastewater from the pilgrim centre Sabarimala in the upper reaches of the river including the place, Pamba, where the pilgrims arrive.
- The Sabarimala temple area is placed in the upper Pamba River catchment area in the centre of a large forest
- the discharge of waste water from Municipalities in the middle and lower reaches of the Pamba.

- forestry and farming especially, the application of fertilizers and pesticides used in plantations
- other sources like rubber factories and further industrial and commercial activities.
- The heavy rainfalls during the monsoon period lead to a steady wash out from the soils directly into the river.
- The water of the Pamba River is influenced by bacteria, a huge amount of nutrients and oxygen consuming matter discharged during the three months pilgrim season.
- River Sand Mining + The extensive sandy plains at Maramon and Cherukole in Pamba are traditionally being used for holding annual religious congregations.

3. Pollution of Yamuna

- 323 million gallons of sewage enter the Yamuna per day through 17 open drains.
- The toxic effluents discharging into the Yamuna carry 125,000 kg of BOD, 250,000 kg of dissolved solids and 125,000 kg of suspended solids per day.



Lake Water Pollution

The causes of lake water pollution is similar to the river water pollution. However, the consequences in the lakewater pollution is more severe as the water is stagnant unlike river water.

1. Siltation of lakes due to dumping of enormous quantities of sediments due to accelerated rate of soil erosion.

2. Toxic effluents from the urban areas.
3. Washing and dumping of tailings or waste sludges from factories into stagnant water.
4. Inorganic nutrients from agricultural fields.
5. Acid rains: they are often called as **'Lake Killers'.**

   Case Study: Lakes of Canada of the State of Ontario

   Out of 250,000 lakes, 50,000 have been adversely affected by phenomenal increase in the acidity of water and significant lowering of pH due to acid rains. Out of these lakes 140 have been declared as dead lakes.

Case Study: Ulsoor Lake Pollution

Polluted by a vast floating layer of non-recycled debris comprising plastic bags and water bottles and even sacks. It witnesses frequent foaming on the surface.

Case Study: Bellandur Lake Pollution

Issue:

- It has become more or less a sewage tank because of untreated sewage water entering into the lake through various inlets. In theory, clean rainwater from Koramangala and Challaghatta (K&C) Valley should flow to Bellandur lake through stormwater drains. However, Bellandur lake gets sewage inflow due to two reasons.
- Improper sewage system due to which untreated sewage water overflows and joins storm water drains, mixes with rain water, which in turn flows to Bellandur lake via Koramangala and Challaghatta Valley.
- Lack of effluent treatment plants to treat industrial wastes from small factories which also get into the storm water drains.
- Fire at the lake: The cooking oil thrown from households that enters the lake from untreated domestic sewage is said to be the cause behind the fire.

Measures Needed for urgent restoration and remedial actions for Lake Pollution in the form of:

- Desilting of the lake is to eliminate contaminants
- Stop all encroachments of the lake with suitable fencing
- Only storm water should be allowed into the lake
- Army units should discontinue effluents from cattle house wash, cow dung wash and army mess wash and consider installation of a biogas plant.
- Plastic bags to be prevented from draining into the lake
- Sewage/manholes at identified locations to be closed.
- Drain water from slum around the lake to be treated before draining into the lake. Preferably, connect the slum storm water and wastewater drain to the nearby Cox Town sewage drain as it is close to the slums
- Prohibit submergence of idols during the festival season
- Remove all slum dwellers from region

- Cultivate and harvest fishes and aquatic plants to deplete the nitrogen and phosphate content

Seawater Pollution

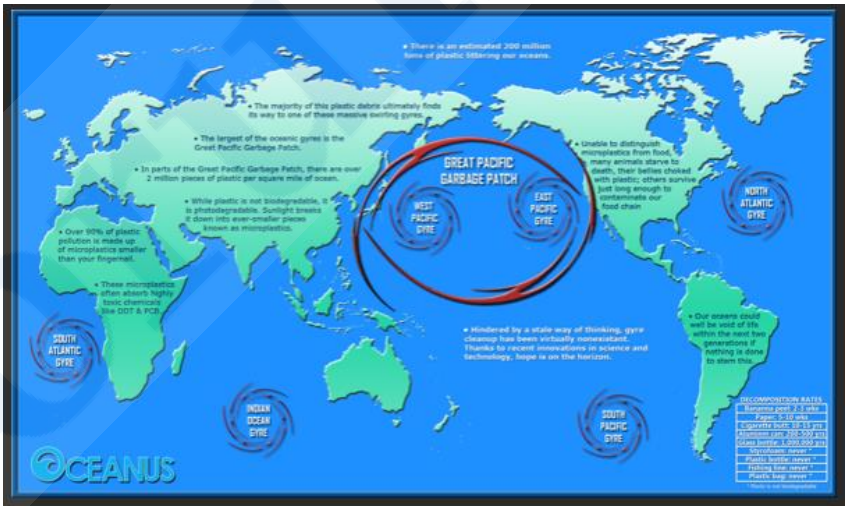
It is polluted mostly near the coast through the disposal of urban and industrial waste matters into the coastal waters.

Causes:

- Discharge of sewage, industrial effluents and toxic chemicals from the urban areas and industrial establishment.
- Discharge of solid waste materials mainly plastics, microbeads, etc. According to UNEP, plastic accounts for 90% of all debris floating in the oceans.
- Leakages of enormous quantity of mineral oil from oil wells and tankers. Ex. Ennore oil spill, Tar balls off Mumbai coast, Deep Horizon disaster, etc.
- Ballast water discharge
- Deep Sea Mining
- Increase in the concentration of heavy minerals like lead, cadmium, chromium, nickel, etc.

Consequences:

- **Oxygen depletion/hypoxia:** Increase in BOD due to eutrophication results in death of marine organisms. Ex. Planktons, mollusks, etc. Wilkinson Report: 1998 Red sea coral bleaching was due to disproportionate growth of algal bloom.
- **The Great Pacific Garbage Patch:**



- **Damage to marine biodiversity:** Bottles, plastics choke fishes, turtles, etc.

  Case study of Chennai oil Spill off (Ennore Port):
  - 40 tonnes of oil spillage (INCOIS)
  - 74 km stretch affected including Marina beach, Pulicat Lake (Bird sanctuary), Pichavaram mangroves
- **Damage to coral reefs** (Rainforest of the oceans)

- According to **Global Coral Reef Monitoring Network,** 20% of corals ex. Chitales are threatened due to toxic chemicals, oil spillage, pesticides, heavy metals, etc. as they introduces pathogens and causes bleaching.
- **Acidification of oceans:** It reduces calcium carbonate mineral affecting coral polyps, oysters, crabs, salmons, etc. in shell and fin formation.
- **Deep sea mining:** Damage to the habitats of benthic organisms like octopus, mollusks, eelgrass, etc.
- **Effect on food chain:** Heavy minerals like nickel, chromium (6), cadmium and bio accumulate in fishes and ultimately enters into human food chain (bioamplification). Ex. Minamata disease, DDT, etc.

Steps taken by Indian Government to reduce coastal pollution:

1. The present government has provided subsidies to the farmers of Tamil Nadu for transition towards **deep sea fishing** instead of bottom trawling fishing.
2. The **Society for Integrated Coastal Management (SICOM**) under Ministry of Environment, Forest and Climate Change is developing 13 beaches for blue flag certification under the **Unified Coastal Areas Management Program.**
3. Indian government has come up with **Coastal Regulation Zone (CRZ) Rules.**
4. India has become member of **Ballast Water Management Convention** under International Maritime Organization.

Issues related to controlling of seawater pollution:

1. The two formidable problems in conservation is:
    - International character of marine resources and right of all countries for their use
    - High mobility of marine organisms.
2. Lack of awareness among fishermen communities.
3. Lack of finance, infrastructure and capacity with Coastal Guards.
4. Absence of waste management facilities at the beaches.

Strategies to handle Oil Spillage:

1. **Oil spill modelling:**
   It provides a clear idea about oil movement and enhances the decision making strategy for quick response.
2. **Mathematical models:**
   The generic model to predict the movement of oil and the habitat specific model for detailed trajectory and impact analysis on marine resources. (Ministry of Earth Sciences)
3. **Use of GIS in estimation:**
   Information on bathymetry, oil concentration and thickness, quantity of dispersed oil may be incorporated in the maps.
4. Ecologically sensitive areas such as coral reefs, seagrass beds, mangroves, mudflats, and wildlife protected areas **may be layered.**

5. **Bioremediation Techniques:** Use of oil Zapper and Oilivorous-S (TERI) to degrade oil contaminants in-situ.
6. **Biostimulation and Bioaugmentation.**

Steps for the conservation of marine resources:

Food Resource:

1. The accurate estimation of the growth and mortality rate of marine organisms is a prerequisite condition to ensure their sustainable yield.
2. Proper survey of fishing areas by applying Eco-sounder techniques, maintaining catch statistics, etc.
3. Accurate prediction of future demand of fishes for human food and animal feed.
4. Proper knowledge of potential reserve
5. Developing and enriching Mari culture, ornamental fishing, marine pasture, etc.
6. Investments in Deep Sea Fishing instead of Bottom Trawling fishing.

International initiatives:

1. Full implementation of Paris Agreement (UNFCCC)
2. Blue Carbon Initiative (UNEP+IUCN+UNESCO) for the conservation and protection of marine and coastal biodiversity is in the right direction.
3. Coral Triangle Programme (WWF) around Indian coastal States.
4. India should become member of LONDON Convention.

Other measures:

1. Use of GIS, Bioremediation methods (Oil Zapper and Oilivorous-S), mathematical models in arresting oil spillage.

Therefore, it is necessary to enact international laws and to enforce them strictly for sustainable utilization of marine resources.

Groundwater Pollution

- Groundwater = rain water or water from surface water bodies, like lakes or streams, that **soaks into the soil and bedrock** and is **stored underground in the tiny spaces between rocks and particles of soil**.
- Groundwater pollution = **when hazardous substances come into contact and dissolve in the groundwater**
- **Causes:**
    - when rain/surface water comes into contact with contaminated soil while seeping into the ground = carry the pollution from the soil to the groundwater.
    - when liquid hazardous substances themselves soak down into the groundwater.
- **Impact in environment and human health:**
    - affect the health of animals and humans
        - when they drink or bathe in water contaminated by the groundwater or

        - when they eat organisms that have themselves been affected by groundwater contamination.
- **Arsenic:** Districts of Bihar, West Bengal, etc.
    - Major sources of arsenic in drinking water are
        - erosion of natural deposits;
        - runoff from orchards; and
        - runoff from glass & electronics production wastes.
    - Arsenic health effects: Some people who drink water containing arsenic well in excess of the MCL for many years could experience **skin damage** or **problems with their circulatory system**, and may have an **increased risk of getting cancer**.
- **Fluoride:** Major hit states: Rajasthan, Gujarat, Andhra Pradesh, etc.

Control of Water Pollution

- The control of water pollution is to reduce the pollution loads from anthropogenic activities to the natural regenerative capacity of the resource.
- Control of water pollution requires appropriate infrastructure and management plans.
- The infrastructure may include **wastewater treatment plants**.
- **Sewage treatment plants** and **industrial wastewater treatment plants** = required to protect water bodies from untreated wastewater.
- **Agricultural wastewater treatment for farms**
- **erosion control from construction sites**
- Nature-based solutions
- **Effective control of urban runoff** includes reducing speed and quantity of flow.

Measures taken by the Government to address the issues of groundwater pollution include the following:-

- Government of India has passed the **Water (Prevention and Control of Pollution) Act, 1974** to safeguard our water resources.
- Preparation of **action plan for sewage management** and **restoration of water quality in aquatic resources by State Governments**;
- **Installation of Online Effluent Monitoring System** to check the discharge of effluent directly into the rivers and water bodies;
- Continuous water quality monitoring systems are being established on industrial units in the country, through the directives issued by CPCB, for getting real time information on the effluent quality.
- Financial assistance for **installation of Common Effluent Treatment Plants for cluster of Small Scale Industrial units**;
- CPCB has made a comprehensive programme on water pollution for controlling point sources by developing industry specific standards and general standards for sewage which

have been notified under Environment (Protection) Act, 1986 which are to be enforced by the SPCBs/PCCs.

- Various steps including **Environmental Auditing**, **promotion of Common Effluent Treatment Plants**, **promotion of Low Waste and No Waste technology**, **augmenting flow in rivers**, **Rain Water Harvesting practices**, **implementation of guidelines prepared for idol immersion in rivers and lakes**, **promotion of Zero Liquid Discharge and sewage treatment infrastructure in the housing projects** etc. are being taken for the abatement of pollution.
- Implementation of **National River Conservation Plan (NRCP) for abatement of pollution** in identified stretches of various rivers.
- MoEFCC) has been supplementing the efforts of the State Governments in abatement of pollution of various rivers and lakes/wetlands under the National River Conservation Plan (NRCP) and National Plan for Conservation of Aquatic Ecosystem (NPCA) respectively.

Area of concern with regard to implementation of measures to control river, lake and groundwater pollution:

- Right now, there are **multiple agencies** involved in river and lake conservation, right from planning to implementation and monitoring. There is a **need to consolidate all these functions for better coordination and accountability**.
- **Lack of coordination** and ownership between the different agencies that are involved in programme/scheme implementation;
- Need for the government to review the l**ow levels of budgetary priority** given to environment programs in the country;
- **Need to strengthen truly representative public participation** in governmental programs;
- The imperatives of a comprehensive river basin approach for curbing river pollution as opposed to the extant town-based approach;
- The **requirement of legislations for**
    - **maintaining minimum amount of water/flow in lakes** and
    - **setting standards for nitrogen and phosphorus as measures of water quality**;

Issues and What more need to be done:

- The **treatment capacity of operational STPs is not adequate** due to an existing gap of more than 38600 KLD in sewage generation and treatment.
- CPCB has issued directions to all SPCBs / PCCs to **make it mandatory for local / urban bodies to set up STPs of adequate capacity** and **provide underground sewerage system to cover areas and bridge the treatment gap**.
- CPCB has issued directions to Municipal authorities of 46 metropolitan cities and 20 State capitals and 118 Ganga basin towns/ cities for treatment and utilization of sewage for restoration of water quality of rivers.

- National Mission for Clean Ganga (NMCG) proposes to **tap the drains and treat the waste water to improve the quality of water in river Ganga**.
- **Despite progress, providing safe drinking water to millions of India's rural people remains a challenge**.

CAG's recommendations to MoEF:

- MoEF/States need to **set out a clear policy on water pollution** which **takes into account prevention and control of water pollution as well as ecological restoration of degraded water bodies**.
- MoEF/CPCB should initiate steps, along with Ministry of Water Resources and all the States to **draw up a comprehensive inventory of all rivers, lakes and ground water sources in India**.
    - It should also undertake a survey to list the entire keystone species associated with each river and lake in India.
    - This should also be placed in the public domain.
- MoEF/CPCB should **intensify its efforts in developing biological indicators** which would shed light on whether the functional integrity of aquatic ecosystems is safeguarded.
- MoEF should **take into account the basin approach** while planning for reduction of pollution of all rivers and lakes in the country.
- **With respect to lakes, all three attributes i.e. the basin, the water body and the command area need to be conserved** instead of the present focus of NLCP on the water body only.
- MoEF needs to **establish enforceable water quality standards** for lakes, rivers and groundwater that would help protect human and ecosystem health.
    - Penalties need to be levied for violations of water quality standards.
    - MoEF, in conjunction with Ministry of Agriculture, needs to **develop standards for pollutants like nitrogen, phosphorus etc**., which arise from agricultural practices, use of pesticides and fertilisers as pollution from agricultural sources is one of the biggest non-point source of pollution.
- States should **involve citizens in proposing and monitoring programs to control pollution** of rivers and lakes.
    - This will help in mobilizing support in civil society for the proposed projects and thus the projects will face less resistance from local people.
    - **Citizens Monitoring Committee and Local Level Lake Monitoring Committees need to be constituted** to provide feedback for more effective implementation.

MoEF/CPCB, in conjunction with the States, should **conduct a city-wise assessment of the levels of pollution in our rivers and lakes.**

Thermal Pollution

- Power plants(thermal and nuclear), chemical and other industries use lot of water for cooling purposes => used hot water is discharged into rivers, streams or oceans.
- Discharge of hot water may increase the temperature of the receiving water by 10 to 15 °C above the ambient water temperature. This is thermal pollution.

Impacts:

- Increase in water temperature decreases dissolved oxygen in water which adversely affects aquatic life.
- Unlike terrestrial organisms, aquatic organisms are adapted to a uniform steady temperature of environment. Sudden rise in temperature kills fishes and other aquatic animals.
- Discharge of hot water in water body affects feeding in fishes, increases their metabolism and affects their growth.
- Their swimming efficiency declines.
- Their resistance to diseases and parasites decreases.

How to reduce thermal pollution?

Store the hot water in cooling ponds, allow the water to cool before releasing into any receiving water body

7. SOIL POLLUTION

Decrease in the quality of soils either due to anthropogenic sources or natural sources or by both is called soil pollution.

7.1 FACTORS OF SOIL POLLUTION

The main factors of soil pollution are:

- Accelerated rate of soil erosion
- Excessive use of chemical fertilizers, pesticides, insecticides and herbicides
- Polluted wastewater from industrial and urban centers
- Dumping of industrial and urban solid wastes
- Water logging and related capillary process
- Leaching processes

7.2 SOURCES OF SOIL POLLUTION

1. **Physical Sources:** it is related to soil erosion and consequent soil degradation caused by natural and anthropogenic sources. The natural factor include intensity of rainfall, temperature and wind, lithology, etc. These factors are further accelerated by human activities like overgrazing, mining, faulty agricultural practices, etc.

2. **Biological Sources:** It includes pathogenic micro-organisms excreted by human beings and animals, bacteria, protozoa, etc.
3. **Airborne Sources:** It includes pollutants released in the air by **human volcanoes'** i.e. chimneys of factories, etc. Huge quantities of particulate matters emitted from cement factories, lime kilns, coal mining, loading and unloading of coal,thermal power plants, etc, reach the soil and thus pollute them.
4. **Chemical Fertilizers and Biocides:** Excessive use of chemical fertilizers especially in the **Green Revolution areas** of India causes alteration in the physical and chemical properties of soil.
5. **Urban and Industrial Sources:** Industrial Effluents, sewages, plastics, solid wastes, etc. changes the physical and chemical composition of the soil.

7.3 ADVERSE EFFECTS OF SOIL POLLUTION

Effects on Human Beings:

- It leads to substantial decrease in the productivity of the soil. It renders land unusable for farming, thus endangering food security of a nation.
- Arsenic containing pesticides and sodium fluoroacetate reaches the food chains and causes gastric and digestive problems.
- Soil erosion through rill and gully erosion converts the land into wastelands.

Effects on Animals:

- Plastics in the soil causes death to animals.
- Fertilizers and pesticides also reaches them through food chains.

Effects on Plants:

- Plant growth process reduces due to over saturation of minerals and nutrients.

7.4 CONTROL OF SOIL POLLUTION

- To implement various control measures of soil erosion.
- Controlled and judicious uses of fertilizers, pesticides and insecticides.
- Development of organic pesticides and insecticides.
- Immediate restriction on the use of DDT.
- Proper disposal of urban and industrial wastes.
- Proper land use and crop management.
- Education to farmers about the proper uses of fertilizers.

8. SOLID WASTE POLLUTION

According to **MoEFCC**, **62 million tonnes of waste** is generated annually in the country at present, out of which 5.6 million tonnes is plastic waste, 0.17 million tonnes is biomedical waste, hazardous waste generation is 7.90 million tonnes per annum and 15 lakh tonnes is e-waste. Only about 75-

80 per cent of the municipal waste gets collected and only 22-28 percent of this waste is processed and treated.

8.1 WHAT IS SOLID WASTE?

- Solid waste is the **unwanted or useless solid materials generated from human activities** in residential, industrial or commercial areas.
- It may be categorised in three ways. According to its:
    1. origin (domestic, industrial, commercial, construction or institutional)
    2. contents (organic material, glass, metal, plastic paper etc)
    3. hazard potential (toxic, non-toxin, flammable, radioactive, infectious etc).

8.2 MAGNITUDE OF THE PROBLEM:

- In metro cities in India, an individual produces an average of **0.8 kg/ waste/person daily**.
- The total municipal solid waste (MSW) generated in urban India has been estimated at **68.8 million tons per year** (0.573 million metric tonnes per day in the year 2008).
- The average collection efficiency of MSW ranges from 22% to 60%.
- MSW typically contains 51% organic waste, 17% recyclables, 11% hazardous and 21% inert waste.
- However, **about 40% of all MSW is not collected at all** and hence
    - lies littered in the city/town
    - finds its way to nearby drains and water bodies
    - causing choking as well as pollution of surface water.
- Unsegregated waste collection and transportation leads to
    - dumping in the open, which generates leachate and gaseous emissions
    - causing nuisance in the surrounding environment.
- Leachate contaminate the groundwater as well as surface water in the vicinity and gaseous emissions contribute to global warming.

8.3 TYPES OF SOLID WASTES

- **Municipal Solid Waste (MSW):**
    a. It consists of household waste, construction and demolition debris, sanitation residue, and waste from streets, generated mainly from residential and commercial complexes.
    b. As per the MoEF it includes commercial and residential waste generated in municipal or notified areas in either solid or semi-solid form excluding industrial hazardous wastes but including treated bio-medical wastes.
    c. It includes Plastics waste, E-waste, construction and demolition waste.
- **Industrial Solid Waste (ISW):** In a majority of cases it is termed as hazardous waste as they may contain toxic substances, are corrosive, highly inflammable, or react when exposed to certain things e.g. gases.
- **Biomedical waste or hospital waste:**

a. It is usually infectious waste that may include waste like sharps, soiled waste, disposables, anatomical waste, cultures, discarded medicines, chemical wastes, etc., usually in the form of disposable syringes, swabs, bandages, body fluids, human excreta, etc.
b. These can be a serious threat to human health if not managed in a scientific and discriminate manner.

8.4 SOLID WASTE MANAGEMENT

Centralised method:

- This method involves collection of municipal waste from all over the local area and by means of landfilling, dump outside the city/nagar panchayat limits.
- This process looks at door-to-door collection of solid waste by waste pickers who hand over to the collection team who then discard the collected waste in the landfill.
- The waste pickers are employees of the Municipal Corporation or Nagar Panchayat.
- The collection team is generally contracted out by a tendering process.

Decentralized method:

- This is a model seen in a few places like Suryapet in Andhra Pradesh and Bangalore in Karnataka.
- The waste is collected ward-wise and is segregated at source into biodegradable and non-biodegradable.
- The biodegradable waste is composted at a nearby facility by different methods of aerobic and anaerobic composting.
- The non-biodegradable waste is further categorised into paper, plastic, metal and other waste and then further collected by recyclers for up-cycling or downcycling of products.

8.5 TREATMENT METHODS FOR SOLID WASTES

- **Thermal Treatment**: Incineration is the combustion of waste in the presence of oxygen, so that the waste is converted into carbon dioxide, water vapour and ash.
    - Also labeled Waste to Energy (WtE) method, it is a means of recovering energy from the waste.
    - **It's advantages** : waste volume reduction, cutback on transportation costs and reduction of greenhouse gas emissions.
    - **Disadvantages**: when garbage is burned, pollutants, such as mercury, lead, dioxins may be released into the atmosphere, and cause health issues.
- **Pyrolysis and Gasification**: In this method, thermal processing is **in complete absence of oxygen or with less amount of air**.
- **Biological Treatment Methods**: This involves **using microorganisms to decompose the biodegradable components of waste**. The 2 types of processes:
    - Aerobic: This needs the presence of oxygen and includes windrow composting, aerated static pile composting & in-vessel composting, vermiculture etc.

- Anaerobic digestion: Takes place in the absence of oxygen.

- **Landfills and Open Dumping**:
  - **Sanitary landfills:** It is the controlled disposal of waste on land in such a way that contact between waste and the environment is significantly reduced and the waste is concentrated in a well-defined area.
  - Dumps are open areas where waste is dumped exposing it to natural elements, stray animals and birds. With the absence of any kind of monitoring and no leachate collection system, this leads to the contamination of both land and water resources.

8.6 RULES AND REGULATIONS ASSOCIATED WITH SOLID WASTE MANAGEMENT

- Under the **74th Constitutional Amendment**, Disposal and management of Municipal Solid Waste is one of the 18 functional domains of the Municipal Corporations and Nagar Panchayats.
- **The various rules and regulations for solid waste management are:**
  1. The Bio-Medical Waste (Management And Handling) Rules
  2. Municipal Solid Waste (Management And Handling) Rules
  3. The Plastic Waste (Management And Handling) Rules
  4. E-Waste (Management And Handling) Rules
  5. Construction and Demolition waste (Management and Handling) Rules

Municipal Solid Waste Management Rules 2016

- It will replace the Municipal Solid Wastes (Management and Handling) Rules, 2000, which have been in place for the past 16 years.
- **Applicable beyond municipal areas** and **have included urban agglomerations, census towns, notified industrial townships, areas under the control of Indian Railways, airports, special economic zones, places of pilgrimage, religious and historical importance, and State and Central Government organisations in their ambit**.

Major Highlights of Solid Waste Management Rules 2016:

- **Segregation at source**
  - The new rules have **mandated the source segregation of waste** in order **to channelise the waste to wealth by recovery, reuse and recycle**.
  - Waste generators would now have to now segregate waste into three streams- Biodegradables, Dry (Plastic, Paper, metal, Wood, etc.) and Domestic Hazardous waste (diapers, napkins, mosquito repellants, cleaning agents etc.) before handing it over to the collector.
  - Institutional generators, market associations, event organisers and hotels and restaurants have been **directly made responsible for segregation and sorting the waste and manage in partnership with local bodies**.
  - **All hotels and restaurants will also be required to segregate biodegradable waste** and set up a system of collection to ensure that such food waste is utilised for composting / biomethanation.

- **Collection and disposal of sanitary waste**
    - The **manufacturers or brand owners of sanitary napkins are responsible** for awareness for proper disposal of such waste by the generator and shall provide a pouch or wrapper for disposal of each napkin or diapers along with the packet of their sanitary products.
- **Collect Back scheme for packaging waste**
    - Brand owners who sale or market their products in packaging material which are non- biodegradable, should put in place a system to collect back the packaging waste generated due to their production.
- **User fees for collection**
    - Municipal authorities **will levy user fees for collection, disposal and processing from bulk generators**.
    - The generator will have to pay "User Fee" to the waste collector and a "Spot Fine" for littering and non-segregation, the quantum of which will be decided by the local bodies.
    - **The integration of rag pickers, waste pickers and kabadiwalas from the informal sector to the formal sector by the state government.**
    - **Stipulate zero tolerance for throwing; burning, or burying the solid waste** generated on streets, open public spaces outside the generator's premises, or in the drain, or water bodies.
- **Waste processing and treatment**
    - it has been advised that the biodegradable waste should be processed, treated and disposed of through **composting or bio-methanation**
    - the rules have mandated bio- remediation or capping of old and abandoned dump sites within five years.
- **Promotion of waste to energy**
    - In a not-so welcoming move, the SWM Rules, 2016 **emphasise promotion of waste to energy plants**.
    - the Ministry of New and Renewable Energy Sources should facilitate infrastructure creation for Waste to Energy plants
- **Revision of parameters and existing standards**
    - the landfill site shall be 100 metres away from a river, 200 metres from a pond, 500, 200 metres away from highways, habitations, public parks and water supply wells and 20 km away from airports/airbase.
- **Management of waste in hilly areas: construction of landfills on hills shall be avoided**.
- **Constitution of a Central Monitoring Committee:** The government has also constituted a Central Monitoring Committee under the chairmanship of Secretary, MoEF&CC to monitor the overall implementation of the rules.

8.7 PLASTIC POLLUTION

It is accumulation of plastic objects (plastic bottles and much more) that adversely affects wildlife, wildlife habitat and humans.

- Plastics that act as pollutants are categorized into micro-, meso-, or macro debris, **based on size**.
- We celebrated 'World Environment Day' (June 5) with a critical theme: **Beat the plastic Pollution**

Critical impact of Plastics

- About 50% of our plastic use is single use (disposable) and it constitutes 10% of the total waste generated.
- Each year, 13 million tonnes of plastic end up in the oceans.
- Researchers exploring the Arctic have found **very high levels of microplastics trapped in the ice**.
- **Plastic disposed of on land degrades slowly and its chemicals leach into the surroundings**.
- Drinking water samples analysed from 14 countries, including India, revealed that 83% have micro-plastics concentrations.
- According to a United Nations Environment Programme report, the overall annual natural capital cost of plastic use in the consumer goods sector is $75 billion.

What should we do?

- In reality, we cannot eliminate plastic use from our day-to-day activities.
- However, we **should not allow plastic to reach the soil or water**.
- The **government should restrict plastic production** and **encourage recycling through appropriate policies**.
- The '**Plastic Waste Management Rules**' need to be strictly followed.
- As most plastic items pass through our hands, public care, with **behavioural change, is necessary**.
    - **Household-wise waste segregation** is the key.
    - Every shopkeeper should go in for abd encourage the use of biodegradable packing materials while shoppers should use cloth bags. Mass public awareness on the dangers of plastic hazards is a prerequisite.
    - **Eco-friendly substitutes (cloth/paper/jute bags, leaves/areca leaf plates, paper straws) should be developed**.
    - For this, scientific and financial support (soft loans and subsidies) is required.
- Charges for plastic bag use and deposit-refund for plastic bottles may be effective options.
- The recent decision by the Cabinet Committee on Economic Affairs on extending the mandate on packing food grains and sugar products in jute bags is welcome.
- Even if the intention is to promote the jute industry, it is a step that reduces plastic pollution. The Swachh Bharat Mission should emerge as a platform for plastic waste management.

Plastic Waste Management (Amendment) Rules 2018

Features:

- the phasing out of Multilayered Plastic (MLP) is now applicable to MLP, which are "non-recyclable, or non-energy recoverable, or with no alternate use."
- prescribe **a central registration system for the registration of the producer/importer/brand owner**.
- lay down that any mechanism for the registration should be automated and should take into account ease of doing business for producers, recyclers and manufacturers.
- The centralised registration system will be evolved by Central Pollution Control Board (CPCB) for the registration of the producer/importer/brand owner.
- a national registry has been prescribed for producers with presence in more than two states,
- a state-level registration has been prescribed for smaller producers/brand owners operating within one or two states.

MICROPLASTICS/MICROBEADS

Microbeads are pieces of plastic, usually spherical in shape, that range in width from a fraction of a millimeter to about a millimeter and a quarter. They're used in soaps because exfoliating products need small, hard particles to rub debris from the skin. These particles can be natural materials, such as ground nut shells or crushed apricot seeds--or they can be manufactured products like microbeads.

Microbeads have become so ubiquitous that an estimated 808 trillion pieces swirl down American drains every day. One percent that escaped the sludge—roughly 8 trillion microbeads—are released directly into our waterways. That's enough plastic to cover 300 tennis courts.

Risks associated with exfoliating agents used in personal care products has alarmed green panel

What are microbeads?

- Microbeads are plastic pieces or fibre measuring less than 1 mm

What are microbeads made of?

- Microbeads used in personal care products are mainly made of polyethylene (PE), but can be also be made of polypropylene (PP), polyethylene terephthalate (PET), polymethyl methacrylate (PMMA) and nylon

What are they mainly used in?

- They are widely used in cosmetics as exfoliating agents and in personal care products such as toothpaste, as well as in biomedical and health science research. In layman's language, these microbeads are so small that a person can barely feel them. Their roundness and particle size create a ball-bearing effect in creams and lotions, resulting in a silky texture and spread ability

Why is it used?

- Microbeads have been used to replace natural exfoliating materials. Microspheres in different colors add visual appeal to cosmetic products because of which their usage is becoming more rampant

What is the danger from them?

Microbeads — largely non-biodegradable — flow through sewer systems and end up in seas and oceans, where they contribute to the huge chunk of plastic soup in the environment

Microbeads are also likely to be transported to wastewater treatment plants. Due to their small size, a substantial proportion passes through the filtration system and enters aquatic environments

8.8 HAZARDOUS WASTES

It is any waste, which by reason of characteristics, such as physical, chemical, biological, reactive, toxic, flammable, explosive or corrosive, causes danger to health, or environment. As per the information furnished by CPCB in the year 2015, the total hazardous waste generation in the country is 7.46 million metric tonnes per annum from about 44,000 industries.

Problems of unscientific disposal of Hazardous and other waste

- Unscientific disposal of hazardous and other waste through burning or incineration **leads to emission of toxic fumes comprising of Dioxins & Furans, Mercury, heavy metals**, **causing air pollution and associated health-related problems**.
- Disposal in water bodies, or in municipal dumps leads to **toxic releases due to leaching in land and water** entailing into **degradation of soil and water quality**.
- The workers employed in such unscientific practices suffer from neurological disorders, skin diseases, genetic defects, cancer etc.

- Hence, there is a need for systematic management of hazardous and other waste in an environmentally sound manner by way of prevention, minimisation, re-use, recycling, recovery, utilisation including co-processing and safe disposal of waste.

The salient features of Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 include the following:-

- It will ensure resource recovery and disposal of hazardous waste in environmentally sound manner.
- For the first time, Rules have been made to distinguish between Hazardous Waste and other wastes.
- Waste Management hierarchy in the sequence of priority of prevention, minimization, reuse, recycling, recovery, co-processing; and safe disposal has been incorporated.
- Co-processing as preferential mechanism over disposal for use of waste as supplementary resource, or for recovery of energy has been provided.
- Responsibilities of State Government for environmentally sound management of hazardous and other wastes have been introduced.
- The following items have been prohibited for import:
    - Waste edible fats and oil of animals, or vegetable origin;
    - Household waste;
    - Critical Care Medical equipment;
    - Tyres for direct reuse purpose;
    - Solid Plastic wastes including Pet bottles;
    - Waste electrical and electronic assemblies scrap;
    - Other chemical wastes especially in solvent form.
- State Government is authorized to prepare integrated plan for effective implementation of these provisions, and have to submit annual report to Ministry of Environment, Forest and Climate Change.
- State Pollution Control Board is mandated to prepare an annual inventory of the waste generated; waste recycled, recovered, utilised including co-processed; waste re-exported and waste disposed and submit to the Central Pollution Control Board by the 30th day of September every year.

8.9 BIOMEDICAL WASTES

- Any kind of waste **containing infectious (or potentially infectious) materials**.
- It includes waste associated with the generation of biomedical waste that visually appears to be of medical or laboratory origin (e.g., packaging, unused bandages, infusion kits, etc.), as well research laboratory waste containing biomolecules or organisms that are restricted from environmental release.
- Examples of infectious waste include **discarded blood, sharps, unwanted microbiological cultures and stocks, identifiable body parts** (including those as a result of amputation),

other human or animal tissue, **used bandages and dressings, discarded gloves**, other medical supplies that may have been in contact with blood and body fluids, and laboratory waste that exhibits the characteristics described above.

- Biomedical waste is **generated from biological and medical sources and activities**, such as the diagnosis, prevention, or treatment of diseases.

Salient features of Bio-Medical Waste Management (Amendment) Rules, 2018:

- Bio-medical waste generators including hospitals, nursing homes, clinics, dispensaries, veterinary institutions, animal houses, pathological laboratories, blood banks, health care facilities, and clinical establishments will have to **phase out chlorinated plastic bags (excluding blood bags) and gloves by March 27, 2019**.
- The State Pollution Control Boards/ Pollution Control Committees have to **compile, review and analyze the information** received and send this information to the Central Pollution Control Board, which seeks detailed information **regarding district-wise bio-medical waste generation**, information on Health Care Facilities having captive treatment facilities, information on common bio-medical waste treatment and disposal facilities.
- Every occupier, i.e. a person having administrative control over the institution and the premises generating biomedical waste **shall pre-treat the laboratory waste, microbiological waste, blood samples, and blood bags through disinfection or sterilization on-site** in the manner as prescribed by the World Health Organization (WHO) or guidelines on safe management of wastes from health care activities and WHO Blue Book 2014 and then sent to the Common bio-medical waste treatment facility for final disposal.

8.10 E-WASTES

- It is a term used to cover **all items of electrical and electronic equipment** and its parts **that have been discarded** by its owner as waste **without the intent of re-use**.
- **Composition**
    - loosely discarded, surplus, obsolete, broken, electrical or electronic devices.
    - computer and its accessories monitors, printers, keyboards, central processing units; typewriters, mobile phones and chargers, remotes, compact discs, headphones, batteries, LCD/Plasma TVs, air conditioners, refrigerators and other household appliances.
- **Why dangerous:**
    - contains toxic substances such as
        - **lead** and cadmium in circuit boards;
        - lead oxide and cadmium in monitor Cathode Ray Tubes (CRTs);
        - mercury in switches and flat biphenyls (PCBs) in capacitors and transformers and

        - brominated flame retardant on printed circuit boards, plastic casing, cable and polyvinyl chloride (PVC) cable insulation that release highly toxic dioxins and furans when burned to retrieve copper from the wires.
    - **presence of elements like lead, mercury, arsenic, cadmium, selenium, hexavalent chromium**, and flame retardants beyond threshold quantities make e-waste hazardous in nature.
    - creates serious pollution upon disposal.

Why e-waste pollution so critical?

- India generates around 2 million tonnes per annum (TPA) of E-waste of which 12% constituted of telecom equipment alone.
- India is the world's 5th largest e-waste producer acc to ASSOCHAM.
- In India, e waste accounts for 4% of global e-waste.
- A recent ASSOCHAM-NEC study on "Electricals & Electronics Manufacturing in India" has revealed that India recycles only 5% of its e-waste and the country is one of the biggest contributors of e-waste in the world.

Salient features of the E-waste (Management) Amendment Rules, 2018:

1. The e-waste collection targets under EPR = have been revised
2. The phase-wise collection targets for e-waste in weight shall be 10% of the quantity of waste generation, with a 10% increase every year until 2023.
    - After 2023 onwards, the target has been made 70% of the quantity of waste generation.
3. Separate e-waste collection targets have been drafted for new producers, i.e. those producers whose number of years of sales operation is less than the average lives of their products.
    - The average lives of the products will be as per the guidelines issued by CPCB from time to time.
4. Producer Responsibility Organizations (PROs) shall apply to the Central Pollution Control board (CPCB) for registration to undertake activities prescribed in the Rules.
5. Under the Reduction of Hazardous Substances (RoHS) provisions, **cost for sampling and testing shall be borne by the government** for conducting the RoHS test.
    - If the product does not comply with RoHS provisions, then the cost of the test will be borne by the Producers.

Norway model:

- Norway has **e-waste take back system** in place.
- The producers/importers of e-waste in Norway are **obliged to be members of a take-back company** and **have to pay a fee for their membership to the take-back companies**. This is how it provides the funding for collection and treatment of the waste.
- The take back companies in Norway need to get an approval from the Norwegian Environment Agency. The approval process includes

- **providing a plan detailing how they will collect e-waste** and treat it in an environmentally sound way.
- ensuring that they will collect all e-waste from their market share which is determined by how much of electronics is put into the market by their members.

8.11 CONSTRUCTION AND DEMOLITION WASTES

- The construction and demolition waste generated is about 530 million tonnes annually.

Government Intervention:

- The Ministry of Environment, Forest and Climate Change notified the Construction & Demolition Waste Management Rules, 2016.
- The rules are an initiative to effectively tackle the issues of pollution and waste management.

Construction and Demolition Waste Management Rules, 2016	**Likely implications**
Application: The rules **shall apply to everyone who generates construction and demolition waste** such as building materials, debris, rubble waste resulting from construction, re-modelling, repair and demolition of any civil structure of individual or organisation or authority.	This **will address the indiscriminate disposal of C& D Waste** and **enable channelization** of the waste **for reuse and recycling** in gainful manner

Responsibility of Waste Generators: ● Every waste generator shall be **responsible for collection, segregation of concrete, soil and others** and storage of construction and demolition waste generated **separately**, **deposit at collection centre** so made by the local body or handover it to the authorised processing facilities, **ensure that there is no littering or deposition** so as to prevent obstruction to the traffic or the public or drains. ● Waste generators shall **pay relevant charges for collection, transaction, processing and disposal** as notified by the concerned authorities;	● Duties of waste generators, service providers would **envisage people's participation (Jan Bhagidari) in scientific management** of C & D waste ● Segregation and channelizing the C & D waste **will improve the other waste utilisation and management** namely organic waste for composting, high calorific waste to energy recovery etc. ● This **will ensure Sustainability of Waste Management System** for C&D Waste
Responsibility of service providers: ● The service providers shall **prepare a comprehensive waste management plan** covering segregation, storage, collection, reuse, recycling transportation and disposal of construction and demolition waste generated within their jurisdiction. ● The service providers **shall remove all construction and demolition waste** in consultation with the concerned local authority on their own or through any agency.	The provision have been introduced on line of concept of Extended Producers Responsibility. Here, the waste generator (Service provider) has been **made responsible for waste generated by them in the public places** to authorized C&D waste recycling facilities.

Responsibility of Local Authority: ● Local Authority shall be **responsible for proper management of construction and demolition waste** within its jurisdiction including **placing appropriate containers for collection of waste**, **removal at regular intervals**, **transportation to appropriate sites for processing and disposal**.	This has been introduced to seek special attention of local bodies/ agencies responsible for waste management in the States. These provisions **will put in place the Institutional framework** for C& D waste management and also **strengthen system** for waste management wherever they exist in the country.
Processing and recycling facility for C & D waste ● The processing / recycling site **shall be away from habitation clusters, forest areas, water bodies, monuments**, National Parks, Wetlands and places of important cultural, historical or religious interest ● **A buffer zone of no development shall be maintained around solid waste processing and disposal facility**, exceeding five Tones per day of installed capacity.	This **will prevent indiscriminate disposal** and **ensure scientific conversion** C&D waste in to useful raw material for buildings/ construction.
Duties of the Central Pollution Control Board(CPCB) ● CPCB shall **prepare operational guidelines** related to environmental management of construction and demolition waste.	This is to **provide technical support** to local bodies, waste recyclers and other stakeholders.
Duties of the Central Government ● The Ministry of Urban Development, and the Ministry of Rural Development Ministry & Panchayat Raj, shall be responsible for **facilitating local bodies in compliance of these rules**; ● The Ministry of Environment, Forest and Climate Change shall be responsible for **reviewing implementation of these rules** as and when required.	Envisage the technical and financial support to the State Agencies from the Central Government for implementation of these Rules and modification of rules according to the requirement in future

8.12 METHODS TO REDUCE POLLUTION

- Recycling
- Reusing
- Waste Minimization
- Mitigation
- Composting
- Bioremediation methods.

Due to unprecedented population growth in developing countries and unsustainable pattern of consumption in the developed ones has created huge amount of wastes. These wastes have the potential to damage the ecological values of our environment. Thus, national and supranational institutions have to bring their policies in tandem to eradicate national and transboundary pollution through concerted efforts.

ForumIAS

CLIMATE CHANGE AND IT'S IMPACTS

Variability, in both time and space, is an inherent feature of climate, as the atmosphere is always in the state of turmoil and instability leading to variations in weather and climatic conditions.

What Is Climate? How Is It Different From Weather?

Weather:

- Weather is the **changes we see and feel outside from day to day**. It might rain one day and be sunny the next.
- Weather is dynamic and **changes from place to place**. It is a combination of wind, temperature, cloudiness, precipitation and visibility.

Climate:

- The difference between weather and climate is the measure of time.
- Climate is the **usual weather of a place averaged over some time period (usually 30 years)**.

Earth's climate:

- Earth's climate is what you get **when you combine all the climates around the world together**.

What Is Climate Change?

- Global warming and climate change - while closely related and sometimes interchangeably used technically refer to two different things.
- **"Global Warming"** applies to the long term trend of rising average global surface temperatures.
- **"Climate change"** is a broader term that reflects the fact that carbon pollution does more than just warm our planet. Carbon pollution is also changing rain and snow patterns and increasing the risk of intense storms and droughts.
- Another distinction between them is that scientists and scholars sees global warming mostly as human induced warming whereas climate change, on the other hand, can mean human induced changes or natural ones, such as ice ages.

Is Earth's Climate Changing?

- The planet has experienced climate change before: the Earth's average temperature has fluctuated throughout the planet's 4.54 billion-year history. The planet has experienced long cold periods ("ice ages") and warm periods ("interglacials") on 100,000-year cycles for at least the last million years.
- **Earth's climate is getting warmer**. But by how much? :: According to **1.5 Degree Report** of **IPCC** presented at **CoP 24 in Katowice, Poland**, the world has already warmed 1C since pre-industrial levels.

Climate Change Facts

- Global greenhouse gas emissions of G20 countries are continuing to increase.
- Between 1990 and 2013, the absolute CO2 emissions of G20 countries, which account for 3/4ths of global CO2 emissions, went up by 56%.
- Trends in global CO2 and total greenhouse gas emissions show that India's emissions have gone up by 4.7% in 2016

- For most major GHG emitters in the world, the emission figures have gone down, barring India and Indonesia
- Nearly 90% of the country's coal-fired power generation capacity is in violation of Sulphur Dioxide (SO2) emission limits notified two years ago.

Climate change: the debate

- While consensus among nearly all scientists, scientific organizations, and governments is that climate change is happening and is caused by human activity, a small minority of voices questions the validity of such assertions and prefers to cast doubt on the preponderance of evidence. **American President Donald Trump and Brazilian President Jail Bolsonaro are planning to withdraw from the Paris Agreement.**
- American historian of science Naomi Oreskes and others have shown the methods by which those with vested interests have funded scientists and politicians to challenge climate change, thereby sowing confusion.

- **Arguments of Climate change deniers:**
  Recent changes attributed to human activity can be seen as part of the natural variations in Earth's climate and temperature, and that it is difficult or impossible to establish a direct connection between climate change and any single weather event, such as a hurricane.
- **Counter argument:**
  While the latter is generally true, decades of data and analysis support the reality of climate change—and the human factor in this process.

What are the major climate change topics?

1. The 2015 Paris accord set a target of limiting global warming to 1.5º C by the end of the century. But diplomats **didn't agree on the details of how their nations will reach that ambitious goal**. The Bonn talks was suppose to flesh out **the rulebook** that countries have to abide by. This included **coming up with international standards** for **how to measure carbon emissions**, to **make sure that one nation's efforts can be compared to another's**.
2. A second debate centers around **how countries take stock of what's been achieved and set new, more ambitious goals for curbing carbon emissions after 2020**.
3. The third big issue concerns money. Experts agree that shifting economies away from fossil fuels and preparing countries for some of the inevitable consequences of climate change will require vast financial resources — including some from the US administration of President Donald Trump, which is doubtful about man-made climate change.
4. Fourth major issue was to find if Donald Trump pulling the US out of the Paris agreement would stall the hopes of progress in climate change negotiations.
5. Further, a major agenda of the meet (CoP 23 in Bonn) was to launch as so-called "***Global Alliance to Power Past Coal*".**

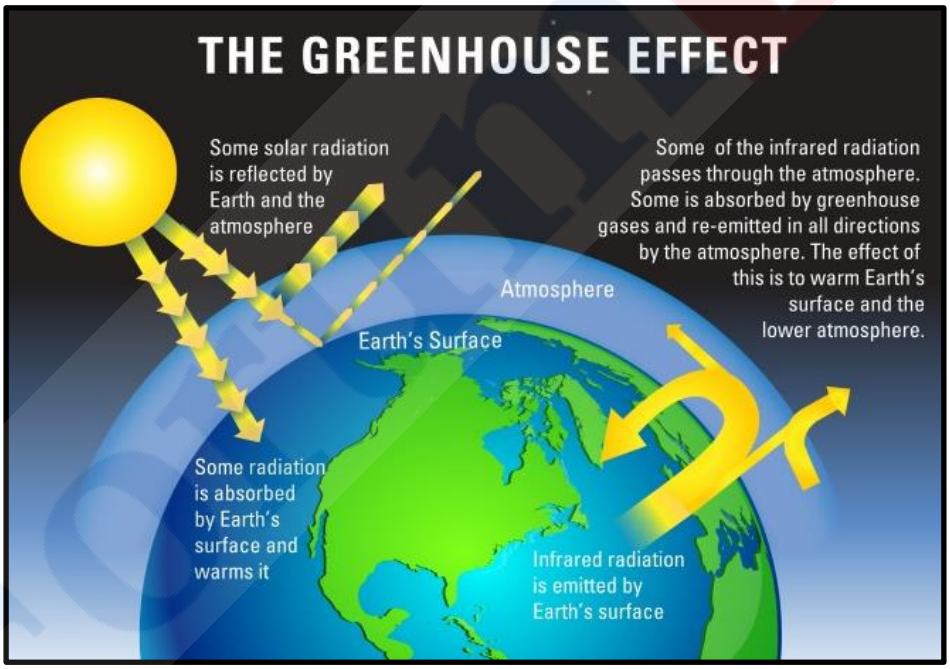
Impacts of Global Warming:

- Rise in sea level
- Changes in rainfall patterns. Example: Kerala Floods, 2018.
- Occurrence of extreme events like frequent intensification of hurricanes and cyclones, recurrent droughts, etc.
- Melting of glaciers and ice caps. Example: Melting of glaciers in Arctic Sea and Greenland.
- Widespread vanishing of populations due to habitat loss. Example: Snow Leopard in the Himalayas.

- Spread of disease (like malaria. etc).
- Bleaching of Coral Reefs.

Greenhouse Effect:

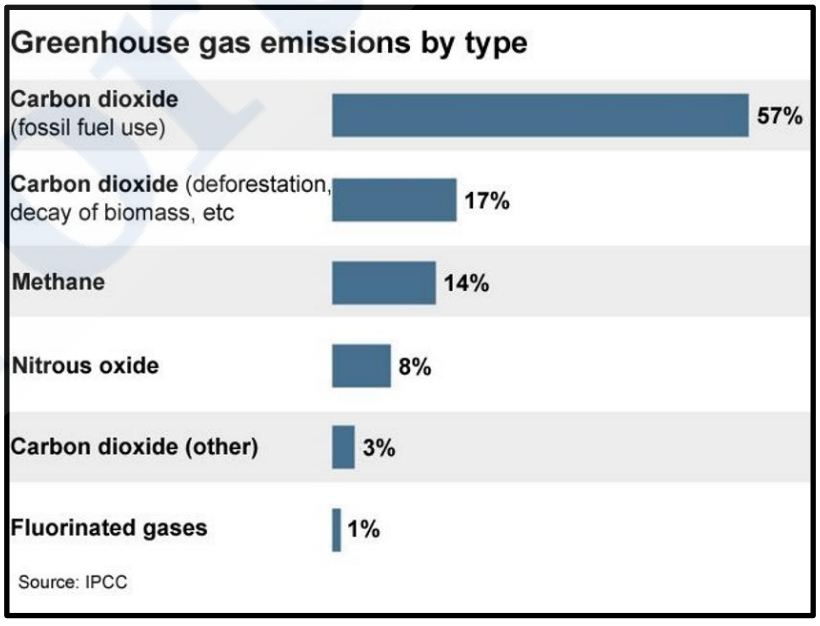
- The greenhouse effect refers to **the way the Earth's atmosphere traps some of the energy from the Sun**.
- The process:
    - Solar energy enters our atmosphere as **shortwave radiation** in the form of ultraviolet (UV) rays (the ones that give us sunburn) and visible light. The sun emits shortwave radiation because it is extremely hot and has a lot of energy to give off. Once in the Earth's atmosphere, clouds and the surface absorb the solar energy. The ground heats up and re-emits energy as **longwave radiation** in the form of infrared rays. Earth emits longwave radiation because Earth is cooler than the sun and has less energy available to give off.
    - Solar energy radiating (**Long wave infrared radiation**) back out to space from the Earth's surface is absorbed by atmospheric greenhouse gases and re-emitted in all directions.
    - The energy that radiates back down to the planet heats both the lower atmosphere and the surface. Without this effect, the Earth would be about 30ºC colder, making our planet hostile to life.



Greenhouse Gases

- A greenhouse gas is **a gas that absorbs and emits radiant energy within the thermal infrared range**. Greenhouse gases cause the greenhouse effect.
- Primary greenhouse gases in Earth's atmosphere = Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3)
- GHGs under **Kyoto Protocol**:
    - CO_2, N_2O and CH_4
    - Sulphur hexafluoride (SF_6),
    - Hydrofluorocarbons (HFCs) and
    - Perfluorocarbons (PFCs).

- A number of entirely human-made greenhouse gases in the atmosphere, such as the **halocarbons** and other **chlorine and bromine containing substances** are dealt with under the **Montreal Protocol**.
- Significance:
    - Without greenhouse gases, the average temperature of Earth's surface would be about −18 °C (0 °F), rather than the present average of 15 °C (59 °F).
    - The atmospheres of Venus, Mars and Titan also contain greenhouse gases.
- Water vapor accounts for by far the largest greenhouse effect (90–85%) because water vapor emits and **absorbs infrared radiation at many more wavelengths** than any of the other greenhouse gases, and there is much more water vapor in the atmosphere than any of the other greenhouse gases. CO_2 makes up only a tiny portion of the atmosphere (0.040%) and constitutes only 3.6% of the greenhouse effect.
- **If water vapour is the most important greenhouse gas, why all the fuss about CO_2?**
    - Water Vapour has a very short atmospheric lifetime (about 10 days) and is very nearly in a dynamic equilibrium in the atmosphere, so it is not a forcing gas in the context of global warming.
        - Scientists have identified carbon dioxide as the dominant greenhouse gas forcing.
        - Methane and nitrous oxide are also major forcing contributors to the greenhouse effect.
- **What will happen if we continue to emit GHGs?**
    - Should greenhouse gas emissions continue at their rate in 2017, Earth's surface temperature could exceed historical values as early as 2047, with potentially harmful effects on ecosystems, biodiversity and human livelihoods.
    - According to 1.5 Degree Report of IPCC, Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate.
    - At current emission rates temperatures could increase by 2 °C, which the United Nations' IPCC designated as the upper limit to avoid "dangerous" levels, by 2036.



2. Causes of climate change

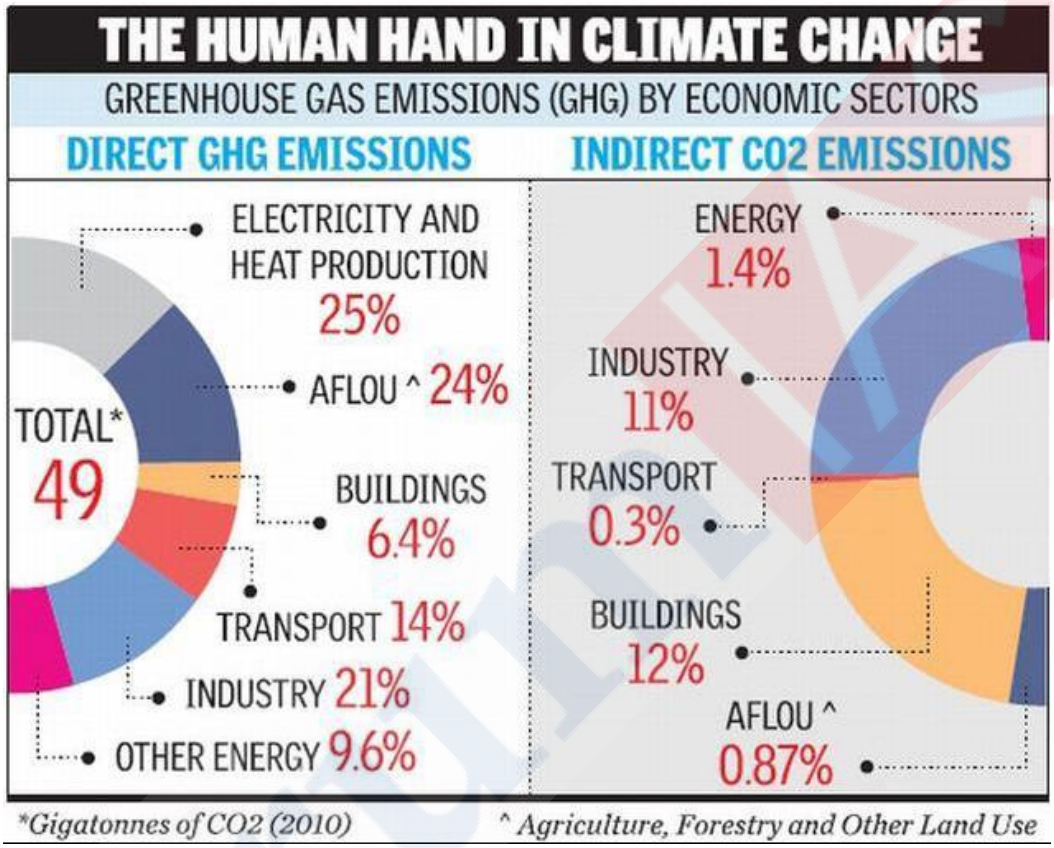
Natural causes:

- **Solar irradiance**
    - Changes in the sun's energy output would cause the climate to change, since the sun is the fundamental source of energy that drives our climate system.
    - Studies show that solar variability has played a role in past climate changes : a decrease in solar activity is thought to have triggered the **Little Ice Age** between approximately 1650 and 1850, when Greenland was largely cut off by ice from 1410 to the 1720s and glaciers advanced in the Alps.
    - But several evidences show that current global warming cannot be explained by changes in energy from the sun:
        - Since 1750, the average amount of energy coming from the sun either remained constant or increased slightly.
        - If the warming were caused by a more active sun, then scientists would expect to see warmer temperatures in all layers of the atmosphere. Instead, they have observed a cooling in the upper atmosphere, and a warming at the surface and in the lower parts of the atmosphere. That's because greenhouse gases are trapping heat in the lower atmosphere.
        - Climate models that include solar irradiance changes can't reproduce the observed temperature trend over the past century or more without including a rise in greenhouse gases.
- **Sunspot Cycles:**
    - The increased sunspot activity (increase in the number of sunspots) causes warming of the earth's surface and its atmosphere and vice versa.
    - Sunspots are darker and cooler areas in the photosphere of the sun.
- **Astronomical Theories**
    - The **Milankovitch Theory or Milankovitch Oscillation**s have tried to explain the causes of climate change through change in the eccentricity of earth's elliptical orbit, obliquity including of the earth's rotational axis and precession of the equinoxes
    - On the basis of above theory, he tried to explain the advancement and retreat of ice sheets during Pleistocene Ice Age.
- **Atmospheric Dust Hypothesis (mainly volcanic eruptions and dusts)**
    - The atmospheric solid particulate matters include dust particles, salt particles, polen, smoke and soot, volcanic dusts and ashes, etc.
    - **Black carbon (BC)** is a solid particle or aerosol, not a gas, but it also contributes to warming of the atmosphere.
        - Unlike GHGs, BC can directly absorb incoming and reflected sunlight in addition to absorbing infrared radiation.
        - BC can also be deposited on snow and ice, darkening the surface and thereby increasing the snow's absorption of sunlight and accelerating melt.
    - Sulfates, organic carbon, and other aerosols can **cause cooling by reflecting sunlight**.

Anthropogenic causes:

- Burning of fossil fuels : People drive cars. People heat and cool their houses. People cook food. All those things take energy. => Burning coal, oil and gas to generate energy => Burning these things puts gases into the air => The gases cause the air to heat up => This can change the climate of a place. It also can change Earth's climate.

- In its **5th Assessment Report**, the **Intergovernmental Panel on Climate Change**, a group of 1,300 independent scientific experts from countries all over the world under the auspices of the United Nations, concluded that there's a better than 95 percent probability that human-produced greenhouse gases such as carbon dioxide, methane and nitrous oxide have caused much of the observed increase in Earth's temperatures over the past 50 years.
- Deforestation, changes in land use, soil erosion and agriculture (including livestock).
- Industrial revolution
- Mining and Quarrying.



Climate Forcing:

- There are a number of natural mechanisms that can upset the global energy balance, for example **fluctuations in the Earth's orbit**, **variations in ocean circulation** and **changes in the composition of the Earth's atmosphere**.
- By altering the global energy balance, such mechanisms "force" the climate to change. Consequently, scientists call them "climate forcing" mechanisms.
- **Climate 'forcings'** are factors in the climate that either increase or decrease the effects to the climate system.
- **Positive forcings** such as greenhouse gases warm the earth while the **negative forcings** such as the volcanic eruptions, etc. cools the earth system.
- Examples of external forcings include:
    1. Surface reflectivity (albedo)
    2. Human induced changes in greenhouse gases
    3. Atmospheric aerosols (volcanic sulfates, industrial output)
- These examples influence the balance of energy entering and leaving the Earth system.

3. Ocean acidification

What is Ocean Acidification?

- When carbon dioxide (CO_2) is absorbed by seawater, chemical reactions occur that **reduces seawater pH**, carbonate ions concentration, and saturation states of biologically important calcium carbonate minerals. These chemical reactions are termed as "ocean acidification".

Dissolving CO_2 in seawater increases the hydrogen ion (H^+) concentration in the ocean, and thus decreases ocean pH, as follows:

$$CO_{2\,(aq)} + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons HCO_3^- + H^+ \rightleftharpoons CO_3^{2-} + 2\,H^+$$

- Calcium carbonate minerals are the building blocks for the skeletons and shells of many marine organisms.
- Since the beginning of the Industrial Revolution, the pH of surface ocean waters has **fallen by 0.1 pH units**. Since the pH scale, like the Richter scale, is logarithmic, this change represents approximately a 30% increase in acidity.
- Present ocean acidification is occurring at approximately **ten times faster rate than anything experienced during the last 300 million years**, **jeopardising the ability of ocean systems to adapt to changes in ocean chemistry due to CO_2**.
- Ocean acidification has the potential to **change marine ecosystems** and **impact many ocean-related benefits to society** such as coastal protection or provision of food and income.
- **Increased ocean temperatures** and **oxygen loss act concurrently** with **ocean acidification** and constitute the '**deadly trio**' of climate change pressures on the marine environment.
- **Future prospects:**
    - Future predictions indicate that the oceans will continue to absorb carbon dioxide, further increasing ocean acidity.
    - Estimates of future carbon dioxide levels, based on business as usual emission scenarios, indicate that by the end of this century the surface waters of the ocean could have acidity levels **nearly 150% highe**r, resulting in a pH that the oceans haven't experienced for more than 20 million years.

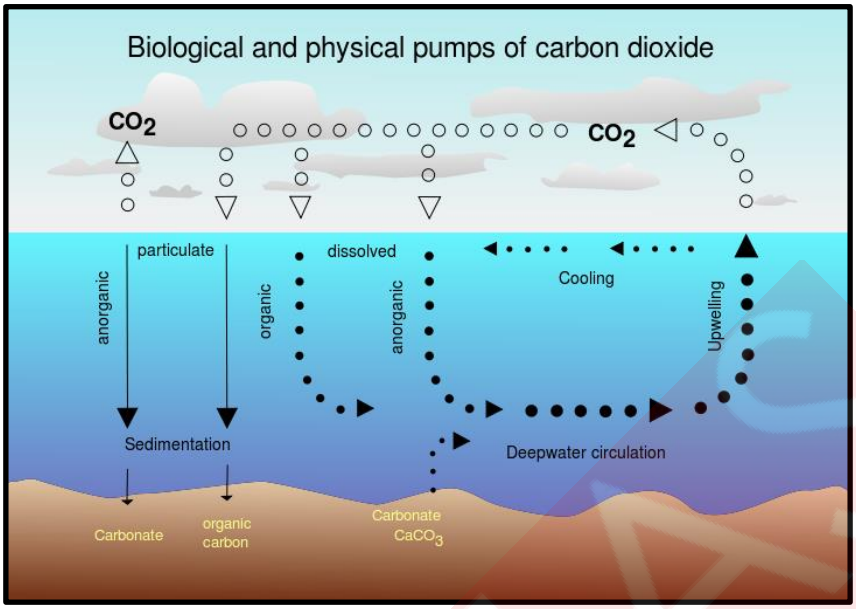
Impacts of Ocean Acidification

- In areas where most life now congregates in the ocean, the seawater is supersaturated with respect to calcium carbonate minerals.
    - This means there are abundant building blocks for calcifying organisms to build their skeletons and shells.
    - However, continued ocean acidification is causing many parts of the ocean to become undersaturated with these minerals, which is likely to affect the ability of some organisms to produce and maintain their shells. Example: oysters, clams, sea urchins, shallow water corals, deep sea corals, and calcareous planktons.
    - Photosynthetic algae and seagrasses may benefit from higher CO_2 conditions in the ocean, as they require CO_2 to live just like plants on land.
    - Certain fish's ability to detect predators is decreased in more acidic waters. When these organisms are at risk, the entire food web may also be at risk.
- An increase in **red tide events** : It could contribute to the accumulation of toxins (domoic acid, brevetoxin, saxitoxin) in small organisms such as anchovies and shellfish, in turn increasing occurrences of amnesic shellfish poisoning, neurotoxic shellfish poisoning and paralytic shellfish poisoning.
- ***Coral***
    - Increasing ocean acidification has been shown to significantly reduce the ability of reef-building corals to produce their skeletons.

- Ocean acidification could compromise the successful fertilization, larval settlement and survivorship of **Elkhorn coral, an endangered species.**
- Ocean acidification could severely impact the ability of coral reefs to recover from disturbance.
- By the end of this century, coral reefs may erode faster than they can be rebuilt. This could compromise the long-term viability of these ecosystems and perhaps impact the estimated one million species that depend on coral reef habitat.

Mitigation: Possible responses

- Reducing the build-up of CO_2 in the atmosphere.
- Reinvigorate action to reduce stressors, such as overfishing and pollution, on marine ecosystems to increase resilience to ocean acidification.
- Climate Engineering
  - **Ocean fertilization** or ocean nourishment is a type of climate engineering based on the purposeful introduction of nutrients to the upper ocean to increase marine food production and to remove carbon dioxide from the atmosphere.
  - **Enhanced weathering** is a chemical approach to remove carbon dioxide involving land- or ocean-based techniques.
    - Ocean-based techniques involve alkalinity enhancement, such as grinding, dispersing, and dissolving olivine, limestone, silicates, or calcium hydroxide to address ocean acidification and CO2 sequestration.
  - **Iron fertilization** of the ocean could stimulate photosynthesis in phytoplankton.
    - The phytoplankton would convert the ocean's dissolved carbon dioxide into carbohydrate and oxygen gas, some of which would sink into the deeper ocean before oxidizing.
    - Adding iron to the ocean increases photosynthesis in phytoplankton by up to 30 times.
  - **Biological pump**, in its simplest form, is the ocean's biologically driven sequestration of carbon from the atmosphere to the ocean interior and seafloor sediments. It is the part of the oceanic carbon cycle responsible for the cycling of organic matter formed mainly by phytoplankton during photosynthesis (soft-tissue pump), as well as the cycling of calcium carbonate (CaCO3) formed into shells by certain organisms such as plankton and mollusks (carbonate pump).



Issues with the mitigation approaches such as adding chemicals to counter the effects of acidification:

- likely to be **expensive**,
- **only partly effective** and **only at a very local scale**,
- **may pose additional unanticipated risks to the marine environment**.
- There has been very little research on the feasibility and impacts of these approaches. Substantial research is needed before these techniques could be applied.

Steps taken:

- Parties to the **United Nations Framework Convention on Climate Change (UNFCCC)** adopted a target of limiting warming to below 2 °C, relative to the pre-industrial level. Meeting this target would require substantial reductions in anthropogenic CO_2 emissions.
- Limiting global warming to below 2 °C would imply **a reduction in surface ocean pH of 0.16 from pre-industrial levels**. This would represent a substantial decline in surface ocean pH.

Way forward to combat Ocean Acidification:

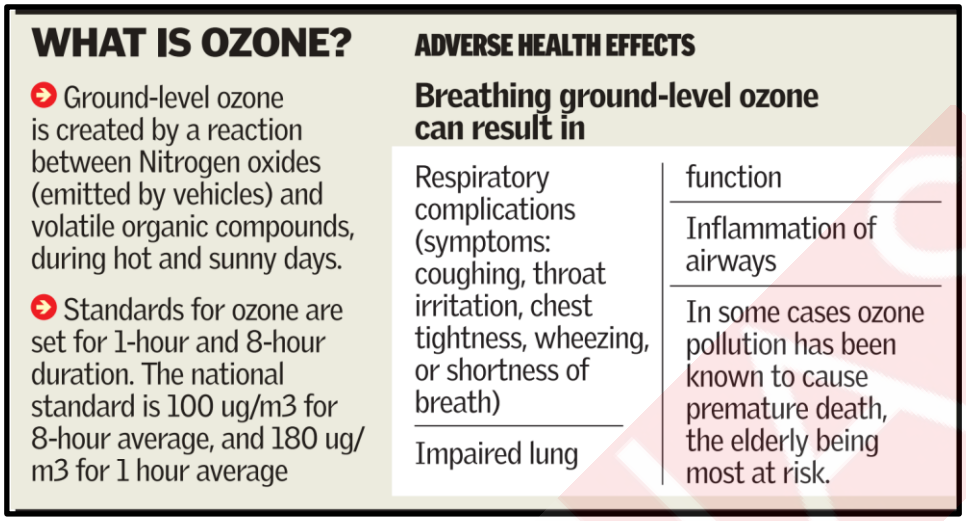
- To combat the worst effects of the deadly trio, **CO_2 emissions need to be cut significantly** and **immediately at the source**.
- Sustainable management, conservation, restoration and strong, permanent protection of at least 30% of the oceans are urgently needed.

4. Ozone depletion

Ozone

- Ozone is formed from di-oxygen by the action of ultraviolet light (UV) and electrical discharges within the Earth's atmosphere.
- It is present in very low concentrations throughout the latter, with its highest concentration high in the ozone layer of the stratosphere, which absorbs most of the Sun's ultraviolet (UV) radiation.
- **Significance:**
    - Ozone is a powerful oxidant (far more so than dioxygen) and has many industrial and consumer applications related to oxidation.

- At ground level, it has harmful effects on the respiratory systems of animals.
- However, in upper atmosphere, it creates ozonosphere, which prevents potentially damaging ultraviolet light from reaching the Earth's surface.
  - Ozonosphere is located 10-18 kilometres above Earth's surface.



Variation in thickness of Ozone Layer:

- The ozone layer is **not uniform throughout the earth**, being thin at equator and thickest at poles.
- It also varies with season, being in general thicker during the spring and thinner during the autumn in the northern hemisphere.

Ozone depletion

- It is the gradual thinning of Earth's ozone layer in the upper atmosphere caused by the release of chemical compounds containing gaseous chlorine or bromine from industry and other human activities.
- The thinning is most pronounced in the polar regions, especially over Antarctica.
- Ozone depletion describes two related events observed since the late 1970s:
  1. a steady lowering of about four percent in the total amount of ozone in Earth's atmosphere (the ozone layer), and
  2. a much larger springtime decrease in stratospheric ozone around Earth's polar regions. This phenomenon is referred to as the ozone hole.
- There are also springtime polar tropospheric ozone depletion events in addition to these stratospheric events.

Causes of Ozone layer depletion

- Main cause of ozone depletion and the ozone hole is manufactured chemicals, especially **manufactured halocarbon refrigerants, solvents, propellants and foam-blowing agents (chlorofluorocarbons (CFCs), HCFCs, halons)**, referred to as ozone-depleting substances (ODS).
  - They are compounds of chlorine, fluorine, and carbon such as CF_3Cl, $CHCl_2F$ etc.
  - These are used as refrigerants in refrigerators, air conditioners, and in cooling plants.
  - These molecules can destroy O_3 molecules and therefore depletion of the O_3 layer.
- **Nitrogen oxides (**such as nitrous oxide)
  - very reactive to O_3 and are also responsible for holes in the ozone layer.
  - released by burning fossil fuels by cars and especially airplanes which fly near the ozone layer.

Process of creation of Ozone Hole

- Ozone-depleting substances are transported into the stratosphere by the winds after being emitted from the surface.
- Polar Regions = much larger variation in sunlight. During the 3 months of winter = dark, no solar radiation.
- Temperatures reduce around or below -80°C for much of the winter. Extremely low Antarctic temperatures cause cloud formation in the relatively "dry" stratosphere.
- These **polar stratospheric clouds** (PSCs) are composed of ice crystals that provide surface for reactions, many of which speed up the degradation of ozone molecules.
- **Chemistry + dynamics + radiation** = Conditions conducive to significant ozone loss in the Polar Regions.
- The sequence of events leading to the spring time depletion of ozone is initiated of the earth's orbit at about 23.5° causes the polar regions to experience continual darkness during their winter season.
- The air above the pole cools and a vortex is formed that isolates and sets the stage for the rapid depletion of ozone by catalytic cycles.
    - **Catalytic cycle** is a series of reactions in which a chemical family or a particular species is depleted, leaving the catalyst unaffected.
- Chlorofluorocarbon-bonds (CFCs) themselves are **not involved in the catalytic process**. Upon reaching the stratosphere, they are subject to higher levels of ultraviolet radiation that decompose the CFCs and release atomic chlorine.

$$Cl + O_3 \rightarrow ClO + O_2 \quad \text{(step 1)}$$

$$ClO + O \cdot \rightarrow Cl + O_2 \quad \text{(step 2)}$$

$$O_3 + O \cdot \rightarrow 2O_2 \quad \text{(Overall reaction)}$$

Consequences of Ozone layer depletion:

- An increase of UV radiation would be expected to affect crops.
    - A number of economically important species of plants, such as rice, depend on Cyanobacteria residing on their roots for the retention of nitrogen.
    - Cyanobacteria are sensitive to UV radiation and would be affected by its increase.
    - Several of the world's major crop species are particularly vulnerable to increased UV, resulting in reduced growth, photosynthesis and flowering.
- Skin cancers, sunburns and premature aging of the skin
    - Basal and squamous cell carcinomas : the most common forms of skin cancer in humans
    - Malignant melanoma : another form of skin cancer
- Cortical cataracts : UV radiation can damage several parts of the eye, including the lens, cornea, retina and conjunctiva
- Weakening of the human immune system
- Planktons are threatened by increased UV radiations

Why Ozone hole mainly in Antarctica not in Arctic pole?

- Southern polar region is more colder and isolated than north => It favors the formation of polar stratospheric clouds (PSCs) which in turn serve as platforms for catalytic ozone breakdown
- As a consequence of having **less land**, the **circulation over the Antarctic is more persistent and vortex-like**, which favours PSCs.

- Air inside the vortex is prevented from mixing with warmer, ozone-rich air from lower latitudes (This vortex is not a feature of the Arctic).

Facts for Prelims:

- ***The International Day for Preservation of Ozone Layer (aka World Ozone Day) is observed every year on September 16*** for the preservation of the Ozone Layer.
- ***2018 Theme:*** 'Keep Cool and Carry On: The Montreal Protocol'.

Intervention to mitigate Ozone Layer Depletion:

The Montreal Protocol on Substances that Deplete the Ozone Layer

- The original Montreal Protocol was agreed on 16 September 1987 and entered into force on 1 January 1989.
- It was conceived after the detection of a large hole in earth's ozone layer over Antarctica.
- **Aim:** The main aim of this treaty was the elimination of Chlorofluorocarbons (CFCs) and HCFCs. As a replacement **HFCs** were proposed
- Montreal Protocol stipulates that the production and consumption of compounds that deplete ozone in the stratosphere-chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform-are to be phased out by 2000 (2005 for methyl chloroform).

Kigali Conference:

- Meeting of Parties (MoP) to the Montreal Protocol of the Vienna Convention for Protection of Ozone Layer took place in October, 2016, in Kigali (Rwanda).
- Why: The negotiations at Kigali were aimed at **including Hydrofluorocarbons (HFCs) in the list of chemicals under the Montreal Protocol** with a view to regulate their production and consumption and phase them down over a period of time with financial assistance from the **Multilateral Fund created under the Montreal Protocol.**
- **What are HFCs?**
    - HFCs are refrigerant gases used for commercial, residential and automotive purposes (and in other applications) but are hundreds to thousands of times more potent that carbon dioxide.
    - They were meant to replace HCFCs (hydrochlorofluorocarbons) in order to protect the ozone layer but their **global warming potential (GWP)** has increasingly become a matter of concern in climate negotiations.
- **What is GWP?**
    - It is a relative measure of how much heat a greenhouse gas traps in the atmosphere.
    - It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide.
- During negotiations held at Kigali India successfully negotiated the baseline years and freeze years which will allow sufficient room for the growth of the concerned sectors using refrigerants being manufactured domestically thus ensuring unhindered growth with least additional cost and maximum climate benefits.
- **Outcome of Kigali Conference:**
    - **there would be two set of baselines or peak years for developing countries**
    - India will have baseline years of 2024, 2025, 2026.
        - This decision gives additional HCFC allowance of 65% that will be added to the Indian baseline consumption and production.
    - The freeze year for India will be 2028, with a condition that there will be a technology review in 2024/2025 and, if the growth in the sectors using refrigerants is above certain agreed threshold, India can defer its freeze up to 2030.

- On the other hand, developed countries will reduce production and consumption of HFCs by 70% in 2029.
- India will complete its phase down in 4 steps from 2032 onwards with cumulative reduction of 10% in 2032, 20% in 2037, 30% in 2042 and 85% in 2047.

- **Significance of Kigali**
  - The Kigali Amendment is one that could avoid global warming by up to 0.5° C
  - India & China are the only countries in the world today that manufacture HFCs. **So, why India has been given a later freeze year?**
    - Because China's air conditioner market is bigger in size meaning its production of HFCs is also larger than India.
    - India's HFC consumption picks up only after 2025 while China will witness rapid emissions of HFCs from 2015-2030
  - The Kigali amendments to the Montreal Protocol will, for the first time, incentivise improvement in energy efficiency in case of use of new refrigerant and technology. Funding for R&D and servicing sector in developing countries has also been included in the agreed solutions on finance.

5. Impacts of climate change

Though all countries are affected by climate change, they are affected in different ways and to different extents.

Developing countries will be particularly badly hit, for three reasons:

- geography (non-temperate latitudes)
- stronger dependence on agriculture
- with their fewer resources comes greater vulnerability.

Impact of Climate Change on Agriculture

- Rise in coconut yields (with some exceptions); reduced apple production
- Negative impacts on livestock in all regions. Livestock of tropical regions would become more prone to infectious and parasitic diseases. Their productivity would decline. Indigenous breeds of India like Rathi, Tharparkar, Red SIndhi, etc. would be at danger.
- According to the **Turn Down The Heat: Climate Extremes, Regional Impacts and the Case for Resilience Report** (prepared by World Bank & looks at the likely impacts of 2°C and 4°C warming on agricultural production, water resources, coastal ecosystems and cities across South Asia, Sub-Saharan Africa, and Southeast Asia):
  - By the 2040s, India will see a significant reduction in crop yields because of extreme heat.
  - Reduced water availability due to changes in precipitation levels and falling groundwater tables are likely to aggravate the situation in India, where groundwater resources are already at a critical level and about 15% of the country's groundwater tables are overexploited.
  - In India, more than 60% of the crop area is rain-fed, making it highly vulnerable to climate-induced changes in precipitation patterns.
  - It is estimated that **by the 2050s, with a temperature increase of 2°C-2.5°C compared to pre-industrial levels, water for agricultural production in the river basins of the Indus, Ganges and Brahmaputra will reduce further** and may impact food adequacy for some 63 million people.
  - An extreme wet monsoon that currently has a chance of occurring only once in 100 years is projected to occur every 10 years by the end of the century.
  - Kolkata and Mumbai are 'potential impact hotspots' threatened by extreme river floods, more intense tropical cyclones, rising sea levels and very high temperatures.

- Significant reduction in crop yields predicted. Some 63 million people may no longer be able to meet their caloric demand.
- Decreasing food availability can also lead to significant health problems.
- Substantial reduction in the flow of the Indus and Brahmaputra in late spring and summer.
- Under 2°C warming by the 2040s, crop production in South Asia may reduce by at least 12%, requiring more than twice the imports to meet per capita demand than is required without climate change.
- Decreasing food availability can also lead to significant health problems, including childhood stunting, which is projected to increase by 35% by 2050 compared to a scenario without climate change.
- Major rivers such as the Ganges, Indus and Brahmaputra, depend significantly on snow and glacial melt water, which makes them susceptible to climate-change induced glacier melt and reductions in snowfall. The World Bank report projects **a rapid increase in the frequency of low snow years in the future, well before 2°C warming takes place**. This could increase the risk of flooding, threatening agriculture.

Climate Change and Soil/Land Degradation

- Land degradation means reduction in the potential of the land to produce benefits from a particular land use under a specified form of land management.
- Changes in climate are recognized as one of the major factors responsible for land degradation affecting sustained development.
- Land degradation encompasses change in chemical, physical and biological property of the soil.
- Soils are also crucial to food security and change in climate has threatened the food security by affecting the soil property.
- The increasing concentration of carbon dioxide in our atmosphere causes the microbes in the soil to work faster to break down organic matter, potentially releasing more carbon dioxide.
- Land exhibited to degradation as a consequence of poor land management could become infertile as a result of climate change.
- Land degradation hazards include wind and water erosion, loss of soil carbon, nutrient decline mass movement, soil structure decline, acid sulphate soils and soil acidification.

Climate Change and Erosion

- Climate change is expected to impact soils through changes in both soil erosion and rainfall.
- Changes in soil surface conditions, such as surface roughness, sealing and crusting, may change with shifts in climate, and hence affect erosion rates.
- Change in erosion can have significant implications for natural assets, agricultural lands and water quality.
- Increased rainfall amounts and intensities will lead to greater rates of erosion unless protection measures are taken.
- A significant potential impact of climate change on soil erosion and sediment generation is associated with the change from snowfall to rainfall.

Climate Change and Groundwater Depletion

- Groundwater depletion, a term often defined as long-term water-level declines caused by sustained groundwater pumping, is a key issue associated with groundwater use.
- Ground water plays a central part in sustaining ecosystems and enabling human adaptation to climate variability and change.

- Increased variability in precipitation and more extreme weather events caused by climate change can lead to longer periods of droughts and floods, which directly affects availability and dependency on groundwater.
- Groundwater depletion and contamination that will seriously compromise much of the world's agriculturally-grown food supply.
- Sea level rise because of climate change may lead to salt water intrusion into coastal aquifers affecting groundwater quality and contaminating drinking water sources.
- Increasing climate-change-induced storm surges will flood coastal areas, threatening the quality of groundwater supplies and compromising their usability.

Impact of Climate Change on Human health

- Higher morbidity and mortality from heat stress and vector/water-borne diseases
- Expanded transmission window for malaria as flooding would create opportunities for breeding of mosquitoes.
- The frequency and severity of Heat waves in Pakistan and India would increase.
- Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in East, South and SouthEast Asia due to projected changes in hydrological cycles.
- Dengue fever is already in evidence at higher levels of elevation in Latin America and parts of East Asia.

The Cryosphere and Global Climate Change

Cryosphere

The cryosphere is those portions of Earth's surface **where water is in solid form**, including sea ice, lake ice, river ice, snow cover, glaciers, ice caps, ice sheets, and frozen ground (which includes permafrost).

Significance:

In Arctic regions, sea ice provides a home for animals like seals and polar bears, feeding and breeding areas for a variety of migrating species, and hunting grounds for local communities.

Acting like a highly reflective blanket, the cryosphere **protects Earth from getting too warm**.

Snow and ice reflect more sunlight than open water or bare ground.

Changes in snow and ice cover affect air

- Melting Ice Causes More Warming

    - When solar radiation hits snow and ice approximately 90% of it is reflected back out to space. As global warming causes more snow and ice to melt each summer, the ocean and land that were underneath the ice are exposed at the Earth's surface.
    - Because they are darker in color, the ocean and land absorb more incoming solar radiation, and then release the heat to the atmosphere. This causes more global warming. In this way, melting ice causes more warming and so more ice melts. This is known as a **feedback**.
- Melting Permafrost Releases Greenhouse Gases
    - Global warming is causing soils in the polar regions that have been frozen for as much as 40,000 years to thaw.
    - As they thaw, carbon trapped within the soils is released into the atmosphere as methane, a powerful greenhouse gas.
- Less Ice on Land Means Sea Level Rises
    - Sea level has been rising about 1-2 millimeters each year as the Earth has become warmer.
    - Some of the sea level rise due to melting glaciers and ice sheets which add water to the oceans that was once trapped on land.

Impact of Climate Change on Water Bodies and water insecurity

- Climate change is expected to exacerbate current stresses on water resources.
- By 2020, between 75 and 250 million people are projected to be exposed to increased water stress due to climate change.
- Warming has resulted in decline in mountain glaciers and snow cover in both hemispheres and this is projected to accelerate throughout the 21st century.
    - This will in turn lead to reducing water availability, hydropower potential, and would change the seasonal flow of rivers in regions supplied by meltwater from major mountain ranges (e.g. Hindu-Kush, Himalaya, Andes).
- By 2050s freshwater availability in Central South, East and South-East Asia, particularly in large river basins, is projected to decrease.
- A warmer climate will accelerate the hydrologic cycle, altering rainfall, magnitude and timing of runoff.
- The IPCC Report 2007 states that the availability of fresh water in India is expected to drop in response to the combined effects of population growth and climate change.
- The IPCC (2007) also suggests that two main drivers of climate change, higher water
- temperature and variations in runoff- are likely to produce adverse changes in water quality affecting human health, ecosystems, and water use.
- Increase in sea-level has serious implications for both human security (increased flood-risks, degraded groundwater quality, etc.) and ecosystems (impact on mangrove forests and coral reefs, etc.), especially so in coastal regions.
- Reduced precipitation and increased evapotranspiration- will reduce recharge and possibly increase groundwater withdrawal rates.
- In coastal areas, sea level rise will exacerbate water resource constraints due to **increased salinisation of groundwater supplies**.
- Available records suggest that the Gangotri glacier is retreating about 28 m per year. Glacial melt is expected to increase under changed climate conditions, which would lead to increased summer flows in some river systems
- In the Indo-Gangetic Plain Region in the past whereby different rivers (including Kosi, Ganga, Ghaghara, Son, Indus and its tributaries and Yamuna) changed their course a number of times. => devastating floods in Nepal and Bihar.

Sea level rise due to Climate Change

- The coastal states of Maharashtra, Goa and Gujarat face a grave risk from the sea level rise, which could flood land (including agricultural land) and cause damage to coastal infrastructure and other property.
- Goa will be the worst hit, losing a large percentage Of its total land area, including many Of its famous beaches and tourist infrastructure.
- Flooding will displace a large number of people from the coasts putting a greater pressure on the civic amenities and rapid urbanisation.
- Sea water percolation due to inundations can diminish freshwater supplies making water scarcer.
- The states along the coasts like Orissa will experience worse cyclones. Many species living along the coastline are also threatened.
- The coral reefs that India has in its biosphere reserves are also saline sensitive and thus the rising sea level threatens their existence too, not only the coral reefs but the phytoplankton, the fish stocks and the human lives that are dependent on it are also in grave danger.
- People living in the Ganges Delta share the flood risks associated with rising sea levels.

Impact on Ocean Acidification (Covered in detail before)

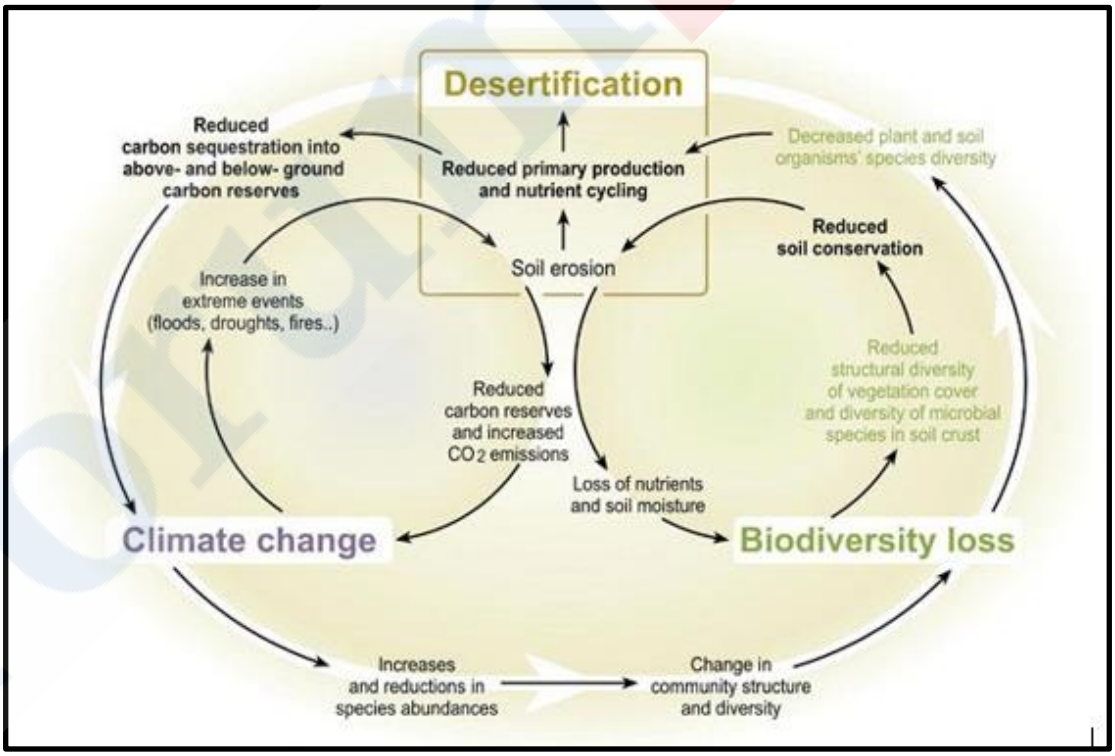
- Ocean acidification is the ongoing decrease in the pH of the Earth's oceans, caused by the uptake of carbon dioxide (CO2) from the atmosphere.
- Measurements made over the last few decades have demonstrated that ocean carbon dioxide levels have risen in response to increased carbon dioxide in the atmosphere, leading to an increase in acidity of oceans.
- Carbon dioxide absorbed into the ocean from the atmosphere reduces calcification rates in reef-building and reef-associated organisms by altering seawater chemistry through decreases in pH.
- Rising acid levels are likely to have impact on specific categories of ocean life: corals, echinoderms, molluscs, crustaceans and fishes.
- More acidic oceans will interfere with the ability of corals to form the reefs.

Impact of Climate Change on Ecosystem and Biodiversity

- According to **International World Wildlife Fund (WWF)**
  - species from the tropics to the poles are at risk.
  - Many species may be unable to move to new areas quickly enough to survive changes that rising temperatures will bring to their historic habitats.
  - 1/5th of the world's most vulnerable natural areas may be facing a "catastrophic" loss of species.
- Impact on **Marine Ecosystems:**
  - They will be affected not only by an increase in sea temperature and changes in ocean circulation, but also by ocean acidification; as the concentration of dissolved carbon dioxide (carbonic acid) rises.
  - This is expected to negatively affect shell forming organisms, corals and their dependent ecosystems.
  - The Bramble Cay melomy is is the first mammal to go extinct due to human-induced climate change.
- Impact on **Mangroves**
  - The ongoing climate change turned out to be a potential threat to the remaining Indian mangroves and other coastal ecosystem.
  - Adverse effects on mangroves extend its serious consequence to the adjoining fragile an ecosystems such as coral reef and seagrass bed..

- Impact on highly diverse and productive mangrove forests will depend upon the rate of sea level rise relative to growth rates and sediments supply, space for and obstacle to horizontal migration, changes in climate-ocean environment.
- Climate unsuitability is an important factor responsible for mangrove's change and disappearance.
- According to **IPCC report**, sea level rise will affect mangroves by eliminating or modifying their present habitats and creating new tidally inundated areas to which some mangrove species may shift.
- Strict protection, preparation of an action plan for each mangrove area, afforestation in potential areas, plantation of species that fail to adapt to sea level rise, and introducing threatened species at higher latitudes are some of the mitigation and management options.

- Impact on **Desert Ecosystem**
  - According to IPCC, climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity.
  - In many dryland areas like Rajasthan and adjoining areas of Punjab and Haryana, the climate is become even more arid and rivers, lakes and underground water sources are drying up. This can have major impacts not only on physical processes (such as the water cycle), but also on ecosystem functions.
  - The UNCCD have recently indicated that: "The climatic effects on land occur at ecosystem and landscape levels".



  - **Increase in extreme events**:
    - Frequent floods will lead to soil erosion and thereby degrading land. It will promote desertification.
    - Droughts on the other hand adversely affects the recharge of soil moisture and groundwater table. Soils dry up and become prone to wind erosion. Ex. Vidarbha, Telangana, etc.

        - Forest fires will cause of forest biome. It will expose the top soil for erosion. This may lead to desertification.
    - **Biodiversity loss:** Climate change may adversely affect biodiversity and exacerbate desertification due to increase in evapotranspiration and a likely decrease in rainfall in drylands
    - **Rural-urban migration:** Climate change leads to decline in agricultural productivity which results in rural-urban migration and abandonment of agricultural land and systematic fallowing. Fallowing and in dry conditions aggravates soil erosion.
- Impact on **Mountain Ecosystems:**
    - Mountain ecosystems are hot spots of biodiversity. However, temperature increases and human activities are causing fragmentation and degradation of mountain biodiversity. Example: Snow Leopards.
    - Himalayas is home to the largest amount of glaciers after the North and the South Poles. However, climate change is threatening this life giver drastically.
    - It is also predicted that there will be an increase in the phenomenon of **Glacial Lake Outburst Floods (GLOFs)** in the eastern and the central Himalayas, causing catastrophic flooding downstream with serious damage to life, property, forests, farms, and infrastructure.

6. Mitigation strategies

Reduce the use of Fossil Fuels:

- Hybrid car that reduce using gasoline.
- Promote public transport or carpool
- **Recycle** can reduce garbage by reusing plastic bags, bottles, papers or glass.
- Stop **open burning** such as burning dry leafs or burning garbage.
- Government should reduce **deforestation**. Trees will help to improve the temperature on earth

Carbon Sequestration

- It is the process involved in **carbon capture** and the **long-term storage of atmospheric carbon dioxide** or other forms of carbon to mitigate or defer global warming.
- Carbon dioxide (CO2) is naturally captured from the atmosphere through biological, chemical, and physical processes.

Carbon Sink

- A **carbon sink** is **a natural or artificial reservoir** that accumulates and stores some carbon-containing chemical compound for an indefinite period.
- The natural sinks are:
    - Trees serve as carbon sinks during growing seasons.
        - In the case of forests and other woodland areas, carbon sequestration is done through photosynthesis.
    - Absorption of carbon dioxide by the oceans via **physicochemical and biological processes**
        - Oceans are considered the main natural carbon sinks, as they are capable of absorbing about 50% of the carbon emitted into the atmosphere.
        - In particular, plankton, corals, fish, algae and other photosynthetic bacteria are responsible for this capture.

Carbon Credit

- It is a credit for greenhouse emissions reduced or removed from the atmosphere from an emission reduction project, which can be used, by governments, industry or private individuals to compensate for the emissions they are generating.
- Carbon credit is a generic term for any tradable certificate or permit representing the right to emit *1 Tonne of Carbon dioxide or the mass of another greenhouse gas with a carbon dioxide equivalent to one tonne of carbon dioxide.*

Carbon Offsetting

- While a **carbon offset** also represents **one tonne of carbon dioxide or equivalent greenhouse gas**, it is **generated by a reduction in emissions made by a voluntary project designed specifically for that purpose**.
- Carbon offsets are generated by projects with clearly defined objectives, usually outside the confines of a company's own operational sites.
- Typical carbon offset projects include building wind turbines or solar farms, supporting methane reduction projects, planting trees or preserving forests.

Carbon Tax

- A carbon tax is a tax levied on the carbon content of fuels.
- It is a form of carbon pricing.
- Revenue obtained via the tax is however not always used to compensate the carbon emissions on which the tax is levied.
- Since greenhouse gas emissions caused by the combustion of fossil fuels are closely related to the carbon content of the respective fuels, a tax on these emissions can be levied by taxing the carbon content of fossil fuels at any point in the product cycle of the fuel.
- The objective of a carbon tax is to reduce the harmful and unfavourable levels of carbon dioxide emissions, thereby decelerating climate change and its negative effects on the environment and human health.
- It is a tax that increases revenue without significantly altering the economy while simultaneously promoting objectives of climate change policy.

Green Finance:

- The idea gets its first mention in the UN document at the UN Conference on Sustainable Development (also known as *Rio+20*), 2012.
- There is no universal *definition* of green finance, though, it mostly refers to **financial investments flowing towards sustainable development projects and initiatives that encourage the development of a more sustainable economy**.
- Initiatives to promote Green Finance:
    - The World Bank Group has set up an informal ***Sustainable Banking Network*** of banking regulators, led by developing countries, to promote sustainable lending practices.
    - In 2015, green bonds issued by governments, banks, corporate and individual projects amounted to US$42 billion.
    - At the global level, more than 20 stock exchanges have issued guidelines on environmental disclosure, and many green indices and green ETFs (exchange-traded funds) have been developed.

Green finance and India

- Attaining the ambitious solar energy target, development of solar cities, setting up wind power projects, developing smart cities, providing infrastructure which is considered as a

green activity and the sanitation drive under the 'Clean India' or 'Swachh Bharat Abhiyan' are all activities needing green finance.

- India created a corpus called the **NCEF (National Clean Energy Fund)** in 2010-11 out of the cess on coal produced/imported (**'polluter pays' principle**) for the purpose of financing and promoting clean energy initiatives and funding research in the area of clean energy.

Issues involved with the mobilisation of green finance:

- Green finance **should not be limited only to investment in renewable energy**, as, for a country like India, coal based power accounts for around 60% of installed capacity.
- **Emphasis should be on *greening coal technology***. In fact, green finance for development and transfer of green technology is important as most green technologies in developed countries are in the private domain and are subject to intellectual property rights (IPRs), making them cost prohibitive.
- Green bonds are perceived as new and attach higher risk and their tenure is also shorter. There is a need to reduce risks to make them investment grade.
- There is also a need for an internationally agreed upon definition of green financing as its absence could lead to over-accounting.
- While environmental risk assessment is important, **banks should not overestimate risks while providing green finance**.
- Green finance should also consider unsustainable patterns of *consumption* as a parameter in deciding finance, particularly conspicuous consumption and unsustainable lifestyles in developed countries.

6. Initiatives taken by India to combat climate change

India's reliance on fossil fuels remains well below China (the most relevant comparator) but also below the US, UK and Europe at comparable stages of development—this echoes India's commitment to never exceed the per capita emission of advanced countries.

Salient Features of India's INDC

- To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation.
- To adopt a climate-friendly and a cleaner path than the one followed hitherto by others at corresponding level of economic development.
- To reduce the emissions intensity of its GDP by **33 to 35 percent by 2030** from 2005 level.
- To achieve about **40 per cent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030**, with the help of transfer of technology and low cost international finance, including from Green Climate Fund.
- To create an additional **carbon sink of 2.5 to 3 billion tonnes of CO2** equivalent through additional forest and tree cover by 2030.
- To better adapt to climate change by enhancing investments in development programmes in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management.
- To mobilize domestic and new and additional funds from developed countries to implement the above mitigation and adaptation actions in view of the resource required and the resource gap.
- To build capacities, create domestic framework and international architecture for quick diffusion of cutting edge climate technology in India and for joint collaborative R&D for such future technologies.

Himalayan Glaciers Monitoring Programme

- Comprehensive programme to scientifically monitor the Himalayan glaciers – Phase I completed; Phase II launched;
- Discussion Paper on State of Himalayan Glaciers released

National Policy on Biofuels: National Policy on Biofuels approved by Cabinet to promote cultivation, production and use of Biofuels for transport and in other applications

Energy Efficiency Standards for Appliances: Energy efficiency ratings made mandatory for 4 key appliances — refrigerators, air conditioners, tube lights and transformers from January 7, 2010

International Solar Alliance: India has launched a historic ***International Solar Alliance (ISA)*** which is envisaged as a coalition of solar resource-rich countries to address their special energy needs and will provide a platform to collaborate on addressing the identified gaps through a common, agreed approach.

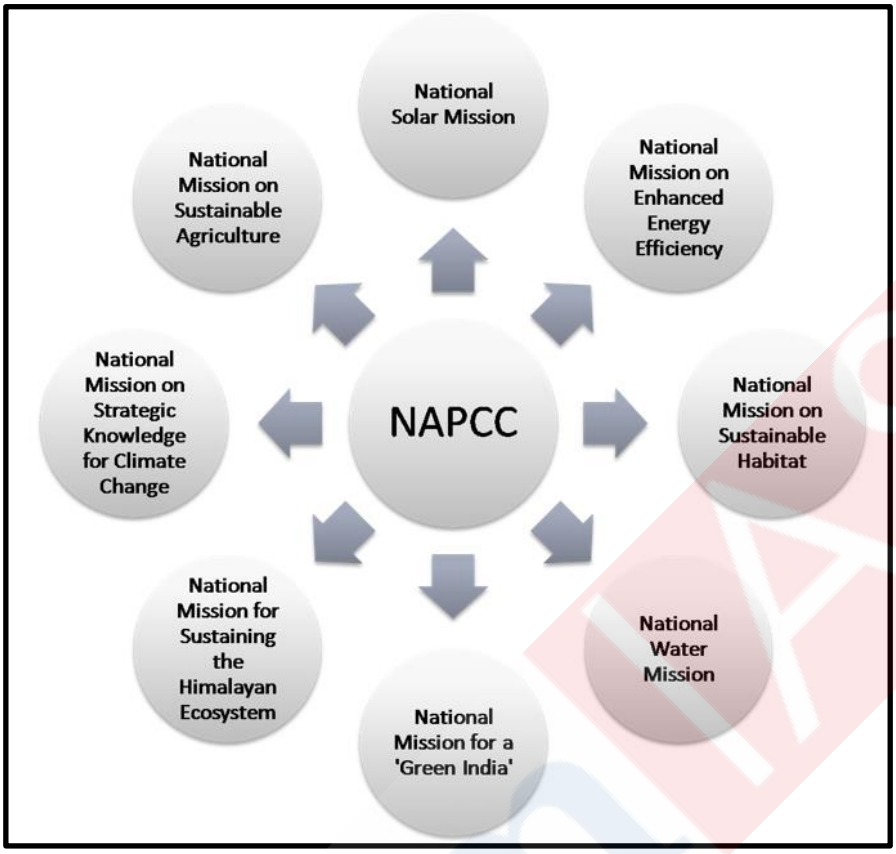
National Adaptation Fund for Climate Change (NAFCC)

- It has been established with a budget provision of Rs. I350 crore for the years 2015–16 and 2016–17. It is meant to assist in meeting the cost of national- and state-level adaptation measures in areas that are particularly vulnerable to the adverse effects of climate change.
- The *overall aim* of the fund is **to support concrete adaptation activities that reduce the adverse effects of climate change facing communities, sectors and states** but are not covered under the ongoing schemes of state and central governments.

Coal Cess and the National Clean Energy Fund

- India is *one of the few countries* around the world to have a *carbon tax* in the form of a cess on coal.
- Not only has India imposed such a cess but it has also been progressively increasing it (form Rs. 50 per tonne of 2010 to Rs. 200 by 2015–16 and Rs. 400 by 2016-17).
- The **NCEF (National Clean Energy Fund)** which is supported by the cess on coal was created for the purposes of financing and promoting *clean energy initiatives*, funding research in the area of clean energy and for any other related activities.

National Action Plan on Climate Change (NAPCC)



- In 2017-18, the PM's Council on Climate Change (PMCCC) directed the missions under the NAPCC to enhance their ambition in respect of adaptation, mitigation and capacity building and prioritize them, besides recommending the setting up of some *new missions* in addition to the existing eight:
    - Considering the adverse impacts that climate change could have on health, a new '**Mission on Climate Change and Health**' is currently under formulation and a National Expert Group on Climate Change and Health has been constituted.
    - The proposed '**Waste-to-Energy Mission**' will incentivize efforts towards harnessing energy from waste and is aimed at lowering India's dependence on coal, oil and gas for power production.
    - The **'National Mission on Coastal Areas**' (NMCA) will prepare an integrated coastal resource management plan and map vulnerabilities along the entire (nearly 7000-km-long) shoreline.
    - The '**Wind Mission**' seeks to increase the share of wind energy in the renewable energy mix of India. It is likely to be given an initial target of producing about 50,000–60,000 MW of power by the year 2022.

Perform Achieve and Trade

- Under the **National Mission on Enhanced Energy Efficiency**
- It was introduced as an instrument for reducing specific energy consumption in energy-intensive industries with a market-based mechanism that allowed the trading of ***ESCerts* (energy saving certificates).**
- The ESCerts, issued by the GoI, are traded through the power exchanges in the country.
- To provide adequate amount of investment, the Reserve Bank of India has included renewable energy in the ***PSL* (priority sector lending)** for scheduled commercial banks.

National Solar Mission – targets 100 GW of solar power by 2022.

National Mission on Sustainable Habitat: To promote energy efficiency as a core component of urban planning, the plan calls for:

- Extending the existing **Energy Conservation Building Code;**
- A greater emphasis on urban waste management and recycling, including power production from waste;
- Strengthening the enforcement of automotive fuel economy standards and using pricing measures to encourage the purchase of efficient vehicles; and
- Incentives for the use of public transportation.

National Water Mission: With water scarcity projected to worsen as a result of climate change, the plan sets a goal of a 20% improvement in water use efficiency through pricing and other measures.

National Mission for Sustaining the Himalayan Ecosystem: The plan aims to conserve biodiversity, forest cover, and other ecological values in the Himalayan region, where glaciers that are a major source of India's water supply are projected to recede as a result of global warming**.**

National Mission for a "Green India": Goals include the Afforestation of 6 million hectares of degraded forest lands and expanding forest cover from 23% to 33% of India's territory.

- It acknowledges the influence forests have on environmental amelioration through climate change mitigation, food security, water security, biodiversity conservation and livelihood security of forest-dependent communities.
- It hinges on **decentralized participatory approach** involving grass root level organizations and community in planning, decision making, implementation and monitoring.

National Mission for Sustainable Agriculture: The plan aims to support climate adaptation in agriculture through the development of climate-resilient crops, expansion of weather insurance mechanisms, and agricultural practices.

National Mission on Strategic Knowledge for Climate Change:

- To gain a better understanding of climate science, impacts and challenges, the plan envisions a new Climate Science Research Fund, improved climate modelling, and increased international collaboration.
- It also encourages private sector initiatives to develop adaptation and mitigation technologies through venture capital funds**.**

National Smart Grid Mission to bring efficiency in power supply

Energy Conservation Building Code

- It is prepared after extensive consultations with all stakeholders, consisting of architects & experts including building material suppliers and developers.
- **The code is expected to assist large number of architects and builders who are involved in design and construction of new residential complexes.**
- It has potential for energy savings to the tune of 125 Billion Units of electricity per year by 2030, equivalent to about 100 million ton of Co2 emission.

Bureau of Energy Efficiency (BEE):

- **A statutory body under Ministry of Power** created in March 2002 under the provisions of the nation's 2001 Energy Conservation Act**.**
- To implement policy and programmes in energy efficiency and conservation.
- **Objective of BEE –**
    - To reduce energy intensity in our country by optimizing energy demand and
    - To reduce emissions of **greenhouse gases (GHG)**, responsible for global warming and climate change.

National Offshore Wind Energy Policy 2015

- *A* major renewable energy policy initiative.

- It aims at helping offshore wind energy development, including setting up of offshore wind power projects and research and development activities in waters, in or adjacent to the country, up to the seaward distance of 200 nautical miles exclusive economic zone (EEZ) of the country from the baseline.

GRIHA – Green Rating for Integrated Habitat Assessment – building – energy rating system

Zero Effect, Zero Defect (ZED) – quality control and energy efficiency certificate for medium and small industries

Smart Cities, AMRUT, HRIDAY – to develop climate resilient urban cities

Bharat Stage IV fuel efficient standards to be implemented by April 2016 across the country and then move to **Bharat Stage V and VI in the near future**

Mass Rapid Transit System – moving people, instead of moving vehicles

HelpUsGreen:

- It is an Indian private project which is **one of 15 ground-breaking projects** from around the world that has **won this year's *UN 'Momentum for Change' climate action award***.
- The project collects flowers from temples and mosques across many cities\towns in Uttar Pradesh and recycles them to produce natural incense, organic fertilizers and biodegradable packaging material.
    - helps in preventing chemical pesticides from entering into the river through temple waste.
- Developed as the world's first profitable solution to the monumental temple waste problem.

7. International initiatives

Earth Summit 1992 : The outcome of this summit was the following documents:

1. Rio Declaration on Environment and Development
2. Agenda 21
3. Convention on Biological Diversity
4. Forest Principles

UN Framework Convention on Climate Change (UNFCCC).

- It is **an international environmental treaty** negotiated at the **United Nations Conference on Environment and Development** (UNCED), informally known as the **Earth Summit**, held in Rio de Janeiro from 3 to 14 June 1992.
- It entered into force on 21 March 1994, after a sufficient number of countries had ratified it.
- Objective of UNFCCC : to **stabilize greenhouse gas concentrations** in the atmosphere at a level that would **prevent dangerous anthropogenic interference** with the climate system.
- **Is UNFCCC is legally binding?**
    - **No.**
    - UNFCCC by itself is **not legally binding.**

United Nations Climate Change conferences

- So far, 23 meetings have taken place.
- The key conventions :
    - COP-3 in 1997 at Kyoto (Japan) : resulted in the **legally binding Kyoto Protocol** on Climate Change
    - COP-7 in 2001 at Marrakech (Morocco) : resulted in **establishment of an *Adaptation Fund*** for financially supporting developing countries better adapt to climate change.
    - COP-16 in 2010 at Cancún (Mexico) : resulted in an announcement for **a 100 billion USD per annum *Green Climate Fund*** for providing financial support to developing countries on their climate change actions.

- COP-21 in 2015 in Paris : resulted in **adoption of the *Paris Agreement*** governing climate change reduction measures **from 2020**.

The Paris Agreement

- The Paris Agreement will enter into force on the 30th day after the date on which **at least 55 countries accounting for at least 55% of the total global greenhouse gas emissions** ratify it.
- The agreement aims to reduce emissions of greenhouse gases, the cause of global warming and consequent climate change, and do it fast enough to **keep the average global temperature from rising above 2º, possibly 1.5ºC compared to pre-industrial times**.
- The agreement will come into force 2020.
- **will replace the Kyoto Protocol**, an existing international agreement on climate change that as finalised in 1997.
- Paris Agreement is ambitious
  - resolves to hold global temperature rise to well below 2ºC above pre-industrial levels
  - pursue efforts towards a 1.5º C temp. limit.

Provisions of Paris Agreement

- A **binding obligation** to submit mitigation contributions **every 5 years** and to pursue domestic measures to achieve them.
- For every 5-year cycle, states must put forward contributions **more ambitious than their last**.
- In addition, the agreement envisages a **"global stocktake" every 5 years to assess collective progress towards long-term goals**.
  - The global stocktake will also take into account **"equity**"(so CBDR also protected) — thus paving the way for conversation on burden-sharing between nations.
- The Paris Agreement requires **developed countries to raise finances with $100 billion per year** as the floor by 2020, to help developing nations in both mitigation and adaptation activities, while other nations are encouraged to provide funding voluntarily.
- The first global evaluation of the implementation of the Paris Agreement is to take place in 2023, and thereafter every five years to help all countries.

Bonn Conference (CoP23): The "Rule Book" and Talanoa Dialogue

- The key agenda of the Bonn conference was to **chalk out the Rule Book.**
- If Paris agreement was constitution, the Rule Book would serve as laws and regulations to implement it towards achieving the goal of Paris Agreement i.e. to limit the Earth's temperature rise to a maximum of 2ºC.
- In the Bonn summit, it was decided that the negotiators will keep working for one year and finalize the rule book by December 2018.
- It is expected that the Rule Book shall be adopted at COP-24 at Katowice(Poland) in December, 2018.
- To ensure that this happens, CoP24 host Poland has decided to work with CoP23 host Fiji and past host Morocco. This year long process has been called ***Talanoa Dialogue***.
- Thus, Talanoa dialogue is **a year long process that allows countries to assess their progress on past climate actions** (stocktaking) and **define the way forward** to implement the legally binding Paris Agreement.

Katowice: 24th meeting of the Conference of the Parties (COP24) to the United Nations Framework Convention on Climate Change.

What was expected:

- The summit aimed to **establish guidelines for implementing and reporting on the Paris Agreement**.
- Countries were looking to **establish an enhanced transparency framework to monitor, verify and report** actions taken **in a systematic, standardised manner**.
- Transparency — what would be done to reduce emissions, how countries would measure and report progress, and how much support industrialised countries would provide — was an important aspect of the discussions.
    - This will inform stocktaking of progress on the Paris Agreement and how much more is needed to cut emissions and raise ambition.
- **Funds were also required from rich countries** for the losses and damages borne by poor nations.
- **Technology transfer and capacity building support** are also issues of importance to vulnerable countries and poor, developing countries that need help to transition from high to low carbon economies.

Outcome:

- While there was some progress on **the process by which the Paris Agreement of 2015 would be implemented**, key issues of concern for the poorest and developing nations were diluted or postponed.
- The **1.5 Degree Report**, which was produced by the **Intergovernmental Panel on Climate Change** in October 2018, showed that the **earth is close to a climate catastrophe**.
- There is **little to no finance available for poor and developing nations**.
- The **details on funding and building capacity have been postponed**.
- Article 9 (the provision of financial support to developing countries from industrialised nations) was ignored; instead, there was an **emphasis on carbon markets and insurance mechanisms**.
- In spite of these problems, **a single rulebook for all countries has been produced** and **will serve as a foundation for more detailed rules and structures**.

Global Alliance to Power Past Coal:

- In the recent Bonn summit, it was **launched by Canada and the UK**.
    - Canada has returned as a proactive nation pushing climate change agenda.
    - With US taking a backseat, Canada might be looking for a leadership role.
- This is a programme to **phase out coal usage in energy production**.
- Immediately, more than 20 countries, including France, Finland, and Mexico have become the part of this initiative.
- It brings together a wide range of businesses and civil society organizations that have united for climate protection.

'Momentum for Change' initiative:

- ***An initiative spearheaded by the UN Climate Change secretariat*** to shine a light on the enormous groundswell of activities underway across the globe that are moving the world toward a highly resilient, low-carbon future.
- It recognizes innovative and transformative solutions that address both climate change and wider economic, social and environmental challenges.

8. Global Climate Funds

- Classification:
    - Depending on the participating countries, global climate funds can either be multilateral or bilateral depending on.

- The funds may further be classified according to their area of focus, namely mitigation, adaptation or REDD(reducing emissions from deforestation and forest degradation).

- Currently, the **Green Climate Fund (GCF)** is the largest, with pledges amounting to US$10.2 billion.
- The second largest is the **Clean Technology Fund (CTF)** with pledges amounting to US$5.3 billion.
- With the capitalization of the GCF and the sunset clause of the CTF, there is ambiguity about the role of the CTF in the climate finance architecture post-2020.

Green Climate Fund (GCF)

- It was ***set up in 2010 under the UNFCCC financial mechanism*** to channel funding from developed countries to developing countries to allow them to mitigate climate change and also adapt to disruptions arising from a changing climate.
- The Green Climate Fund will support projects, programmes, policies and other activities in developing country Parties using thematic funding windows.
- It is intended to be the centrepiece of efforts to raise Climate Finance of $100 billion a year by 2020.
- The Fund will strive to maximize the impact of its funding for adaptation and mitigation, and seek a balance between the two, while promoting environmental, social, economic and development co-benefits and taking a gender-sensitive approach..

The GEF (Global Environment Facility)

- ***It was established on the eve of the 1992 Rio Earth Summit*** to help tackle our planet's most pressing environmental problems.
- It is an international partnership of 183 countries, international institutions, civil society organizations and the private sector that addresses global environmental issues.
- ***GEF funds are available to developing countries and countries with economies in transition*** to meet the objectives of the international environmental conventions and agreements.
- **The World Bank serves as the GEF Trustee**, administering the GEF Trust Fund.
- **It is a FINANCIAL MECHANISM for five major international environmental conventions:**
    1. the Minamata Convention on Mercury,
    2. the Stockholm Convention on Persistent Organic Pollutants (POPs),
    3. the United Nations Convention on Biological Diversity (UNCBD),
    4. the United Nations Convention to Combat Desertification (UNCCD) and
    5. the United Nations Framework Convention on Climate Change (UNFCCC).

9. Criticisms of international initiatives (focus through mitigation and adaptation methods)

- Trump has a favour for fossil fuel (coal) based economy. US not being part of any climate change actions may **add 0.1 to 0.3º C to global warming by 2100**. Some more reluctant countries **may also follow the steps of US** and quit the climate deal. Example - Brazil.
- Developed nations are not willing to accept the historical role they have played in the emission of GHGs. The international initiatives have failed to make them accountable.
- The $100 billion figure does not appear in the legally binding part of the Paris Agreement
- **Climate change does not affect all countries equally** and hence no surety of equal action or concern shown by all participating nations.

    - Low-lying island states face an existential threat from rising sea levels while others, especially countries near the Arctic Circle, may experience greater agricultural output and easier access to natural resources as a result of the thawing of permafrost
- **Developing countries**, especially in Africa, are still left out or stuck with low-tech options. These nascent markets are seen as too disaggregated and high risk for investors.
- The developed nations are mostly focussing on mitigation approaches and are reluctant to transfer technologies for adaptation approaches.

How can the situation be improved?

- Faced with global ecological limits, focus has **to shift from 'environmental risk management' to 'economic growth within ecological limits'.**
- It is in responding to this mega-trend that India's climate policy could have been more forward looking. **The focus everywhere is shifting from production patterns to consumption patterns**.
- Nearly 2/5th of the cumulative emission reductions required by 2050 could come from efficiency improvements.
- Key systems such as the transport, energy, housing and food systems should be transformed.
- India should have integrated its Smart Cities campaign into a plan for low carbon development of cities.
- A greater focus on sharing rather than owning cars would impact the fastest growing emissions..
- Periodic reviews of national contributions should also be undertaken.
- Building state-level profiles of GHG emissions from different sectors can help inform us about different focus areas for each state.
- To fulfill financial needs, India must strategically seek other sources such as the Green Climate Fund and leverage the International Solar Alliance.

10. International Solar Alliance

Objectives

- Promote solar technologies and investment in the solar sector.
- Formulate projects and programme to promote solar applications.
- Develop innovative Financial Mechanisms to reduce cost of capital.
- Build a common Knowledge e-Portal.
- Facilitate capacity building for promotion and absorption of solar technologies and R&D among member countries.

Potential of International Solar Alliance

- Until December 2015, Germany, China, Japan, the U.S., and Italy accounted for 70 per cent of the 227 GW of solar PV deployed globally.
- Developing countries, especially in Africa have large solar potential. But these nascent markets are seen as too disaggregated and high risk for investors.
- In effect, three factors continue to block the rapid scale-up of solar energy:
    - financing is still too costly for developers;
    - **solar-related plans and policies are often incoherent** and increase risks for developers and investors; and
    - there is **insufficient R&D investment in solar**.
- ISA's vision and mission is to **take solar from the lab (or rich world markets) to (developing country) streets**.
- ISA is being designed as **a platform to bring together countries with rich solar potential** (along with solar innovators, developers, and financiers) **to aggregate demand for solar across member countries**, **creating a global buyers' market for solar energy**, and thereby

reducing prices, facilitating the deployment of existing solar technologies at scale, and promoting collaborative solar R&D and capacity.

- The cost of finance for solar projects in many developing countries is often prohibitively high. ISA envisions that collective measures can facilitate the flow of over $1 trillion into solar projects.
- ISA hopes to facilitate **collaborative, cross-country R&D**.
- ISA has plans to address related market-limiting factors, by launching **standardised skill training programmes** and **reducing information asymmetries through a 24x7 knowledge hub**.

Challenges faced by ISA:

- **Funding**: Although alliance talks about developing "innovative financial mechanisms", it does not address how the capital would be provided.
- **Technology Sharing**: There is need to create a comprehensive framework to share the modern solar technologies at low cost.
- The longer-term danger : whether it devolves into a **bloated bureaucracy**.
    - Although conceived as an intergovernmental institution, ISA is not intended to be a typical international bureaucracy.
    - A **tight budget** and a **direct link to the private sector** would hold ISA accountable to real action on the ground.
- The more proximate danger is that 121 potential member countries get caught up in a battle over legal form, membership rights, and giving precedence to procedure over pragmatism.

Climate Change is a natural phenomena but recent human activities have pushed it to the extent where there is no returning back. The policymakers both at national and international levels need to understand that it is not the earth that is at danger rather it is the humanity which will go extinct. The earth or Goddess Gaia has the natural ability to regulate its mechanism known as homeostasis. Every individual from every nation has to participate equally and energetically to fight our common enemy i.e Climate Change. The time demands that humanity must stop seeing humans as their enemies rather see this changing phenomena as the common enemy. This will save trillions of dollars being diverted towards development of arsenals, which can be effectively used for mitigation and adaptation measures in developing and least developed countries.

CGP 2019

ENVIRONMENTAL ISSUES

ENVIRONMENTAL ISSUES

The **relationship** between **Environment and human**, that is **essential and necessary** has been established since time immemorial. However, **unprecedented population growth** in the developing nations and **unsustainable consumption patterns** in the developed nations have burdened both **'assimilative' and 'absorptive' capacity of Mother Nature.**

The **anthropogenic activities** have caused immense damage to the nature and its ecosystem functioning. These activities like **unsustainable mining and quarrying, reckless deforestation, indiscriminate use of fertilizers and pesticides** that has altered the mutualistic relationship between human and nature have resulted into **environmental issues like desertification, soil erosion, bleaching of coral reefs, ozone depletion, etc.**

But in the race of economic development, humanity forgot that it's not nature whose existence is threatened rather it's the humanity itself would arrive to the brink of collapse in future. Therefore, to ensure **equity and equality** in the distribution of natural resources both for **present as well as future** lies at the heart of dilemma between **environmental consciousness and economic development.**

1. DEFORESTATION

Deforestation is a mass elimination of trees which continues to **threaten tropical forests,** their biodiversity and the ecosystem services they provide. The conversion of forests through felling, clearance and burning through anthropogenic activities into non-forest use like **agriculture, urbanization and industrialization** is called deforestation. However, the term deforestation is more associated with felling of trees in the **equatorial rainforests region like Amazon rainforest, Congo rainforest,** etc.
The extent of deforestation can be understood through realizing the fact that world has been losing forest land equivalent to the size of **1,000 football fields every one hour in the last 25 years.**

1.1 Importance of Forests:

- **Forest and Climate:** Forest acts as lungs of earth. They are rain magnets and does carbon sequestration. They stabilize the climate and helps in mitigation and adaptation of climate change.
- **Forest and Land:** Forests promote soil formation, prevents soil erosion and soil degradation and are home to major gene pool centers.
- **Forest and Water:** Forests reduces runoff and promotes percolation thus recharging groundwater. They also contribute heavily in the hydrological cycle.
- **Forest and Humans:** Forest provides food, timber, wool, hides, gums, etc. They are sources of livelihoods for many people.
- **Forest and Tribals:** Forests are integral for the survivability of the indigenous people as they provide basic resources for their food and livelihoods.

1.2 Forest Data of India:

- With a forest cover of **24.4 percent,** India stands well **behind its target of 33 percent**, and much behind the neighbouring country of **Bhutan which boasts a cover of 72 percent.** Meanwhile, the country is roughly on an equal footing with **China that has a green cover of 21.7 percent.**
- In February this year, the **Forest Survey of India (FSI)** published its **State of Forest 2017,** which recorded a **modest increase of 1 percent** in the forest cover, from 7,01,673 sq km in 2015 to 7,08,273 sq km in 2017.
- According to recent data acquired through RTI from the Ministry of Environment and Forest revealed that on an average forest land diverted across the country stands at 135 hectares per day.
- Karnataka, Madhya Pradesh, Chattisgarh, Maharashtra, Arunachal Pradesh and Jharkhand are the states where maximum diversion of forests has taken place.

1.1 Causes of Deforestation

Anthropogenic Activities:

- Expansion of Agriculture
- Commercial Logging

- Urbanization and Industrialization
- Mining and Quarrying
- Wood as Domestic Fuel Supply
- Shifting Cultivation
- Negligence

Natural Factors:

- Lightning
- Global Warming

1.4 Consequences of Deforestation:

- Reduction in Carbon Sequestration
- Depleting underground Water Table
- Decrease in Soil Productivity
- Reduction in livelihood Opportunities
- Increase in intensity and Magnitude of Natural Disasters
- Biodiversity Extinction

1.5 Forests and Climate Change

- Deforestation = one of the main contributors to climate change.
- It comes in many forms, **natural fires, agricultural clear cutting, livestock ranching,** and **untenable logging for timber**, degradation due to climate change, and etc.
- **Deforestation = 2nd largest anthropogenic source of carbon dioxide** to the atmosphere, after fossil fuel combustion.
- Deforestation and forest degradation contribute to atmospheric greenhouse gas emissions through combustion of forest biomass and **decomposition of remaining plant material and soil carbon**.
- It used to **account for more than 20% of carbon dioxide emissions**, but it's currently somewhere around the 10% mark.
- Averaged over all land and ocean surfaces, temperatures warmed roughly 1.53 °F (0.85 °C) between 1880 and 2012, according to the Intergovernmental Panel on Climate Change.

Striving towards achieving INDC goal through increase in forest cover

- India is striving towards achieving its NDC goal of **creating additional carbon sink of 2.5 to 3.0 billion tonnes of CO_2** equivalent through additional forest and tree cover by 2030.
- As per present assessment **total carbon stock in forest is estimated to be 7,082 million tonnes**. There is an increase of 38 million tonnes in the carbon stock of country as compared to the last assessment.

1.6 State of Forest Report 2017 and its Analysis:

- Published by **Forest Survey of India** (under MoEFCC), Dehradun
- India has **21.73% of geographic area under forest**. India posted a **marginal 0.21% rise in the area under forest** between 2015 and 2017, according to the **biennial India State of Forest Report (SFR) 2017.**
- State with largest forest area = **Madhya Pradesh** (77,414 km2)
    - Haryana = Minimum forest cover (by area & by %age)
- Andhra Pradesh, Karnataka and Kerala topped the States that posted an increase in forest cover.
- In India's **north-east** however, forest cover **showed a decrease.**
- The category of **'very dense forest'**— defined as a canopy cover over 70% — and an indicator of the quality of a forest, **saw a dramatic rise** but the category of '**moderately dense forest' (40%-70%) saw a decline** from 2015.
- India's total forest cover increased by 0.94 per cent in the last two years, shows the State of Forest Report 2017
- India is ranked 10th in the world, with 24.4% of land area under forest and tree cover.
- The forest survey for the **first time mapped 633 districts** and relied on satellite-mapping.

- **BAMBOO:** Earlier this year, the government ceased to define bamboo as a tree to promote economic activity among tribals. The survey found that India's **bamboo bearing area rose** by 1.73 million hectares (2011) to 15.69 million hectares (2017).
- The report also points towards an **expansion of agro-forestry and private forestry**. There is a jump from 42.77m3 in the 2011 assessment to 74.51m3 in timber production in 'Trees outside Forests' (TOF) category.
- That most of the increase in the forest cover was observed in Very Dense Forest (VDF). The increase in forest cover in VDF is followed by increase in open forest.

Class	*Area sq kms*	*% of geographical area*	*% of geographical area (SFR 2015)*
Very Dense Forest	98,158	2.99	2.26
Moderately Dense Forest (all lands with tree cover including mangrove cover with canopy density between 40-70%)	3,08,318	9.38	9.59
Open Forest (all lands with tree cover including mangrove cover with canopy density between 10-40%)	3,01,797	9.18	9.14
Total Forest Cover	7,08,273	21.54	21.34

Difference between Forest Cover and Recorded Forest Area?

- "Forest Cover" refers to **all lands more than one hectare in area with a tree canopy of more than 10% irrespective of land use, ownership and legal status**.
    - It may include even orchards, bamboo, and palm.
- "Forest Area" refers to **all the geographic areas recorded as 'Forest' in government records** under Indian Forests Act, 1927 and under other respective local acts.
    - Such areas with less than 10% tree cover such as cold deserts, alpine pastures will be excluded from the assessment.

Assessment of the Forest Report:

Forest and Tree Cover of the country **has increased by 8,021 sq km (1 %)** as compared to assessment of 2015. The **very dense forest has increased by 1.36 %** as compared to last assessment.

Assessment:

- The increasing trend of forest and tree cover is largely due to the **various national policies** aimed at conservation and sustainable management of our forests like **Green India Mission**, **National Agro-Forestry policy (NAP)**, **REDD plus policy**, **Joint Forest Management (JFM)**, **National Afforestation Programme** and **funds under Compensatory Afforestation to States**.
- **Successful agroforestry practices, better conservation of forests, improvement of scrub areas to forest areas, increase in mangrove cover, conservation and protection activities** have also led to increase in the forest and tree cover.
- **Green Highways (Plantations & Maintenance) Policy** to develop 1,40,000 km long tree line with plantation along with both sides of national highways will go a long way in enhancing the forest & tree cover.

Top 5 states where forest cover has decreased are Mizoram (531 sq km), Nagaland (450 sq km), Arunachal Pradesh (190 sq km), Tripura (164 sq km) and Meghalaya (116 sq km).

Assessment:

- It is important to mention here that these states are in the North Eastern region of the country where the total forest cover is very high i.e. **more than 70% in each state**.
- The main reasons for the decrease are - **shifting cultivation**, other biotic pressures, **rotational felling**, **diversion of forest lands for developmental activities**, **submergence of forest cover**, **agriculture expansion and natural disasters**.

Water bodies inside forests have increased by 2,647 sq km over a decade

- Forests play a vital role in water conservation and improve the water regime in the area.
- State Forest Departments besides plantation and protection also undertake steps to improve water conservation through different interventions such as **building Check dams**, **vegetation barriers**, **percolation ponds**, **contour trenches** etc. under various Central & State Government schemes
- **Maharashtra (432 sq kms), Gujarat (428 sq kms), Madhya Pradesh (389 sq kms) are top three states** showing increase in water bodies within forest areas.

Mangrove cover of the country has shown a positive change

- As per ISFR 2017, **mangrove forests have increased by 181 sq kms**.
- **Maharashtra (82 sq kms), Andhra Pradesh (37 sq kms) and Gujarat (33 sq kms) are the top three gainers** in terms of mangrove cover.
- 7 out of the **12 mangrove states** have shown an increase in mangrove cover and none of them show any negative change.
- Mangrove ecosystems are **rich in biodiversity** and provide a number of ecological services. They also play a major role in **protecting coastal areas from erosion, tidal storms and tsunamis**.

Criticisms of Forest Report:

1. According to the report, forest and tree cover together registered a 1% rise over the previous estimate two years ago. However, such an estimate listing very dense, moderately dense, open and scrub forests mapped through remote sensing does not really provide deep insights into the integrity of the green areas.
2. There has been an increase over the baseline cover of 20% at the turn of the century. Yet, tree cover is not the same as having biodiverse, old-growth forests.
3. The ecosystem services performed by plantations that have a lot of trees grown for commercial purposes cannot be equated with those of an undisturbed assemblage of plants, trees and animals.
4. The Ministry's report has calculated a cumulative loss of forests in Mizoram, Nagaland and Arunachal of nearly 1,200 sq. km. Any gains achieved through remediation programmes in Odisha, Assam, Telangana, Rajasthan, Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir and Manipur cannot compensate the loss in North East adequately.

1.7 Government Initiatives Towards Conservation of Forests:

The National Mission for a Green India: The objectives of the Mission: increased forest/tree cover and improved quality of forest cover in two to eight million hectares, alongwith improved ecosystem services including biodiversity, hydrological services, increased forest-based livelihood income of households, living in and around the forests, and enhanced annual CO2 sequestration.

Implementation:

- Mission implementation will be on a decentralized participatory approach with involvement of grass root level organizations in planning, decision making, implementation and monitoring.
- The gram sabha and the committees mandated by the gram sabha, including revamped JFMCs will oversee implementation at the village level.

The Partnership for Land Use Science (FOREST PLUS)

- A joint programme by the **United States Agency for International Development (USAID**) and Ministry of Environment, Forest and Climate Change **(MoEF&CC)**
- To strengthen capacity for **REDD (Reducing Emissions from Deforestation and Forest Degradation) implementation in India**.
- The programme brings together experts from India and the United States to develop technologies, tools and methods of forest management to meet the technical challenges of managing forests for the health of ecosystem, carbon stocks, biodiversity and livelihood.

National Redd+ Strategy

- Complying with the UNFCCC decisions on REDD+, India has prepared its **National REDD+ Strategy**.

REDD + : Reducing Emissions by Deforestation and Degradation

An initiative finalized under the UN's Paris Agreement in 2015
A mechanism developed by Parties to the United Nations Framework Convention on Climate Change (UNFCCC)
It **creates a financial value for the carbon stored in forests** by **offering incentives for developing countries to reduce emissions from forested lands** and **invest in low-carbon paths to sustainable development**.
Developing countries would receive results-based payments for results-based actions.
REDD+ goes beyond simply deforestation and forest degradation and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks.

- The Strategy builds upon existing national circumstances which have been updated in line with India's National Action Plan on Climate Change, Green India Mission and India's Nationally Determined Contribution (NDC) to UNFCCC.
- India has begun implementing REDD+ pilot projects, developing protocols for improving measurement, reporting, and verification (MRV) and safeguard information systems (SIS).

Compensatory Afforestation Act, 2016

This act provides for setting up **Compensatory Afforestation Fund Management and Planning Authority (CAMPA)** at both **central and state level** to ensure **expeditious and transparent utilization of amounts realized in lieu of forest land diverted for non-forest purpose**.The utilization of funds is expected to mitigate the impact of diversion of such forest land.

Why CAMPA:

- Continuous diversion of forests(20,000-25,000 hectares per year acc to MoEFCC) => a large sum of money is being accumulated by the government.
- At present, more than Rs 40,000 crore has been realized and it is increasing at the rate of about Rs 6,000 crore every year.
- So, **to manage this money** + **to utilize it for the designated purposes** = the CAMPA is proposed to be set up.
- The **compensatory afforestation money** and **NPV** are supposed to be **collected from the user agency by the state government** where the project is located, and **deposited with the central government**. The money will eventually flow back to the state to be used for afforestation or related works.

Draft National Forest Policy 2018

Background:

- The first National Forest Policy in independent India took effect in 1952, with a second edition in 1988.
- Once finalized, the 2018 policy will guide the forest management of the country for the next 25-30 years.

Salient features of the draft policy:

- **Objective**: To **safeguard the ecological and livelihood security of people**, of present and future generations, based on sustainable management of the forests for the flow of ecosystem services.
- **Aim :** Bringing a minimum of **one-third of India's total geographical area under forest or tree cover**.
    - In the hills and mountainous regions, the aim will be to maintain two-thirds of the area under forest and tree cover.
- **Conservation:** It proposes to **restrict "schemes and projects which interfere with forests** that cover steep slopes, catchments of rivers, lakes, and reservoirs, geologically unstable terrain and such other ecologically sensitive areas".
- **New Bodies**: It suggests **setting up of two national-level bodies**—**National Community Forest Management (CFM) Mission** and **National Board of Forestry (NBF)**—**for better management of the country's forests**.
- **Afforestation:** "**Public-private participation models will be developed for undertaking afforestation and reforestation activities** in degraded forest areas and forest areas available with forest development corporations and outside forests".
    - It calls for "**promotion of trees outside forests and urban greens**", while stating that it will be taken up in "mission mode".
- Efforts will be made to **achieve harmonization between policies and laws like Forest Rights Act** (FRA) 2006".

- **Community participation:** "India has a rich and varied experience in participatory forest management and thus there is **need to further strengthen this participatory approach**, for which a **National Community Forest Management (CFM) Mission** will be launched."
    - All efforts to ensure synergy between gram sabha & JFMC (Joint Forest Management Committee) will be taken for ensuring successful community participation in forest management".
- **Finances required for management of forests: The compensatory afforestation fund** which is being transferred to the states **would be a major source of funds for taking up afforestation and rehabilitation works** in degraded forest areas as well as for bringing new areas under forest and tree cover.
- **Forest fire**: It addressed the issue of forest fires, stating that "**adequate measures would be taken to safeguard ecosystems from forest fires**, **map the vulnerable areas** and **develop and strengthen early warning systems and methods to control fire**, based on remote sensing technology and community participation."
- **Climate change**: It emphasized on **integrating climate change concerns into forest management** while noting that forests acts as a natural sink of carbon dioxide thereby assisting in climate change mitigation.
- **Wildlife conservation**: "**wildlife rich areas and corridors outside protected areas would be identified and maintained** for ensuring ecological and genetic continuity."
- **Human-wildlife conflict**: To tackle rising human-wildlife conflict, the draft outlined **short-term and long-term actions**.

1.8 Critical Analysis of Government Initiatives

Compensatory Afforestation Act, 2016

Difficulties in implementation :

- Lack of availability of non-forest land for afforestation.
    - Law says : **the land selected should preferably be contiguous to the forest being diverted**, so that it is easier for forest officials to manage it.
    - But in case that is not possible, land in any other part of the state can be used for the purpose.
    - **If no suitable non-forest land is found, degraded forests can be chosen for afforestation, but in that case, twice the area of diverted forest has to be afforested. Still, there is difficulty in finding land**, especially in smaller states, and in heavily forested ones like Chhattisgarh.
- The purposes for which the money can be used.
    - **The fund was envisaged to be used only for "compensatory" afforestation**, but the Act has expanded the list of works that this money can be utilised for
        - the general afforestation programme run through the Green India Mission.
        - Forest protection,
        - forest management,
        - forest and wildlife related infrastructure development,
        - wildlife conservation,
        - facilitating the relocation of people from protected wildlife areas etc.
    - Critics say **this will take the focus away from the prime objective of compensating for the forest cover lost to industrial or infrastructure development**.

Criticism: As per civil society groups

- Provisions of the Act fundamentally are opposed to Forest Rights Act (FRA) and **did not address legal rights of scheduled tribes and other traditional forest dwellers (OTFDs)**. Reason: consent of gram sabhas for implementation of compensatory afforestation on their customary lands **not required**.
- Community forest rights (CFRs) recognized under the FRA now constituted a new forest category to be governed and managed by the gram sabhas and forest rights holders. Therefore, any government programme on forest lands, including with CAMPA funds, had to be compatible with that law.
- **The structure of funding and implementation proposed under CAMPA Bill was entirely opposed to the structure of forest governance established by FRA**

- Major reason for poor implementation of FRA = the **opposition of the forest bureaucracy to empowerment of gram sabhas and democratization of forest governance**
- CAMPA Bill would serve only to empower notoriously unaccountable bureaucracy to further deprive forest dwellers and tribals of their livelihood by forcibly undertaking plantations on their customary lands
- **In many cases, under the name of infrastructure development, the funds have been misused for administrative and non-budgeted tasks**.

Way forward:

- CAMPA funds can be used for securing the existing natural tracks, make forests contiguous, safeguarding habitat and providing fair compensation to the local stakeholders.
- National Highway Authority of India (NHAI) has suggested that the **CAMPA funds could be used for mitigation of wildlife deaths on roads by creating underpasses and by-passes for animals**.
- Wildlife impact assessment has to be conducted over the kind of infrastructure the CAMPA money has created.

Draft National Forest Policy 2018

Criticism of the policy:

- The draft policy **persists with the outdated approach on plantations** to tackle the challenge of climate change.
- The draft policy **fails to mention or address the degradation of growing stock in the natural forests**.
- The policy remains **vague on the issue of forests rights for forest dwelling communities.**
    - FRA is a major movement in forest areas at present and its progress has been very lackadaisical over a decade of its implementation in India.
- The draft policy
    - **Does not discuss in detail the issue of diversion of forest land for mining** and other purposes.
    - Orients itself more on the conservation and preservation of forest wealth rather than regenerating them through people's participation.
    - **Mentions major forestry issues ailing the forest sector, but it doesn't provide answers to them** as to how these objectives will be achieved considering the competitive demands for forestlands.

2. SOIL EROSION

Soil erosion refers to the **wearing away of a field's topsoil** by the natural physical forces of water and wind or through forces associated with farming activities such as tillage. Erosion, whether it is by water, wind or tillage, involves **three distinct actions – soil detachment, movement and deposition**.

- Soil compaction, low organic matter, loss of soil structure, poor internal drainage, salinisation and soil acidity problems = can accelerate the soil erosion process.

2.1 Extent of Soil Erosion in India:

- *The **National Assessment of Shoreline Changes** along Indian coast* says that almost 1/3rd of India's 6,632 km coastline was lost to soil erosion between 1990 and 2016.
- It has been estimated that an area of 80 mha of our total area is exposed to wind and water erosion out of which 40 million hectares of land has undergone serious erosion.
- About 45 million hectares of land is subject to severe wind erosion in Rajasthan, Punjab, Haryana, Gujarat and Western Uttar Pradesh.
- According to ICAR, there are 40 lakh hectares of ravines. Out of which 28 lakh hectares are in the states of Uttar Pradesh, Madhya Pradesh, Rajasthan and Gujarat.
- In Madhya Pradesh about 4 to 8 lakh hectares are affected by deep gullies and ravines along the banks of rivers Chambal and Kali Sindh.
- The flood plains of Ganga and its tributaries in Uttar Pradesh and Bihar also suffer from soil erosion due to water. The Siwalik Range has also been badly affected by gully erosion. Erosion by Chos in Punjab is most marked in Hoshiarpur district.
- It has been estimated that 15 lakh hectares of forest land is cleared for shifting agriculture every year. Ex. Nilgiris, Lushai Hill, Naga Hills, etc.
- Coastal erosion is evidenced along the coast of Kerala by uprooting of coconut trees.

2.2 Causes of soil erosion

Natural Factors:

- **Water erosion:** Runoff water is responsible for much soil erosion, moving the soil particles by surface creep, saltation and suspension. Water erosion can be through splash erosion, sheet erosion, rill erosion and gully formations. The slope of land is potent factor in determining the velocity of water and the consequent soil erosion.
- **Erosion due to waves and glaciers:** Soil erosion by tidal waves along coasts and erosion among the higher reaches of Himalayas by glaciers.
- **Wind erosion:** Winds blowing at considerable speed in arid and semi-arid lands with little rainfall remove the fertile, arable, loose soils leaving behind a depression devoid of top soil.

Anthropogenic factors:

- **Deforestation:** Roots of trees and plants bind the soil particles and regulate the flow of water, thus saving soil from erosion. Ex. Chos of Punjab and Ravines of Madhya Pradesh are result of deforestation.
- **Overgrazing:** It leads to loose structure of the soil especially during dry period. The soil gets easily washed away during rains.
- **Faulty methods of agriculture:** The most outstanding are wrong ploughing, lack of crop rotation, indiscriminate use of chemical fertilizers, over-irrigation and practice of shifting cultivation.
- **Soil Compaction:** It occurs when soil particles are pressed together, reducing pore space between them. It reduces percolation and promotes run-off.

Soil compaction, low organic matter, loss of soil structure, poor internal drainage, salinization and soil acidity problems are other serious soil degradation conditions that can accelerate the soil erosion process.

2.3 Consequences of Soil Erosion:

- **Productivity loss**: It leads to loss of soil fertility and fall in agricultural productivity.
- **Ecological problems:** The agricultural runoff releases nutrient into water bodies and causes eutrophication. Ground water level is lowered and there is decrease in soil moisture.
- **Environmental hazards:** The incidence and damaging power of landslides increases. Frequency and intensity of floods and droughts increases.
- **Social problems:** It leads to rural out-migration and slums development, social conflicts and low sex ratio in urban areas.
- **Economic problems:** There is loss of livelihood in rural areas and contribution of agriculture in GDP reduces.

2.4 Government Initiatives Towards Prevention and Remediation:

- ICAR, through National Bureau of Soil Survey and Land Use Planning, Nagpur **conducted scientific soil survey** time to time **for assessing the extent and nature of soil erosion and land degradation across the country**.
- In order to prevent soil erosion and land degradation, Ministry of Agriculture is implementing various watershed programmes, namely;
    - National Watershed Development Project for Rainfed Areas (NWDPRA),
    - Soil Conservation in the Catchments of River Valley Project and Flood Prone River (RVP&FPR) and
    - Reclamation and Development of Alkali & Acid Soils (RADAS) across the country.
- Ministry of Rural Development is also implementing **Integrated Watershed Management Programme (IWMP)** for the purpose.
- About 57.61 million ha area has been developed under various watershed development programmes of Ministry of Agriculture and Ministry of Rural Development since inception upto 2011-12.
- Besides, 1.5 million ha sodic land has been reclaimed using gypsum technology and 0.5 million ha saline land have been reclaimed using sub-surface drainage technology across the country.

2.5 What more needs to be done to prevent Soil Erosion:

- **Careful tilling:** Because tilling activity breaks up the structure of soil, **doing less tilling with fewer passes will preserve more of the crucial topsoil**.
- **Crop rotation: allows organic matter to build up, making future plantings more fertile**.
- Contour bunding and Farming
- Strip Cropping
- Terracing
- Shelter Belt
- **Mulching: Applying a layer of mulch to the soil** top allows the soil to slowly **soak up water, as it protects against rain impact, and restores pH levels =** erosion prevention
- **Increased structure for plants: Introducing terraces** or other means of stabilizing plant life or even the soil around them can help reduce the chance that the soil loosens and erodes.
- **Water control:** specialized chutes and runoff pipes can help to direct these water sources away from the susceptible areas
    - **Retaining Walls** can be built around the area of erosion to **prevent water run-off**.
    - Gully Reclamation

3. DESERTIFICATION

Desertification is defined as "a type of land degradation in which a relatively dry land region becomes increasingly arid, typically losing its bodies of water as well as vegetation and wildlife."

- Desertification **does not refer to the expansion of existing deserts** according to UNCCD.
- It occurs because dryland ecosystems (which cover over 1/3rd of the world's land area) are extremely vulnerable to overexploitation and inappropriate land use.
- It is caused primarily by human activities and climatic variations.
- Poverty, political instability, deforestation, overgrazing and bad irrigation practices can all undermine the productivity of the land.

3.1 Causes of Desertification:

Anthropogenic Activities:

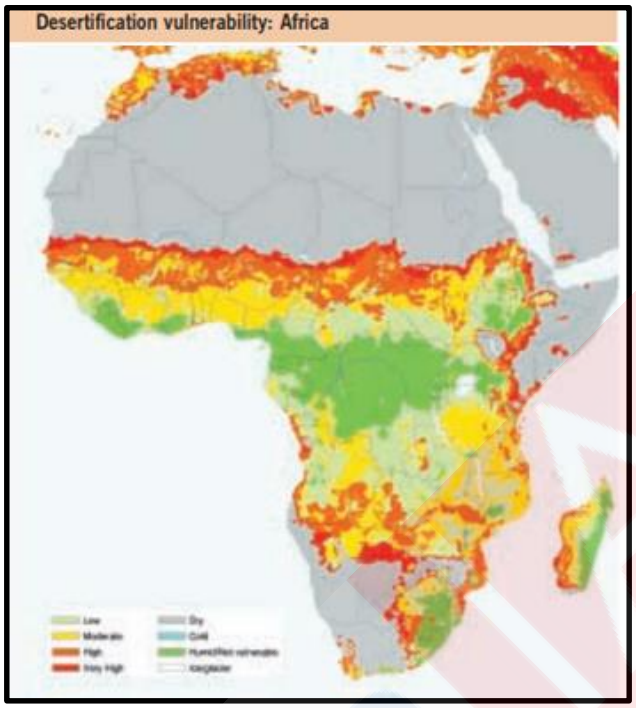
- The extension of cultivation in marginal lands,
- Inadequate soil and water conservation measures,
- Tillage for agriculture,
- Overgrazing and deforestation for fuel or construction materials.
- Intensive cropping systems and
- Poor irrigation management and overexploitation of groundwater.
- According to **State of India's Environment 2017: In Figures** book published by the Centre for Science and Environment and Down to Earth magazine
    - Increasing desertification of India's soil, is a fundamental threat to agriculture
    - **Nearly 30 per cent of India is degraded or facing desertification**.
    - **Of India's total geographical area of 328.72 million hectares (MHA), 96.4 MHA is under desertification**.
    - In 8 states—Rajasthan, Delhi, Goa, Maharashtra, Jharkhand, Nagaland, Tripura and Himachal Pradesh—around 40 to 70% of land has undergone desertification.
    - More to it, 26 of 29 Indian states have reported an increase in the area undergoing desertification in the past 10 years.
    - Biggest reasons for desertification:
        - Loss of soil cover, mainly due to rainfall and surface runoff
            - It is responsible for 10.98% of desertification in the country.
            - Water erosion in both hot and cold desert areas, across various land covers and with varying levels of severity.
        - wind erosion.

Natural Factors:

- **Natural Disasters:** There are some cases where the land gets damaged because of natural disasters, including drought.
- **Climate Change:** As the days get warmer and periods of drought become more frequent, desertification becomes more and more eminent. Unless climate change is slowed down, huge areas of land will become desert; some of those areas may even become uninhabitable as time goes on.

3.2 Case Study: Sahara Desert

- Scientists agree, that there is a natural cause for the existence of desert in the place where is now the Sahara desert: **a natural climate cycle cause a lack of water in this area from time to time**.
- There is a suggestion that the last time that the Sahara was converted from savannah to desert it was partially due to overgrazing by the cattle of the local population.
- Extent of Desertification in Sahara.



3.3 Consequences of Desertification

- **Impact on farming:** If an area becomes a desert, then it's almost impossible to grow substantial crops there without special technologies.
- **Hunger**: Inadequate farm production => farms produce will become much scarcer, and the people who live in those local areas will be a lot more likely to try and deal with hunger problems. Animals will also go hungry, which will cause even more of a food shortage.
- **Flooding**: Without the plant life in an area, flooding is a lot more eminent.
    - Not all deserts are dry; those that are wet could experience a lot of flooding because there is nothing to stop the water from gathering and going all over the place.
- **Poor Water Quality**: Water quality declines because the plant life plays a significant role in keeping the water clean and clear; without its presence, it becomes a lot more difficult for you to be able to do that.
- **Overpopulation**: When areas start to become desert, animals and people will go to other areas where they can actually thrive. This causes crowding and overpopulation, which will, in the long run, end up continuing the cycle of desertification that started this whole thing anyway.

3.4 International Initiatives To Prevent Deforestation:

Desertification and the Sustainable Development Goals:

The 2030 Agenda for Sustainable Development declares that "we are determined to **protect the planet from degradation**, including through sustainable consumption and production, sustainably managing its natural resources and taking urgent action on climate change, so that it can support the needs of the present and future generations". Specifically, **Goal 15** states our resolve to halt and reverse land degradation.

United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (UNCCD)

- A Convention **to combat desertification** and **mitigate the effects of drought through national action programs** that incorporate long-term strategies supported by international cooperation and partnership arrangements.
- It is the only internationally **Legally binding** framework set up to address the problem of desertification.
- The Convention is based on the principles of participation, partnership and decentralization
- India is a signatory to **United Nations Convention to Combat Desertification** (UNCCD).
- The **National Action Programme for combating desertification** was prepared in 2001 to take appropriate action in addressing the problems of desertification.

3.5 Indian Government Initiatives to Prevent Deforestation:

- Programmes that address issues related to land degradation and desertification:
    - Integrated Watershed Management Programme (IWMP),
    - National Afforestation Programme (NAP),
    - National Mission for Green India (GIM),
    - The Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS)
    - National Watershed Development Project for Rainfed Areas (NWDPRA),
    - Command Area Development and
- With a view to mitigate adverse impact of land degradation/desertification, increasing the productivity of agricultural land and sustaining foodgrain production, Government of India, Ministry of Agriculture is implementing various Schemes/Programmes, namely;
    - National Project on Organic Farming (NPOF),
    - National Food Security Mission (NFSM),
    - Rashtriya Krishi Vikas Yojana (RKVY),
    - Integrated Scheme of Oilseeds, Pulses, Oil Palm and Maize (ISOPOM)

3.6 What more need to be done to control deforestation:

To reduce the severity of the desertification process, adoption of proper and regular management practices such as following are suggested:

- **Identifying suitable areas for afforestation** with the **selection of suitable climate-resilient multipurpose tree species**, perennial forage and fodder species.
- Managing soil erosion by **adopting location-specific soil and water conservation practices**.
- Dealing with soil salinity in agricultural lands through **proper irrigation water management**, development and **maintenance of surface and subsurface drainage systems**.
- Adopting proper agriculture and land management practices.
- Converging these activities with the ongoing national and state government programmes like **Joint Forest Management**, **Integrated Watershed Management Programme** and Mahatma Gandhi National Rural Employment Guarantee Act, etc.

4. SAND MINING

Sand Mining is the process of the **actual removal of sand from the foreshore including rivers, streams and lakes**. Sand is **mined from beaches and inland dunes and dredged from ocean beds and river beds**. A related process is the **mining of mineral sands**, such as mineral deposits like diamond, gold and silver.

4.1 Uses of Sand

Use of Sand in manufacturing industry: It is used for manufacture of both common and optical glasses.

Use of Sand in infrastructure sector:

- Sand is **an ingredient in plaster and concrete**
- It is **added to clays to reduce shrinkage and cracking in the manufacture of bricks**.
- **River sand is used along with cement, gravel, water and steel** for making reinforced concrete.
- **Along with cement and water, it is used as mortar** for joint filling and plastering.

4.2 Environmental significance of sand:

- It **provides suitable substrate for many benthic organisms**.
- It is an unavoidable component for psammophile (sand loving or shallow sandy water creature) fishes as it **provides breeding, spawning, feeding and hiding grounds**.
- Inter-beds of sand within floodplain deposits **act as aquifer systems storing large quantities of ground water**.
- sand **acts as an efficient filter for various pollutants** => **maintains the quality of water in rivers** and other aquatic ecosystems.

4.3 Issues with Sand Mining:

In earlier days, mining of sand did not create any problem to river ecosystem as the **quantity of mining was well within the replenishment limits**. However, **increase in population** and the **rise in economic and industrial developments** during the past few decades have **aggravated mining of river sand many folds higher than natural replenishments**

Impact of sand mining on environment:

- Excessive in-stream sand-and-gravel mining
    - lowers the stream bottom, which may lead to bank erosion.
    - is a threat to bridges, river banks and nearby structures.
    - results in the **destruction of aquatic and riparian habitat** through large changes in the channel morphology.
    - Impacts include bed degradation, bed coarsening, lowered water tables near the streambed, and channel instability.
- Depletion of sand in the streambed and along coastal areas **causes the deepening of rivers and estuaries** + **enlargement of river mouths and coastal inlets**.
- Bed degradation from in-stream mining **lowers the elevation of stream flow and the floodplain water table** => can eliminate water table-dependent woody vegetation in riparian areas, and **decrease wetted periods in riparian wetlands**.
- Saline-water intrusion from the nearby sea

Impact on humans:

- Sand mining also affects the adjoining groundwater system and the uses that local people make of the river.
- Degraded stream habitats result in **loss of fisheries productivity**, biodiversity, and recreational potential. Severely degraded channels may lower land and aesthetic values.
- Sand mining transforms the riverbeds into large and deep pits; as a result, the **groundwater table drops** leaving the drinking water wells on the embankments of these rivers dry.

Impact upon the river's water quality:

- Increased short-term turbidity at the mining site due to resuspension of sediment,
- Sedimentation due to stockpiling and dumping of excess mining materials and organic particulate matter
- Oil spills or leakage from excavation machinery and transportation vehicles.

4.4 Case study: National Chambal Sanctuary

- **Last of the wild and breeding gharials left =** Found in maximum strength in National Chambal Sanctuary running across three states (UP, MP and Rajasthan)
- Mining of sand banks is destructive for gharial population as **sand banks are essential for nesting and basking**. **Gharials lay their eggs under sand beds, but illegal sand mining destroys their nests**.
- **Local inhabitants are cultivating river banks** immediately adjacent to the river and this is **causing considerable disturbance to the natural habitat of gharials**.
- Villagers residing along the river are **flattening ravines present in the sanctuary for farming**.'
- The 425 km stretch of the Chambal River was declared a **protected area in 1979.**

4.5 Government intervention to control sand mining:

- **Legal provision: Sand is a minor mineral, as defined under section 3(e) of the Mines and Minerals (Development and Regulation) Act, 1957 (MMDR Act)**.
- Section 15 of the MMDR Act **empower state governments to make rules for regulating the grant of mineral concessions** in respect of minor minerals and for purposes connected therewith.
- The regulation of grant of mineral concessions for minor minerals is, therefore, within the legislative and administrative domain of the state governments.
- Under the power granted to them by section 15 of the MMDR Act, State Governments have framed their own minor minerals concession rules.
- Further, section 23C of the MMDR Act, 1957 **empowers state governments to frame rules to prevent illegal mining, transportation and storage of mineral sand for purposes connected therewith**.
- Control of illegal mining is, therefore, under the legislative and administrative jurisdiction of state governments.
- Ministry of Environment, Forest and Climate Change has issued **Sustainable Sand Mining Management Guidelines, 2016**, which, inter-alia, addresses the issues relating to regulation of sand mining.
- Salient features of the Guidelines:
    - It provides for a detailed programme for **ensuring that mining of river sand is done in a sustainable manner**;
    - **Grant of Environment Clearance for minor minerals, including sand and gravel**, for mining lease of area up to 5 hectares will be done **by the District Environment Impact Assessment Authority** headed by the District Collector / District Magistrate.

4.6 Sand Mining Framework

Objectives:

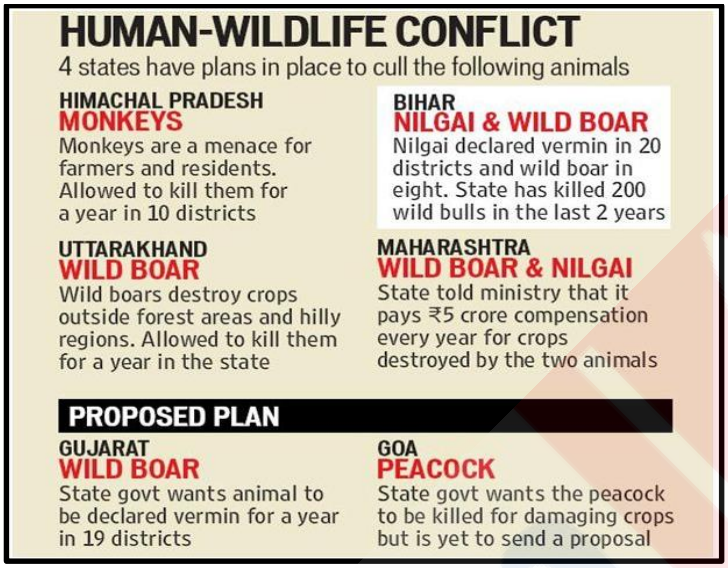
- To help states deal with the sand mining issues, including demand supply deficit and illegal extraction

Significance:

- This will help states to frame their policies, taking into consideration their objectives, endowments and state deployment of resources
- The framework **addresses the issues of state objectives, demand-supply assessment, measures to sand availability, allocation model, transportation and monitoring mechanism**.
- it also includes suggestions for faster clearances /approvals and using its interventions in complete process chain of sand mining.
- The framework also **lays emphasis on alternatives of sand i e manufactured sand, import of sand etc.**

5. HUMAN-ANIMAL CONFLICT

Human-animal conflict simply refers to the **interaction between man and animal** and **resultant negative impact on man and his resources or animal and its habitat**. The conflicts between the man and animal become more frequent in recent times.



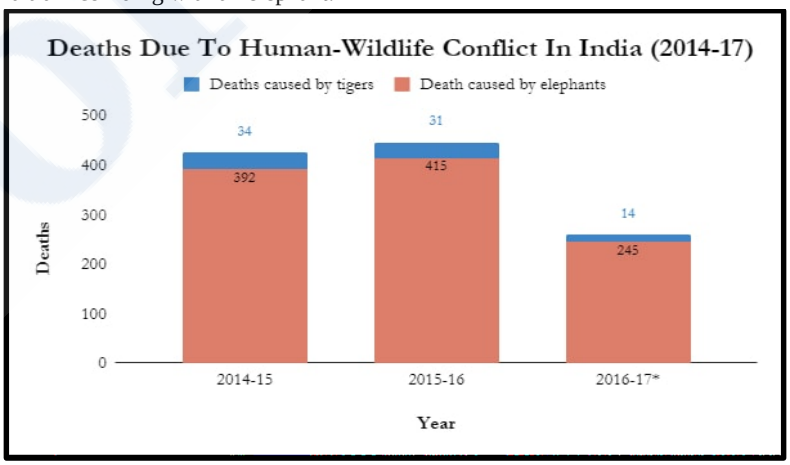
The incidents of Man-Animal Conflicts can be categorized into following major types:

- Human beings get killed or injured by wild animals
- Livestock/Cattle reared by man get killed or injured
- Crop cultivated by man damaged
- Wild animals get killed or injured

5.1 Statistics: A total of 1,557 people were killed due to human-elephant conflict between 2014-15 and 2017-18 (till November 2017).

Recent cases of the conflict:

- A tigress named Avni, who was believed to have turned man-eater and killed 13 people in the last two years in Yavatmal district Pandharkawada area, was shot dead in Borati forest.
- An incident of a train colliding with an elephant.



5.2 Reasons behind growing cases of Man-Animal Conflict:

- Changing times + Ever-increasing population = the lines between human settlements and forests have started to blur => more number of conflicts.
- **rapid urbanization and industrialisation** have led to **diversion of forest land to non-forest purposes** => the wildlife habitat is shrinking. This habitat fragmentation may be result of construction of roads especially big Highways and canals passing through dense jungles and the big mines.
- **Encroachment in the forest lands by local people** => shrinkage of wildlife habitats especially on the fringes which has increased the pressure on the limited natural resources in the forest areas.
- **Increased disturbance due to collection of fuel wood, fodder, NTFPs, water etc. from the forests.** There are numerous incidences where the cattle graziers were killed/ mauled by tiger/ panther/ bear.
- **Livestock grazing** in the forest areas
- **Increase in area under cultivation around wildlife habitats** and **changed cropping pattern.** People have started growing commercial crops like sugarcane and banana, which provide good hiding place for the wild animals like wild boar, sloth bear and panther.
- **Infestation of wildlife habitat by the invasive exotic weeds** (like Lantana, Eupatorium and Parthenium etc) have resulted in **decreased availability of edible grasses** for the wild herbivores. As a result, **herbivores come out of forest area** and **cause depredation of agricultural crops** on the fringes.
- **Monoculture of teak** in the large scale forest plantations has also adversely affected the wildlife habitat value of the forest areas.
- During summer, water becomes scarce. The livestock and wild animals have to share the limited water sources on the fringes or inside forest. **Human interference with the natural drainage system in forest areas** and **diversion of water towards habitation** has further complicated the issue.
- **Poaching of herbivores => Decreased prey base** => Carnivores moving out of forest in search of prey and indulge in cattle lifting.

5.3 Measures that can be taken to mitigate Man-Animal Conflict:

- **Stop fragmentation of wildlife habitat and wildlife corridors.** While going for construction of dams, long canals for irrigation and Highways through the forest areas, **ensure that the connectivity through wildlife corridors is not disturbed**.
- One method is to make a mixture of oil, used car grease, fresh elephant dung and crushed chili (piri piri), which is slathered on ropes which are strung around fields of crops. When elephants run into these ropes the substance **burns their skin and the pungent odor repels them**.
- Ensure that both humans and animals have the space they need. Protecting key areas for wildlife, creating buffer zones and investing in alternative land uses are some of the solutions.
- **Control poaching** : Poaching of wild animals should be stopped so that the number of wild animals can stabilize at its carrying capacity which would reach equilibrium in the ecosystem and this equilibrium between the numbers of prey animals and predators in the forest ecosystem would be maintained.
- **Stop plant monoculture** of species like teak; instead go for mixed plantations of miscellaneous, bamboo and fruit species which will provide
- To increase water availability in the forests, **soil and moisture conservation measures** (SMC) like vegetative checks dams, loose boulder check-dams, cement plugs, nala bunding, water tanks, should be taken in the forest.
- **Providing LPG to villagers** who frequently go to the forest areas specially wildlife habitats to fetch fuel wood.
    - Maharashtra Forest Department has started in big way to distribute LPG to villagers residing on the fringes under Joint Forest Management Program and Village Eco-Development Program.
- **Eco-development activities** in villages to elicit the cooperation of the local community in the management of the Protected Areas.
- Eco-Tourism = create an alternate source of income for local people = it can help in minimizing man-animal conflict on account of crop depredation or livestock killing.
- **Awareness Raising** through meetings and pamphlets etc that they should avoid going deep into the forest areas. If they have to go in any case, they should go in groups and they should keep talking to each other to detract the wild animals. School children in vulnerable villages should be educated about the importance of wildlife and human coexistence with it.
- **Stone fencing or Solar Fencing around agriculture fields** situated near wildlife habitat/forest areas.

- **Controlling crop pattern.** Crops like sugarcane, Banana, Bajra, tuhar should not be allowed to be grown near forest areas. These crops attract wildlife for food as well as good hiding place.
- **Paying ex-gratia/Compensation to** the victims of wildlife attack **so that the people will not become enemy of the wild animals**.
    - Otherwise people tend to take revenge from the wild animals by killing them by poison, trap, hacking or shooting as has been noticed in many cases.
- **Relocation/Rehabilitation of problematic and disadvantaged wild animal should be considered.**

5.4 Guidelines for management of human-animal conflict

The management of human-animal conflict is handled by **State Government as per Rules, Guidelines in vogue.** Some of the mechanisms in mitigation of human animal conflict include :

- Provisions under Section 11 of Wild Life (Protection) Act, 1972 **empower the Chief Wildlife Warden** and authorised officer **to take necessary steps** to handle problematic wild animals.
- **Standard Operating Procedures/guidelines for management of major problematic animals** like tiger, elephant, leopard, rhino etc are being used by the respective state governments.
- **Construction/erecting of physical barriers**, such as barbed wire fence, solar powered electric fence, bio-fencing using cactus, boundary wall etc. to prevent the entry of wild animals into crop field.
- Improvement of wildlife habitats by **augmenting the availability of food and water** in forest areas to reduce the entry of animals from forest to human habitations.
- The Ministry has issued guidelines in context of human-wildlife conflict to the Chief Wildlife Wardens of all the State

5.5 Steps taken by the Central/State Governments for improvement of natural habitat of wild animals includes:

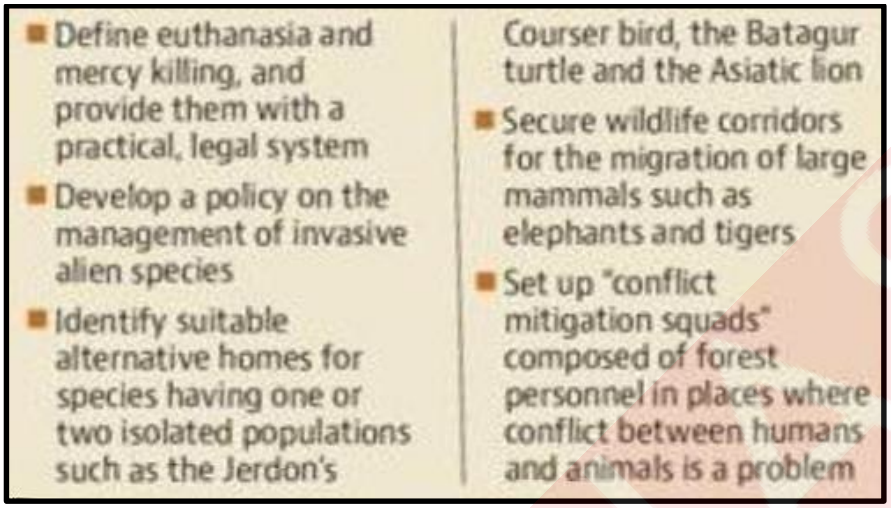
- **A network of Protected Areas** namely viz., national park, Sanctuaries, Conservation Reserves and Community Reserving covering important wildlife habitat **have been created all over the country** under the provisions of the Wild Life (Protection) Act, 1972.
- **Financial assistance is provided to the State/Union Territory governments** under the Centrally Sponsored Schemes of 'Integrated Development of Wildlife Habitats', 'Project Tiger' and 'Project Elephant' for providing better protection to wildlife, and improvement of its habitats.
- The MoEF&CC, with financial assistance from Ad-hoc Compensatory Afforestation Fund Management and Planning Authority (CAMPA), has **formulated a scheme to provide assistance to the States for 'Augmentation of Fodder and Water in Protected Areas/Forest Areas'**, aimed at improving habitat in the areas by making provision for augmenting grass, fodder and water to the wild herbivores.
- The Wild Life (Protection) Act, 1972 provides regulatory functions for taking up activities in National Parks and Sanctuaries to protect the wildlife habitats.
- Payment of ex-gratia amount to victims of wild animal attack is provided with a view to reduce retaliatory killings.
- Periodic awareness campaigns to sensitize guide and advise the general public on man-animal conflict, including dissemination of information through various forms of media.
- Financial assistance is provided under Centrally Sponsored Scheme (CSS) of Integrated Development of Wildlife Habitats (IDWH) and Project Tiger for voluntary relocation of villages from within Protected Areas. This helps in moving people away from wildlife rich habitats and thus reducing conflict situations.
- Recently (Oct 2018), in possibly the first-of-its-kind move, the **Uttar Pradesh government has made the man-animal conflict a 'State Declared Disaster'** bringing such incidents under the ambit of State Disaster Response Fund (SDRF) to ensure better coordination and relief during such mishaps in the state.

5.6 Issues with the government intervention to mitigate man-animal conflict:

- Majority of the States awarded compensation for loss of livestock, human injury and death. Only 18 states provided compensation for property damage.
- 22 states provide for compensation for crop loss (states like Gujarat and Rajasthan do not provide compensation for crop loss)
- Inconsistencies in eligibility, application, assessment, implementation and payment procedures across States in giving compensation.
- Discrepancies in eligibility procedure for filling compensation for loss.

Source: 2010 to 2015 data by Bengaluru Centre for wildlife studies on man-human conflict

5.7 Way forward for the government:


- Define euthanasia and mercy killing, and provide them with a practical, legal system
- Develop a policy on the management of invasive alien species
- Identify suitable alternative homes for species having one or two isolated populations such as the Jerdon's Courser bird, the Batagur turtle and the Asiatic lion
- Secure wildlife corridors for the migration of large mammals such as elephants and tigers
- Set up "conflict mitigation squads" composed of forest personnel in places where conflict between humans and animals is a problem

6. EUTROPHICATION

Inorganic plant nutrients are water soluble nitrates and phosphates that **cause excessive growth of algae and other aquatic plants**. The **excessive growth of algae and aquatic plants due to added nutrients** is called eutrophication.
Eutrophication is characterized by **excessive plant and algal growth** due to the increased availability of one or more limiting growth factors needed for **photosynthesis** such as sunlight, carbon dioxide, and nutrient fertilizers.

- Eutrophication occurs naturally over centuries as lakes age and are filled in with sediments.
- However, **human activities have accelerated the rate and extent of eutrophication** through both point-source discharges and non-point **loadings of limiting nutrients, such as nitrogen and phosphorus, into aquatic ecosystems** (i.e., cultural eutrophication), with dramatic consequences for drinking water sources, fisheries, and recreational water bodies.

6.1 Factors responsible behind eutrophication:

- **Use of fertilisers**: Agricultural practices and the use of fertilisers in the soil contribute to the accumulation of nutrients. When these nutrients reach high concentration levels and the ground is no longer able to assimilate them, they are carried by rain into rivers and groundwater that flow into lakes or seas.
- **Adding fertilizers to enhance primary productivity** and increase the density and biomass of recreationally and economically important fishes via bottom-up effects on higher trophic levels.
- **Discharge of waste water into water bodies**:
    - wastewater is discharged directly into water bodies such as rivers, lakes and seas.
    - The result of this is the **release of a high quantity of nutrients which stimulates the disproportionate growth of algae**.
    - When water is treated by means of water treatment plants before discharge into the environment, the treatments applied are not always such as to reduce the organic load, with the consequent accumulation of nutrients in the ecosystem.
- **Reduction of self-purification capacity**:
    - Over the years, lakes accumulate large quantities of solid material transported by the water (sediments).
    - These sediments are such as to able to absorb large amounts of nutrients and pollutants.
    - Consequently, the **accumulation of sediments starts to fill the basin** and, increasing the interactions between water and sediment, the resuspension of nutrients present at the bottom of the basin is facilitated. This phenomenon could in fact lead to a further deterioration of water quality, accentuating the processes connected with eutrophication.

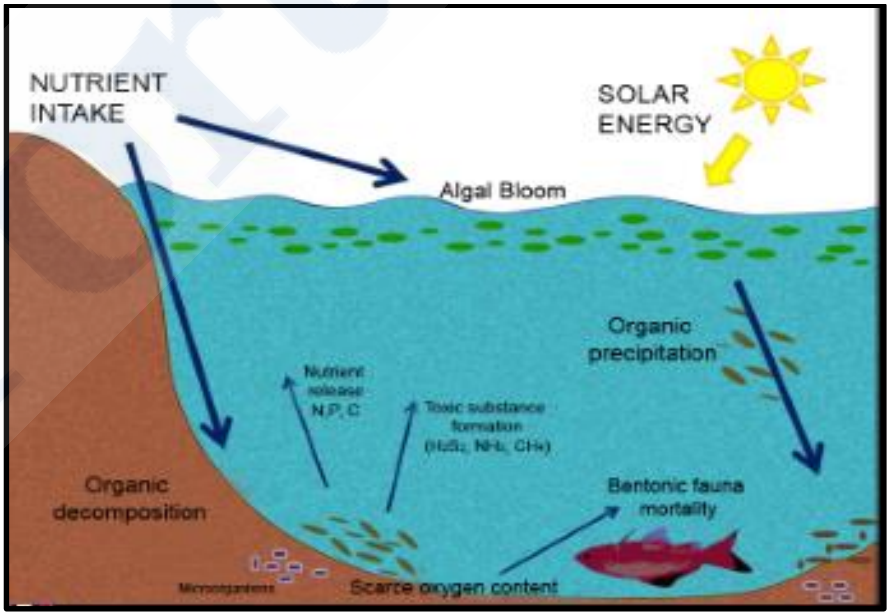


Fig: Eutrophication process

6.2 Consequences of Eutrophication

Impact on human life:

- They may interfere with the use of the water by clogging water intake pipes, changing the taste and odour of water and cause a buildup of organic matter.
- Poisonings of domestic animals, wildlife, and even humans by blooms of toxic cyanobacteria
- Disappearance or significant reduction of quality fish with very negative effects on fishing
- **Prohibition of touristic use of the lake and bathing**, due to both the foul odour on the shores caused by the presence of certain algae, as well as the turbidity; **bathing is dangerous because certain algae cause skin irritation.**

Impact on environment:

- **Creation of dense blooms of noxious, foul-smelling phytoplankton** that **reduce water clarity and harm water quality**
- Algal blooms **limit light penetration**, **reducing growth and causing die-offs of plants in littoral zones** while also **lowering the success of predators that need light to pursue and catch prey**
- Furthermore, high rates of photosynthesis associated with eutrophication can **deplete dissolved inorganic carbon** and **raise pH to extreme levels during the day**.
    - Elevated pH can in turn '**blind' organisms that rely on perception of dissolved chemical** cues for their survival by impairing their chemosensory abilities
- When these dense algal blooms eventually die, **microbial decomposition severely depletes dissolved oxygen**, creating a hypoxic or **anoxic** 'dead zone' lacking sufficient oxygen to support most organisms.
- Some algal blooms **produce noxious toxins (e.g., microcystin and anatoxin-*a*)**.

6.3 Measures to control Eutrophication

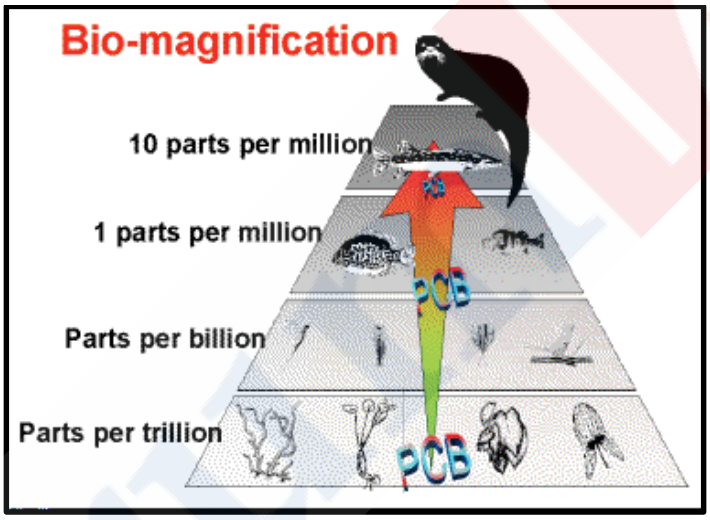
- Pass legislations to regulate point-source loading of nutrients
- Need to employ a variety of strategies for (1) **diversion of excess nutrients**, (2) **altering nutrient ratios**, (3) **physical mixing**, (4) **shading water bodies** with opaque liners or water-based stains, and (5) **application of potent algaecides and herbicides**.
- Water quality can often be improved by **reducing nitrogen and/or phosphorus inputs into aquatic systems**
- **Use of algaecides**, such as copper sulfate = effective at reducing HABs temporally
    - Criticism: **algaecides are expensive to apply** and **do not control the primary cause of the problem**
- The **alteration of a food web to restore ecosystem health** secondary consumers (planktivorous fishes) are removed either through the addition of tertiary consumers (piscivorous fishes) or harvesting, which **allows for the dominance of large-bodied, generalist grazers** (e.g., *Daphnia*) **to control phytoplankton**

6.4 Way Forward:

- **Improvement of the purifying performance of wastewater treatment plants**, installing tertiary treatment systems to **reduce nutrient concentrations**;
- Implementation of **effective filter ecosystems to remove nitrogen and phosphorus present in the run-off water** (such as phyto-purification plants);
- **Reduction of phosphorus in detergents**;
- **Rationalisation of agricultural techniques** through **proper planning of fertilisation** and **use of slow release fertilisers**;
- Use of alternative practices in animal husbandry to limit the production of waste water.

7. Bioaccumulation and Biomagnification

- Bioconcentration and bioaccumulation **occur within an organism**, but biomagnification **occurs across levels of the food chain**.
- Bioamplification (or biomagnification) refers to **an increase in the concentration of a substance as you move up the food chain**.
    1. This often occurs because the pollutant is persistent, meaning that it cannot be, or is very slowly, broken down by natural processes.
    2. These persistent pollutants are transferred up the food chain faster than they are broken down or excreted.
- In contrast, bioaccumulation occurs within an organism, where **a concentration of a substance builds up in the tissues** and **is absorbed faster than it is removed**.
- Bioaccumulation often occurs in two ways:
    1. by eating contaminated food, and
    2. by absorption directly from water. This second case is specifically referred to as bioconcentration. Bioconcentration is the **accumulation of a chemical in or on an organism when the source of chemical is solely water**.



7.1 Mechanism

- While excess fertilizers cause eutrophication, pesticides cause bioaccumulation and biomagnification.
- Pesticides which enter water bodies are introduced into the aquatic food chain.
- They are then absorbed by the phytoplanktons and aquatic plants.
- These plants are eaten by the herbivorous fish which are in turn eaten by the carnivorous fish which are in turn eaten by the water birds.
- **At each link in the food chain these chemicals which do not pass out of the body are accumulated and increasingly concentrated resulting in biomagnification of these harmful substances**.

7.2 Consequences

Impact on environment:

- One of the effects of accumulation of high levels of pesticides such as DDT is that **birds lay eggs with shells that are much thinner than normal**.
    - This results in the premature breaking of these eggs, killing the chicks inside.
    - Birds of prey such as hawks, eagles and other fish eating birds are affected by such pollution.
- Although **DDT** has been banned in India for agricultural use and is to be used only for malaria eradication, it is still used in the fields as it is cheap.

Impact on Humans

- The toxic elements like **mercury, cadmium, arsenic,** etc. through these processes can enter the food chain. They have harmful effects on human health
- Mercury through the process of magnification can cause **Minamata disease.**

7.3 Measures to control

- Effectively banning DDT.
- Controlling industrial effluents outflows into oceans and rivers.
- Passing legislations to ban those toxic substances that have the potential to biomagnify and cause detrimental health effects.

8. CORAL BLEACHING

Corals live in tropical waters throughout the world, generally close to the surface where the sun's rays can reach the algae.

- While corals get most of their nutrients from the byproducts of the algae's photosynthesis, they also have barbed, venomous tentacles they can stick out, usually at night, to grab zooplankton and even small fish.

8.1 How coral reefs are formed?

- Coral polyps are tiny, soft-bodied organisms related to sea anemones and jellyfish.
- At their base is a hard, protective limestone skeleton called a calicle, which forms the structure of coral reefs.
- Reefs begin when a polyp attaches itself to a rock on the seafloor, then divides, or buds, into thousands of clones.
- The polyp calicles connect to one another, creating a colony that acts as a single organism.
- As colonies grow over hundreds and thousands of years, they join with other colonies and become reefs.

8.2 What is coral bleaching?

- Coral bleaching is **the loss of intracellular endosymbionts** (*Symbiodinium*, also known as zooxanthellae) **through either expulsion or loss of algal pigmentation.**
- When a coral bleaches, it is not dead.
- **Why coral bleaching**: **When corals are stressed by changes in conditions such as temperature, light, or nutrients**, they expel the symbiotic algae living in their tissues, causing them to turn completely white.

8.3 Factors responsible

- **Increased (most commonly) or reduced water temperatures**: Warm water prompts algae inside the coral to leave, which starves coral and turns it white.
- Oxygen starvation caused by an increase in zooplankton levels as a result of overfishing.
- Increased solar irradiance (Photosynthetically Active Radiation and ultraviolet band light).
- Changes in water chemistry (acidification).
    - Major part of pollution comes from land-based run off, oil spills, nutrients and pesticides from agriculture, wastewater, industrial effluent, untreated sewage and others.
    - Toxic chemicals like POPs and PAHs **can destroy or damage reef communities by affecting coral's reproduction and growth.**
- Marine debris like plastic, glass, metal, rubber abandoned fishing nets and other gear often get entangle and kill reef organisms and break or damage them.
- Increased sedimentation due to silt runoff
- Bacterial infections
- Changes in salinity

8.4 Case study: Bleaching in Australia's Great Barrier Reef:

The Great barrier reef:

- It is the world's largest coral reef system composed of over 2,900 individual reefs and 900 islands stretching for over 2,300 kilometres over an area of approximately 344,400 square kilometres.
- The reef is located in the Coral Sea, off the coast of Queensland, Australia.
- This reef structure is composed of and built by billions of tiny organisms, known as coral polyps. It was selected as a World Heritage Site in 1981.
- **What has happened:**
    - Incidents of mass bleaching has killed more than a third of the coral in the northern and central parts of Australia's Great Barrier Reef.
    - Coral along large swathes of the 2,300-kilometre reef have been killed by rising sea temperatures linked to climate change, leaving behind skeletal remains.
    - The northern reaches of the reef suffered an unprecedented two successive years of severe bleaching in 2016 and 2017.
- **Factors responsible:** Experts say the bleaching has been triggered by
    - **global warming and El Nino**, a warming of parts of the Pacific Ocean that changes weather worldwide.

    - Farming runoff
    - Development
    - Predatory crown-of-thorns starfish
- **Suggested solutions**
    - Reducing the exposure of corals to physical stressors
    - Boosting coral regeneration rates by cultivating reef-building coral larvae that attract other important marine species

8.5 Measures to Control Coral Bleaching

- Effective implementation of the Paris Agreement so as to limit the average temperature rise within 1.5 C compared to pre-industrial levels through proper adherence to INDC targets.
- Controlling ocean water pollution by restricting flows of untreated industrial effluents, oil leakages, etc.
- Phasing out ocean bottom trawling by deep ocean fishing.
- Controlling and eliminating introduction of invasive alien species.
- Ensuring that the developmental projects like Carmichael coal mine in Australia, Bharat Sethum Project in Gulf of Mannar, etc. does not leads to destruction or bleaching of coral reefs.

9. GENETICALLY MODIFIED ORGANISM(GMO)

A GMO or genetically engineered organism is **an organism whose genetic material has been altered using genetic engineering techniques.** An organism **in which one or more genes (called transgenes) have been introduced** into its genetic material from another organism using recombinant DNA technology.

9.1 Examples of GMOs

Bt Cotton (Genetically modified cotton)

- It was **developed to reduce the heavy reliance on pesticides**.
- The Bacterium **Bacillus Thuringiensis (Bt) naturally produces a chemical harmful only to a small fraction of insects**(larvae of moths and butterflies, beetles, and flies etc) and harmless to other forms of life.
- The **Gene coding for (Bt) toxin has been inserted into cotton**, causing cotton to produce this natural insecticide in its tissues.

Bt Brinjal

- A transgenic brinjal created by inserting a crystal protein gene (Cry1Ac) from the soil bacterium Bacillus thuringiensis into the genome of various brinjal cultivators.
- Itis developed to give resistance against lepidopteran insects, in particular the Brinjal Fruit and Shoot Borer (FSB).
- The insertion of the Gene, along with other genetic elements like promoters, terminators and an antibiotic resistance marker gene into the brinjal plant is accomplished using Agrobacterium-mediated genetic transformation.

Dhara Mustard Hybrid-11 (DMH-11)

- A genetically modified variety of mustard.
- Developed by the Delhi University's Centre for Genetic Manipulation of Crop Plants under a government-funded project.

9.2 Difference between a Living Modified Organism(LMO) and a GMO

- a Living Modified Organism is capable of growing, and typically refers to agricultural crops.
- Genetically Modified Organisms include both LMOs and organisms which are not capable of growing, i.e. are dead.

9.3 Arguments in support of Genetically Modified (GM) crops

Impact on farmers:

- **GM Crops** offer **improved yields, enhanced nutritional value, longer shelf life** and **resistance to drought, frost or insect pests**.
- Herbicide/Pest/Viral/Fungal/bacteria resistance = reduce any loss in yields => increasing profitability for farmers.
- **slow-ripening +** Quality improvement (protein and oil)
- Herbicide resistance + Disease resistance + Cod tolerance + Salinity tolerance
- Desired change can be achieved in very few generations.
- **Allows greater precision in selecting characteristics**.

Impact on human health:

- Value addition (Vitamins, micro-and macro-elements).
- Additional access to minerals can be provided and thus deficiencies can be curbed (Especially in women and children)

Impact on food security:

- GM food => eradicate hunger. **"It is better to die eating GM food instead of dying of hunger**".
- Better flavour and colour + Early maturing + All year availability
- Regulatory mechanism in India is adequate. Government can reject a GM crop for commercial cultivation if field trials find the product is not suitable for the environment or human consumption.

Potential benefits for environment:

- Genetically engineered resistance to pests and diseases **could greatly reduce the use of pesticides and insecticides needed for crop protection**. => reduce environmental impact

- unsustainable irrigation practices => Large areas of crop-land have become saline = **Genetic modification could produce salt-tolerant varieties**.

9.4 Arguments against Genetically Modified (GM) crops

- **Unintended environmental impacts** :
  - harming non--target and/or beneficial species in the case of crops with engineered insecticidal properties
  - The potential for pests to evolve resistance to the toxins produced by GM crops.
  - The **likelihood of transgenes escaping from cultivated crops into wild relatives**.
  - The risk of these toxins affecting non-target organisms.
- **At present, there is no evidence to suggest that GM foods are unsafe. However, there are no absolute guarantees, either**.
- **Impact on farmers:**
  - **Autonomy of farmers affected** because the **seeds of these tech crops are monopolized and are marketed by big private firms**. If he is unable/does not provide us the requisite seeds, we have a problem.
  - Genetic erosion of our local varieties.
- Higher costs for farmers, as well as lost premiums and markets.
- The danger of **unintentionally introducing allergens and other anti-nutrition factors in foods**.
- According to data provided by FAO, the **highest yields in mustard are from the five countries which do not grow GM mustard** — U.K., France, Poland, Germany and Czech Republic — and not from the GM-growing US or Canada.
- Reduced effectiveness to pesticides
- Playing with nature and its mechanisms.

Arguments in support of introduction to GM mustard

- **Introduction of GM Mustard may reduce dependence on edible oil.**
  - **India is the world's 2nd largest consumer of edible oil after China**
  - 14.5-15.5 million tonnes of the total 20-21 mt annual consumption is imported.

Counter-arguments to GM mustard's high yield

- **Yields claims are not reliable:** The yield claims on which GM mustard has been cleared are not reliable. They are based on comparisons with 30-year-old cultivars, and not on more recent high-yielding hybrids.
- If India wants to increase mustard production yield rapidly and safely, then the government can adopt the practice of "**System of Mustard Intensification"**, for which successful trials have been done in Bihar through a World Bank project. Results showed higher yields and better income. And all of this was done without the spraying of any toxic herbicides.

Is the objection to GM justified?

- No. **GM technology has already been commercialised in India through Bt cotton**.
  - **country's cotton production has gone up more than 2½ times** since Bt hybrids were first planted in 2002.
  - No evidence of Bt cotton causing any adverse human or animal health effects has emerged.
- Argument against GM Mustard : cotton is not a food crop, while mustard is India's largest edible oil-yielding crop.
  [Counter Argument]: cotton-seed yields not only fibre (lint), but also oil and oilcake (meal) fed to animals.
  - Cotton-seed oil = 2nd largest produced edible oil in the country (1.4 million tonnes) after mustard (2 million tonnes). That makes cotton also a food crop.
  - 95% of India's cotton production is Bt = its harmful toxins would already have been consumed directly or indirectly during the last decade and more.
  - India imports soybean oil and rapeseed oil = they are predominantly GM.
  - **Developer of GM Mustard = is a government-funded institution.**
    - Bt cotton = proprietary technology of an MNC Monsanto.

9.5 Worldwide Practice:

- GM crops have been gaining acceptance.
- However, their use still remains highly skewed.
  - Only **29 countries allow commercial cultivation of GM crops** while a similar number also allow their import.

- And **most of the 170 million hectares under GM crops are in the USA, Brazil, Argentina, India and China**.
- Moreover **98% of GM cultivation falls under four main crops: soybean, maize, cotton and canola**.

9.6 What needs to be done?

- Crops should be released only after full satisfaction on the assessment of their impact on plants, animals and human beings.
- **Field trials in India must ensure that there are sufficient safeguards** against such violations.
- If GM food is allowed to be sold to consumers, they must have the **right to know what they are buying**, and **labelling should be made mandatory**.
- A **strong regulatory authority** should also be established for overseeing matters related to GM crops.
- Dependence on GM crops is a risky proposition. Hence, India can use other technologies = increase productivity by molecular breeding and integrated pest management.

10. ACID RAIN

When rain falls through polluted air, it can pick up some of the pollutants (oxides of nitrogen and sulphur) and turn more acidic—producing acid rain = **Air pollution converts the rain into a weak acid**.

10.1 Causes of Acid Rain

- Mixing of Sulfur and Nitrogen particles with the wet components of rain.
- Sources of Sulfur and Nitrogen particles
    - emissions given out from industries
    - burning of fossil fuels
    - lightning strike in the atmosphere releases nitrogen ions
    - sulphur is released from volcanic eruptions.

The reaction behind formation of Acid Rain

- Sulphur dioxide and nitrogen dioxide undergo oxidation and then they react with water resulting in the formation of sulphuric acid and nitric acid respectively.

  $2SO_2\,(g) + O_2\,(g) + 2H_2O\,(l) \rightarrow 2H_2SO_4\,(aq)$

  $4NO_2\,(g) + O_2\,(g) + 2H_2O\,(l) \rightarrow 4HNO_3\,(aq)$

10.2 Impacts of Acid Rain

Impact on Environment

- When acid rain accumulates in lakes or rivers, it gradually turns the entire water more acidic.
- Fish thrive only in water that is neutral or slightly acidic (typically with a pH of 6.5–7.0).
- Once the acidity drops below about pH 6.0, fish soon start to die—and if the pH drops to about 4.0 or less, all the fish will be killed.
- It also **causes the death of forests, reduces the fertility of soil, and damages buildings by eating away stonework**

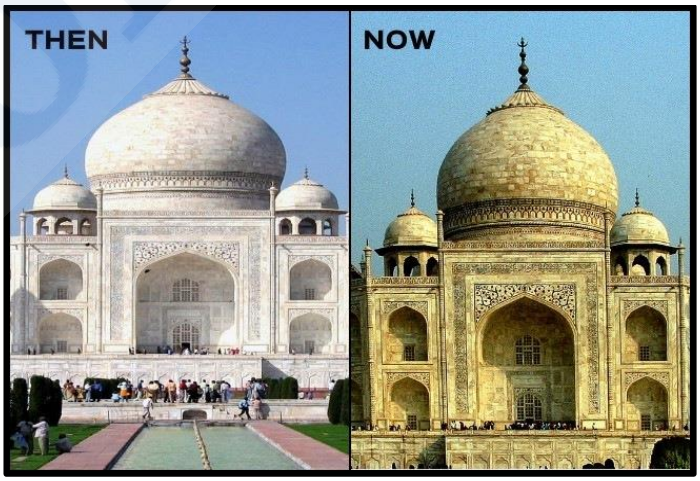
10.3 Difficulties in Tackling Acid Rain

- It can happen over very long distances.
- In one notable case, sulphur dioxide air pollution produced by power plants in the UK was blamed for causing acid rain that fell on Scandinavian countries such as Norway, producing widespread damage to forests and the deaths of thousands of fish in acidified lakes.

10.4 Case study : Impact of acid rain on the Taj Mahal

- Agra has many power plants and industries which **emit the oxides of sulphur and nitrogen** in the atmosphere.
- People continue to use **low-quality coal and firewood as domestic fuel**
- All these led to acid rain.
- Acid rain reacted with the marble (calcium carbonate) of Taj Mahal. This caused damage to this wonderful structure

$$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2$$



10.5 Steps taken by Government to protect Taj Mahal

- Agra will be converted into a city that relies only on "biofuel".
- The government has set a deadline for addressing the water pollution that affects the iconic monument.
- Establishment of Taj Trapezium Zone
    - It is an area of 10,400 sq. km around the Taj Mahal to protect the monument from pollution.
    - The Supreme Court has banned the use of coke/coal in industries located in the TTZ with a mandate for switching over from coke/coal to natural gas, relocating them outside the TTZ or shutting down.

CGP 2019

ENVIRONMENT BIODIVERSITY

ForumIAS

BIODIVERSITY

1. BASICS OF BIODIVERSITY

1.1 What is Biodiversity?

"Biodiversity" is often defined as the **variety of all forms of life, from genes to species, through to the broad scale of ecosystems.** "Biodiversity" was coined as a contraction of "biological diversity" in 1985, but the new term arguably has taken on a meaning and import all its own. **E. O. Wilson** heralded the popularity of this concept.

1.2 Levels of biodiversity

- Genetic Diversity
- Species Diversity
- Ecological Diversity

Genetic diversity

- All species on Earth are somewhat related through genetic connections. And the more closer a species is related to another, the more genetic information the two species will share.
- These species will also look more similar. The closest relations of an organism are members of its own species.
- Members of a **species share genes**. Genes are the bits of biochemical information that partly determine how an organism looks, behaves, and lives.
- Moreover, members of a species **share intricate mating behaviors.** These behaviors help them to identify each other as potential partners.
- Virtually every species in an environment has a similar and closely related species in a neighboring environment.

Western and Eastern gray squirrels are great examples in this case.

1. Western gray squirrels, which inhabit the west side of the **Rocky Mountains**, have more similarities than differences with the eastern gray squirrels.
2. However, these two types of squirrels **don't share a common mating behavior**. Even when placed in the same environment, eastern and western squirrels don't mate because they are two different species.
3. These two species share a more general set of traits.
4. The squirrel family, for example, encompasses chipmunks, prairie dogs, and gray squirrels.
5. These animals share various features such as muscle anatomy, number of teeth, as well as shape and details of the skull

- Mammals share characteristics such as hair, three bones in the middle ear, and breastfeeding their young. Likewise, all mammals are distantly related to vertebrates. Vertebrates are animals with backbones.
- Every animal has the same cell structure as fungi, plants, and some microorganisms. Lastly, all organisms have ribonucleic acid (RNA) molecule. Moreover, **most of them have deoxyribonucleic acid (DNA)**. All these imply that species have come from one, common ancestor.
- However, they diverge and develop distinctive attributes with time, and hence promote biodiversity in their own unique way.

Species diversity

- A wide variety of species exists in an environment. And that's what is referred to as species diversity.
- Species are the **standard measure of biological diversity** in light of the fact that they are the basic **units of biological classification**.
- The number of various species in a given ecosystem or environment is described as **Species Richness**.
- The total number of species in the world is about 10 million. However, only 1.75 million species have been named scientifically to date.

Some regions have many species.

- Tropical North and South America, for example, have approximately 85,000 flowering plants.
- Tropical and Subtropical Asia have at least 50,000 while tropical and subtropical Africa has about 35,000.

- Conversely, all of Europe has about 11,300 vascular plants. Other environments such as a polluted stream, have incredibly low numbers of species.

What is the significance of species diversity?

- The composition of species in a given ecosystem is the result of long lasting evolution. Each species has adapted to its own **niche**, which is characterized by certain features (e.g. **temperature range, availability of food or light**) enabling the species to reproduce and thus maintain its population.
- Living in an ecosystem, the species interacts with its environment (e.g. mussels take particles out of the water, reed forms root systems) and thus performs certain functions (increasing the light availability for plant growth, preventing sediment erosion).
- The loss of one species affects many other species and causes imbalance.Any species that will take over the lost species niche will most certainly not replace all of the functions it used to perform.
- When species get extinct, their services for the global biosphere are lost forever. It is impossible to replace it.

How do human activities affect species diversity?

- Over-exploitation, pollution and habitat conversion are the main threats to species diversity. They cause a gradual loss of species on local, regional and global levels.
- Additionally, the introduction of species into new ecosystems destroys natural balance.
- The ever growing tendencies of tourism, transport, profit-oriented food production (e.g. single-crop agriculture, selective (?) aquaculture), and industry enforce these human activities.
- Global warming and population growth continually increase these pressures on biodiversity. These issues will be discussed in more detail in the chapter "Urgencies".

Why prevent the loss of species diversity?

- It should have become clear that the loss of species is accompanied by a loss of functionality, some of which directly affect human life in a severe way: reduction of commercially used fish stocks, and erosion of soil and sediment are only two examples.
- To date, scientists have counted and described some 1.7 million living organisms, but the planet's total number is estimated at between 5 and 30 million, with some scientists putting forward figures of 80 million or more. Just as not even the whole inventory of the earth's species has been made, very little is known about the role and the potential that each of them has for increasing the quality of human life.
- It is therefore necessary to prevent the loss of species' diversity in order to avoid the loss of opportunities to gain from it.

Ecological diversity

- Ecological or ecosystem diversity is the **variety of ecosystems in an area.** It involves the complex network of various species present in the ecosystems and the dynamic interactions between them.
- An ecosystem is made up of organisms from several different species living together in an environment and their connections through the flow of nutrients, energy, and matter.
- An ecosystem can cover a small area, like a pond, or a large area, like an entire forest.
- The **primary source of energy** in virtually every ecosystem is the **sun** whose radiant energy is transformed into chemical energy by the plants.
- Animals eat the plants, allowing the energy to flow through the systems. The animals are, in turn, eaten by other animals. Fungi decompose organisms to obtain energy and in the process recycle nutrients back into the soil. Hence, an ecosystem is a collection of living components and non-living components that are connected by energy flow.
- It is difficult to measure ecological diversity because every ecosystem on earth merges into the surrounding ecosystems.

1.3 Measurement of Biodiversity

Biodiversity is measured through two major components:

1. **Species Richness:** It is a measure of the number of species found in a community.
    - **Alpha Diversity:** It refers to the diversity within a particular area or ecosystem usually expressed by the number of species.

- **Beta Diversity:** It is a comparison of diversity between ecosystems, usually measured as change in amount of species.
- **Gamma Diversity:** It is a measure of the overall diversity for the different ecosystems within a region.

2. **Species Evenness:** It measures the proportion of species at a given site. Low evenness indicates that fes species dominate the region

1.4 Services Provided by Biodiversity

Ecosystem Services:

- Recharging of groundwater, decontaminating polluted waters, etc.
- Soil formation, prevention of soil erosion and degradation.
- Nutrient storage and recycling.
- Carbon sequestration and promotes climate stability.
- Maintenance of ecosystems.
- Recovery from sudden unpredictable events.

BIological Services:

- Provides food like meat, fruits, etc.
- Medicinal resources.
- Timber products.
- Ornamental services.

1.5 Causes for Biodiversity Loss

Anthropogenic Activities:

- Deforestation for expansion of agriculture, commercial logging, urbanization and industrialization
- Habitat destruction
- Uncontrolled hunting and poaching.
- Pollution
- Destruction of wetlands and coastal ecosystems.
- Introduction of invasive alien species.

Natural Reasons:

- Earthquakes.
- Volcanic Eruptions.
- Forest Fires.
- Competition within species.
- Lack of pollination and diseases.

1.5 Types of Biodiversity Conservation Methods

1. In situ Conservation

In situ conservation refers to the **conservation of species in their natural ecosystem or natural habitat.** It involves protecting and maintaining the natural environment or ecosystem so that all constituent species are conserved. The factors that endanger the existence of species in the environment are eliminated by an appropriate mechanism.

In situ conservation is advantageous in several ways, including the following:

- It is an **economical and convenient way** of conserving biodiversity
- It provides a way for preserving numerous organisms at the same time
- In a natural habitat, living organisms have the **opportunity to adapt** to different
- Environmental conditions as well as to **evolve into a better life form.**

However, in situ conservation is not without a shortcoming. It requires an extensive area, which can be difficult due to increasingly growing demand for space. In situ conservation of biodiversity can be done in protected areas such as:

- National parks
- Sanctuaries
- Biosphere reserves
- Reserved Forests
- Protected Forests

2. Ex Situ Conservation

The conservation of biodiversity **outside of their natural environments or ecosystems** is known as ex-situ conservation. It involves conservation of **wild and cultivated species** as well as **genetic resources.**

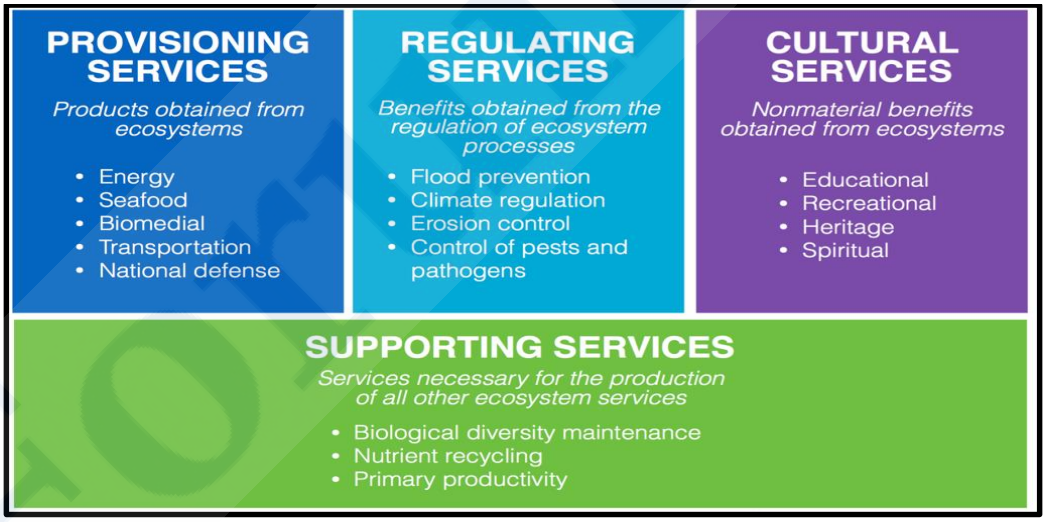
Ex-situ conservation utilizes a wide range of techniques and facilities and it can be accomplished in the following ways:

- By establishing **gene banks**, where sperm, ova, and seeds are stored at controlled temperatures and humidity
- Forming **zoo and botanical gardens**. These can be beneficial for research purposes and for promoting public awareness of various organisms.
- Collecting microbial culture and in **vitro plant tissue**
- **Artificial propagation of plants and captive breeding of animals**, with the possibility of reintroducing them back into the wild.

Ex-situ conservation is an excellent way of averting the stresses on living organisms as a result of competition for resources such as food, water, and space.

1.6 Ecosystem Services

- Ecosystem services means **processes provided by the nature to support human life.**
  For example, Pollination, decomposition of waste, water purification, renewal of soil fertility and moderation of floods.
- Ecosystem processes are often overlooked, and are not generally valued as part of the economy until they cease to function.
- When economic value is assigned to these services, it becomes very high.
  For example, insect pollinators help produce many commercially important fruits such as almonds, melons, blueberries, and apples.
- The global economic value of pollination services performed by insects has been valued at $217 billion per year.
- Similarly, in other ecosystem service water purification just involves filtering of rain water by soil and by microbes that can break down nutrients and contaminants, and reduce metal ions, slowing their spread into the environment.
- Wetland and riparian plants absorb nitrogen,and trap sediments that decrease water quality.
-



2. INDIAN BIO-GEOGRAPHICAL CLASSIFICATION

2.1 India- a Species-Rich Nation:

- India ranks among the top ten species-rich nations in the world. India has **four global biodiversity hotspots.**
- They are the **Eastern Himalaya, Indo-Burma region, the Western Ghats, and the Sundarbans.**
- The varied edaphic, climatic and topographic conditions and years of geological stability have resulted in a wide range of ecosystems and habitats which include numerous forests, grasslands, wetlands, deserts, and coastal and marine ecosystem.
- With this 2.4% of the world's land area, India accounts for about **7-8% of recorded species** of the world. India is **one of the 17 Mega Biodiversity Nation** in the world.
- From about 70 per cent of the total geographical area surveyed by the Ministry of Environment and Forests in India, 45,500 plant species (including fungi and lower plants) and 91,000 animal species, representing about seven percent of the world's flora and 6.5 per cent of the world's fauna, respectively, have been described.
- The Pride of India lies in its nearly 6,500 native plants which are still used in the indigenous healthcare systems. It is a country with rich biodiversity.
- With only 2.4 per cent of the total land area of the world, the known biological diversity of India contributes to about **8 per cent to the known global biological diversity.**
- It has been estimated that **at least 10 percent of the country's recorded wild flora, and ten percent of its wild fauna, are on the threatened list.**

2.2 Biogeographic Zones in India:

India is a country with very typical g**eology, terrain conditions, topography, land use, geographic and climatic factors.** Based on these factors, the country can be divided into **eleven recognizable biogeographic zones.**

- Trans-Himalayan Region
- Himalayan Zone
- The Alpine and Subalpine Forest
- Indian Desert Zone
- Semi-arid Region
- Western Ghats
- Deccan Plateau
- Gangetic Plains
- Coastal Regions
- North-East Region
- Andaman and Nicobar Islands.

These zones encompass a variety of ecosystems - mountains, plateaus, rivers, forests, deserts, wetlands, lakes, mangroves, coral reefs, coasts and islands.

1. Trans-Himalayan Region

Trans-Himalayan Region covers about **5.6 per cent of the total geographical area.** It includes the high altitude, cold and arid mountain areas of Ladakh, Jammu & Kashmir, North Sikkim, Lahaul and Spiti areas of Himachal Pradesh.

The **Biogeographic Provinces** are:

- 1A: Himalaya - Ladakh Mountains (3.3 %)
- 1B: Himalaya -Tibetan Plateau (2.2%)
- 1C: Trans - Himalaya Sikkim (< 0.1 %).

This zone has **sparse alpine steppe vegetation** that harbours several **endemic species.** It is a favourable habitat for the **biggest** populations of **wild sheep and goat in the world.** The other rare fauna includes **Snow Leopard** (Uncia uncia) and the migratory **Black necked Crane** (Grus nigricollis). The cold dry desert of this zone represents an extremely fragile ecosystem.

2. The Himalayan Zone :

Himalayan Zone, in the far North is another biogeographic zone. It covers about **6.4 per cent of the total geographical area** in India. It includes some of the highest peaks in the world. This zone makes India as one of the **richest areas in terms of habitats and species.** The steep slopes, unconsolidated soils and intense rainfall render the zone extremely fragile.

The **Biogeographic Provinces** are:

- 2A: Himalaya - North West Himalaya (2.1%)

- 2B: Himalaya - West Himalaya (1.6%)
- 2C: Himalaya - Central Himalaya (0.2%)
- 2D: Himalaya - East Himalaya (2.5%)

3. The Alpine and subalpine forests:

The Alpine and subalpine forests, **grassy meadows** and **moist mixed deciduous forests** provide diverse habitat for endangered species of bovids such as

- Bharal (Pseudois nayaur),
- Ibex (Capra ibex),
- Markhor (Capra falconeri),
- Tahr (Hemitragus jemlahicus), and

Other rare and endangered species restricted to this zone include **Hangul** (Cervus eldi eldi) and **Musk Deer** (Moschus moschiferus).

4. The Indian Desert Zone

It is another important biodiversity zone. It covers about **6.6 per cent** of the total geographical area. It includes the **Thar and the Kutch deserts.**

The **Biogeographic Provinces** are:

- 3A: Desert –Thar (5.4%)
- 3B: Desert –Kutch (1.1%).

It has large expanses of grassland that supports several endangered species of mammals such as Wolf (Canis lupus), Caracal (Felis caracal), Desert Cat (Felis libyca) and birds of conservation interest viz., Houbara Bustard (Chlamydotis undulata) and the **Great Indian Bustard** (Ardeotis nigriceps).

5. The Semi-arid biodiversity Region in India

It covers about **16.6 per cent of the total geographical** area. It is a **transition zone** between the **desert and the dense forests of Western Ghats.** Peninsular India has two large regions, which are climatically semi-arid. This semi-arid region also has several artificial and natural lakes and marshy lands.

The **Biogeographic Provinces** are:

- 4A: Semi - Arid - Punjab Plains (3.7%)
- 4B: Semi - Arid - Gujarat Rajputana (12.9%).

The dominant grass and palatable shrub layer in this zone supports the **highest wildlife biomass.** The cervid species of **Sambar** (Cervus unicolor) and **Chital** (Axis axis) are restricted to the better wooded hills and moisture valley areas respectively.

The **Lion** (Leo persica) which is one of the endangered carnivore species is restricted to a small area in Gujarat. The Caracal (Felis caracal), Jackal (Canis aureus) and Wolf (Canis lupus) are some of the endangered species that are characteristic of this region.

6. The Western Ghats in India

It is a major biodiversity zone. It covers about **4.0 per cent of the total geographical area.** It is one of the major **tropical evergreen forest** regions in India.

The zone stretches from the hills to the South of the **Tapti River in the North to Kanyakumari in the South**. In the West, this zone is bound by the coast.

The **Biogeographic Provinces** are:

- 5A: Western Ghats - Malabar Plains (2.0%)
- 5B: Western Ghats -Western Ghats Mountains (2.0%).

This zone represents **one of the biodiversity 'hotspots** with some 15,000 species of higher plants, of which 4,000 (27 per cent) are endemic to the region. The Western Ghats harbour viable populations of most of the vertebrate species found in peninsular India, besides an endemic faunal element of its own.

Significant species endemic to this region include

- Nilgiri Langur (Presbytis johni),
- Lion Tailed Macaque (Macaca silenus),
- Grizzled Giant Squirrel (Ratufa macroura),
- Malabar Civet (Viverricula megaspila),

- Nilgiri Tahr (Hemitragus hylocrius) and
- Malabar Grey Hornbill (Ocyceros griseus).

The **Travancore Tortoise** (Indotestudo forsteni) and **Cane turtle** (Heosemys silvatica) are two endangered taxa restricted to a small area in central Western Ghats.

7. The Deccan Plateau

It is another **major biodiversity zone** in India. It covers about **42 per cent** of the total geographical area. It is a **semi-arid** region that falls in the **rain shadow area of the Western Ghats.** This biogeographic zone of peninsular India is by far the **most extensive zone.** These include India's finest forests, particularly in the States of Madhya Pradesh, Maharashtra and Orissa. Majority of the **forests are deciduous** in nature with regions of greater biological diversity in the hill ranges.

The **Biogeographic Provinces** are:

- 6A: Deccan Peninsular - Central Highlands (7.3%)
- 6B: Deccan Peninsula - Chota Nagpur (5.4%)
- 6C: Deccan Peninsular - Eastern Highlands (6.3%)
- 6D: Deccan Peninsular - Central Plateau (12.5%)
- 6E: Deccan Peninsular - Deccan South (10.4%).

It consists of deciduous forests, thorn forests and degraded scrubland, all of which support diverse wildlife species. Species such as Chital (Axis axis), Sambar (Cervus unicolor), Nilgai (Boselaphus tragocamelus) and Chousingha (Tetracerus quadricornis) are abundant in this zone. Some other species like Barking deer (Muntiacus muntjak) and **Gaur** (Antilope cervicapra) are more frequent in, or are restricted to moist areas. They are still found in fairly large numbers. Species with small populations include the Elephant (Elephas Maximus) in Bihar-Orissa and Karnataka-Tamil Nadu belts, **Wild Buffalo** (Bubalus bubalis) in a small area at the junction of Orissa, Madhya Pradesh and Maharashtra and the hard ground **Swamp Deer** (Cervus duvauceli), now restricted to a **single locality in Madhya Pradesh.**

8. Gangetic Plain:

The next important biodiversity zone is the Gangetic Plain. It covers about **10.8 per cent** of the total geographical area in India. It is a flat alluvial region lying to the North and South of the Ganga River and its major tributaries and in the foothills of the Himalayas.

The **Biogeographic Provinces** are:

- 7A: Gangetic Plain - Upper Gangetic Plains (6.3%)
- 7B: Gangetic Plain - Lower Gangetic Plains (4.5%).

The Gangetic plain is topographically homogenous for hundreds of kilometers. The characteristic fauna of this region include **Rhino** (Rhinoceros unicornis), Elephant (Elephas maximus), Buffalo Bubalus bubalis), **Swamp Deer** (Cervus duvauceli), **Hog-Deer** (Axis porcinus) and **Hispid Hare** (Caprolagus hispidus).

9. India has an extensive coastal belts.

These constitute about **2.5 per cent of the total geographical area.** This belt includes very vast sandy beaches, mangroves, mud flats, coral reefs and marine angiosperm pastures. The coastal regions are also considered as the wealth and health zones of India.

The **Biogeographic Provinces** are:

- 8A: Coasts - West Coast (0.6%)
- 8B: Coasts - East Coast (1.9%)
- 8C: Coasts –Lakshadweep (< 0.1%).

The coastline from Gujarat to Sunderbans is estimated to be 5,423 km long. A total of 25 islets constitute the Lakshadweep, which are of coral origin. They have a t**ypical reef lagoon system, rich in biodiversity.**

10. The North-East Region

It is another biodiversity zone. It covers about **5.2 per cent of the total geographical area**, in India. It represents the **transition zone** between the **Indian, Indo-Malayan and Indo-Chinese bio-geographical regions** as well as being a meeting point of the Himalayan mountains and peninsular India.

The **Biogeographic Provinces** are:

- 9A: North - East - Brahmaputra Valley (2.0%)
- 9B: North - East –North East Hills (3.2%).

The North-East is thus the **biogeographical 'gateway'** for much of India's fauna and flora. It is a **major biodiversity hotspot.** A diverse set of habitats coupled with long term geological stability has allowed the development of **significant levels of endemism i**n all animal and plant groups.

11. The Andaman and Nicobar Islands

They are very unique biodiversity zones. They constituting about 0.3 percent of the total geographical area. They are one of the three **tropical moist evergreen forests** zones in India. The islands house an array of flora and fauna which are not found elsewhere.

The **Biogeographic Provinces** are:

- 10A: Islands –Andamans (0.2%)
- 10B: Islands –Nicobars (0.1%).

The North-South elongated groups of 348 Andaman Islands have a close biogeographical affinity with Myanmar.

The Nicobar Islands, lying only 90 kms away from Sumatra have much stronger Indonesian and South-East Asian elements. These islands are centres of high endemism. They contain some of India's finest evergreen forests. They support a wide diversity of corals.

Eastern Himalaya is another biodiversity hotspot. Phyto-geographically, the Eastern Himalaya forms a distinct floral region and comprises of Nepal, Bhutan, states of East and North-East India, and a contiguous sector of Yunnan province in South-Western China.

In the whole of Eastern Himalaya, there are an estimated 9,000 plant species, out of which 3,500 (i.e. 39 per cent) are endemic. In the Indian portion, there occurs some 5,800 plant species, roughly 2,000 (i.e. 36 per cent) of which are endemic. At least 55 flowering plants endemic to this area are recognized as rare, for example, the **Pitcher Plant** (Nepenthes khasiana).

3. WILDLIFE DISEASES

Wildlife means feral animals, captive wild animals and wild animals. Feral animal is an animal of a domesticated species that now lives without direct human supervision or control. **Wild animal** is an animal that has a **phenotype** unaffected by human selection and lives independent of direct human supervision or control.

3.1 What causes disease in plants and wildlife?

- Most plant diseases are caused by **fungi, bacteria, and viruses**. Although the term disease is usually used only for the destruction of live plants, the action of dry rot and the rotting of harvested crops in storage or transport is similar to the roots of growing plants; both are caused by bacteria and fungi.
- Wild animals can play a major role in disease transmission and so they are important when addressing certain diseases in domestic animals or humans.
- **Climate change** is expected to lead to substantial changes in wildlife disease patterns and frequency.
- Conflicts between biodiversity conservation, public health and domestic animal health may further intensify as contact between humans, domestic animals and wild animals increases.
- Initiatives that seek to reduce f**ragmentation of habitats** or to i**mprove access to the countryside** may lead to **new infection routes** emerging for plant and animal diseases, both into and out of the natural environment.
- Pests and diseases and their vectors may be native or non-native. There are particular links to aspects of **non-native species** policy and response.

3.2 Harmful Diseases Through Animals

Rabies

- Rabies is a **viral disease** that affects the **central nervous system** of mammals, including humans.

Ebola

- Ebola hemorrhagic fever is a severe, often-fatal disease in **humans and nonhuman primates** (some monkeys, gorillas, and chimpanzees).
- Ebola is considered to be a **zoonosis**.
- The main **natural reservoir** is thought to be some **species of bats** native to tropical forests.
- Large die-offs of endangered species of non-human primates have been linked to infection with Ebola and infected animals can then serve as a source of infection of Ebola in humans.
- Human outbreaks of Ebola virus are most likely linked to hunting and handling of infected wildlife.

Foot and Mouth Disease

Wild boar can serve as a reservoir for a number of diseases, including **foot and mouth disease, pseudorabies, classical swine fever, African swine fever and brucellosis.**

- These diseases can have a critical impact on the domestic swine sector and result in heavy production losses due to high mortality and slaughter for disease control purposes.
- Also, outbreaks in domestic pigs usually lead to the establishing of trade bans between partners.

3.3 Consequences of Wildlife Diseases

- **Extinction of Species:** Wildlife diseases has the potential to wipe out the entire species. Example: Christmas Island Rat got extinct.
- **Threat to Endemic Species:** The outbreak of diseases can cause heavy losses of endemic species thus pushing them towards the verge of extinction.

CANINE DISTEMPER VIRUS ATTACK IN GIR WILDLIFE SANCTUARY

Asiatic Lion, one of the most majestic animals of wild, is today restricted to just **Gir National Park in Gujarat**, in India.

Once an undisputed king of the wilderness, today, the species suffer the danger of extinction. In the month of September, there have been **23 cases of deaths** of Asiatic Lions.

The major cause for the death is attributed to the **Canine Distemper disease** and **Babesiosis Infection.** Out of 23 deaths, 4 deaths have been caused by Canine Distemper Disease and 17 by Babesiosis Infection.

Canine distemper is a **contagious and serious disease caused by a virus** that attacks the respiratory, gastrointestinal and nervous systems of puppies and dogs.

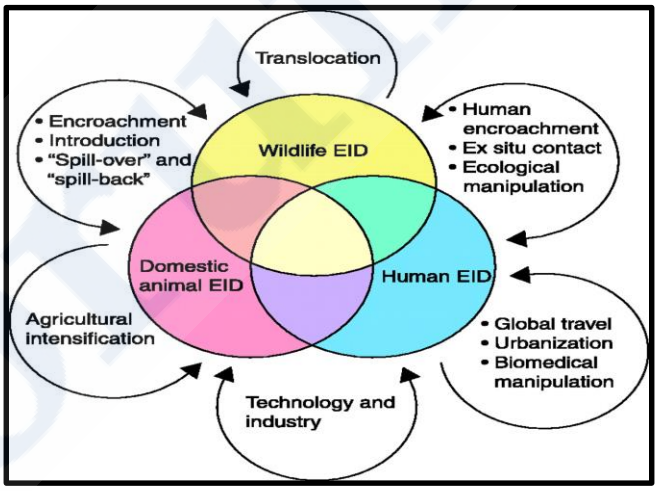
The virus can also be found in wildlife such as foxes, wolves, coyotes, raccoons, skunks, mink and ferrets and has been reported in lions, tigers, leopards and other wild cats as well as seals.

- **Threat to Agricultural Crops:** Outbreak of diseases in the wildlife can spread to agricultural crops. Destruction of agricultural crops can cause famines like in Ireland. **Infection in potatoes caused severe famine in Ireland.**
- **Threat to Humans:** Recent outbreak of Ebola virus in Liberia, Guinea, etc. has taken numerous lives.
- **Threat to Tourism:** Species extinction and outbreak of diseases can cause immense harm to the tourism industry which are dependent on the biological diversity.

3.4 Wildlife Disease Management:

The basic forms of management strategies exist for wildlife disease, which are as follows:

- Prevention of introduction of disease
- Control of existing disease
- Eradication
- **Management of diseases** of wild animals usually requires a change in human activities.
- Most important method is by **restricting translocation** of wild animals to prevent movement of disease.



4. CAUSES OF SPECIES EXTINCTION

4.1 Why Does Extinction Matters?

- Biodiversity - the variety of species and their habitats - plays an **important role in ecosystem function** and in the many services ecosystems provide.
- These include **nutrient and water cycling, soil formation and retention, resistance against invasive species, plant pollination, climate regulation, and pest and pollution control.**
- Escalating biodiversity loss has widespread implications for both human and environmental security.
- The **monetary value of goods and services** provided by ecosystems is estimated to amount to some **33 trillion dollars per year** – nearly twice the global production resulting from human activities.
- An estimated 50,000-70,000 plant species are used in **traditional and modern medicine** worldwide.
- About 100 million metric tons of aquatic organisms, including fish, molluscs and crustaceans are taken from the wild every year and represent a **vital contribution to world food security.**
- Meat from wild animals forms a critical contribution to **food sources and livelihoods** in many countries with high levels of poverty and food insecurity.

4.2 Natural Reasons for Species Extinction

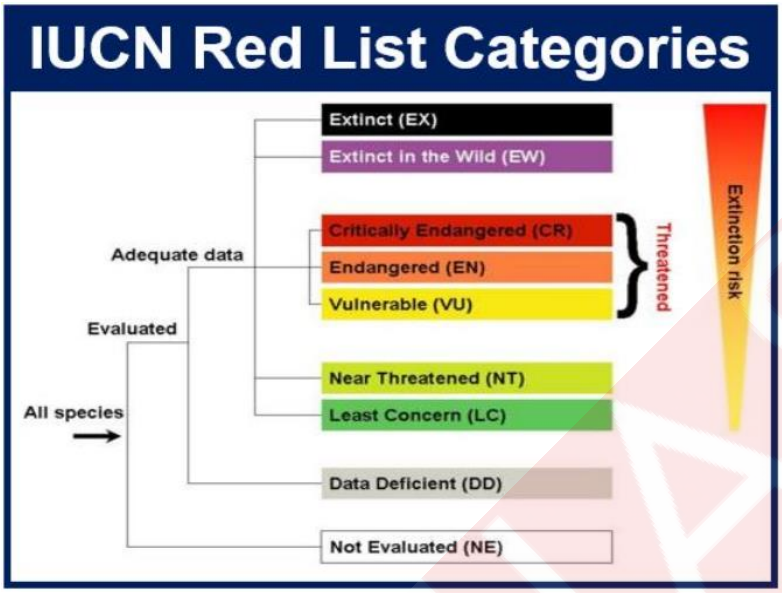
1. **Mass extinctions**. Ex. Ordovician, Cretaceous (Dinosaurs), etc.
2. **Rivalry among specie**s. Ex Competitive Exclusion
3. **Natural disasters** like catastrophic floods, earthquakes, landslides, forest fires, etc.
   Case study on Kaziranga National Park:
   Assam flood 2017: 70% of the park inundated; 17 rhinoceros, 170 hog deer dead
4. **Lack of pollination**
5. **Outbreak of diseases.** Ex. Christmas island rat got e**xtinct.**

4.3 Anthropogenic Reasons for Species Extinction:

1. **Deforestation, population growth and habitat destruction** (Swamp deer – critically endangered)
2. **Unregulated hunting and poaching:** The number of rhinos poached in South Africa alone has increased by 9,000% since 2007 - from 13 to a record 1,200 in 2014 (WWF).
3. **Over-killing:** It has pushed Baleen whale shark to critically endangered status.
4. **Man-induced climate change:** Bramble Cay Melomy (Great Barrier Reef) became the first mammal to go extinct due to sea level rise.
5. **Introduction of invasive alien species**: Introduction of Burmese Python in Everglade (Florida) and African catfish in Krishna River.
6. **Chemical, nuclear and biological warfare.**

4.4 Initiatives:

- Convention on International Trade in Endangered Species of Fauna and Flora (CITES)
- UNESCO's Man and Biosphere Programme
- UNEP and IUCN
- IUCN Red List:



- Convention on the conservation of migratory species (CMS)
- The wildlife Trade Monitoring Network (TRAFFIC)
- International Whaling Commission (IWC)
- Coalition against wildlife trafficking (CAWT)
- Global Tiger Forum (GTF)
- Convention on Biological Diversity (CBD)
- International Tropical Timber Organization (ITTO)
- United Nations Forum on Forests (UNFF)

4.5 Strategies for Wildlife Conservation:

- **Funding:** National governments should appropriate optimal funds. Ex. USA = $200 million annually.
- **Protected area network:** Buffer zones (10 km) around Biosphere Reserves, national parks, wildlife sanctuaries should be declared as eco-fragile zones.

  Case study on Vulture:
  - Population of White Backed, Long Billed and Slender Billed vultures have declined by more than 90% due to diclofenac in India.
  - Upgraded from Schedule 4 to Schedule 1 of Wildlife (Protection) Act, 1972.
  - BNHS and Haryana Government: Vulture Captive Care Facility
- **Conservation efforts:** Projects like Project Tiger (1973), Project Hangul, Integrated development of Wildlife Habitats are in the right direction.

  Case study of Kruger Park for protecting Rhinoceros:
  - Injecting poison in the horn of rhinoceros
  - Cutting off the horns by authorities
  - Placing spider cameras in the horns
- **Community participation:** Involvement of local people and tribals in protecting critical habitats.

  Case study of Olive Ridley Turtle (IUCN = vulnerable)

  In Astranga (Odisha), a group of 13 teenagers:
  - Created awareness among fishing communities to use hooks to fish instead of nets and trawlers to protect turtles.
  - Initiated a programme to control the population of stray dogs in the area as they ate the eggs of turtles.
  - Prevented the construction of a port.
- **Role of media:** Efforts of BBC Earth, Animal Planet, Discovery Channel, David Attenborough, etc. should be promoted to full extent.

- **Awareness campaign:** Involvement of film actors Ex. Leonardo Di Caprio for Climate Change, Amitabh Bachchan for Gujarat Tourism, special chapters in NCERT, making people aware that teeth of elephants and horns of rhinoceros have no medicinal value, prohibiting use of diclofenac and ketoprofen, etc. Ex. Gaj Yatra for protection of elephants.
- All national governments especially Vietnam, Thailand, China should **ban trade** in ivory, horns of rhinoceros, tiger skin, etc.

5. INVASIVE ALIEN SPECIES

Invasive Alien Species (IAS) are the **second biggest threat to biodiversity** (after habitat destruction) and are a major cost to the economic well being of the planet. They cause **enormous and often irreversible harm to biodiversity** around the world by displacing native and useful species and changing ecosystems. They are responsible for the extinction or decline of many species and continue to pose a huge threat to many more. They cost economies billions of dollars every year, in lost production, control and mitigation efforts, loss of ecosystem services and many other ways.

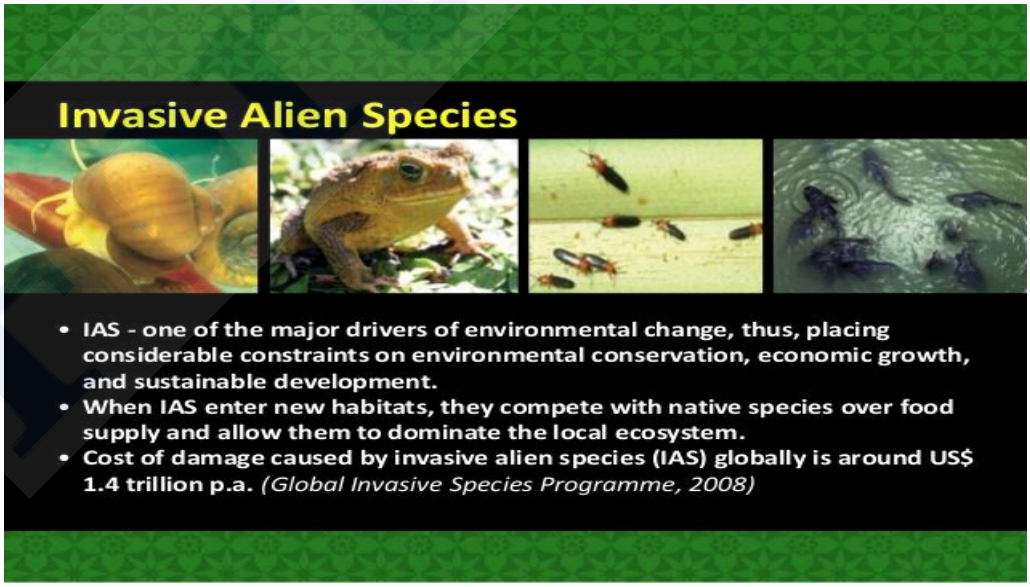
An alien species is considered invasive only if it **establishes and spreads in its new location**, and has **adverse impacts on the environment**, the economy or human health. IAS are not restricted to plants and mammals, but come from almost every major taxon of organisms. Many alien populations undergo a lag phase after initial establishment, and may **remain unobtrusive/non-invasive for a long time** before suddenly changing, becoming invasive and spreading rapidly.

Human activities have dramatically increased opportunities for species to travel around the world and to become invasive Alien species enter countries through both legal and illegal routes, and introductions can be both intentional and unintentional.

5.1 Definitions

The understanding and management of invasive alien species (IAS) is an immature, emerging science and its terminology continues to evolve and change. There is currently no convenient glossary of terms that provides a comprehensive set of definitions based on fully understood processes. Terms such as alien, invasive, weed, introduced, feral, exotic and more are sometimes used interchangeably, or to describe the same thing.

- **Alien species** – a species that has been **intentionally or unintentionally** introduced to a location, area, or region where it does not occur naturally.
- **Invasive species** – a species that has established and spread or has the potential to do so outside of its natural distribution range, and which then threatens ecosystems, habitats and/or other species, potentially causing economic and/or environmental damage, or harm to human health.
- **Invasive alien species (IAS)** – An alien species that has established and spread, and which causes, or has the potential to cause, harm to the environment, economies, or human health. There are various versions of the IAS definition.
    - For example, the **Convention on Biological Diversity (CBD)** defines an IAS as an alien species whose establishment and spread threatens ecosystems, habitats or species with economic or environmental harm.
    - According to the **IUCN** an IAS is an alien species which becomes established in natural or semi-natural ecosystems or habitats, is an agent of change, and threatens native biological diversity.



5.2 The Process of Invasion

The main phases in the invasion process are:

1. Introduction of the species

- Species coming from another place must survive during and after the journey.
- Many species fail to survive unless they are cared for (e.g. aquarium fish).
- However, almost all invasive plants spread as seeds which do not require special care while being transported.

2. Establishment and reproduction of the introduced species

- The survivors must persist and reproduce successfully (i.e. there usually needs to be more than one individual) until they establish a self-sustaining population.

3. Spread

- In certain cases, established populations will multiply rapidly and spread across the landscape.
- This is the explosion phase and may only happen after a considerable lag phase.

The lag phase

- Some species show no lag phase, and will begin to **spread rapidly and uncontrollably** as soon as they establish.
- On the other hand, many IAS have a lag phase, during which they occur at **low densities and their impacts are not noticeable**.
- The duration of this lag phase will vary depending on the species, and circumstances, and may be only a few months, or as long as centuries.
- Once the population starts increasing (explosion phase), the impacts will rapidly become apparent.
- Following the explosion phase, the growth levels out of the population reaches the carrying capacity of the environment.
- The variable duration of the lag phase means that one cannot assume that an apparently benign alien species is safe to ignore, as it may change. It is therefore preferable not to allow an alien species to become established, even if there is no immediate indication that it is invasive.

5.3 Examples of Invasive Alien Species in India

Flora

- Needle Bush
- Lantana Camara
- Calotropis
- Water Hyacinth
- Impatiens Balsam
- Parthenium

Fauna

- Giant African Snail
- Myna
- Pigeon
- Donkey

5.4 Impacts of Invasive Alien Species

- The number of species that have gone extinct due to IAS is high, and all major taxa are affected. For example, the **island of Guam in the Pacific Ocean** has lost almost all its native forest bird species, two native mammals and nine native reptiles to one IAS, the brown tree snake (Boiga irregularis).
- In a different example, although humans probably destroyed much of the endemic palm on Easter island, every single seed found by archaeologists had been gnawed by the introduced **Kiore or Pacific rat** (Rattus exulans), undoubtedly contributing to the palm's extinction.
- The introduction of the **predatory Nile perch** to Lake Victoria (in eastern Africa) precipitated a flood of extinctions in the endemic cichlid fish.
- The introduction of alien organisms into a new environment can have **serious negative consequences for the environment and local biodiversity,** for industries and users of natural resources, and also for the health and welfare of those associated with the affected systems.
- While impacts can be direct and indirect, the principal consequences can be grouped into three main categories - **ecological, economic and public health and society.**

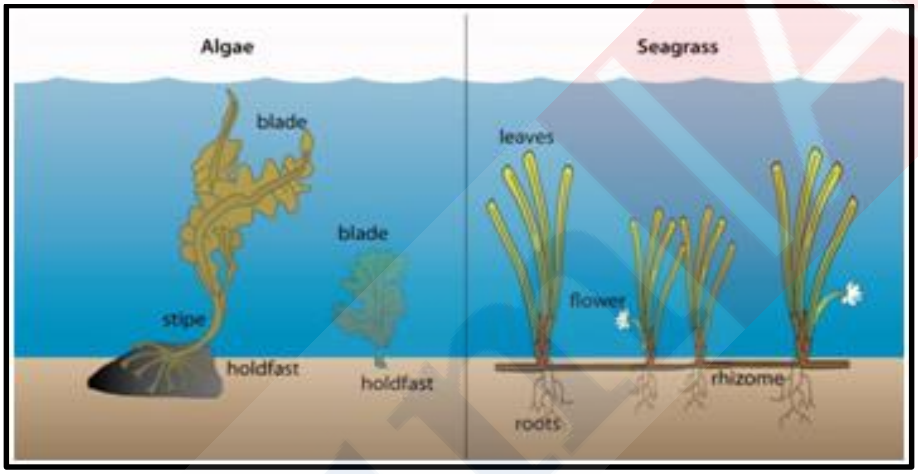
6. SEAWEEDS AND SEAGRASSES

6.1 What is seaweed?

Marine macroalgae, or seaweeds, are plant-like organisms that generally live attached to rock or other hard substrata in coastal areas. Macroalgae (seaweeds) can be classified into three broad groups as **red algae, brown algae and green algae,** based on their pigmentation.

6.2 What is Seagrass?

Seagrasses are found in shallow salty and brackish waters in many parts of the world, from the **tropics to the Arctic Circle.** Seagrasses are so-named because most species have **long green, grass-like leaves.** They are often confused with seaweeds, but are actually more closely related to the **flowering plants t**hat you see on land. **Seagrasses have roots, stems and leaves, and produce flowers and seeds.** They evolved around 100 million years ago, and today there are approximately 72 different seagrass species that belong to four major groups.



6.3 Difference between sea grasses and sea weeds

Sea weeds	Sea grasses
seaweeds, are plant-like organisms that generally live attached to rock or other hard substrata in coastal areas.	**Seagrass** can easily be confused with marine macroalgae. While **seagrasses** are considered vascular plants and have roots, stems and leaves
Sea weeds only produces spores	Sea grass produces flowers,seeds and fruits
Sea weeds does not have roots. It uses 'holdfasts' to anchor itself to other objects.	Sea grass has roots.
Sea weeds are macroalgae	Seagrass is a flowering plant
Sea weeds uses extracts nutrients from the water	Seagrass uses its roots to extract nutrients from the sediments
Sea weeds are threatened by damaging fishing methods and pollution	Sea grasses also threatened by damaging fishing methods and pollution
There estimated to be between 5000 and 6000 known species of seaweeds	The recorded number of spices seagrass approximately 60.

6.4 Importance of Seaweeds

Seaweed plays an important and vital role in the marine ecosystem, providing food and shelter for a host of creatures such as green sea urchins, lobsters, and young fish. It is also an important **resource for people.** Almost all are algae, which is one of the simplest forms of plant life because they have no roots, stems, leaves, and flowers.

- Seaweeds are potentially excellent sources of **highly bioactive secondary metabolites** that could represent useful leads in the development of new functional ingredients.
- It provides a **food source for coastal birds** and helps to shore up the vital dune system.
- They are used as **animal and fish feed**.
- They can be used as **fuels**.
- They are used in **cosmetic industries.**
- They are integral component of i**ntegrated aquaculture.**
- They help in **removal of toxic metals** from industrial effluents.

6.5 Threats to seaweeds

- In recent years there has been a decline and shift in **distribution of kelps** and other seaweed species. These changes are believed to be the **result of climate change.**
- There is also evidence that the **sea is becoming more acidic**, because it absorbs a large portion of carbon dioxide. Although the long-term effects are unknown, this could be damaging as it may begin to corrode the exterior of some calcified seaweeds.
- Bottom trawling fishing also caused destruction of seaweeds.
- Thermal pollution and oil contamination along the coastline also causes destruction.

6.6 Importance of Seagrass

- Seagrasses are flowering plants that are an important part of the **food web.**
- They provide **food for turtles, manatees and a variety of fish** and habitat for filter-feeding organisms and foraging sea life such as sea urchins and sea cucumbers.
- Seagrasses are a **nursery ground** for pink shrimp, lobster, snapper and other sea life and stabilize the ocean bottom by trapping sediments. Seagrasses offer food and habitat for juvenile fish, crustaceans and shellfish.
- They **filter the water of sediments,** release oxygen into the water and **stabilizes the bottom** with their roots.

6.7 Threats to Seagrasses

- Seagrasses are related to land based plants. Like them, they have leaves, stems and flowers, as well as roots. In healthy beds, when leaves are damaged from storms, unusual cold, or overgrazing, seagrasses grow back quickly.
- But prop dredging, causing deep cuts in the ocean floor, causes damage to the root systems of seagrasses.
- These "cuts," most often caused by water jet skis and motorboats, make scars in the seagrass meadows that take years to re-grow.
- These lines are cuts made by prop dredging. In rough weather, vast clouds of calcium carbonate, the limestone that was created from ancient coral beds becomes suspended in the water and severely limits visibility for days.

7. BIODIVERSITY (WILDLIFE) CONSERVATION IN INDIA

7.1 National Biodiversity Strategy and Action Plan (NBSAP) Project:

Under this scheme a National Policy and Action Strategy on Biological Diversity (NPASBD) has been formulated with the following objectives:

- Assessment and stocktaking of biodiversity related information at state level including distribution of endemic and endangered species.
- Emphasis on participation of decentralized state level planning sectors.
- To prepare detailed micro-level action plans at different levels under the framework of **Convention on Biological Diversity** and NBSAP.

7.2 Wildlife Protection Act 1972

The Wildlife Protection Act, 1972 is a **Central Act of Parliament** providing for the protection of wild animals, birds and plants and for matters connected therewith or ancillary or incidental thereto with the view to ensuring the ecological and environmental securities of the country.

- It extends to the whole of India **except the state of Jammu and Kashmir.**
- The act provides for the constitution of a **National Board for Wildlife with the Prime Minister as the Chairperson.**
- The National Board shall promote the conservation and development of wildlife and forests by such measures as it thinks fit.
- The act also provides for the constitution of a **State Board for Wildlife** to advise the state government in matters connected with the protection of wildlife.
- The act **regulates the hunting of wild animals and protection of specified plants.**
- It also empowers the State Government to **notify Sanctuaries, National Parks, and Game Reserves.**
- The Act prohibits hunting of animals except with permission of authorized officer when an animal has become dangerous to human life or property or as disabled or deceased as to be beyond recovery.
- It has also set up a **National Tiger Conservation Authorit**y and regulates trade or commerce in wild animals, animal articles and trophies.
- It has notified **five kinds of protected areas** i.e National Parks, Sanctuaries, Conservation Reserves, Community Reserves and Tiger Reserves.

7.3 Appraisal of Wildlife Protection Act 1972

- The meaning of the wildlife in this Act is very wide and inclusive of all kinds of flora and fauna.
- The Act has failed to maintain balance between the wildlife protection and the forest rights of the indigenous people. Example: Tribal families have been denied the rights of fishing and collecting forest products in Pench Tiger Reserve.
- The Act has ensured that the economic activities like laying of pipes, erection of electricity poles, etc. does not affect the wildlifes.
- The Act has restricted illegal trade in animals and their products to some extent. Example: In 2002 the manufacture of shahtoosh shawls from Chiru or Tibetan Antelope has finally been banned in the state of Jammu and Kashmir.
- Placing many wild animal and plants under Schedule has protected them from going extinct.

7.4 Biological Diversity Act, 2002

The Act envisages following goals:

- To **protect and conserve** rich biodiversity of the country.
- To protect the knowledge of biological communities having high medicinal values from their use by foreign individuals and organizations.
- To check and **control biopiracy.**
- Setting up of **National Biodiversity Authority (NBA), State Biodiversity Boards (SBB) and Biodiversity Management Committees (BMC).**
- To promote conservation, sustainable use and documentation of biodiversity.

The Act has also made the following provisions for the use of Indian biodiversity:

- Prior permission for the use of Indian biological resources by foreign individuals and organizations from NBA is mandatory.

- The indigenous knowledge of India's biodiversity cannot be used by foreign individuals and organizations without formal permission from NBA.
- It is mandatory for Indian industry to give prior intimation to the the concerned SSB about obtaining any biological resource for commercial use.
- Citizens, entities, local people, vaidyas and hakims are exempted from permission from NBA for the use of biological resources within the country for medicinal purposes.

7.5 Appraisal of Biological Diversity Act, 2002

- Since companies are commercially utilising biological resources when extracting oil or brewing or distilling alcohol, they should be sharing monetary benefits gained from these activities with the SBB. But in reality the Act has failed to ensure that the benefits percolate to the indigenous people.
- The second major issue with the BD Act is the **absence of provisions to deal with the criminal procedures for search, seizure or arrest**. Juxtaposing this with the Indian Forest Act, 1927 and the Wild Life Protection Act, 1972, which have specific provisions to deal with search, seizure and arrest, indicates the procedural injustice posed by the BD Act.
- Absence of documentation of biodiversity of India has resulted into destruction of biodiversity through mining and quarrying, industrialization, etc.
- Biopiracy ahss not been restricted upto the desired extent.
- Each day, 333 acres of forest are legally diverted on an average under the provisions of the Forest (Conservation) Act, 1980.

7.6 Cartagena Protocol and Nagoya Protocol

India has signed and ratified these conventions to follow international regulatory framework for safe transfer, handling and use of Living Modified Organisms (LMO's).

7. PROTECTED AREA NETWORKS

7.1 What is protected Area Network (PAN)

- A protected area is a **clearly defined geographical space,** recognised, dedicated and managed, through legal or other effective means, to achieve the long term **conservation of nature with associated ecosystem services and cultural values.**
- Protected areas are at the core of efforts towards conserving nature and the services it provides us food, clean water supply, medicines and protection from the impacts of natural disasters.
- Their role in helping **mitigate and adapt to climate change** is also increasingly recognized; it has been estimated that the **global network of protected areas stores at least 15% of terrestrial carbon**.

Protected areas i.e, national parks, Biosphere Reserve, National Parks, Wildlife Sanctuaries, Coastal Protected Areas, Sacred Grooves, **Biodiversity Hotspots** so on are a mainstay of biodiversity conservation, while also contributing to people's livelihoods, particularly at the local level.

7.2 Biosphere Reserves

What is a Biosphere Reserve?

A Biosphere Reserve is a **special ecosystem** or a **specialized environment** with a flora and fauna that require protection and nurturing. These reserves are managed and studied for the conservation of various life forms found here. They are **subjects of scientific and natural interest.**

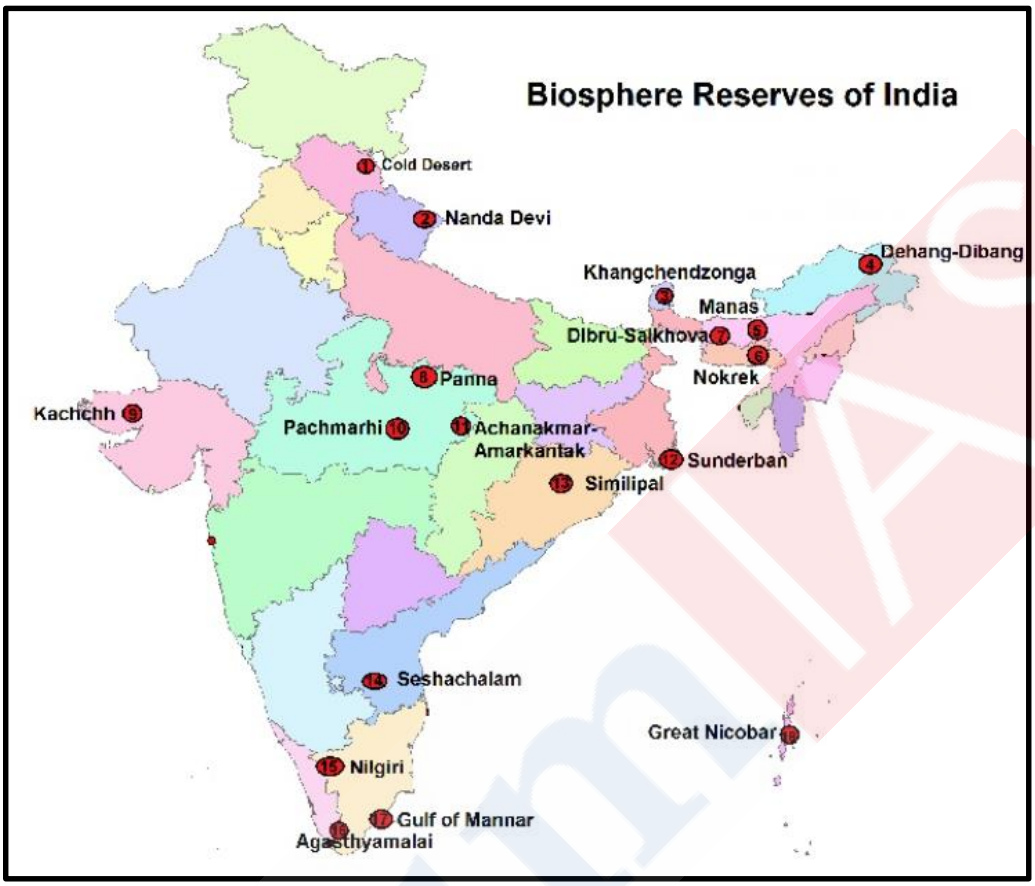
The **World Network of Biosphere Reserves**, currently comprising 669 sites/regions designated by **UNESCO** in 120 countries since 1976, is a unique global network explicitly linking sustainable development and biodiversity conservation. While the **core area(s)** and sometimes **buffer zone(s**) of all biosphere reserves (BRs) comprise protected areas as recognised by IUCN, the **outer transition area**, where most of the inhabitants of BRs live, cannot be regarded as a protected area as often, these transition areas include towns and cities.

*According to UNESCO, "**Biosphere reserves are areas of terrestrial and coastal ecosystems promoting solutions to reconcile the conservation of biodiversity with its sustainable use. They are internationally recognized, nominated by national governments and remain under sovereign jurisdiction of the states where they are located".***

Biosphere reserves of India

- The **Ministry of Environment, Forest and Climate Change,** Government of India defines Biosphere Reserves thus "Biosphere Reserves (BRs) are representative parts of natural and cultural landscapes extending over large area of terrestrial or coastal/marine ecosystems or a combination thereof and representative examples of biogeographic zones/province".
- The Government of India has established about **18 different Biosphere Reserves** in the country. Of these, **10 are part of the World Network of Biosphere Reserves**, set up under the auspices of the **UNESCO Man and Biosphere (MAB) Programme.**
- Not only are animals protected in the Biosphere Reserves of our country but the natural lifestyle of the indigenous people is also promoted.
- The communities in these regions are encouraged to retain their agrarian lifestyle and **develop harmony with the plants and animals.**
- The Biosphere Reserves of India correspond roughly to the **IUCN Category V Protected Areas** list and are often designed to include one or more national parks and national sanctuaries.
- The **buffer zones** of these Biosphere Reserves are **open to economic activities as well.**

List of Biosphere reserves in India



7.3 National Parks

What is a 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 CHAPTER IV, WPA 1972.

There are 104 existing national parks in India covering an area of 40,501 km^2, which is 1.23% of the geographical area of the country (**National Wildlife Database, Aug. 2018**). In addition to the above 75 National Parks covering an area of 16,608 km^2 are proposed in the Protected Area Network Report (Rodgers & Panwar 1988). The network of parks will go up 179 after full implementation of the above report.

7.4 Wildlife Sanctuaries

What is a wildlife sanctuary?

Sanctuary is an area which is of adequate **ecological, faunal, floral, Geo-morphological, natural or zoological significance.** The Sanctuary is declared for the purpose of protecting, propagating or developing wildlife or its environment.

- Certain rights of people living inside the Sanctuary could be permitted.
- Further, during the settlement of claims, before finally notifying the Sanctuary, the Collector may, in consultation with the Chief Wildlife Warden, allow the continuation of any right of any person in or over any land within the limits of the Sanctuary.
- A sanctuary is a protected area which is reserved for the conservation of only animal and human activities like harvesting of timber, collecting minor forest products and private ownership rights are allowed as long as they do not interfere with well-being of animals.

- **Boundaries of sanctuaries are not well defined** and controlled biotic interference is permitted.

Declaration of area as Sanctuary

- To be included in a sanctuary, the **State Government** shall issue a notification specifying the **limits of the area** which shall be comprised within the sanctuary and declare that the said area shall be sanctuary on and from such date as may be specified in the notification.
- Provided that where any part of the **territorial waters** is to be so included, **prior concurrence of the Central Government** shall be obtained by the State Government.
- Provided further that the **limits of the area of the territorial waters** to be included in the sanctuary shall be determined in consultation with the **Chief Naval Hydrographer of the Central Government** and after taking adequate measures to protect the occupational interests of the local fishermen.

List of important wildlife sanctuaries in India

S no	Name of the Sanctuaries	Location
1.	Kaziranga wildlife sanctuary	Assam
2.	Manas wildlife sanctuary	Assam
3.	Gir national park & wildlife sanctuary	Gujarat
4.	Sundarbans national park	West bengal
5.	Periyar national park & wildlife sanctuary	kerala
6.	Kanha national park	Madhya pradesh
7.	Bandhavgarh national park	Madhya pradesh
8.	Ranthambore national park & wildlife sanctuary	Rajasthan
9.	Bharatpur bird sanctuary	Rajasthan
10.	Tal chappar wildlife sanctuary	Rajasthan
11.	Sariska wildlife sanctuary	Rajasthan
12.	Chilka lake bird sanctuary	odisha
13.	Nandankanan zoo	odisha
14.	Corbett national park	Uttarakhand
15.	Bandipur national park	karnataka
16.	Parambikulam wildlife sanctuary	Kerala
17.	Mudumalai national park & wildlife sanctuary	Tamil nadu
18.	Govind wildlife sanctuary	Uttarakhand
19.	Indian wildass sanctuary	Gujarat
20.	Aralam wildlife sanctuary	Kerala

7.5 Marine/Coastal Protected Areas

What is Coastal Protected Area?

An area **within or adjacent to the marine environment,** together with its overlying waters and associated flora, fauna, and historical and cultural features, which has been reserved by legislation or other effective means, including custom, with the effect that its marine and/or coastal biodiversity enjoys a higher level of protection than its surroundings.

What is Marine Protected Areas

A marine protected area is **essentially a space in the ocean where human activities are more strictly regulated** than the surrounding waters similar to parks we have on land. These places are given special protections for natural or historic marine resources by local, state, territorial, native, regional, or national authorities.

How to manage

- There are many different types of MPAs with the protection measures ranging from multiple-use to strict protection within 'no-take' or 'no-access' zones.
- Most MPAs tend to be more permissive, often implementing zones or seasonal restrictions that allow certain types of use.
- The IUCN protected area management categories reflect the diverse range of purposes for which marine protected areas are declared.
- IUCN has published specific guidelines on how to apply its protected area management categories to MPAs, aiming to help authorities to maintain consistency in the ways that the management of both terrestrial and marine protected areas is described

7.6 Sacred Grooves

What is Sacred Groove?

Sacred groves comprise of **patches of forests or natural vegetation** from a few trees to forests of several acres, that are usually **dedicated to local folk deities** (Example: Ayyanar and Amman) or tree spirits (Vanadevatha). These spaces are **protected by local communities** because of their **religious beliefs and traditional rituals** that run through several generations.

Why sacred Grooves are important?

- These Sacred groves are one of the forest ecosystems conserved by local communities reinforced by religious sentiments towards the forests in Western Ghats of India.
- Sacred groves are an **example for positive human intervention** in conserving forests.
- They help in mitigation and adaptation of climate change.
- They protect and conserve the local wildlife diversities.
- They provide important food and economic resources on which local livelihoods are based.
- The contributions of local communities towards the managements of sacred groves are mainly in terms of providing protection and tree enrichment.
- Sacred groves occur in many parts of India viz., Western Ghats, Central India, northeast India, etc.

Types of sacred groves

- Traditional Sacred Groves – It is the place where the village deity resides, who is represented by an elementary symbol.
- Temple Groves – Here a grove is created around a temple and conserved.

7.7 Biodiversity Hotspots

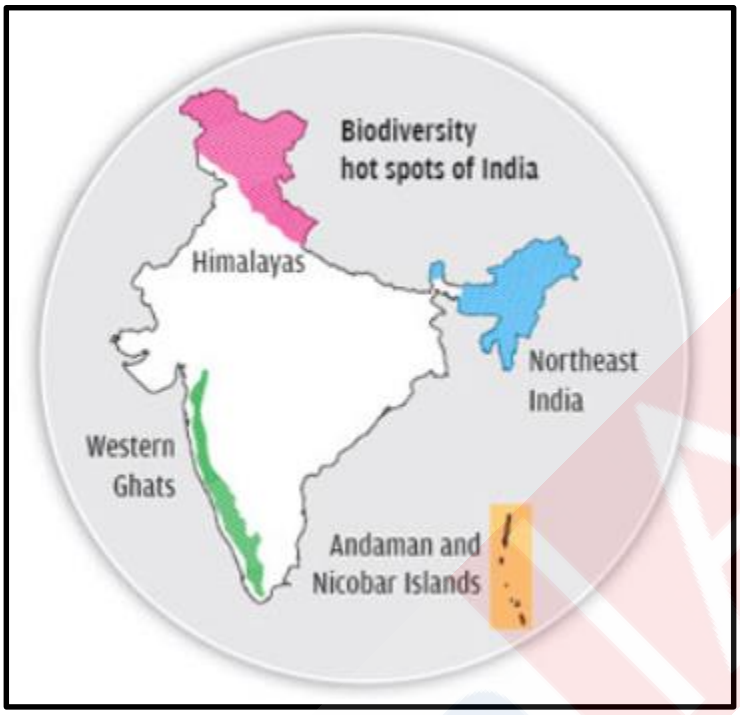
What is a biodiversity hotspot?

A biodiversity hotspot is a **biogeographic region** that is both a significant **reservoir of biodiversity** and is **threatened with destruction**.

There are currently **36 recognized biodiversity hotspots**. These are Earth's most biologically rich, yet threatened terrestrial regions.

To qualify as a biodiversity hotspot, an area must meet two strict criteria:

- Contain at least 1,500 species of vascular plants found nowhere else on Earth (known as "endemic" species).
- Have lost at least 70 percent of its primary native vegetation.



- Many of the biodiversity hotspots exceed the two criteria.
- **For example, both the Sundaland Hotspot in Southeast Asia and the Tropical Andes Hotspot in South America have about 15,000 endemic plant species.**
- The loss of vegetation in some hotspots has reached a startling 95 percent.

Who lives in biodiversity hotspots

- The 36 biodiversity hotspots are home to around 2 billion people, including some of the world's poorest,many of whom rely directly on healthy ecosystems for their livelihood and well-being.
- The hotspots provide crucial ecosystem services for human life, such as provision of clean water, pollination and climate regulation.
- These remarkable regions also hold some of the highest human population densities on the planet, but the relationship between people and biodiversity is not simply one where more people lead to greater impacts on biodiversity.
- Much of human-biodiversity impacts lies not in human density but rather in human activity.
- Conservation in the hotspots promotes sustainable management of these essential natural resources and supports economic growth, which also reduces drivers of violent conflict.
- CEPF works with civil society in the hotspots to protect biodiversity.

8. CONSERVATION PROJECTS IN INDIA

Wildlife conservation is an activity in which people make conscious efforts to protect earth's biological diversity.
Wildlife conservation activities relate to the protection of plants and animal species, and their habitats. Conservation efforts are made with a goal to **preserve the nature, and the endangered species for the future generations.**

- Wildlife conservation is very important because wildlife and wilderness play an important role in maintaining the ecological balance.
- The World Wildlife Fund is an international organization making worldwide efforts for the conservation of nature, and the protection of endangered species.
- Wildlife conservationists work to identify plant and animal species that require protection.

8.1 Wildlife Conservation Efforts in India:

- Project Tiger
- Project Elephant
- Project Snow Leopard
- Vultures

8.2 Project Tiger

Project Tiger was launched in the year 1973. The **Wildlife (Protection) Act, 1972** was amended in the year 2006. Since then, the Government has taken several initiatives in the field of tiger conservation. Tiger conservation was given statutory backing. The newly-created **NTCA** was mandated to carry out estimation of population of tiger and its natural prey species and assess status of their habitat.

Methods to Conserve Tigers

The **Tiger Task Force** realized that a major lacuna in tiger conservation was the absence of a credible, scientific national monitoring protocol that will inform policy-makers and wildlife managers on:

- Spatial extent and the size of tiger population in India.
- Welfare factors in these and neighbouring habitat (prey status, human pressure, other wildlife species, status and habitat conditions);
- Trends in the population and area occupied over time.

The national status assessment exercise provides details such as the size of tiger population, extent, covariates of prey, co-predators, habitat and human impact. It has been observed that tiger population in India has **increased at an average rate of about 5.8 per cent since the year 2006.**

National Status Assessment on Project Tiger

- For the national status assessment 2014, **Spatially Explicit Capture Recapture (SECR)** in a joint distribution approach, with ecologically relevant covariates was used.
- This approach makes use of two samples the first sample is collected by the forest staff of **18 tiger states** and is constituted by structured protocols that are easy and economical to generate information.
- On the presence of tigers and relative abundance, along with information on prey, co-predators, habitat and human impact. The second sample is carried out by trained wildlife biologists who collect information using camera traps on tiger, leopard and prey abundance.
- Individual tigers and leopards are identified using a customized software that uses the stripe and spot patterns (similar to human fingerprints) to identify individuals.
- The Tiger Estimation exercise is the world's largest wildlife survey effort in terms of coverage, intensity of sampling and quantum of camera trapping.
- An amount of Rs. 10.22 crore will be invested by the Government in the fourth cycle of All India Tiger Estimation.
- Financial assistance to the tune of Rs. 7 crore will be provided to the States through the ongoing Centrally Sponsored Scheme of Project Tiger.
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8.3 Project Elephant

Project Elephant (PE) was launched by the Government of India in the year **1992** as a Centrally Sponsored Scheme with following objectives :

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

Financial and Technical support are being provided to major elephant bearing States in the country. The Project is being mainly implemented in **16 States** / UTs, viz. Andhra Pradesh, Arunachal Pradesh, Assam, Chhattisgarh, Jharkhand, Karnataka, Kerala, Maharashtra, Meghalaya, Nagaland, Orissa, Tamil Nadu, Tripura, Uttarakhand, Uttar Pradesh, West Bengal.

Main activities under the Project are as follows:

- Ecological restoration of existing natural habitats and migratory routes of elephants;
- Development of scientific and planned management for conservation of elephant habitats and viable population of Wild Asiatic elephants in India;
- Promotion of measures for mitigation of man elephant conflict in crucial habitats and moderating pressures of human and domestic stock activities in crucial elephant habitats;
- Strengthening of measures for protection of Wild elephants from poachers and unnatural causes of death;
- Research on Elephant management related issues;
- Public education and awareness programmes;
- Eco-development
- Veterinary care
- Elephant Rehabilitation/Rescue Centers

Elephant Reserves:

Till now **28 Elephant Reserves (ERs)** extending over about 61830.08 sq km have been formally notified by various State Governments. Consent for establishment 2 more ERs – Khasi Elephant Reserve in Meghalaya and Dandeli Elephant Reserve in Karnataka has been accorded by MoEF&CC. Inclusion of Bhadra Wildlife Sanctuary in Mysore Elephant Reserve has also been approved by the Ministry. The concerned State Governments are yet to notify these ERs.

Monitoring of Illegal Killing of Elephants (MIKE) Programme

- Mandated by **COP resolution of CITES**, MIKE program started in **South Asia** in the year 2003 with following purpose.
- To provide information needed for elephant range States to make appropriate management and enforcement decisions, and to build institutional capacity within the range States for the long-term management of their elephant populations.

The main objectives of the MIKE are:

- To measure levels and trends in the illegal hunting of elephants;
- To determine changes in these trends over time; and
- To determine the factors causing or associated with such changes, and to try and assess in particular to what extent observed trends are a result of any decisions taken by the Conference of the Parties to CITES.
- Under the programme CITES, data are being collected from all sites on monthly basis in specified MIKE patrol form and submitted to Sub Regional Support Office for South Asia Programme located in Delhi who are assisting Ministry in the implementation of the programme.

Mike Sites in India

- Chirang Ripu (Assam)
- Dhang Patki (Assam)
- Eastern Dooars (WB)
- Deomali (Arun Pradesh)
- Garo Hills (Meghalaya)
- Mayurbhanj (Orissa)
- Mysore (Karnataka)
- Nilgiri (T N)
- Shivalik (Uttarakhand)
- Wayanad (Kerala)

8.4 Project Snow Leopard

- Over 180,000 km2 of Snow Leopard range is spread over the **five Himalayan states of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh**, and within most of these states, over a quarter of their area lies within the snow leopard's range. The snow leopard is a globally **endangered species** about which little is known.
- India is perhaps home to **10% of the global population** in less than 5% of its global range, thus having a substantial proportion of its global population.
- The estimated world population of Snow Leopards in the world is 3,500-7,000, out of which about 500 cats are spreading across the States of Jammu & Kashmir, Himachal Pradesh, Uttaranchal, Sikkim and Arunachal Pradesh in India.
- About 600-700 Snow Leopards are reported to be in the zoos around the world including a few individuals that are housed at the **Padmaja Naidu Zoological Park, Darjeeling and Nainital Zoo, Uttaranchal.**
- Factors such as decline in wild prey populations, poaching for skin and body parts, and retaliatory killings to decrease livestock depredations are the main threats to the conservation of Snow Leopard in India.
- The **Project Snow Leopard started in 2009** to promote knowledge based and adaptive conservation framework that fully involves the local communities, who share the snow leopard's range, in conservation efforts.

Conservation challenges in Himalayas

- The potential habitat of snow leopards across the Greater and Trans-Himalayan landscape, in general, is experiencing drastic socio-economic changes over the past few decades.
- Major changes have been documented in the **Spiti Valley of the Lahaul and Spiti district**, owing to the advent of **green pea** (*Pisum sativum*) cultivation during the mid-1980s.
- The advent of apple cultivation around the same time in Kinnaur district over the past two decades show that the economy of the region has rapidly shifted from traditional agro-pastoralism to market-driven agriculture.
- Consequently, human population growth, agricultural expanse, and excessive livestock grazing have been pervasive in the region.

Conservation Action

- Snow leopards have been given the **highest level of legal protection in India under the Indian Wildlife (Protection) Act, 1972.** Also, India is a signatory to the **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Convention on the Conservation of Migratory Species of Wild Animals (CMS)**, providing additional protection to the snow leopard.
- Improved livestock corral to reduce depredation, livestock insurance program to compensate livestock loss to the local community, and establishing grazing-free reserves to increase wild prey population.
- The most recent forms of participatory local conservation initiatives are those of **'Snow Leopard Enterprise' (SLE)** that focuses on empowering local women by facilitating the production of 'wildlife friendly' wool products, and engagement of snow leopard conservationists with pashmina wool growers to develop sustainable grazing practices for pashmina production and trade.
- Over the past decade, the snow leopard range countries have joined hands to develop national and transboundary conservation initiatives in the form of **National Snow Leopard Ecosystem Priority Protection (NSLEP)**, **Snow Leopard Survival Strategy (SLSS), and Global Snow Leopard and Ecosystem Protection Program (GSLEP)**.
- As part of GSLEP, two large landscapes have been identified in India across Himachal Pradesh, Ladakh (Jammu & Kashmir), and Uttarakhand to secure breeding populations of snow leopard.
- Several institutions and organizations working towards enhancing knowledge on snow leopard ecology and its conservation in India include (but may not be restricted to) Wildlife Institute of India, Nature Conservation Foundation – Snow Leopard Trust, World Wildlife Fund for Nature – India (WWF), and Snow Leopard Conservancy.

8.5 Project Vultures

Why project vulture?

In recent times vultures have seen a marked decline of many species. Indiscriminate usage of **diclofenac** as pain killers in the cattle has caused **renal failures** in the vultures. Unfortunately, **power lines** are also a key factor in the loss of many birds. Losses of vultures increases the spread of diseases such as **rabies and anthrax** which can have devastating effects on other wildlife populations.

Vulture to the environment & ecology

- Vultures are an important ecological component, occurring at the **top of the food chain.**
- Healthy vulture population numbers are a clear indication of a well-balanced environment.
- Vultures also play an important cultural, economic and aesthetic role, and are a symbol of our national heritage.
- The vulture performs a number of important tasks which are vitally beneficial to humans, as well as the environment at large. These tasks include their **"clean-up" properties; ridding the environment of decomposing carcasses.**
- This prevents the spread of diseases such as anthrax, brucellosis and rabies.

Government of India on Conservation of vultures

- **The Ministry of Health and Family Welfare** issued Gazette Notification dated 4.7.2008 prohibiting manufacture of Diclofenac for animal use and later by Gazette Notification dated 17.7.2015 restricting on packaging of multi-dose vials of Diclofenac to single dose.
- The Ministry of Health and Family Welfare had been requested for stopping veterinary use of Diclofenac and later for restriction on packaging of Diclofenac (human formulations) to single dose packaging for human use and to discourage veterinary use of Diclofenac and incentivize the use of Meloxicam.
- A survey conducted by the **Bombay Natural History Society** under a special project sponsored in the year 2000 by the Ministry of Environment, Forest and Climate Change revealed that there has been more than 90 percent decline in the populations of three species of vultures viz, White Backed, Long Billed and Slender Billed in many parts of the country.

The following are the important steps taken by Government for protection of Vultures in the country:

1. Protection status of White backed, Long Billed and Slender Billed Vultures has been upgraded from **Schedule IV to Schedule I of the Wild Life (Protection) Act, 1972.**
2. Two workshops were organized in in consultation with scientists in New Delhi in September 2000 and April, 2004 to work out a comprehensive strategy for conservation of vultures.
3. Bombay Natural History Society in collaboration with the Haryana State Forest Department has taken up a project on conservation breeding of vultures.
4. A '**Vulture Captive Care facility**' has been established at **Panchkula.**
5. The State Governments have been advised to set up vulture care centres for the conservation of three species of vultures.
6. Government of India has formulated a **National Action Plan (2006) on Vulture Conservation.** The Action Plan provides for strategies, actions for containing the decline of vulture population through ex-situ, in-situ vulture conservation.
7. Department of forests of all states/UTs has been requested to constitute a Monitoring committee for vulture conservation with a view to implement the Action Plan, 2006 and for recovery of existing vulture sites.
8. Captive breeding centres at Zoos at Bhopal, Bhubaneswar, Junagarh and Hyderabad have also been set up through Central Zoo Authority.
9. State of Haryana has established **Safe Vulture Zones under Project Jatayu.**
10. Ministry has also taken initiatives to strengthen the mass education and awareness for vulture conservation.

******END******

CGP 2019

CLIMATE CHANGE

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CLIMATE CHANGE AND IT'S IMPACTS

Variability, in both time and space, is an inherent feature of climate, as the atmosphere is always in the state of turmoil and instability leading to variations in weather and climatic conditions.

What Is Climate? How Is It Different From Weather?

Weather:

- Weather is the **changes we see and feel outside from day to day**. It might rain one day and be sunny the next.
- Weather is dynamic and **changes from place to place**. It is a combination of wind, temperature, cloudiness, precipitation and visibility.

Climate:

- The difference between weather and climate is the measure of time.
- Climate is the **usual weather of a place averaged over some time period (usually 30 years)**.

Earth's climate:

- Earth's climate is what you get **when you combine all the climates around the world together**.

What Is Climate Change?

- Global warming and climate change - while closely related and sometimes interchangeably used technically refer to two different things.
- **"Global Warming"** applies to the long term trend of rising average global surface temperatures.
- **"Climate change"** is a broader term that reflects the fact that carbon pollution does more than just warm our planet. Carbon pollution is also changing rain and snow patterns and increasing the risk of intense storms and droughts.
- Another distinction between them is that scientists and scholars sees global warming mostly as human induced warming whereas climate change, on the other hand, can mean human induced changes or natural ones, such as ice ages.

Is Earth's Climate Changing?

- The planet has experienced climate change before: the Earth's average temperature has fluctuated throughout the planet's 4.54 billion-year history. The planet has experienced long cold periods ("ice ages") and warm periods ("interglacials") on 100,000-year cycles for at least the last million years.
- **Earth's climate is getting warmer**. But by how much? :: According to **1.5 Degree Report** of **IPCC** presented at **CoP 24 in Katowice, Poland**, the world has already warmed 1C since pre-industrial levels.

Climate Change Facts

- Global greenhouse gas emissions of G20 countries are continuing to increase.
- Between 1990 and 2013, the absolute CO2 emissions of G20 countries, which account for 3/4ths of global CO2 emissions, went up by 56%.
- Trends in global CO2 and total greenhouse gas emissions show that India's emissions have gone up by 4.7% in 2016

- For most major GHG emitters in the world, the emission figures have gone down, barring India and Indonesia
- Nearly 90% of the country's coal-fired power generation capacity is in violation of Sulphur Dioxide (SO2) emission limits notified two years ago.

Climate change: the debate

- While consensus among nearly all scientists, scientific organizations, and governments is that climate change is happening and is caused by human activity, a small minority of voices questions the validity of such assertions and prefers to cast doubt on the preponderance of evidence. **American President Donald Trump and Brazilian President Jail Bolsonaro are planning to withdraw from the Paris Agreement.**
- American historian of science Naomi Oreskes and others have shown the methods by which those with vested interests have funded scientists and politicians to challenge climate change, thereby sowing confusion.

- **Arguments of Climate change deniers:**
  Recent changes attributed to human activity can be seen as part of the natural variations in Earth's climate and temperature, and that it is difficult or impossible to establish a direct connection between climate change and any single weather event, such as a hurricane.
- **Counter argument:**
  While the latter is generally true, decades of data and analysis support the reality of climate change—and the human factor in this process.

What are the major climate change topics?

1. The 2015 Paris accord set a target of limiting global warming to 1.5º C by the end of the century. But diplomats **didn't agree on the details of how their nations will reach that ambitious goal**. The Bonn talks was suppose to flesh out **the rulebook** that countries have to abide by. This included **coming up with international standards** for **how to measure carbon emissions**, to **make sure that one nation's efforts can be compared to another's**.
2. A second debate centers around **how countries take stock of what's been achieved and set new, more ambitious goals for curbing carbon emissions after 2020**.
3. The third big issue concerns money. Experts agree that shifting economies away from fossil fuels and preparing countries for some of the inevitable consequences of climate change will require vast financial resources — including some from the US administration of President Donald Trump, which is doubtful about man-made climate change.
4. Fourth major issue was to find if Donald Trump pulling the US out of the Paris agreement would stall the hopes of progress in climate change negotiations.
5. Further, a major agenda of the meet (CoP 23 in Bonn) was to launch as so-called "***Global Alliance to Power Past Coal***".

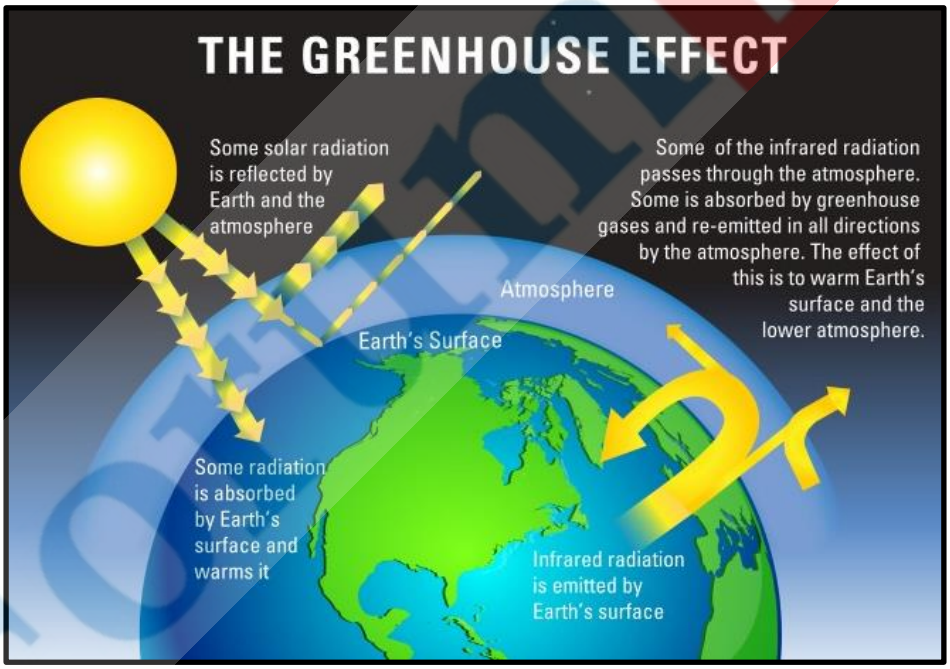
Impacts of Global Warming:

- Rise in sea level
- Changes in rainfall patterns. Example: Kerala Floods, 2018.
- Occurrence of extreme events like frequent intensification of hurricanes and cyclones, recurrent droughts, etc.
- Melting of glaciers and ice caps. Example: Melting of glaciers in Arctic Sea and Greenland.
- Widespread vanishing of populations due to habitat loss. Example: Snow Leopard in the Himalayas.

- Spread of disease (like malaria. etc).
- Bleaching of Coral Reefs.

Greenhouse Effect:

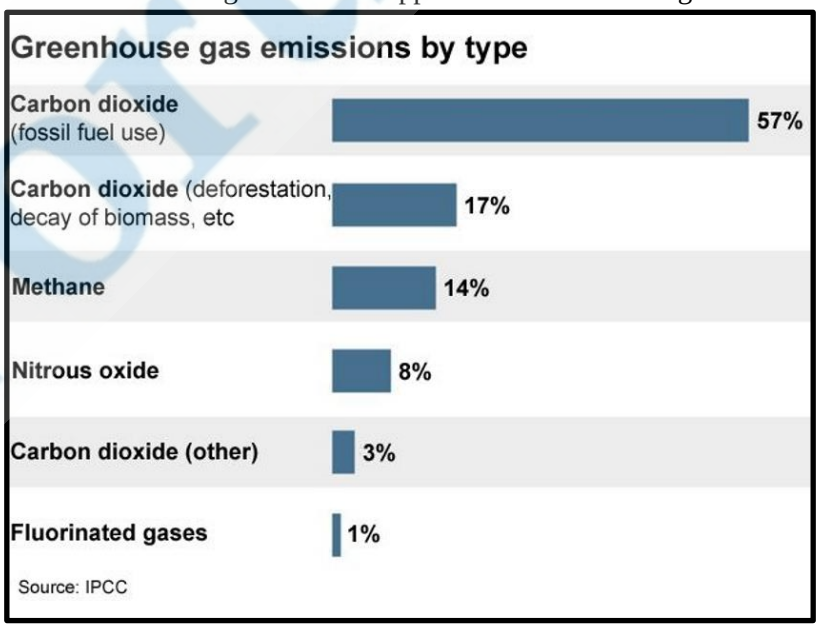
- The greenhouse effect refers to **the way the Earth's atmosphere traps some of the energy from the Sun**.
- The process:
    - Solar energy enters our atmosphere as **shortwave radiation** in the form of ultraviolet (UV) rays (the ones that give us sunburn) and visible light. The sun emits shortwave radiation because it is extremely hot and has a lot of energy to give off. Once in the Earth's atmosphere, clouds and the surface absorb the solar energy. The ground heats up and re-emits energy as **longwave radiation** in the form of infrared rays. Earth emits longwave radiation because Earth is cooler than the sun and has less energy available to give off.
    - Solar energy radiating (**Long wave infrared radiation**) back out to space from the Earth's surface is absorbed by atmospheric greenhouse gases and re-emitted in all directions.
    - The energy that radiates back down to the planet heats both the lower atmosphere and the surface. Without this effect, the Earth would be about 30ºC colder, making our planet hostile to life.



Greenhouse Gases

- A greenhouse gas is **a gas that absorbs and emits radiant energy within the thermal infrared range**. Greenhouse gases cause the greenhouse effect.
- Primary greenhouse gases in Earth's atmosphere = Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3)
- GHGs under **Kyoto Protocol**:
    - CO_2, N_2O and CH_4
    - Sulphur hexafluoride (SF_6),
    - Hydrofluorocarbons (HFCs) and
    - Perfluorocarbons (PFCs).

- A number of entirely human-made greenhouse gases in the atmosphere, such as the **halocarbons** and other **chlorine and bromine containing substances** are dealt with under the **Montreal Protocol**.
- Significance:
    - Without greenhouse gases, the average temperature of Earth's surface would be about −18 °C (0 °F), rather than the present average of 15 °C (59 °F).
    - The atmospheres of Venus, Mars and Titan also contain greenhouse gases.
- Water vapor accounts for by far the largest greenhouse effect (90–85%) because water vapor emits and **absorbs infrared radiation at many more wavelengths** than any of the other greenhouse gases, and there is much more water vapor in the atmosphere than any of the other greenhouse gases. CO_2 makes up only a tiny portion of the atmosphere (0.040%) and constitutes only 3.6% of the greenhouse effect.
- **If water vapour is the most important greenhouse gas, why all the fuss about CO_2?**
    - Water Vapour has a very short atmospheric lifetime (about 10 days) and is very nearly in a dynamic equilibrium in the atmosphere, so it is not a forcing gas in the context of global warming.
        - Scientists have identified carbon dioxide as the dominant greenhouse gas forcing.
        - Methane and nitrous oxide are also major forcing contributors to the greenhouse effect.
- **What will happen if we continue to emit GHGs?**
    - Should greenhouse gas emissions continue at their rate in 2017, Earth's surface temperature could exceed historical values as early as 2047, with potentially harmful effects on ecosystems, biodiversity and human livelihoods.
    - According to 1.5 Degree Report of IPCC, Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate.
    - At current emission rates temperatures could increase by 2 °C, which the United Nations' IPCC designated as the upper limit to avoid "dangerous" levels, by 2036.



2. Causes of climate change

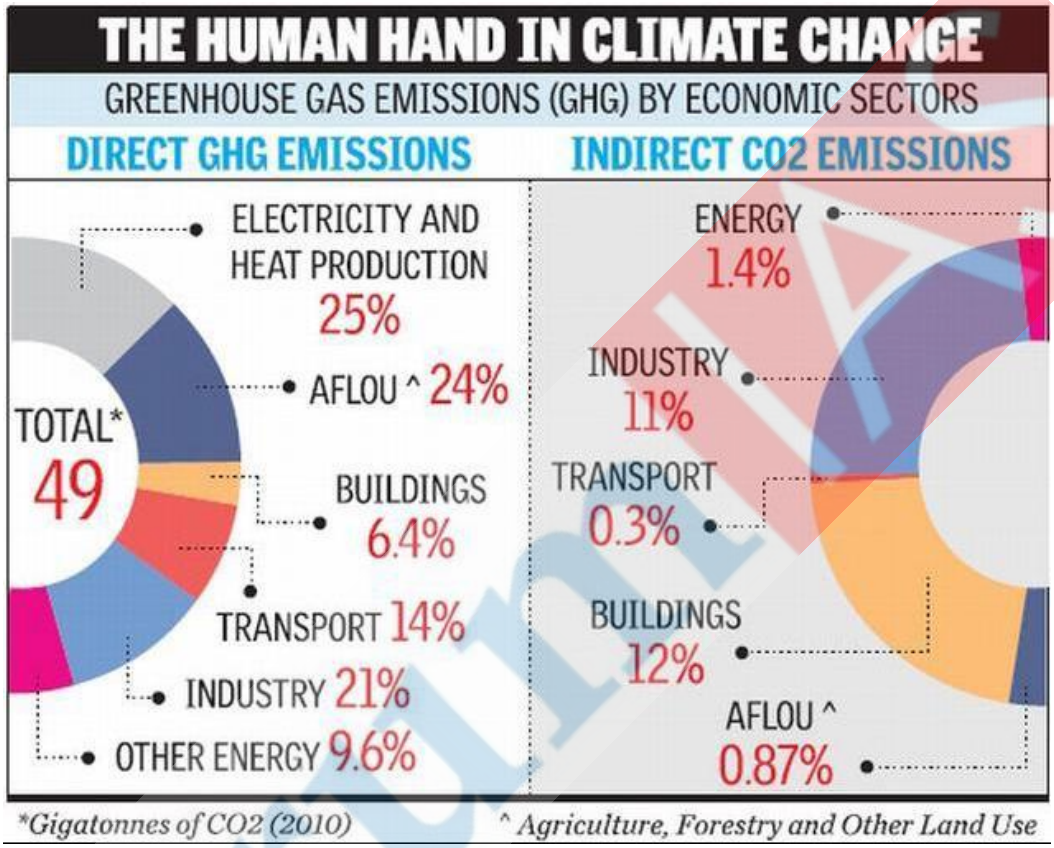
Natural causes:

- **Solar irradiance**
    - Changes in the sun's energy output would cause the climate to change, since the sun is the fundamental source of energy that drives our climate system.
    - Studies show that solar variability has played a role in past climate changes : a decrease in solar activity is thought to have triggered the **Little Ice Age** between approximately 1650 and 1850, when Greenland was largely cut off by ice from 1410 to the 1720s and glaciers advanced in the Alps.
    - But several evidences show that current global warming cannot be explained by changes in energy from the sun:
        - Since 1750, the average amount of energy coming from the sun either remained constant or increased slightly.
        - If the warming were caused by a more active sun, then scientists would expect to see warmer temperatures in all layers of the atmosphere. Instead, they have observed a cooling in the upper atmosphere, and a warming at the surface and in the lower parts of the atmosphere. That's because greenhouse gases are trapping heat in the lower atmosphere.
        - Climate models that include solar irradiance changes can't reproduce the observed temperature trend over the past century or more without including a rise in greenhouse gases.
- **Sunspot Cycles:**
    - The increased sunspot activity (increase in the number of sunspots) causes warming of the earth's surface and its atmosphere and vice versa.
    - Sunspots are darker and cooler areas in the photosphere of the sun.
- **Astronomical Theories**
    - The **Milankovitch Theory or Milankovitch Oscillation**s have tried to explain the causes of climate change through change in the eccentricity of earth's elliptical orbit, obliquity including of the earth's rotational axis and precession of the equinoxes
    - On the basis of above theory, he tried to explain the advancement and retreat of ice sheets during Pleistocene Ice Age.
- **Atmospheric Dust Hypothesis (mainly volcanic eruptions and dusts)**
    - The atmospheric solid particulate matters include dust particles, salt particles, polen, smoke and soot, volcanic dusts and ashes, etc.
    - **Black carbon (BC)** is a solid particle or aerosol, not a gas, but it also contributes to warming of the atmosphere.
        - Unlike GHGs, BC can directly absorb incoming and reflected sunlight in addition to absorbing infrared radiation.
        - BC can also be deposited on snow and ice, darkening the surface and thereby increasing the snow's absorption of sunlight and accelerating melt.
    - Sulfates, organic carbon, and other aerosols can **cause cooling by reflecting sunlight**.

Anthropogenic causes:

- Burning of fossil fuels : People drive cars. People heat and cool their houses. People cook food. All those things take energy. => Burning coal, oil and gas to generate energy => Burning these things puts gases into the air => The gases cause the air to heat up => This can change the climate of a place. It also can change Earth's climate.

- In its **5th Assessment Report**, the **Intergovernmental Panel on Climate Change**, a group of 1,300 independent scientific experts from countries all over the world under the auspices of the United Nations, concluded that there's a better than 95 percent probability that human-produced greenhouse gases such as carbon dioxide, methane and nitrous oxide have caused much of the observed increase in Earth's temperatures over the past 50 years.
- Deforestation, changes in land use, soil erosion and agriculture (including livestock).
- Industrial revolution
- Mining and Quarrying.



Climate Forcing:

- There are a number of natural mechanisms that can upset the global energy balance, for example **fluctuations in the Earth's orbit**, **variations in ocean circulation** and **changes in the composition of the Earth's atmosphere**.
- By altering the global energy balance, such mechanisms "force" the climate to change. Consequently, scientists call them "climate forcing" mechanisms.
- **Climate 'forcings'** are factors in the climate that either increase or decrease the effects to the climate system.
- **Positive forcings** such as greenhouse gases warm the earth while the **negative forcings** such as the volcanic eruptions, etc. cools the earth system.
- Examples of external forcings include:
    1. Surface reflectivity (albedo)
    2. Human induced changes in greenhouse gases
    3. Atmospheric aerosols (volcanic sulfates, industrial output)
- These examples influence the balance of energy entering and leaving the Earth system.

3. Ocean acidification

What is Ocean Acidification?

- When carbon dioxide (CO_2) is absorbed by seawater, chemical reactions occur that **reduces seawater pH**, carbonate ions concentration, and saturation states of biologically important calcium carbonate minerals. These chemical reactions are termed as "ocean acidification".

Dissolving CO_2 in seawater increases the hydrogen ion (H^+) concentration in the ocean, and thus decreases ocean pH, as follows:

$$CO_{2\,(aq)} + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons HCO_3^- + H^+ \rightleftharpoons CO_3^{2-} + 2\,H^+$$

- Calcium carbonate minerals are the building blocks for the skeletons and shells of many marine organisms.
- Since the beginning of the Industrial Revolution, the pH of surface ocean waters has **fallen by 0.1 pH units**. Since the pH scale, like the Richter scale, is logarithmic, this change represents approximately a 30% increase in acidity.
- Present ocean acidification is occurring at approximately **ten times faster rate than anything experienced during the last 300 million years**, **jeopardising the ability of ocean systems to adapt to changes in ocean chemistry due to CO_2**.
- Ocean acidification has the potential to **change marine ecosystems** and **impact many ocean-related benefits to society** such as coastal protection or provision of food and income.
- **Increased ocean temperatures** and **oxygen loss act concurrently** with **ocean acidification** and constitute the '**deadly trio**' of climate change pressures on the marine environment.
- **Future prospects:**
    - Future predictions indicate that the oceans will continue to absorb carbon dioxide, further increasing ocean acidity.
    - Estimates of future carbon dioxide levels, based on business as usual emission scenarios, indicate that by the end of this century the surface waters of the ocean could have acidity levels **nearly 150% higher**, resulting in a pH that the oceans haven't experienced for more than 20 million years.

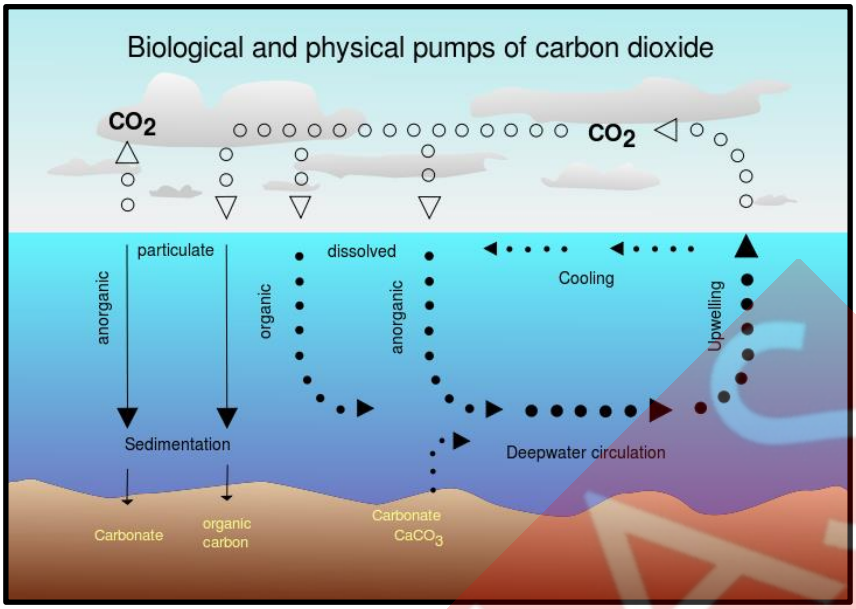
Impacts of Ocean Acidification

- In areas where most life now congregates in the ocean, the seawater is supersaturated with respect to calcium carbonate minerals.
    - This means there are abundant building blocks for calcifying organisms to build their skeletons and shells.
    - However, continued ocean acidification is causing many parts of the ocean to become undersaturated with these minerals, which is likely to affect the ability of some organisms to produce and maintain their shells. Example: oysters, clams, sea urchins, shallow water corals, deep sea corals, and calcareous planktons.
    - Photosynthetic algae and seagrasses may benefit from higher CO_2 conditions in the ocean, as they require CO_2 to live just like plants on land.
    - Certain fish's ability to detect predators is decreased in more acidic waters. When these organisms are at risk, the entire food web may also be at risk.
- An increase in **red tide events** : It could contribute to the accumulation of toxins (domoic acid, brevetoxin, saxitoxin) in small organisms such as anchovies and shellfish, in turn increasing occurrences of amnesic shellfish poisoning, neurotoxic shellfish poisoning and paralytic shellfish poisoning.
- ***Coral***
    - Increasing ocean acidification has been shown to significantly reduce the ability of reef-building corals to produce their skeletons.

- Ocean acidification could compromise the successful fertilization, larval settlement and survivorship of **Elkhorn coral, an endangered species.**
- Ocean acidification could severely impact the ability of coral reefs to recover from disturbance.
- By the end of this century, coral reefs may erode faster than they can be rebuilt. This could compromise the long-term viability of these ecosystems and perhaps impact the estimated one million species that depend on coral reef habitat.

Mitigation: Possible responses

- Reducing the build-up of CO_2 in the atmosphere.
- Reinvigorate action to reduce stressors, such as overfishing and pollution, on marine ecosystems to increase resilience to ocean acidification.
- Climate Engineering
  - **Ocean fertilization** or ocean nourishment is a type of climate engineering based on the purposeful introduction of nutrients to the upper ocean to increase marine food production and to remove carbon dioxide from the atmosphere.
  - **Enhanced weathering** is a chemical approach to remove carbon dioxide involving land- or ocean-based techniques.
    - Ocean-based techniques involve alkalinity enhancement, such as grinding, dispersing, and dissolving olivine, limestone, silicates, or calcium hydroxide to address ocean acidification and CO2 sequestration.
  - **Iron fertilization** of the ocean could stimulate photosynthesis in phytoplankton.
    - The phytoplankton would convert the ocean's dissolved carbon dioxide into carbohydrate and oxygen gas, some of which would sink into the deeper ocean before oxidizing.
    - Adding iron to the ocean increases photosynthesis in phytoplankton by up to 30 times.
  - **Biological pump**, in its simplest form, is the ocean's biologically driven sequestration of carbon from the atmosphere to the ocean interior and seafloor sediments. It is the part of the oceanic carbon cycle responsible for the cycling of organic matter formed mainly by phytoplankton during photosynthesis (soft-tissue pump), as well as the cycling of calcium carbonate (CaCO3) formed into shells by certain organisms such as plankton and mollusks (carbonate pump).



Issues with the mitigation approaches such as adding chemicals to counter the effects of acidification:

- likely to be **expensive**,
- **only partly effective** and **only at a very local scale**,
- **may pose additional unanticipated risks to the marine environment**.
- There has been very little research on the feasibility and impacts of these approaches. Substantial research is needed before these techniques could be applied.

Steps taken:

- Parties to the **United Nations Framework Convention on Climate Change (UNFCCC)** adopted a target of limiting warming to below 2 °C, relative to the pre-industrial level. Meeting this target would require substantial reductions in anthropogenic CO_2 emissions.
- Limiting global warming to below 2 °C would imply **a reduction in surface ocean pH of 0.16 from pre-industrial levels**. This would represent a substantial decline in surface ocean pH.

Way forward to combat Ocean Acidification:

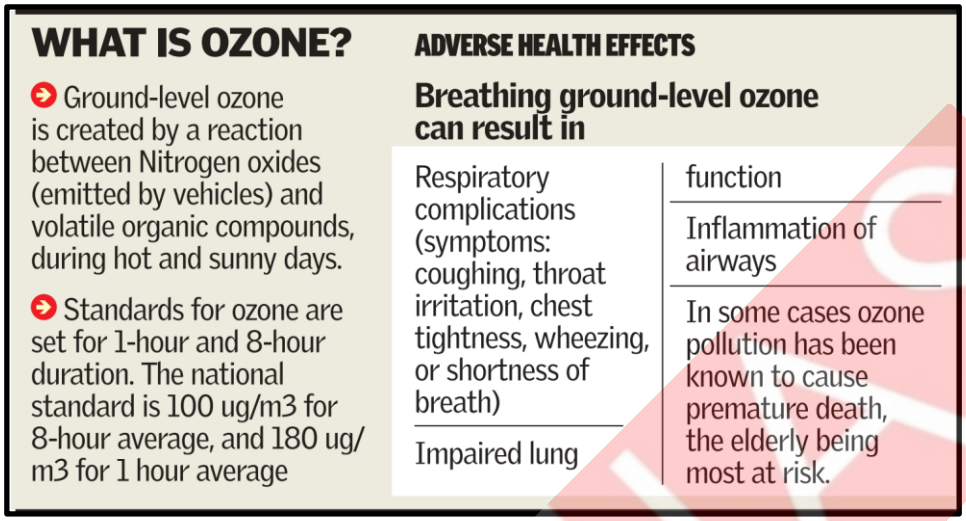
- To combat the worst effects of the deadly trio, **CO_2 emissions need to be cut significantly** and **immediately at the source**.
- Sustainable management, conservation, restoration and strong, permanent protection of at least 30% of the oceans are urgently needed.

4. Ozone depletion

Ozone

- Ozone is formed from di-oxygen by the action of ultraviolet light (UV) and electrical discharges within the Earth's atmosphere.
- It is present in very low concentrations throughout the latter, with its highest concentration high in the ozone layer of the stratosphere, which absorbs most of the Sun's ultraviolet (UV) radiation.
- **Significance:**
    - Ozone is a powerful oxidant (far more so than dioxygen) and has many industrial and consumer applications related to oxidation.

- At ground level, it has harmful effects on the respiratory systems of animals.
- However, in upper atmosphere, it creates ozonosphere, which prevents potentially damaging ultraviolet light from reaching the Earth's surface.
  - Ozonosphere is located 10-18 kilometres above Earth's surface.



Variation in thickness of Ozone Layer:

- The ozone layer is **not uniform throughout the earth**, being thin at equator and thickest at poles.
- It also varies with season, being in general thicker during the spring and thinner during the autumn in the northern hemisphere.

Ozone depletion

- It is the gradual thinning of Earth's ozone layer in the upper atmosphere caused by the release of chemical compounds containing gaseous chlorine or bromine from industry and other human activities.
- The thinning is most pronounced in the polar regions, especially over Antarctica.
- Ozone depletion describes two related events observed since the late 1970s:
  1. a steady lowering of about four percent in the total amount of ozone in Earth's atmosphere (the ozone layer), and
  2. a much larger springtime decrease in stratospheric ozone around Earth's polar regions. This phenomenon is referred to as the ozone hole.
- There are also springtime polar tropospheric ozone depletion events in addition to these stratospheric events.

Causes of Ozone layer depletion

- Main cause of ozone depletion and the ozone hole is manufactured chemicals, especially **manufactured halocarbon refrigerants, solvents, propellants and foam-blowing agents (chlorofluorocarbons (CFCs), HCFCs, halons)**, referred to as ozone-depleting substances (ODS).
  - They are compounds of chlorine, fluorine, and carbon such as CF_3Cl, $CHCl_2F$ etc.
  - These are used as refrigerants in refrigerators, air conditioners, and in cooling plants.
  - These molecules can destroy O_3 molecules and therefore depletion of the O_3 layer.
- **Nitrogen oxides (**such as nitrous oxide)
  - very reactive to O_3 and are also responsible for holes in the ozone layer.
  - released by burning fossil fuels by cars and especially airplanes which fly near the ozone layer.

Process of creation of Ozone Hole

- Ozone-depleting substances are transported into the stratosphere by the winds after being emitted from the surface.
- Polar Regions = much larger variation in sunlight. During the 3 months of winter = dark, no solar radiation.
- Temperatures reduce around or below -80°C for much of the winter. Extremely low Antarctic temperatures cause cloud formation in the relatively "dry" stratosphere.
- These **polar stratospheric clouds** (PSCs) are composed of ice crystals that provide surface for reactions, many of which speed up the degradation of ozone molecules.
- **Chemistry + dynamics + radiation** = Conditions conducive to significant ozone loss in the Polar Regions.
- The sequence of events leading to the spring time depletion of ozone is initiated of the earth's orbit at about 23.5° causes the polar regions to experience continual darkness during their winter season.
- The air above the pole cools and a vortex is formed that isolates and sets the stage for the rapid depletion of ozone by catalytic cycles.
    - **Catalytic cycle** is a series of reactions in which a chemical family or a particular species is depleted, leaving the catalyst unaffected.
- Chlorofluorocarbon-bonds (CFCs) themselves are **not involved in the catalytic process**. Upon reaching the stratosphere, they are subject to higher levels of ultraviolet radiation that decompose the CFCs and release atomic chlorine.

$$Cl + O_3 \rightarrow ClO + O_2 \quad \text{(step 1)}$$

$$ClO + O \cdot \rightarrow Cl + O_2 \quad \text{(step 2)}$$

$$O_3 + O \cdot \rightarrow 2O_2 \quad \text{(Overall reaction)}$$

Consequences of Ozone layer depletion:

- An increase of UV radiation would be expected to affect crops.
    - A number of economically important species of plants, such as rice, depend on Cyanobacteria residing on their roots for the retention of nitrogen.
    - Cyanobacteria are sensitive to UV radiation and would be affected by its increase.
    - Several of the world's major crop species are particularly vulnerable to increased UV, resulting in reduced growth, photosynthesis and flowering.
- Skin cancers, sunburns and premature aging of the skin
    - Basal and squamous cell carcinomas : the most common forms of skin cancer in humans
    - Malignant melanoma : another form of skin cancer
- Cortical cataracts : UV radiation can damage several parts of the eye, including the lens, cornea, retina and conjunctiva
- Weakening of the human immune system
- Planktons are threatened by increased UV radiations

Why Ozone hole mainly in Antarctica not in Arctic pole?

- Southern polar region is more colder and isolated than north => It favors the formation of polar stratospheric clouds (PSCs) which in turn serve as platforms for catalytic ozone breakdown
- As a consequence of having **less land**, the **circulation over the Antarctic is more persistent and vortex-like**, which favours PSCs.

- Air inside the vortex is prevented from mixing with warmer, ozone-rich air from lower latitudes (This vortex is not a feature of the Arctic).

Facts for Prelims:

- ***The International Day for Preservation of Ozone Layer (aka World Ozone Day) is observed every year on September 16*** for the preservation of the Ozone Layer.
- ***2018 Theme:*** 'Keep Cool and Carry On: The Montreal Protocol'.

Intervention to mitigate Ozone Layer Depletion:

The Montreal Protocol on Substances that Deplete the Ozone Layer

- The original Montreal Protocol was agreed on 16 September 1987 and entered into force on 1 January 1989.
- It was conceived after the detection of a large hole in earth's ozone layer over Antarctica.
- **Aim:** The main aim of this treaty was the elimination of Chlorofluorocarbons (CFCs) and HCFCs. As a replacement **HFCs** were proposed
- Montreal Protocol stipulates that the production and consumption of compounds that deplete ozone in the stratosphere-chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform-are to be phased out by 2000 (2005 for methyl chloroform).

Kigali Conference:

- Meeting of Parties (MoP) to the Montreal Protocol of the Vienna Convention for Protection of Ozone Layer took place in October, 2016, in Kigali (Rwanda).
- Why: The negotiations at Kigali were aimed at **including Hydrofluorocarbons (HFCs) in the list of chemicals under the Montreal Protocol** with a view to regulate their production and consumption and phase them down over a period of time with financial assistance from the **Multilateral Fund created under the Montreal Protocol.**
- **What are HFCs?**
    - HFCs are refrigerant gases used for commercial, residential and automotive purposes (and in other applications) but are hundreds to thousands of times more potent that carbon dioxide.
    - They were meant to replace HCFCs (hydrochlorofluorocarbons) in order to protect the ozone layer but their **global warming potential (GWP)** has increasingly become a matter of concern in climate negotiations.
- **What is GWP?**
    - It is a relative measure of how much heat a greenhouse gas traps in the atmosphere.
    - It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide.
- During negotiations held at Kigali India successfully negotiated the baseline years and freeze years which will allow sufficient room for the growth of the concerned sectors using refrigerants being manufactured domestically thus ensuring unhindered growth with least additional cost and maximum climate benefits.
- **Outcome of Kigali Conference:**
    - **there would be two set of baselines or peak years for developing countries**
    - India will have baseline years of 2024, 2025, 2026.
        - This decision gives additional HCFC allowance of 65% that will be added to the Indian baseline consumption and production.
    - The freeze year for India will be 2028, with a condition that there will be a technology review in 2024/2025 and, if the growth in the sectors using refrigerants is above certain agreed threshold, India can defer its freeze up to 2030.

- On the other hand, developed countries will reduce production and consumption of HFCs by 70% in 2029.
- India will complete its phase down in 4 steps from 2032 onwards with cumulative reduction of 10% in 2032, 20% in 2037, 30% in 2042 and 85% in 2047.

- **Significance of Kigali**
  - The Kigali Amendment is one that could avoid global warming by up to 0.5° C
  - India & China are the only countries in the world today that manufacture HFCs. **So, why India has been given a later freeze year?**
    - Because China's air conditioner market is bigger in size meaning its production of HFCs is also larger than India.
    - India's HFC consumption picks up only after 2025 while China will witness rapid emissions of HFCs from 2015-2030
  - The Kigali amendments to the Montreal Protocol will, for the first time, incentivise improvement in energy efficiency in case of use of new refrigerant and technology. Funding for R&D and servicing sector in developing countries has also been included in the agreed solutions on finance.

5. Impacts of climate change

Though all countries are affected by climate change, they are affected in different ways and to different extents.

Developing countries will be particularly badly hit, for three reasons:

- geography (non-temperate latitudes)
- stronger dependence on agriculture
- with their fewer resources comes greater vulnerability.

Impact of Climate Change on Agriculture

- Rise in coconut yields (with some exceptions); reduced apple production
- Negative impacts on livestock in all regions. Livestock of tropical regions would become more prone to infectious and parasitic diseases. Their productivity would decline. Indigenous breeds of India like Rathi, Tharparkar, Red SIndhi, etc. would be at danger.
- According to the **Turn Down The Heat: Climate Extremes, Regional Impacts and the Case for Resilience Report** (prepared by World Bank & looks at the likely impacts of 2°C and 4°C warming on agricultural production, water resources, coastal ecosystems and cities across South Asia, Sub-Saharan Africa, and Southeast Asia):
  - By the 2040s, India will see a significant reduction in crop yields because of extreme heat.
  - Reduced water availability due to changes in precipitation levels and falling groundwater tables are likely to aggravate the situation in India, where groundwater resources are already at a critical level and about 15% of the country's groundwater tables are overexploited.
  - In India, more than 60% of the crop area is rain-fed, making it highly vulnerable to climate-induced changes in precipitation patterns.
  - It is estimated that **by the 2050s, with a temperature increase of 2°C-2.5°C compared to pre-industrial levels, water for agricultural production in the river basins of the Indus, Ganges and Brahmaputra will reduce further** and may impact food adequacy for some 63 million people.
  - An extreme wet monsoon that currently has a chance of occurring only once in 100 years is projected to occur every 10 years by the end of the century.
  - Kolkata and Mumbai are 'potential impact hotspots' threatened by extreme river floods, more intense tropical cyclones, rising sea levels and very high temperatures.

- Significant reduction in crop yields predicted. Some 63 million people may no longer be able to meet their caloric demand.
- Decreasing food availability can also lead to significant health problems.
- Substantial reduction in the flow of the Indus and Brahmaputra in late spring and summer.
- Under 2°C warming by the 2040s, crop production in South Asia may reduce by at least 12%, requiring more than twice the imports to meet per capita demand than is required without climate change.
- Decreasing food availability can also lead to significant health problems, including childhood stunting, which is projected to increase by 35% by 2050 compared to a scenario without climate change.
- Major rivers such as the Ganges, Indus and Brahmaputra, depend significantly on snow and glacial melt water, which makes them susceptible to climate-change induced glacier melt and reductions in snowfall. The World Bank report projects **a rapid increase in the frequency of low snow years in the future, well before 2°C warming takes place**. This could increase the risk of flooding, threatening agriculture.

Climate Change and Soil/Land Degradation

- Land degradation means reduction in the potential of the land to produce benefits from a particular land use under a specified form of land management.
- Changes in climate are recognized as one of the major factors responsible for land degradation affecting sustained development.
- Land degradation encompasses change in chemical, physical and biological property of the soil.
- Soils are also crucial to food security and change in climate has threatened the food security by affecting the soil property.
- The increasing concentration of carbon dioxide in our atmosphere causes the microbes in the soil to work faster to break down organic matter, potentially releasing more carbon dioxide.
- Land exhibited to degradation as a consequence of poor land management could become infertile as a result of climate change.
- Land degradation hazards include wind and water erosion, loss of soil carbon, nutrient decline mass movement, soil structure decline, acid sulphate soils and soil acidification.

Climate Change and Erosion

- Climate change is expected to impact soils through changes in both soil erosion and rainfall.
- Changes in soil surface conditions, such as surface roughness, sealing and crusting, may change with shifts in climate, and hence affect erosion rates.
- Change in erosion can have significant implications for natural assets, agricultural lands and water quality.
- Increased rainfall amounts and intensities will lead to greater rates of erosion unless protection measures are taken.
- A significant potential impact of climate change on soil erosion and sediment generation is associated with the change from snowfall to rainfall.

Climate Change and Groundwater Depletion

- Groundwater depletion, a term often defined as long-term water-level declines caused by sustained groundwater pumping, is a key issue associated with groundwater use.
- Ground water plays a central part in sustaining ecosystems and enabling human adaptation to climate variability and change.

- Increased variability in precipitation and more extreme weather events caused by climate change can lead to longer periods of droughts and floods, which directly affects availability and dependency on groundwater.
- Groundwater depletion and contamination that will seriously compromise much of the world's agriculturally-grown food supply.
- Sea level rise because of climate change may lead to salt water intrusion into coastal aquifers affecting groundwater quality and contaminating drinking water sources.
- Increasing climate-change-induced storm surges will flood coastal areas, threatening the quality of groundwater supplies and compromising their usability.

Impact of Climate Change on Human health

- Higher morbidity and mortality from heat stress and vector/water-borne diseases
- Expanded transmission window for malaria as flooding would create opportunities for breeding of mosquitoes.
- The frequency and severity of Heat waves in Pakistan and India would increase.
- Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in East, South and SouthEast Asia due to projected changes in hydrological cycles.
- Dengue fever is already in evidence at higher levels of elevation in Latin America and parts of East Asia.

The Cryosphere and Global Climate Change

Cryosphere

The cryosphere is those portions of Earth's surface **where water is in solid form**, including sea ice, lake ice, river ice, snow cover, glaciers, ice caps, ice sheets, and frozen ground (which includes permafrost).

Significance:

In Arctic regions, sea ice provides a home for animals like seals and polar bears, feeding and breeding areas for a variety of migrating species, and hunting grounds for local communities.

Acting like a highly reflective blanket, the cryosphere **protects Earth from getting too warm**.

Snow and ice reflect more sunlight than open water or bare ground.

Changes in snow and ice cover affect air

- Melting Ice Causes More Warming

    - When solar radiation hits snow and ice approximately 90% of it is reflected back out to space. As global warming causes more snow and ice to melt each summer, the ocean and land that were underneath the ice are exposed at the Earth's surface.
    - Because they are darker in color, the ocean and land absorb more incoming solar radiation, and then release the heat to the atmosphere. This causes more global warming. In this way, melting ice causes more warming and so more ice melts. This is known as a **feedback**.
- Melting Permafrost Releases Greenhouse Gases
    - Global warming is causing soils in the polar regions that have been frozen for as much as 40,000 years to thaw.
    - As they thaw, carbon trapped within the soils is released into the atmosphere as methane, a powerful greenhouse gas.
- Less Ice on Land Means Sea Level Rises
    - Sea level has been rising about 1-2 millimeters each year as the Earth has become warmer.
    - Some of the sea level rise due to melting glaciers and ice sheets which add water to the oceans that was once trapped on land.

Impact of Climate Change on Water Bodies and water insecurity

- Climate change is expected to exacerbate current stresses on water resources.
- By 2020, between 75 and 250 million people are projected to be exposed to increased water stress due to climate change.
- Warming has resulted in decline in mountain glaciers and snow cover in both hemispheres and this is projected to accelerate throughout the 21st century.
    - This will in turn lead to reducing water availability, hydropower potential, and would change the seasonal flow of rivers in regions supplied by meltwater from major mountain ranges (e.g. Hindu-Kush, Himalaya, Andes).
- By 2050s freshwater availability in Central South, East and South-East Asia, particularly in large river basins, is projected to decrease.
- A warmer climate will accelerate the hydrologic cycle, altering rainfall, magnitude and timing of runoff.
- The IPCC Report 2007 states that the availability of fresh water in India is expected to drop in response to the combined effects of population growth and climate change.
- The IPCC (2007) also suggests that two main drivers of climate change, higher water
- temperature and variations in runoff- are likely to produce adverse changes in water quality affecting human health, ecosystems, and water use.
- Increase in sea-level has serious implications for both human security (increased flood-risks, degraded groundwater quality, etc.) and ecosystems (impact on mangrove forests and coral reefs, etc.), especially so in coastal regions.
- Reduced precipitation and increased evapotranspiration- will reduce recharge and possibly increase groundwater withdrawal rates.
- In coastal areas, sea level rise will exacerbate water resource constraints due to **increased salinisation of groundwater supplies**.
- Available records suggest that the Gangotri glacier is retreating about 28 m per year. Glacial melt is expected to increase under changed climate conditions, which would lead to increased summer flows in some river systems
- In the Indo-Gangetic Plain Region in the past whereby different rivers (including Kosi, Ganga, Ghaghara, Son, Indus and its tributaries and Yamuna) changed their course a number of times. => devastating floods in Nepal and Bihar.

Sea level rise due to Climate Change

- The coastal states of Maharashtra, Goa and Gujarat face a grave risk from the sea level rise, which could flood land (including agricultural land) and cause damage to coastal infrastructure and other property.
- Goa will be the worst hit, losing a large percentage Of its total land area, including many Of its famous beaches and tourist infrastructure.
- Flooding will displace a large number of people from the coasts putting a greater pressure on the civic amenities and rapid urbanisation.
- Sea water percolation due to inundations can diminish freshwater supplies making water scarcer.
- The states along the coasts like Orissa will experience worse cyclones. Many species living along the coastline are also threatened.
- The coral reefs that India has in its biosphere reserves are also saline sensitive and thus the rising sea level threatens their existence too, not only the coral reefs but the phytoplankton, the fish stocks and the human lives that are dependent on it are also in grave danger.
- People living in the Ganges Delta share the flood risks associated with rising sea levels.

Impact on Ocean Acidification (Covered in detail before)

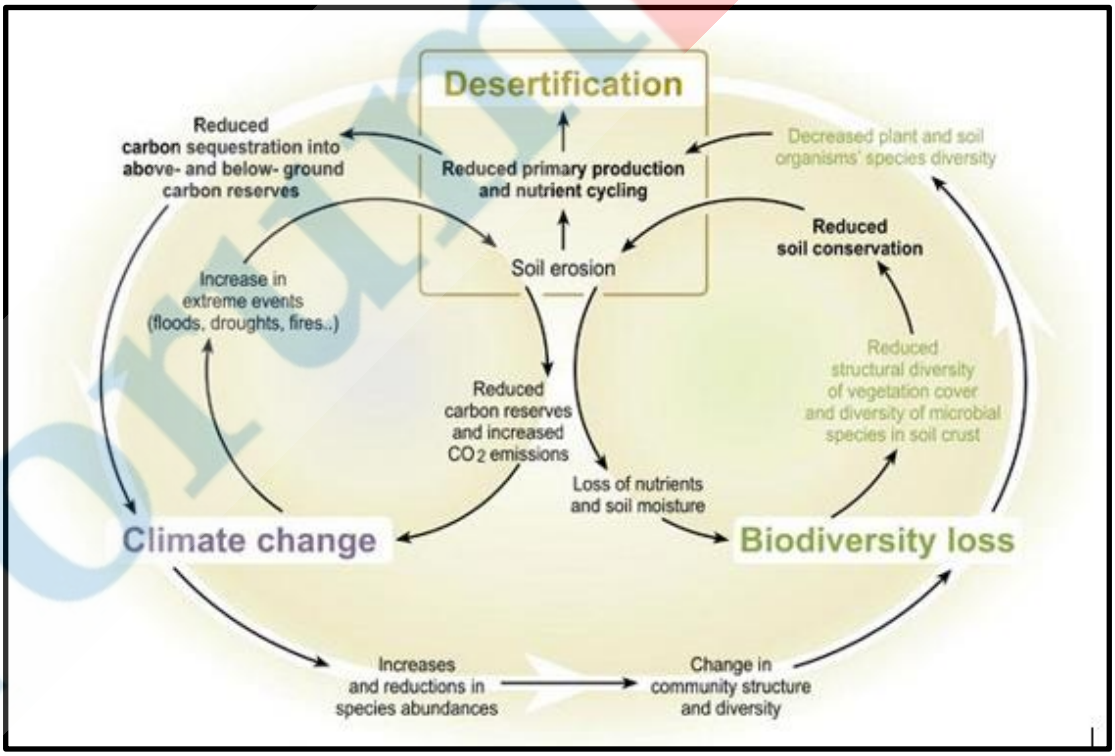
- Ocean acidification is the ongoing decrease in the pH of the Earth's oceans, caused by the uptake of carbon dioxide (CO2) from the atmosphere.
- Measurements made over the last few decades have demonstrated that ocean carbon dioxide levels have risen in response to increased carbon dioxide in the atmosphere, leading to an increase in acidity of oceans.
- Carbon dioxide absorbed into the ocean from the atmosphere reduces calcification rates in reef-building and reef-associated organisms by altering seawater chemistry through decreases in pH.
- Rising acid levels are likely to have impact on specific categories of ocean life: corals, echinoderms, molluscs, crustaceans and fishes.
- More acidic oceans will interfere with the ability of corals to form the reefs.

Impact of Climate Change on Ecosystem and Biodiversity

- According to **International World Wildlife Fund (WWF)**
  - species from the tropics to the poles are at risk.
  - Many species may be unable to move to new areas quickly enough to survive changes that rising temperatures will bring to their historic habitats.
  - 1/5th of the world's most vulnerable natural areas may be facing a "catastrophic" loss of species.
- Impact on **Marine Ecosystems:**
  - They will be affected not only by an increase in sea temperature and changes in ocean circulation, but also by ocean acidification; as the concentration of dissolved carbon dioxide (carbonic acid) rises.
  - This is expected to negatively affect shell forming organisms, corals and their dependent ecosystems.
  - The Bramble Cay melomy is is the first mammal to go extinct due to human-induced climate change.
- Impact on **Mangroves**
  - The ongoing climate change turned out to be a potential threat to the remaining Indian mangroves and other coastal ecosystem.
  - Adverse effects on mangroves extend its serious consequence to the adjoining fragile an ecosystems such as coral reef and seagrass bed..

- Impact on highly diverse and productive mangrove forests will depend upon the rate of sea level rise relative to growth rates and sediments supply, space for and obstacle to horizontal migration, changes in climate-ocean environment.
- Climate unsuitability is an important factor responsible for mangrove's change and disappearance.
- According to **IPCC report**, sea level rise will affect mangroves by eliminating or modifying their present habitats and creating new tidally inundated areas to which some mangrove species may shift.
- Strict protection, preparation of an action plan for each mangrove area, afforestation in potential areas, plantation of species that fail to adapt to sea level rise, and introducing threatened species at higher latitudes are some of the mitigation and management options.

- Impact on **Desert Ecosystem**
  - According to IPCC, climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity.
  - In many dryland areas like Rajasthan and adjoining areas of Punjab and Haryana, the climate is become even more arid and rivers, lakes and underground water sources are drying up. This can have major impacts not only on physical processes (such as the water cycle), but also on ecosystem functions.
  - The UNCCD have recently indicated that: "The climatic effects on land occur at ecosystem and landscape levels".



  - **Increase in extreme events**:
    - Frequent floods will lead to soil erosion and thereby degrading land. It will promote desertification.
    - Droughts on the other hand adversely affects the recharge of soil moisture and groundwater table. Soils dry up and become prone to wind erosion. Ex. Vidarbha, Telangana, etc.

        - Forest fires will cause of forest biome. It will expose the top soil for erosion. This may lead to desertification.
    - **Biodiversity loss:** Climate change may adversely affect biodiversity and exacerbate desertification due to increase in evapotranspiration and a likely decrease in rainfall in drylands
    - **Rural-urban migration:** Climate change leads to decline in agricultural productivity which results in rural-urban migration and abandonment of agricultural land and systematic fallowing. Fallowing and in dry conditions aggravates soil erosion.
- Impact on **Mountain Ecosystems:**
    - Mountain ecosystems are hot spots of biodiversity. However, temperature increases and human activities are causing fragmentation and degradation of mountain biodiversity. Example: Snow Leopards.
    - Himalayas is home to the largest amount of glaciers after the North and the South Poles. However, climate change is threatening this life giver drastically.
    - It is also predicted that there will be an increase in the phenomenon of **Glacial Lake Outburst Floods (GLOFs)** in the eastern and the central Himalayas, causing catastrophic flooding downstream with serious damage to life, property, forests, farms, and infrastructure.

6. Mitigation strategies

Reduce the use of Fossil Fuels:

- Hybrid car that reduce using gasoline.
- Promote public transport or carpool
- **Recycle** can reduce garbage by reusing plastic bags, bottles, papers or glass.
- Stop **open burning** such as burning dry leafs or burning garbage.
- Government should reduce **deforestation**. Trees will help to improve the temperature on earth

Carbon Sequestration

- It is the process involved in **carbon capture** and the **long-term storage of atmospheric carbon dioxide** or other forms of carbon to mitigate or defer global warming.
- Carbon dioxide (CO2) is naturally captured from the atmosphere through biological, chemical, and physical processes.

Carbon Sink

- A **carbon sink** is **a natural or artificial reservoir** that accumulates and stores some carbon-containing chemical compound for an indefinite period.
- The natural sinks are:
    - Trees serve as carbon sinks during growing seasons.
        - In the case of forests and other woodland areas, carbon sequestration is done through photosynthesis.
    - Absorption of carbon dioxide by the oceans via **physicochemical and biological processes**
        - Oceans are considered the main natural carbon sinks, as they are capable of absorbing about 50% of the carbon emitted into the atmosphere.
        - In particular, plankton, corals, fish, algae and other photosynthetic bacteria are responsible for this capture.

Carbon Credit

- It is a credit for greenhouse emissions reduced or removed from the atmosphere from an emission reduction project, which can be used, by governments, industry or private individuals to compensate for the emissions they are generating.
- Carbon credit is a generic term for any tradable certificate or permit representing the right to emit *1 Tonne of Carbon dioxide or the mass of another greenhouse gas with a carbon dioxide equivalent to one tonne of carbon dioxide.*

Carbon Offsetting

- While a **carbon offset** also represents **one tonne of carbon dioxide or equivalent greenhouse gas**, it is **generated by a reduction in emissions made by a voluntary project designed specifically for that purpose**.
- Carbon offsets are generated by projects with clearly defined objectives, usually outside the confines of a company's own operational sites.
- Typical carbon offset projects include building wind turbines or solar farms, supporting methane reduction projects, planting trees or preserving forests.

Carbon Tax

- A carbon tax is a tax levied on the carbon content of fuels.
- It is a form of carbon pricing.
- Revenue obtained via the tax is however not always used to compensate the carbon emissions on which the tax is levied.
- Since greenhouse gas emissions caused by the combustion of fossil fuels are closely related to the carbon content of the respective fuels, a tax on these emissions can be levied by taxing the carbon content of fossil fuels at any point in the product cycle of the fuel.
- The objective of a carbon tax is to reduce the harmful and unfavourable levels of carbon dioxide emissions, thereby decelerating climate change and its negative effects on the environment and human health.
- It is a tax that increases revenue without significantly altering the economy while simultaneously promoting objectives of climate change policy.

Green Finance:

- The idea gets its first mention in the UN document at the UN Conference on Sustainable Development (also known as *Rio+20*), 2012.
- There is no universal *definition* of green finance, though, it mostly refers to **financial investments flowing towards sustainable development projects and initiatives that encourage the development of a more sustainable economy**.
- Initiatives to promote Green Finance:
    - The World Bank Group has set up an informal ***Sustainable Banking Network*** of banking regulators, led by developing countries, to promote sustainable lending practices.
    - In 2015, green bonds issued by governments, banks, corporate and individual projects amounted to US$42 billion.
    - At the global level, more than 20 stock exchanges have issued guidelines on environmental disclosure, and many green indices and green ETFs (exchange-traded funds) have been developed.

Green finance and India

- Attaining the ambitious solar energy target, development of solar cities, setting up wind power projects, developing smart cities, providing infrastructure which is considered as a

green activity and the sanitation drive under the 'Clean India' or 'Swachh Bharat Abhiyan' are all activities needing green finance.

- India created a corpus called the **NCEF (National Clean Energy Fund)** in 2010-11 out of the cess on coal produced/imported (**'polluter pays' principle**) for the purpose of financing and promoting clean energy initiatives and funding research in the area of clean energy.

Issues involved with the mobilisation of green finance:

- Green finance **should not be limited only to investment in renewable energy**, as, for a country like India, coal based power accounts for around 60% of installed capacity.
- **Emphasis should be on *greening coal technology***. In fact, green finance for development and transfer of green technology is important as most green technologies in developed countries are in the private domain and are subject to intellectual property rights (IPRs), making them cost prohibitive.
- Green bonds are perceived as new and attach higher risk and their tenure is also shorter. There is a need to reduce risks to make them investment grade.
- There is also a need for an internationally agreed upon definition of green financing as its absence could lead to over-accounting.
- While environmental risk assessment is important, **banks should not overestimate risks while providing green finance**.
- Green finance should also consider unsustainable patterns of *consumption* as a parameter in deciding finance, particularly conspicuous consumption and unsustainable lifestyles in developed countries.

6. Initiatives taken by India to combat climate change

India's reliance on fossil fuels remains well below China (the most relevant comparator) but also below the US, UK and Europe at comparable stages of development—this echoes India's commitment to never exceed the per capita emission of advanced countries.

Salient Features of India's INDC

- To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation.
- To adopt a climate-friendly and a cleaner path than the one followed hitherto by others at corresponding level of economic development.
- To reduce the emissions intensity of its GDP by **33 to 35 percent by 2030** from 2005 level.
- To achieve about **40 per cent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030**, with the help of transfer of technology and low cost international finance, including from Green Climate Fund.
- To create an additional **carbon sink of 2.5 to 3 billion tonnes of CO2** equivalent through additional forest and tree cover by 2030.
- To better adapt to climate change by enhancing investments in development programmes in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management.
- To mobilize domestic and new and additional funds from developed countries to implement the above mitigation and adaptation actions in view of the resource required and the resource gap.
- To build capacities, create domestic framework and international architecture for quick diffusion of cutting edge climate technology in India and for joint collaborative R&D for such future technologies.

Himalayan Glaciers Monitoring Programme

- Comprehensive programme to scientifically monitor the Himalayan glaciers – Phase I completed; Phase II launched;
- Discussion Paper on State of Himalayan Glaciers released

National Policy on Biofuels: National Policy on Biofuels approved by Cabinet to promote cultivation, production and use of Biofuels for transport and in other applications

Energy Efficiency Standards for Appliances: Energy efficiency ratings made mandatory for 4 key appliances — refrigerators, air conditioners, tube lights and transformers from January 7, 2010

International Solar Alliance: India has launched a historic ***International Solar Alliance (ISA)*** which is envisaged as a coalition of solar resource-rich countries to address their special energy needs and will provide a platform to collaborate on addressing the identified gaps through a common, agreed approach.

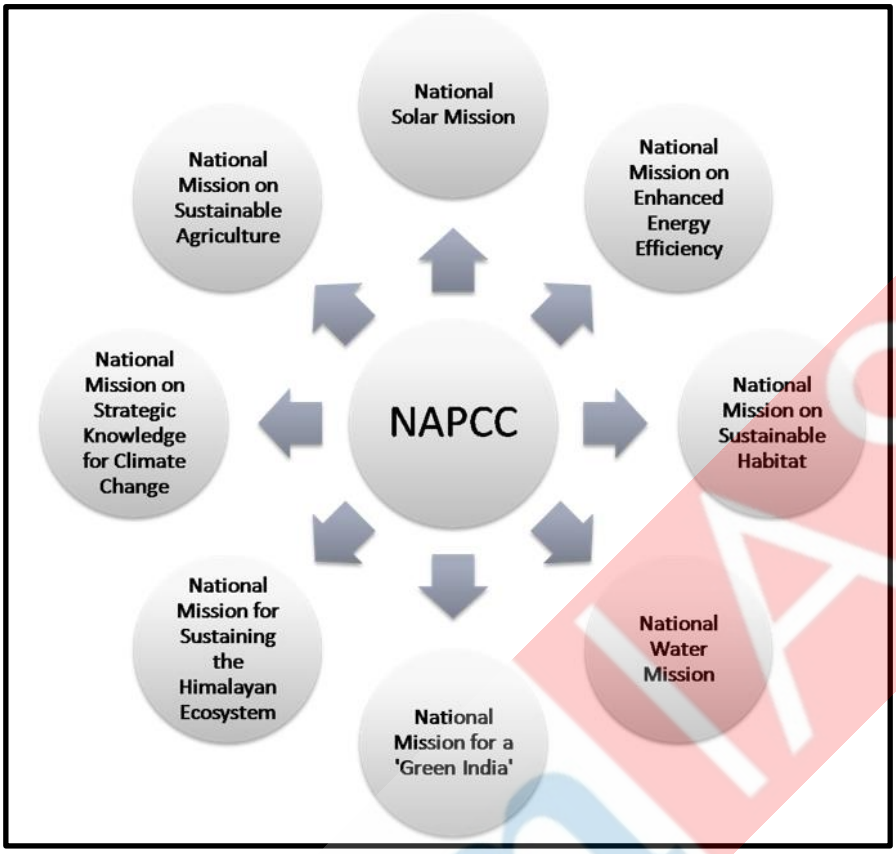
National Adaptation Fund for Climate Change (NAFCC)

- It has been established with a budget provision of Rs. I350 crore for the years 2015–16 and 2016–17. It is meant to assist in meeting the cost of national- and state-level adaptation measures in areas that are particularly vulnerable to the adverse effects of climate change.
- The *overall aim* of the fund is **to support concrete adaptation activities that reduce the adverse effects of climate change facing communities, sectors and states** but are not covered under the ongoing schemes of state and central governments.

Coal Cess and the National Clean Energy Fund

- India is *one of the few countries* around the world to have a *carbon tax* in the form of a cess on coal.
- Not only has India imposed such a cess but it has also been progressively increasing it (form Rs. 50 per tonne of 2010 to Rs. 200 by 2015–16 and Rs. 400 by 2016-17).
- The **NCEF (National Clean Energy Fund)** which is supported by the cess on coal was created for the purposes of financing and promoting *clean energy initiatives*, funding research in the area of clean energy and for any other related activities.

National Action Plan on Climate Change (NAPCC)



- In 2017-18, the PM's Council on Climate Change (PMCCC) directed the missions under the NAPCC to enhance their ambition in respect of adaptation, mitigation and capacity building and prioritize them, besides recommending the setting up of some *new missions* in addition to the existing eight:
    - Considering the adverse impacts that climate change could have on health, a new '**Mission on Climate Change and Health**' is currently under formulation and a National Expert Group on Climate Change and Health has been constituted.
    - The proposed '**Waste-to-Energy Mission**' will incentivize efforts towards harnessing energy from waste and is aimed at lowering India's dependence on coal, oil and gas for power production.
    - The **'National Mission on Coastal Areas**' (NMCA) will prepare an integrated coastal resource management plan and map vulnerabilities along the entire (nearly 7000-km-long) shoreline.
    - The '**Wind Mission**' seeks to increase the share of wind energy in the renewable energy mix of India. It is likely to be given an initial target of producing about 50,000–60,000 MW of power by the year 2022.

Perform Achieve and Trade

- Under the **National Mission on Enhanced Energy Efficiency**
- It was introduced as an instrument for reducing specific energy consumption in energy-intensive industries with a market-based mechanism that allowed the trading of ***ESCerts*** **(energy saving certificates).**
- The ESCerts, issued by the GoI, are traded through the power exchanges in the country.
- To provide adequate amount of investment, the Reserve Bank of India has included renewable energy in the ***PSL*** **(priority sector lending)** for scheduled commercial banks.

National Solar Mission – targets 100 GW of solar power by 2022.

National Mission on Sustainable Habitat: To promote energy efficiency as a core component of urban planning, the plan calls for:

- Extending the existing **Energy Conservation Building Code;**
- A greater emphasis on urban waste management and recycling, including power production from waste;
- Strengthening the enforcement of automotive fuel economy standards and using pricing measures to encourage the purchase of efficient vehicles; and
- Incentives for the use of public transportation.

National Water Mission: With water scarcity projected to worsen as a result of climate change, the plan sets a goal of a 20% improvement in water use efficiency through pricing and other measures.

National Mission for Sustaining the Himalayan Ecosystem: The plan aims to conserve biodiversity, forest cover, and other ecological values in the Himalayan region, where glaciers that are a major source of India's water supply are projected to recede as a result of global warming**.**

National Mission for a "Green India": Goals include the Afforestation of 6 million hectares of degraded forest lands and expanding forest cover from 23% to 33% of India's territory.

- It acknowledges the influence forests have on environmental amelioration through climate change mitigation, food security, water security, biodiversity conservation and livelihood security of forest-dependent communities.
- It hinges on **decentralized participatory approach** involving grass root level organizations and community in planning, decision making, implementation and monitoring.

National Mission for Sustainable Agriculture: The plan aims to support climate adaptation in agriculture through the development of climate-resilient crops, expansion of weather insurance mechanisms, and agricultural practices.

National Mission on Strategic Knowledge for Climate Change:

- To gain a better understanding of climate science, impacts and challenges, the plan envisions a new Climate Science Research Fund, improved climate modelling, and increased international collaboration.
- It also encourages private sector initiatives to develop adaptation and mitigation technologies through venture capital funds**.**

National Smart Grid Mission to bring efficiency in power supply

Energy Conservation Building Code

- It is prepared after extensive consultations with all stakeholders, consisting of architects & experts including building material suppliers and developers.
- **The code is expected to assist large number of architects and builders who are involved in design and construction of new residential complexes.**
- It has potential for energy savings to the tune of 125 Billion Units of electricity per year by 2030, equivalent to about 100 million ton of Co2 emission.

Bureau of Energy Efficiency (BEE):

- **A statutory body under Ministry of Power** created in March 2002 under the provisions of the nation's 2001 Energy Conservation Act**.**
- To implement policy and programmes in energy efficiency and conservation.
- **Objective of BEE –**
    - To reduce energy intensity in our country by optimizing energy demand and
    - To reduce emissions of **greenhouse gases (GHG)**, responsible for global warming and climate change.

National Offshore Wind Energy Policy 2015

- *A* major renewable energy policy initiative.

- It aims at helping offshore wind energy development, including setting up of offshore wind power projects and research and development activities in waters, in or adjacent to the country, up to the seaward distance of 200 nautical miles exclusive economic zone (EEZ) of the country from the baseline.

GRIHA – Green Rating for Integrated Habitat Assessment – building – energy rating system

Zero Effect, Zero Defect (ZED) – quality control and energy efficiency certificate for medium and small industries

Smart Cities, AMRUT, HRIDAY – to develop climate resilient urban cities

Bharat Stage IV fuel efficient standards to be implemented by April 2016 across the country and then move to **Bharat Stage V and VI in the near future**

Mass Rapid Transit System – moving people, instead of moving vehicles

HelpUsGreen:

- It is an Indian private project which is **one of 15 ground-breaking projects** from around the world that has **won this year's *UN 'Momentum for Change' climate action award*.**
- The project collects flowers from temples and mosques across many cities\towns in Uttar Pradesh and recycles them to produce natural incense, organic fertilizers and biodegradable packaging material.
    - helps in preventing chemical pesticides from entering into the river through temple waste.
- Developed as the world's first profitable solution to the monumental temple waste problem.

7. International initiatives

Earth Summit 1992 : The outcome of this summit was the following documents:

1. Rio Declaration on Environment and Development
2. Agenda 21
3. Convention on Biological Diversity
4. Forest Principles

UN Framework Convention on Climate Change (UNFCCC).

- It is **an international environmental treaty** negotiated at the **United Nations Conference on Environment and Development** (UNCED), informally known as the **Earth Summit**, held in Rio de Janeiro from 3 to 14 June 1992.
- It entered into force on 21 March 1994, after a sufficient number of countries had ratified it.
- Objective of UNFCCC : to **stabilize greenhouse gas concentrations** in the atmosphere at a level that would **prevent dangerous anthropogenic interference** with the climate system.
- **Is UNFCCC is legally binding?**
    - **No.**
    - UNFCCC by itself is **not legally binding.**

United Nations Climate Change conferences

- So far, 23 meetings have taken place.
- The key conventions :
    - COP-3 in 1997 at Kyoto (Japan) : resulted in the **legally binding Kyoto Protocol** on Climate Change
    - COP-7 in 2001 at Marrakech (Morocco) : resulted in **establishment of an *Adaptation Fund*** for financially supporting developing countries better adapt to climate change.
    - COP-16 in 2010 at Cancún (Mexico) : resulted in an announcement for **a 100 billion USD per annum *Green Climate Fund*** for providing financial support to developing countries on their climate change actions.

- COP-21 in 2015 in Paris : resulted in **adoption of the *Paris Agreement*** governing climate change reduction measures **from 2020**.

The Paris Agreement

- The Paris Agreement will enter into force on the 30th day after the date on which **at least 55 countries accounting for at least 55% of the total global greenhouse gas emissions** ratify it.
- The agreement aims to reduce emissions of greenhouse gases, the cause of global warming and consequent climate change, and do it fast enough to **keep the average global temperature from rising above 2º, possibly 1.5ºC compared to pre-industrial times**.
- The agreement will come into force 2020.
- **will replace the Kyoto Protocol**, an existing international agreement on climate change that as finalised in 1997.
- Paris Agreement is ambitious
  - resolves to hold global temperature rise to well below 2ºC above pre-industrial levels
  - pursue efforts towards a 1.5º C temp. limit.

Provisions of Paris Agreement

- A **binding obligation** to submit mitigation contributions **every 5 years** and to pursue domestic measures to achieve them.
- For every 5-year cycle, states must put forward contributions **more ambitious than their last**.
- In addition, the agreement envisages a **"global stocktake" every 5 years to assess collective progress towards long-term goals**.
  - The global stocktake will also take into account **"equity**"(so CBDR also protected) — thus paving the way for conversation on burden-sharing between nations.
- The Paris Agreement requires **developed countries to raise finances with $100 billion per year** as the floor by 2020, to help developing nations in both mitigation and adaptation activities, while other nations are encouraged to provide funding voluntarily.
- The first global evaluation of the implementation of the Paris Agreement is to take place in 2023, and thereafter every five years to help all countries.

Bonn Conference (CoP23): The "Rule Book" and Talanoa Dialogue

- The key agenda of the Bonn conference was to **chalk out the Rule Book.**
- If Paris agreement was constitution, the Rule Book would serve as laws and regulations to implement it towards achieving the goal of Paris Agreement i.e. to limit the Earth's temperature rise to a maximum of 2ºC.
- In the Bonn summit, it was decided that the negotiators will keep working for one year and finalize the rule book by December 2018.
- It is expected that the Rule Book shall be adopted at COP-24 at Katowice(Poland) in December, 2018.
- To ensure that this happens, CoP24 host Poland has decided to work with CoP23 host Fiji and past host Morocco. This year long process has been called ***Talanoa Dialogue***.
- Thus, Talanoa dialogue is **a year long process that allows countries to assess their progress on past climate actions** (stocktaking) and **define the way forward** to implement the legally binding Paris Agreement.

Katowice: 24th meeting of the Conference of the Parties (COP24) to the United Nations Framework Convention on Climate Change.

What was expected:

- The summit aimed to **establish guidelines for implementing and reporting on the Paris Agreement**.
- Countries were looking to **establish an enhanced transparency framework to monitor, verify and report** actions taken **in a systematic, standardised manner**.
- Transparency — what would be done to reduce emissions, how countries would measure and report progress, and how much support industrialised countries would provide — was an important aspect of the discussions.
    - This will inform stocktaking of progress on the Paris Agreement and how much more is needed to cut emissions and raise ambition.
- **Funds were also required from rich countries** for the losses and damages borne by poor nations.
- **Technology transfer and capacity building support** are also issues of importance to vulnerable countries and poor, developing countries that need help to transition from high to low carbon economies.

Outcome:

- While there was some progress on **the process by which the Paris Agreement of 2015 would be implemented**, key issues of concern for the poorest and developing nations were diluted or postponed.
- The **1.5 Degree Report**, which was produced by the **Intergovernmental Panel on Climate Change** in October 2018, showed that the **earth is close to a climate catastrophe**.
- There is **little to no finance available for poor and developing nations**.
- The **details on funding and building capacity have been postponed**.
- Article 9 (the provision of financial support to developing countries from industrialised nations) was ignored; instead, there was an **emphasis on carbon markets and insurance mechanisms**.
- In spite of these problems, **a single rulebook for all countries has been produced** and **will serve as a foundation for more detailed rules and structures**.

Global Alliance to Power Past Coal:

- In the recent Bonn summit, it was **launched by Canada and the UK**.
    - Canada has returned as a proactive nation pushing climate change agenda.
    - With US taking a backseat, Canada might be looking for a leadership role.
- This is a programme to **phase out coal usage in energy production**.
- Immediately, more than 20 countries, including France, Finland, and Mexico have become the part of this initiative.
- It brings together a wide range of businesses and civil society organizations that have united for climate protection.

'Momentum for Change' initiative:

- ***An initiative spearheaded by the UN Climate Change secretariat*** to shine a light on the enormous groundswell of activities underway across the globe that are moving the world toward a highly resilient, low-carbon future.
- It recognizes innovative and transformative solutions that address both climate change and wider economic, social and environmental challenges.

8. Global Climate Funds

- Classification:
    - Depending on the participating countries, global climate funds can either be multilateral or bilateral depending on.

    - The funds may further be classified according to their area of focus, namely mitigation, adaptation or REDD(reducing emissions from deforestation and forest degradation).
- Currently, the **Green Climate Fund (GCF)** is the largest, with pledges amounting to US$10.2 billion.
- The second largest is the **Clean Technology Fund (CTF)** with pledges amounting to US$5.3 billion.
- With the capitalization of the GCF and the sunset clause of the CTF, there is ambiguity about the role of the CTF in the climate finance architecture post-2020.

Green Climate Fund (GCF)

- It was ***set up in 2010 under the UNFCCC financial mechanism*** to channel funding from developed countries to developing countries to allow them to mitigate climate change and also adapt to disruptions arising from a changing climate.
- The Green Climate Fund will support projects, programmes, policies and other activities in developing country Parties using thematic funding windows.
- It is intended to be the centrepiece of efforts to raise Climate Finance of $100 billion a year by 2020.
- The Fund will strive to maximize the impact of its funding for adaptation and mitigation, and seek a balance between the two, while promoting environmental, social, economic and development co-benefits and taking a gender-sensitive approach..

The GEF (Global Environment Facility)

- ***It was established on the eve of the 1992 Rio Earth Summit*** to help tackle our planet's most pressing environmental problems.
- It is an international partnership of 183 countries, international institutions, civil society organizations and the private sector that addresses global environmental issues.
- ***GEF funds are available to developing countries and countries with economies in transition*** to meet the objectives of the international environmental conventions and agreements.
- **The World Bank serves as the GEF Trustee**, administering the GEF Trust Fund.
- **It is a FINANCIAL MECHANISM for five major international environmental conventions:**
    1. the Minamata Convention on Mercury,
    2. the Stockholm Convention on Persistent Organic Pollutants (POPs),
    3. the United Nations Convention on Biological Diversity (UNCBD),
    4. the United Nations Convention to Combat Desertification (UNCCD) and
    5. the United Nations Framework Convention on Climate Change (UNFCCC).

9. Criticisms of international initiatives (focus through mitigation and adaptation methods)

- Trump has a favour for fossil fuel (coal) based economy. US not being part of any climate change actions may **add 0.1 to 0.3º C to global warming by 2100**. Some more reluctant countries **may also follow the steps of US** and quit the climate deal. Example - Brazil.
- Developed nations are not willing to accept the historical role they have played in the emission of GHGs. The international initiatives have failed to make them accountable.
- The $100 billion figure does not appear in the legally binding part of the Paris Agreement
- **Climate change does not affect all countries equally** and hence no surety of equal action or concern shown by all participating nations.

    - Low-lying island states face an existential threat from rising sea levels while others, especially countries near the Arctic Circle, may experience greater agricultural output and easier access to natural resources as a result of the thawing of permafrost
- **Developing countries**, especially in Africa, are still left out or stuck with low-tech options. These nascent markets are seen as too disaggregated and high risk for investors.
- The developed nations are mostly focussing on mitigation approaches and are reluctant to transfer technologies for adaptation approaches.

How can the situation be improved?

- Faced with global ecological limits, focus has **to shift from 'environmental risk management' to 'economic growth within ecological limits'.**
- It is in responding to this mega-trend that India's climate policy could have been more forward looking. **The focus everywhere is shifting from production patterns to consumption patterns**.
- Nearly 2/5th of the cumulative emission reductions required by 2050 could come from efficiency improvements.
- Key systems such as the transport, energy, housing and food systems should be transformed.
- India should have integrated its Smart Cities campaign into a plan for low carbon development of cities.
- A greater focus on sharing rather than owning cars would impact the fastest growing emissions..
- Periodic reviews of national contributions should also be undertaken.
- Building state-level profiles of GHG emissions from different sectors can help inform us about different focus areas for each state.
- To fulfill financial needs, India must strategically seek other sources such as the Green Climate Fund and leverage the International Solar Alliance.

10. International Solar Alliance

Objectives

- Promote solar technologies and investment in the solar sector.
- Formulate projects and programme to promote solar applications.
- Develop innovative Financial Mechanisms to reduce cost of capital.
- Build a common Knowledge e-Portal.
- Facilitate capacity building for promotion and absorption of solar technologies and R&D among member countries.

Potential of International Solar Alliance

- Until December 2015, Germany, China, Japan, the U.S., and Italy accounted for 70 per cent of the 227 GW of solar PV deployed globally.
- Developing countries, especially in Africa have large solar potential. But these nascent markets are seen as too disaggregated and high risk for investors.
- In effect, three factors continue to block the rapid scale-up of solar energy:
    - financing is still too costly for developers;
    - **solar-related plans and policies are often incoherent** and increase risks for developers and investors; and
    - there is **insufficient R&D investment in solar**.
- ISA's vision and mission is to **take solar from the lab (or rich world markets) to (developing country) streets**.
- ISA is being designed as **a platform to bring together countries with rich solar potential** (along with solar innovators, developers, and financiers) **to aggregate demand for solar across member countries**, **creating a global buyers' market for solar energy**, and thereby

reducing prices, facilitating the deployment of existing solar technologies at scale, and promoting collaborative solar R&D and capacity.

- The cost of finance for solar projects in many developing countries is often prohibitively high. ISA envisions that collective measures can facilitate the flow of over $1 trillion into solar projects.
- ISA hopes to facilitate **collaborative, cross-country R&D**.
- ISA has plans to address related market-limiting factors, by launching **standardised skill training programmes** and **reducing information asymmetries through a 24x7 knowledge hub**.

Challenges faced by ISA:

- **Funding**: Although alliance talks about developing "innovative financial mechanisms", it does not address how the capital would be provided.
- **Technology Sharing**: There is need to create a comprehensive framework to share the modern solar technologies at low cost.
- The longer-term danger : whether it devolves into a **bloated bureaucracy**.
    - Although conceived as an intergovernmental institution, ISA is not intended to be a typical international bureaucracy.
    - A **tight budget** and a **direct link to the private sector** would hold ISA accountable to real action on the ground.
- The more proximate danger is that 121 potential member countries get caught up in a battle over legal form, membership rights, and giving precedence to procedure over pragmatism.

Climate Change is a natural phenomena but recent human activities have pushed it to the extent where there is no returning back. The policymakers both at national and international levels need to understand that it is not the earth that is at danger rather it is the humanity which will go extinct. The earth or Goddess Gaia has the natural ability to regulate its mechanism known as homeostasis. Every individual from every nation has to participate equally and energetically to fight our common enemy i.e Climate Change. The time demands that humanity must stop seeing humans as their enemies rather see this changing phenomena as the common enemy. This will save trillions of dollars being diverted towards development of arsenals, which can be effectively used for mitigation and adaptation measures in developing and least developed countries.